May 2014






First Update to the

Climate Change Scoping Plan

Building on the Framework

Pursuant to AB 32

The California Global Warming Solutions Act of 2006

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Executive Summary

California is a collection of farmers, surfers, factory workers, outdoor enthusiasts, tech geeks, truckers, world-class researchers, celebrity actors, and many more—who come from all around the world to live and work in one of the most beautiful, vibrant, and ecologically and culturally diverse places on Earth. We are sustained, in more ways than one, by the mountains, deserts, rivers, streams, forests, farmlands, rangelands, coastline, and temperate climate that form our natural environment and characterize our great State.

These resources, and their natural beauty, enable our continued economic and cultural growth. They attract a wide array of businesses and workers who want to live here. They are a primary reason that California is: the eighth largest economy in the world; home to the most small businesses, Fortune 500 companies, and fastest-growing businesses in the United States; the national leader in global trade and direct investment; and tops in the United States in many economic sectors, including agriculture, biotech, clean energy, entertainment, high-tech, manufacturing, tourism, and more.

Accordingly, Californians of all backgrounds and political persuasions have supported policies and planning to protect our natural environment and the high quality of life it provides. The result is a decades-long, broad commitment to ensuring clean air and water, an efficient and productive use of energy and resources, a healthy workforce, and vital cities and towns. Our collective will to protect the environment is a valuable resource in itself, whose benefits enhance economic growth and prosperity in our state and help shape California's distinct identity.

With climate change threatening our resources, economy, and quality of life, California is squarely focused on addressing it and protecting our natural and built environments. Just as California has done dozens of times before on other environmental issues, it is leading on climate change, with an approach that will enable better, lasting economic growth and allow the California lifestyle to endure.

The 2006 adoption of Assembly Bill 32 propelled California further into an international leadership role in the fight against global climate change. By building on decades of successful actions to cut pollution and promote cleaner and more efficient energy, AB 32 solidified California's commitment to tackling climate change in a comprehensive way.

Since 2006, the State has continued to steadily implement a set of actions that are driving down greenhouse gas (GHG) emissions, cleaning the air, diversifying the energy and fuels that power our society, and spurring innovation in a range of advanced technologies. These efforts have put California on course to achieve the near-term 2020 emissions limit, and have created a framework for ongoing climate action that can be built upon to maintain and continue reductions beyond 2020 as required by AB 32.

California's approach to climate change is not simply about reducing greenhouse gas emissions. It is built upon the principle that economic prosperity and environmental sustainability are one and the same. And it continues the State's long and successful legacy of building a world-class economy in concert with some of the most effective environmental and public health policies on the planet.

By remaining steadfastly committed to this approach, we can not only do our part to tackle climate change, we can also forge a cleaner, healthier, and more sustainable future for all Californians.

In the words of Governor Brown, our collective challenge is to "build for the future, not steal from it." That is what this Plan is designed to do.

First Update to the Climate Change Scoping Plan

This First Update to California's Climate Change Scoping Plan (Update) was developed by the Air Resources Board (ARB) in collaboration with the Climate Action Team and reflects the input and expertise of a range of state and local government agencies. The Update reflects public input and recommendations from business, environmental, environmental justice, and community-based organizations provided in response to the release of prior drafts of the Update, a Discussion Draft in October 2013 and a draft Proposed Update in February 2014.

Progress to Date

California is on track to meet the near-term 2020 greenhouse gas limit and is well positioned to maintain and continue reductions beyond 2020 as required by AB 32. The set of actions the State is taking is driving down greenhouse emissions and moving us steadily in the direction of a cleaner energy economy. Many of these actions have been bold, ambitious, and truly trail-blazing. Some are more recent, while others precede the passage of AB 32.

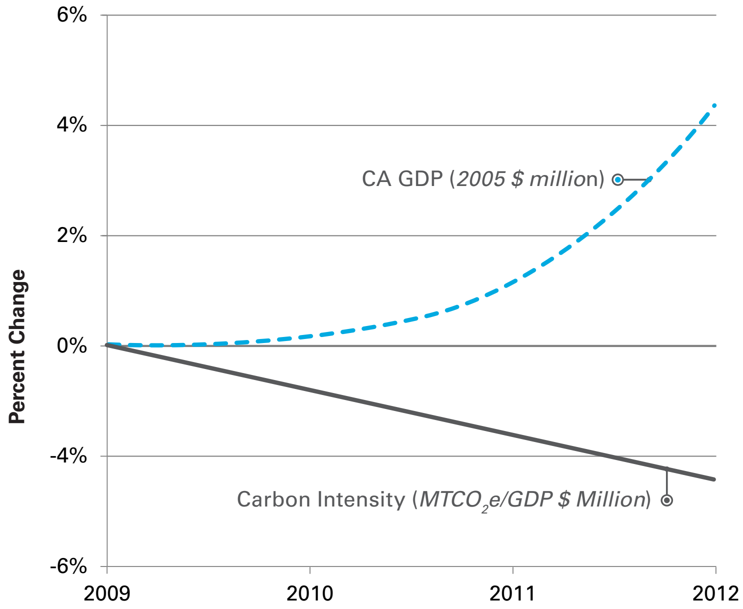
Collectively, these actions are evidence of California's ability to show that it is possible to break the historical connection between economic growth and associated increases in energy demand, combustion of carbon-intensive resources, and pollution. We have shown it is possible to break this chain by relying on cleaner technologies, more efficiency, and more renewable energy sources. And we know that preventing the worst impacts of climate change will require accelerated development and diffusion of these technologies across the world. Stable, flexible, yet durable policies like those developed under AB 32 are key.

Cleaner and More Efficient Energy

California continues to be a global leader in energy efficiency. Since energy efficiency efforts began 40 years ago, Californians have saved $74 billion in reduced electricity costs. As the State's first priority for providing for its energy needs, ongoing efficiency efforts—like new green building standards now in effect for homes and businesses and new standards for appliances, televisions, and other "plug loads"—continue to reduce energy use and emissions, make our businesses and economy more efficient, and cut energy costs.

California has also made tremendous strides in harnessing its abundant renewable energy resources. Currently, about 23 percent of the State's electricity comes from renewable power. This will increase to at least 33 percent by 2020 under new requirements set in place by Governor Brown and the Legislature in 2011. Renewable energy is rapidly coming down in cost and is already cost-effective in California for millions of homes and businesses, and in certain utility applications. Once thought of as exotic and alternative, renewable energy technologies have now become an integral part of California's energy mix.

Figure ES1: 2009-2012 CA GDP & Carbon Intensity Trends



'Carbon Intensity,' the amount of carbon pollution related to the State's economy, has fallen steadily over the last three years. California is getting more economic growth for each ton of greenhouse gases emitted overall.

Source: DOF & 2012 GHG Inventory

Cleaner Transportation

California has taken a number of innovative actions to cut emissions from the transportation sector. Collectively, the State's set of vehicle, fuels, and land use policies will cut in half emissions from passenger transportation and drivers' fuel costs over the next 20 years.

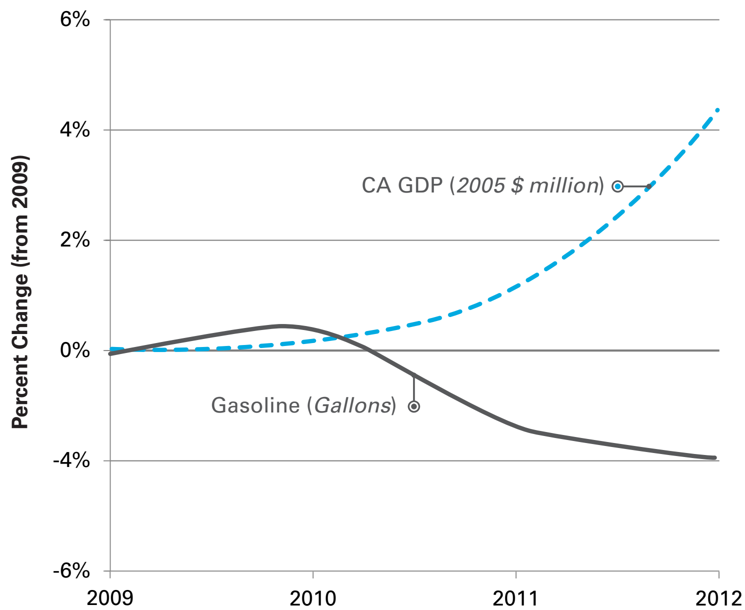
California's Low Carbon Fuel Standard (LCFS) is beginning to drive the production of a broad array of cleaner fuels. Since its launch in 2011, the regulation has generated a multitude of unique approaches for cleaner fuels. The LCFS is driving the necessary transition to cleaner fuels and is providing California businesses and consumers with more choices for the fuels they use. Companies in California and elsewhere are rising to the challenge by finding innovative ways to produce cleaner, low carbon fuels.

The cars on California's roads are also undergoing a transformation. California's vehicle GHG standards—authorized by AB 1493 (Pavley) in 2002, first approved in 2004, and extended in 2012—are delivering both carbon dioxide (CO_2) reductions and savings at the pump. These standards are now federal law and the benefits of California's policies will be realized nationwide, dramatically scaling up emission reductions. The transition to a fleet of lower-emitting, more-efficient vehicles in California will continue beyond 2020, as these rules cover model years through 2025, and turnover of the fleet will deliver additional benefits from these rules for many more years. Most recently, ARB is working with the U.S. EPA and the U.S. Department of Transportation's National Highway Traffic and Safety Administration (NHTSA) on national GHG standards and corresponding fuel efficiency standards for medium- and heavy-duty trucks.

California's pioneering zero emission vehicle (ZEV) regulation is also driving a transformation of the fleet. As a result of ARB's ZEV program and Governor Brown's Executive Order B-16-12, California will see 1.5 million zero emission vehicles on the State's roads by 2025. Each day, more and more zero emission vehicles and cleaner, more efficient cars are driving on our streets and highways—visible signs of the transformation of California's transportation sector.

California is also making major strides toward reducing the number of miles people drive, through more sustainable local and regional housing, land use, and transportation planning. To date, seven Metropolitan Planning Organizations have adopted Sustainable Community Strategies. In addition to helping drive GHG emission reductions, these plans will help create more livable communities that offer greater housing and transportation options; improved access to resources and services; safer, more vibrant neighborhoods; and healthier lifestyles where people can live, work, and play without having to travel long distances or sit through congestion.

Figure ES2: 2009-2012 CA GDP & ON-Road Gasoline Use Trends



The amount of gasoline used in California has steadily declined since 2009 while the the State's economy grew by five percent over the same time period.

Source: DOF & BOE

Cap-and-Trade Program

Last year, California successfully launched the most comprehensive greenhouse gas Cap-and-Trade Program in the world. As the emissions cap is gradually reduced over time, and as additional sources are brought under the cap to include the vast majority of emissions in the State, the program will ensure that California remains on track to continually reduce emissions and meet the 2020 limit. Looking out into the future, the Cap-and-Trade Program will play a critical role in keeping California on the right emissions reduction trajectory to meet ongoing reduction targets at the lowest possible cost. The program is also sending a clear signal that investment in clean, low carbon technologies will pay off. This includes the millions of households and small business customers of the State's largest electric utilities who will see a twice a year "Climate Credit" on their electricity bills. In April 2014, this credit averaged $35 throughout the State. Investing this credit in simple items that improve energy efficiency, such as energy efficient LED light bulbs, can help customers save even more.

On January 1, 2014, California linked its Cap-and-Trade Program with Québec's. By successfully linking cap-and-trade programs across jurisdictions and increasing opportunities for emission reductions, this linkage represents another important step in California's efforts to collaborate with other partners around the globe to address climate change.

Building on the Framework

Through AB 32, California has established an effective framework for climate action. This Update includes an in-depth discussion of climate change science, reflecting the Intergovernmental Panel on Climate Change's recently released Fifth Assessment and input from a distinguished team of scientific expert reviewers. The science clearly highlights the need for action—greenhouse gas emissions must be cut 80 percent below 1990 levels by mid-century to stave off the worst impacts of climate change. Setting a mid-term target and sector-specific targets will help guide our path.

Reaching our ultimate objective—reducing California's greenhouse gas emissions to the scientifically recognized level necessary for climate stabilization— will require California to keep building on the framework by continuing to pursue the maximum technologically feasible and cost-effective actions that will steadily drive down greenhouse gas emissions over the coming decades. It is also clear that many of these same actions are needed to reduce emissions of smog-forming and toxic pollutants to meet federal air quality requirements and ensure that all Californians have healthful air.

This Update lays out a set of new actions that will move the State further along the path to a low-carbon, sustainable future, including specific recommended actions with lead agency assignments and anticipated due dates. Some of the actions are near-term, while others are focused on longer-term efforts that will provide major benefits well into the future.

Every major economic sector in the State will need to play an increasing role in this effort. Success will require the creation of new policies in some sectors, and expanding and refining existing policies in others. We must continue working to find the right combination of policy-based "push" and incentive-based "pull" to accelerate commercial markets for clean energy and efficiency. And we have to coordinate and align public investments in ways that most effectively leverage private resources.

The Great Unifier

Climate change presents an unprecedented set of challenges for California. We are already experiencing its impacts and know that they will only increase. But it can also be a great unifier. It gives us the opportunity to focus on doing more with less; to work across programmatic, policy and political boundaries; and to figure out ways to achieve various goals more quickly and more effectively. The task is to continue building on the steps we have already taken by further integrating climate thinking and sustainability programming into the range of actions we take to grow the economy, protect the environment and public health, and plan for the future.

The strategies we pursue to cut greenhouse gas emissions from our cars, trucks, buses, trains and industries can support ongoing efforts to improve air quality up and down the State, especially in our most heavily impacted communities. Efficiency and conservation programs in the water sector needed to cut emissions will also drive critically needed efforts to enhance supply and reliability priorities. We can cut emissions from our waste stream while also increasing home-grown sources of low-carbon energy and fuels. And we can manage our natural lands and valuable agricultural resources in ways that both achieve climate objectives and enhance their long-term sustainability.

With strategic investment and coordinated policy-making, California can slash emissions from trucks and trains while at the same time building a world-class goods movement and freight-delivery system. We can modernize our rail and passenger transportation systems to move people in ways that both reduce greenhouse gases and increase mobility options and safety. We can take actions to cut emissions of potent short-lived climate pollutants that will also deliver key public health benefits. And we can align strategies that both support reduction goals and bolster our ability to deal with the impacts of climate change already underway.

The reality is that while climate change demands it, these and myriad other examples described in this Update are exactly the types of actions California must take in any case to build for our future.

Mid-Term Target

As supported by many of California's climate scientists and economists, a key step needed to build on California's framework for climate action is to establish a mid-term statewide emission reduction target. Cumulative emissions drive climate change, and a continuum of action is needed to reduce emissions not just to stated limits in 2020 or 2050, but also every year in between. The target will ensure that the State stays on course and expands upon the successes we have achieved to date so that we can achieve our long-term objective of reducing California's greenhouse gas emissions to the scientifically recognized level necessary for climate stabilization. A mid-term target, informed by climate science, will be critical in helping to frame the additional suite of policy measures, regulations, planning efforts, and investments in clean technologies that are needed to continue driving down emissions. It will also send a clear signal that California is solidifying its commitment to a low-carbon future, giving businesses the long-term certainty they need to plan for the future.

Each of the major sectors highlighted in this Update must play a role in supporting the statewide effort to continue reducing emissions. As steps are taken to develop a statewide target, sector targets will also be developed that reflect the opportunities for reductions that can be achieved through existing and new actions, policies, regulations and investments.

Sector-Specific Actions

Energy

The actions outlined in this Update support California's efforts to build a state-of-the-art energy generation, supply and distribution system that is clean, affordable and reliable. Many of the actions expand upon existing policy frameworks that have made our State a global leader in areas like energy efficiency, demand response, and renewable energy generation. Others reflect the need to incorporate new and rapidly evolving technologies like energy storage, demand response, and a smarter grid into the fabric of California's energy system.

A core element of the Update is the development of a comprehensive greenhouse gas reduction program for the State's electric and energy utilities by 2016. This approach will enable California to pull together and coordinate a range of policies, technologies, and investments needed to achieve the most cost-effective emission reductions across the sector, in line with meeting mid-term and long-term statewide targets. It also will give utilities, electricity providers and a range of other businesses the flexibility and the right incentives to pursue the most innovative strategies to cut emissions.

Transportation, Land Use, Fuels, and Infrastructure

Over the past several decades, California has pioneered a host of innovative policies in the transportation sector that have cut air pollution and greenhouse emissions. This Update builds on a set of existing policies and lays out new strategies that will continue to push down emissions and scale up clean, advanced technologies across the entire transportation sector. It calls for targeted investment in critical infrastructure projects that will be necessary to keep California on track to meet our ongoing climate objectives. And it recognizes the need to closely integrate climate planning with efforts to meet California's air quality goals.

Meeting California's long-term air quality and climate objectives will require the State to continue building on efforts underway to put more low and zero-emission vehicles on the road. These efforts also need to be expanded to include an increasing focus on cleaner medium- and heavy-duty vehicles. At the same time, we must continue working to figure out the right mix of policies and incentives for increasing reductions in the carbon content of transportation fuels. And we must invest in building the cleanest, most advanced systems and infrastructure to move people and goods in the State. Key approaches to this include high speed rail and the Sustainable Freight Initiative.

Agriculture

California's agricultural industry provides hundreds of thousands of jobs and tens of billions of dollars in economic value to the State each year. The long-term sustainability of the sector is vital to California's economic future. This Update describes a set of actions to ensure California's agricultural sector continues to thrive in the face of a changing climate and plays a key role in the State's efforts to continue reducing greenhouse emissions.

There is a range of opportunities for greenhouse gas emission reductions and sequestration in the agriculture sector. Technological advancements allow for more precise irrigation techniques, which cut energy costs and preserve valuable water resources. Strategic approaches to conservation will keep valuable agricultural lands in operation and help eliminate greenhouse gas emissions that result from conversion. And capturing methane from agriculture operations will provide climate benefits while also affording opportunities to produce bioenergy and biofuels. The coordinated effort to develop the right mix of policies and incentives described in this Update will help keep California's agriculture sector thriving into the future.

Water

Water is the lifeblood of our State and economy, and integrally connected to our food supply and energy systems. With the declaration of a drought emergency, the State needs to employ a range of approaches that will cut emissions, maximize efficiency and conservation, and enhance water quality and supply reliability, while also addressing growing climate resiliency requirements.

A greater focus on integrated policy design in the water sector is needed as California implements strategies that will support our State's longer-term climate objectives. State policy and regulatory frameworks must be developed that allow for, and incentivize, effective regional integrated planning and implementation. We need to employ pricing policies that will maximize efficiency and conservation efforts in the water sector, and put in place mandatory conservation measures to reduce greenhouse gas emissions and maintain water supply reliability during drought periods.

Waste

California's goal of reaching 75 percent recycling and composting by 2020 provides an opportunity to achieve substantial GHG emission reductions across the waste sector, while providing other significant economic and environmental co-benefits. Much of what is traditionally considered "waste" can be a resource for other uses. California must take advantage of waste materials to generate energy to power our homes and cars, and to improve our working lands.

Compostable organics represent over a third of California's disposed waste, and are the primary source of fugitive methane emissions at landfills. A new organics management approach for California that will divert this material to minimize emissions at landfills and provide feedstock for critically needed alternatives to agricultural amendments and for low carbon fuel manufacturing.

Achieving the 75 percent waste diversion goal will require substantial expansion of the collection, recycling, and manufacturing industries within California. This Update sets forth a series of actions to support this industrial growth and calls on California to manage its waste at home in ways that will support greenhouse gas emission reductions, environmental co-benefits, and job growth.

Natural and Working Lands

Three-quarters of California's landmass comprises biologically diverse landscapes such as forests, woodlands, shrublands, grasslands and wetlands. These natural and working lands provide a multitude of economic and environmental benefits, and must play an increasingly important role in California's efforts to prepare for and adapt to the impacts of climate change. Natural and working lands must also play a key role to help achieve California's long-term climate objectives. We have to start investing now in strategies that ensure these lands are managed in ways that maximize their carbon benefits while also ensuring landscape resilience; protecting and enhancing the State's water supplies; safeguarding the State's wildlife, fish, and plants; and promoting sustainable rural communities.

This Update describes a series of policies, actions, and strategic investments to enhance, protect, and conserve California's natural and working lands in ways that will provide important climate benefits as well as a more resilient California that is better prepared for climate risks such as more frequent and severe wildfires, varying and unpredictable water availability, and stressors on species and natural communities. A key element of this approach is the development of a "Forest Carbon Plan" by 2016 that will set mid and long-term greenhouse gas reduction planning targets, and identify funding and investment needs.

Short-Lived Climate Pollutants

Over the past several decades, California's actions to improve air quality and protect public health have resulted in significant reductions in potent short-lived climate pollutants, which include black carbon, methane, and hydrofluorocarbons. These pollutants remain in the atmosphere for shorter periods of time and have much larger global warming potentials compared to CO_2.

While we must continue taking steps to rapidly reduce CO_2 emissions, additional efforts to cut emissions of short-lived climate pollutants can yield immediate climate benefits. In addition, fast and sustainable actions to reduce these emissions can help to achieve other benefits though avoided impacts on agriculture, water availability, ecosystems, and human health. The reduction of methane would reduce background tropospheric ozone concentrations, which would help with progress towards healthy air quality and avoid crop yield losses and forest damage due to the direct action of ozone on plant growth. Black carbon impacts cloud formation and precipitation, and black carbon deposits on glaciers and snowpack accelerate melting. Reducing black carbon and methane emissions will help reduce the risk for premature deaths, air pollution-related hospitalizations, and associated medical expenses each year.

California is committed to continuing to reduce emissions of short-lived climate pollutants, particularly where efforts will result in air quality and public health co-benefits. ARB will develop a short-lived climate pollutant strategy by 2015 that will include an inventory of sources and emissions, the identification of additional research needs, and a plan for developing necessary control measures.

Green Buildings

Buildings in California represent a significant source of greenhouse gas emissions. Over the past five years, California has solidified its commitment to green building; leading the way with State buildings, improving building standards, continuing to raise the bar with voluntary programs at the local level, and greening existing buildings. We must continue to build on this approach by ensuring successful implementation of current initiatives and expanding the long term focus towards zero-carbon buildings.

This Update describes a set of actions to continue cutting emissions from California's building sector including the development of a comprehensive greenhouse gas emission reduction program for new construction, existing building retrofits, and operation and maintenance. This Update describes a set of actions to continue cutting emissions from California's building sector including the development of a comprehensive greenhouse gas emission reduction program for new construction, existing building retrofits, and operation and maintenance of certified green buildings.

Courage, Creativity, and Boldness

Climate change has presented us with unprecedented challenges—challenges that cannot be met with traditional ways of thinking or conventional solutions. As Governor Brown has recognized, meeting these challenges will require "courage, creativity, and boldness."

It will require California to continue to lead the world in pioneering effective strategies toward a cleaner, more sustainable economy. It will require us to continue sharing our successful approaches to climate policy with others, including continuing to partner and collaborate with other state, national, and global leaders as we work toward common goals. And it will require further engaging California's citizens, businesses, and its most creative minds to continue building a state that provides low carbon, high-quality lifestyles.

As we take these steps, we understand that we don't have all of the answers today. But, we are on the right path. We have a framework for action in place that is driving down emissions, spurring innovation across a range of clean and advanced technology sectors, improving the air Californians breathe, and creating more livable communities. By building on this framework with the set of actions outlined in this Update, we can do our part to meet the challenge of global climate change, and in the process, continue to build the clean, sustainable future that all Californians deserve.

I. Introduction: Building on the Framework

This Scoping Plan Update builds upon the successful framework established by the initial Scoping Plan by outlining priorities and recommendations for the State to achieve its long-term climate objectives. The unified approach in this Update describes actions for California to undertake to ensure it continues on a path toward a cleaner, more sustainable and prosperous future. This approach is designed to ensure the State is able to meet its long-term climate objectives that will achieve continual emission reductions in the most cost-effective ways, while simultaneously supporting a range of economic, environmental, water supply, energy security, environmental justice, and public health priorities.

Assembly Bill 32 (AB 32), the California Global Warming Solutions Act of 2006 (AB 32, Statutes of 2006, Chapter 488) declares that global warming poses a serious threat to the economic well-being, public health, natural resources, and environment of California and charges the California Air Resources Board (ARB) with "monitoring and regulating sources of emissions of greenhouse gases that cause global warming in order to reduce emissions of greenhouse gases" (Health and Safety Code section 38510). AB 32 provided initial direction on creating a comprehensive multi-year program to limit California's greenhouse gas (GHG) emissions at 1990 levels by 2020 and initiate the transformations required to achieve the State's long-range climate objectives. One specific requirement is to prepare a "scoping plan" for achieving the maximum technologically feasible and cost-effective GHG emission reductions by 2020 (Health and Safety Code section 38561(a)). ARB is required to update the plan for achieving the maximum technologically feasible and cost-effective reductions in GHG emissions at least once every five years (Health and Safety Code section 38561(h)). The language of AB 32 is included in Appendix A.

The initial Scoping Plan was approved in 2008, as required by AB 32, and reapproved in 2011. The initial Scoping Plan contained a mix of recommended strategies that combined direct regulations, market-based approaches, voluntary measures, policies, and other emission reduction programs calculated to meet the 2020 statewide GHG emission limit and initiate the transformations needed to achieve the State's long-range climate objectives. The passage of the Global Warming Solutions Act, and its ongoing implementation, has put California on a path to continually reduce GHG emissions by adopting and implementing regulations and other programs to reduce emissions from cars, trucks, electricity production, fuels, and other sources.

While the path to limit emissions to 1990 levels by 2020 is transformative in its own right, reducing emissions to meet the State's long-range objectives will require continued progress toward efficient clean energy in every sector of the economy and new opportunities to value and integrate agricultural, natural, and working lands into a comprehensive climate policy framework. The State's 2050 objective of reducing emissions to 80 percent below 1990 levels, as reflected in Executive Order S-3-05 and Governor Brown's Executive Order B-16-2012 (which is specific to the transportation sector), is consistent with an Intergovernmental Panel on Climate Change (IPCC)[1] analysis of the emissions trajectory that would stabilize atmospheric GHG concentrations at 450 parts per million carbon dioxide equivalent (CO_2e) and reduce the likelihood of catastrophic climate change.

1 The IPCC is the leading international body for the scientific assessment of climate change established in 1988 under the auspices of the United Nations.

Continuing progress to the 2050 objective requires California to maintain and build upon its existing programs, scale up deployment of clean technologies, and provide more low-carbon options to accelerate GHG emission reductions, especially after 2020.

A. AB 32: California's Global Warming Solutions Act

Under AB 32, California has established a unique, broad program of regulatory and market mechanisms to achieve real, quantifiable, cost-effective GHG emission reductions. Since 2006, ARB has carried out the following specific tasks required by AB 32:

- **Determine the 1990 GHG emission level to serve as the 2020 emission limit:** In December 2007, the Board approved the 2020 limit of 427 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) GHG emissions.
- **Adopt a regulation requiring GHG emission reporting:** In December 2007, the Board approved a regulation requiring the largest industrial sources in California to report and verify their GHG emissions.
- **Identify and adopt regulations that could be enforceable by January 1, 2010:** In 2007, the Board identified nine discrete early action measures, which have all been adopted.
- **Develop a scoping plan for achieving the maximum technologically feasible and cost-effective GHG emission reductions by 2020 and update the report every five years to continue to consider future achievement of maximum technologically feasible and cost-effective GHG emission reductions:** The first Scoping Plan was approved by the Board in 2008 and reapproved in 2011. This report is the first update to the Scoping Plan.
- **Maintain and continue GHG emission reductions beyond 2020:** This first update presents the priorities and recommendations for achieving the State's longer-term emission reduction objectives.

Meeting the State's climate objectives requires a coordinated and cohesive statewide strategy based on informed decisions that draw upon research, technology, infrastructure, the State's policy priorities, and potential co-benefits. Planning must continue to further align the State's longer-term GHG reduction strategies with other State policy priorities, including those related to economic development, water, waste, natural resources, agriculture, clean energy, transportation, and land use.

B. Building on California's Environmental Legacy

Just as California has done time and again over the past 40 years, the State is decoupling economic growth from pollution and waste. Continually, California has implemented rational, well-supported policies that have—among many other accomplishments—dramatically cut pollution from new cars, made its new buildings and appliances the most efficient in the country, phased out lead from gasoline and created the cleanest-burning transportation fuels in the world, phased out dirty coal- and oil-burning power plants, and brought entire new industries to life and clean technologies to market.

This progress did not come without battles, debates, or skepticism. But in each case, armed with strong scientific backing, California persevered, prevailed, and ultimately provided a case study to the world that proved a conventional wisdom false: Economic growth is not inherently linked to pollution, increasing energy consumption, or consumption of fossil resources.

California has successfully pioneered dozens of new energy and environmental policies that repeatedly demonstrate that economic growth does not have to be one of a set of trade-off considerations or come at a cost to future generations.

California's policy successes derive from the fact that, when faced with the certainty of reasonable policy, businesses innovate and successfully cut pollution with consumer-oriented solutions that drive their markets forward and continue economic growth. The result is fewer emissions, improved public and environmental health, and better products that allow industries and businesses to grow and flourish.

Many others throughout the world look to adopt or mimic California's leading policies and build similar markets for clean technologies. California is regarded as a global leader for developing successful policy solutions to deal with pressing environmental problems—whether it is other states or the federal government adopting California vehicle and fuel standards; subnational governments in Canada and Mexico looking to do the same; or delegations from countries in Europe, Asia, and Australia visiting to learn how we monitor and control air pollution, improve vehicle and building efficiency, develop smarter communities, and build markets for clean energy and fuels.

Through the Global Warming Solutions Act, California is continuing to lead with effective policies to address global climate change. Once again, we are proving conventional wisdom wrong, and showing that we can dramatically reduce emissions of GHGs while growing our economy.

Since the initial Scoping Plan was released, California has put in place a number of measures that have already led to significant emission reductions, and a transformation to a strong, stable low-carbon economy in California is under way. We are on the right path. Our actions are reducing GHG emissions, spurring innovation across a range of clean and advanced technology sectors, improving the air Californians breathe, and creating more livable communities. All the while, our economy continues to grow, and we continue to add jobs more quickly than the rest of the country. By continuing down this path, California will do its part to meet the challenge of global climate change, and in the process, continue to build the clean, sustainable future all Californians deserve.

SUCCESS STORY

Propel Fuels Moves to California

Propel Fuels is a renewable biofuels company which relocated to California specifically because of the economic opportunities created by AB 32's Low Carbon Fuel Standard (LCFS). The LCFS encourages investment in a wide variety of alternative transportation fuels, and Propel specializes in providing E85 (ethanol) flex fuel and other fuels. Part of Propel's unique business model involves placing its fuel pumps at already-existing gas stations. The company supplies individual motorists, truck operators and commercial vehicle fleets. Propel had $4.5 million in revenue in 2012, and was 42nd on Forbes Magazine's list of "Most Promising Companies".

However, we know we need to do more, and we need to move faster. The world is watching, just as it always has, and is banking on our success to spur broader action. It is critical that California continues to lead and implement successful policies that can expand beyond our borders.

C. Initial Scoping Plan

With the development of the initial Scoping Plan, California became the first state in the nation with a comprehensive set of GHG emission reduction strategies involving every sector of the economy. The measures and policies in the Scoping Plan set California on a trajectory toward a clean-energy future. The recommended reduction measures drive innovation, improve the environment, enhance public health, and support the growth of clean energy technologies and businesses. By moving first, California is well-positioned to lead in the race to develop the clean technology products, patents, and projects the global market demands and needs to address climate change.

The comprehensive approach in the initial Scoping Plan addressed key criteria, including technological feasibility, cost-effectiveness, overall societal benefits, and impacts on specific sectors such as small business and disproportionately impacted communities. The thorough planning process underlying the initial Scoping Plan and this Update helps to ensure that California meets its GHG reduction targets in a way that promotes and rewards innovation, helps to foster economic growth, and delivers improvements to the environment and public health, including in the most affected communities.

Key elements of the initial Scoping Plan included the following:

- Expand and strengthen energy efficiency programs, including building and appliance standards.
- Increase electricity generation from renewable resources to at least 33 percent of the statewide electricity mix by 2020.
- Establish targets for passenger vehicle-related GHG emissions for regions throughout California and pursue policies and incentives to achieve those targets. Included with this strategy is support for the development and implementation of a high speed rail system to expand mobility choices and reduce GHG emissions.
- Adopt and implement measures pursuant to existing State laws and policies, including California's clean car standards and the Low Carbon Fuel Standard.
- Develop a cap-and-trade program to ensure the target is met, while providing flexibility to California businesses to reduce emissions at low cost.

The initial Scoping Plan identified specific GHG emission reduction measures that would assist the State in meeting the 2020 limit. A discussion of the status of all of the Scoping Plan measures is included in Appendix B.

D. Purpose of Update

This Update identifies the next steps for California's leadership on climate change. While California continues on its path to meet the near-term 2020 greenhouse gas limit, it must also set a clear path toward long-term, deep GHG emission reductions. This report highlights California's success to date in reducing its GHG emissions and lays the foundation for establishing a broad framework for continued emission reductions beyond 2020, on the path to 80 percent below 1990 levels by 2050.

This first Update to the initial AB 32 Scoping Plan (Update) describes progress made to meet the near-term objectives of AB 32 and defines California's climate change priorities and activities for the next several years. It also frames activities and issues facing the State as it develops an integrated framework for achieving both air quality and climate goals in California beyond 2020. Specifically, this Update covers a range of topics:

- An update of the latest scientific findings related to climate change and its impacts, including short-lived climate pollutants.
- A review of progress-to-date, including an update of Scoping Plan measures and other state, federal, and local efforts to reduce GHG emissions in California.
- Potential technologically feasible and cost-effective actions to further reduce GHG emissions by 2020.
- Recommendations for establishing a mid-term emissions limit that aligns with the State's long-term goal of an emissions limit 80 percent below 1990 levels by 2050.
- Sector-specific discussions covering issues, technologies, needs, and ongoing State activities to significantly reduce emissions throughout California's economy through 2050.
- Priorities and recommendations for investment to support market and technology development and necessary infrastructure in key areas.
- A discussion of the ongoing work and continuing need for improved methods and tools to assess economic, public health, and environmental justice impacts.

Progressing toward California's long-term climate goals will require that GHG reduction rates be significantly accelerated. Emissions from 2020 to 2050 will have to decline at more than twice the rate of that which is needed to reach the 2020 statewide emissions limit.

In addition to our climate objectives, California also must meet federal clean air standards. Emissions of criteria air pollutants, including ozone precursors (primarily oxides of nitrogen, or NO_x) and particulate matter, must be reduced by, a currently estimated, 90 percent by 2032 to comply with federal air quality standards. The scope and scale of emission reductions necessary to improve air quality is similar to that needed to meet long-term climate targets. Achieving both objectives will align programs and investments to leverage limited resources for maximum benefit.

Accelerating progress on this scale will require both continuation of existing policies and implementation of new ones to help significantly scale market adoption of the cleanest, most-efficient technologies. It will require a new approach to energy production and utilization, and strong mid-term targets to measure and guide the State's progress. This document outlines the challenges we face to achieve this vision, which will be the subject of ongoing climate and investment planning efforts in California in the coming years.

E. Process for Developing the Update

This Update was developed with input from State and local agencies, community and environmental justice organizations, and other interested stakeholders in an open and public process.

ARB held an initial public workshop in June 2013 to discuss preliminary concepts for this Update. As part of the workshop, ARB and other State agency representatives provided a vision for each focus area for 2050 and challenges that must be addressed to meet that vision. ARB and other State agencies also co-hosted public regional workshops with local air districts and metropolitan planning organizations throughout the State (Bay Area, South Coast, and San Joaquin Valley). The workshops were convened to discuss preliminary concepts for this Update (similar to the initial workshop) and to provide a local/regional perspective on both progress to date and regional priorities for California's climate program.

A discussion draft of the Update was released for public comment on October 1, 2013. The discussion draft was presented at a public meeting and a Board hearing later that month to further solicit public input. After consideration of comments received, staff released a draft Proposed Update on February 10, 2014, and presented it to the Board for discussion at its February 20, 2014, meeting. At that meeting, the Board directed staff to make specific changes to the draft report. A draft environmental analysis (EA) of the Proposed Update was released for a 45-day public comment period on March 14, 2014. After considering public comments received and Board direction, ARB staff released a final First Update, along with the summary of comments received on the draft EA and ARB's responses to those comments, and the final EA on May 15, 2014.

Under the guidance of the Climate Action Team, ARB and other State agencies collaborated during the development of the Update to identify and describe a long-term vision and near-term activities to put California on the path to its 2050 emission reductions goal. To help guide in this effort, ARB identified six key focus areas comprising major components of the State's economy to evaluate and describe the larger transformative actions that will be needed to meet the State's more expansive emission reduction needs by 2050.

Climate Action Team

California Environmental Protection Agency

Governor's Office of Planning and Research

California Air Resources Board

Business, Consumer Services, and Housing Agency

Government Operations Agency

California Natural Resources Agency

California Department of Public Health

Office of Emergency Services

California Transportation Agency

California Energy Commission

California Public Utilities Commission

Department of Food and Agriculture

Department of Forestry and Fire Protection

Department of Fish and Wildlife

Department of Transportation

Department of Water Resources

Department of Resources, Recycling and Recovery

State Water Resources Control Board

The focus areas include:

- Energy
- Transportation (Vehicles/Equipment, Sustainable Communities, Housing, Fuels, and Infrastructure)
- Agriculture
- Water
- Waste Management
- Natural and Working Lands

State agency focus area workgroups were created in 2013 to conduct these evaluations. Various State agencies took lead roles. For example, the California Energy Commission (CEC) took the lead for the energy sector and ARB took the lead for transportation. Each workgroup developed a working paper which formed the foundation upon which the agencies, with stakeholder input, identified recommendations for policy or program priorities for the next five years. Recommended action items for meeting the longer-term GHG emission reduction goals are presented in Chapter IV. The working papers are included in Appendix C.

AB 32 requires ARB to convene an Environmental Justice Advisory Committee (Committee) to advise it in developing the Scoping Plan and any other pertinent matters in implementing AB 32 (Health and Safety Code section 38591). The Board convened the Committee in 2007 to advise it on the development of the initial Scoping Plan. The Board reconvened the Committee to advise it on the development of this Update. The Committee met four times from June 2013 to April 2014 to discuss the Update. The Committee focused their discussions on each Scoping Plan sector and developed comprehensive recommendations that ARB considered in drafting this Update. The Committee's "Final Recommendations on the Proposed AB 32 Scoping Plan" provided recommendations for each Scoping Plan sector and overarching environmental justice policy. The final recommendations included the need for monitoring and assessing potential impacts of the State's climate programs; a call for a 2030 target of, at a minimum, 40 percent reduction from 1990 levels and a 2040 target of, at a minimum, 60 percent reduction from 1990 levels; a call for California to reduce its energy use and transition to 100 percent renewable energy; financial support for transportation in disadvantaged communities; and amendments to the Cap-and-Trade Regulation that would exclude direct allocation and offset credits. The Committee's final recommendations are included in Appendix E.

ARB also convened a panel of economic experts to serve as advisors during the development of this Update and provide recommendations for evaluating the economic impacts associated with AB 32. The advisors were invited to participate in teleconferences, review draft documents, and provide feedback to ensure that the economic impacts of programs implemented under AB 32 are analyzed with the best available data and methods. ARB consulted with the advisors on the best means of assessing economic impacts to date, as well as estimating future impacts of existing or new emission reduction strategies. ARB will continue to seek expert economic advice in the evaluation of the impacts of AB 32 and the Scoping Plan on California's economy as the program continues to be implemented.

In addition, a group of distinguished scientists with expertise in observed climate change in California, projection of future climate change impacts, and short-lived climate pollutants, provided input on the latest climate science discussion in the Update.

ARB also held numerous meetings and conference calls with individuals and stakeholder groups such as industry associations, environmental groups, tribes, and small businesses on specific issues or recommendations to address in this Update.

II. Latest Understanding of Climate Science

The latest climate science further underscores the urgent need to accelerate GHG emission reductions to avoid the most severe impacts of climate change. Focusing on additional measures to reduce emissions of climate-warming pollutants with shorter atmospheric lifetimes (known as short-lived climate pollutants) could provide immediate air quality and public health benefits while helping to slow the rate of human-caused climate change.

Scientific Expert Reviewers

Dr. Daniel Cayan	*Scripps Institution of Oceanography, UC San Diego and U.S. Geological Survey*
Dr. Michael Prather	*UC Irvine*
Dr. V. Ramanathan	*Scripps Institution of Oceanography, UC San Diego*

Climate scientists agree that global warming trends and other shifts in the climate system observed over the past century are almost certainly attributed to human activities and are proceeding at a rate that is unprecedented when compared with climate change that human society has lived through to date. Climate change is measured by examining recent shifts in the features (statistics, including extremes) that are associated with average weather, such as temperature, wind patterns, and precipitation, plus long-term trends in the great ice sheets, Arctic sea ice, and mean sea level. Since the development of the Scoping Plan, even stronger scientific evidence continues to mount that document that the climate is changing and that its impacts are widespread and occurring now. This evidence includes rising temperatures, shifting snow and rainfall patterns, and increased incidence of extreme weather events. To ensure that this new evidence on the impacts of climate change is accurately summarized, this chapter was reviewed by a group of distinguished scientists with expertise in observed climate change in California, projection of future climate change impacts, and short-lived climate pollutants.

The recently released Summary for Policymakers (SPM)[2] portion of Working Group I (WGI), the first in a series of reports comprising the IPCC Fifth Assessment Report (AR5), affirms that the planet is warming, that human beings are "extremely likely" (indicating 95 percent certainty) to be the primary cause, and that some of the impacts of greatest concern, such as glacial melting, are accelerating at a faster pace than documented in previous assessments.

This understanding of the climate system in AR5 results from combining observations, theoretical studies of feedback processes, and model simulations. Compared to earlier reports, more detailed observations and improved climate models now enable the attribution of detected changes to human influences in more climate system components and at higher spatial resolution. The consistency of observed and modeled changes across the climate system, including regional temperatures, the water cycle, the global energy budget, sea ice, and oceans (including ocean acidification) point to global climate change resulting primarily from human-caused increases in GHG concentrations.

2 *www.climate2013.org/images/report/WG1AR5_SPM_FINAL.pdf*

The IPCC report notes a continued rate of global warming along with the increasing radiative forcing driven by greenhouse gases. The rate of global surface air temperature warming over the past 15 years—about 0.05°C per decade—has been slower than the average rate since 1951, but the last decade is still the warmest observed, and each of the last three decades has been successively warmer than any preceding decade since 1850. The key findings include:

Increased certainty on humans' role: Scientists are now more certain than ever that observed warming can be attributed primarily to human activities such as exploitation of fossil fuels and deforestation. The report underscores the growing body of scientific evidence confirming the serious detrimental impacts of increasing atmospheric GHG burden.

Accelerating impacts of climate change: Several indicators of climate change are advancing faster than found in previous assessments.

- ***Ice Loss:*** Arctic summer sea ice retreat was unprecedented and sea surface temperatures were anomalously high in comparison to at least the last 1,450 years. The melting of ice sheets over the past decade is happening several times faster than it was in the 1990s. Glacial melt has accelerated as well. There is high confidence that current glacier extents are out of balance with current climatic conditions, indicating that glaciers, ice sheets, and sea ice will continue to shrink in the future even without further temperature increases.
- ***Sea-Level Rise:*** The rate of sea level rise since the mid-nineteenth century has been larger than the mean rate during the previous two millennia. Over the period 1901 to 2010, global mean sea level rose by 7.48 inches (19 centimeters). Global mean sea level will continue to rise during the twenty-first century, and the rate of sea level rise will exceed that observed during 1971 to 2010 due to increased ocean warming (leading to the thermal expansion of the water) and increased loss of mass from glaciers and ice sheets.
- ***Ocean Acidification:*** Due to excess carbon dioxide in the atmosphere, the pH of seawater has decreased. This increased acidity poses risks to ocean ecosystems—the development of many shellfish, plankton, and other forms of ocean life—as well as to people who depend on oceans for their livelihood.
- ***Heat Waves:*** It is likely that human influence has already contributed to the observed changes in the frequency and intensity of daily temperature extremes on the global scale since the mid-twentieth century, and has significantly increased the probability of occurrence of heat waves in some locations.
- ***Air Quality:*** There is high confidence that warming is decreasing baseline surface ozone globally, but higher methane emissions are counteracting and overriding this impact. There is medium confidence that locally higher surface temperatures in polluted regions will increase peak levels of ozone and particulate matter 2.5 microns or smaller ($PM_{2.5}$), but a no confidence level is attached to the overall impact of climate change on $PM_{2.5}$.

As documented in the AR5 report, accumulating observations underscore the fact that the important parts of the climate system have a long memory. Continued emissions of GHG will cause further warming and changes in all components of the climate system. Cumulative emissions of CO_2 largely determine global mean surface warming by the late twenty-first century and beyond. Most aspects of climate change will persist for many centuries, even if CO_2 emissions are radically reduced. This represents a substantial multi-century climate change commitment created by past, present, and future CO_2 emissions. Limiting climate change will require substantial and sustained reductions of GHG emissions.

California is a large state that is particularly vulnerable to the effects of climate change. The State is facing a range of impacts, including increases in extreme heat, wildfires, drought, extreme storms, coastal flooding, and erosion, and reductions in the Sierra Nevada springtime snowpack. Climate change also threatens to affect water availability. Climate and hydrological models indicate that warming will likely diminish river discharge in the Colorado Basin as global climate change advances over the next several decades. A new study[3] suggests that both the California drought and the polar vortex, two persistent extreme weather outcomes observed this past winter season, may be linked to the same underlying cause: climate change as a result of warming from the accumulation of GHGs. California's efforts to reduce GHG emissions and avoid the worst impacts of climate change must occur in parallel with planning for and adaptation to climate change that is already occurring, as well the climate change that is already in the pipeline out to 2050 and beyond, immaterial of future mitigation.

The climate effects of emissions from different climate-forcing pollutants vary in terms of both magnitude and duration. There is growing recognition, both from a scientific and regulatory perspective, that mitigation of short-lived climate pollutants would lead to immediate reductions in the rate of climate change. Although there is no precise definition of short-lived climate pollutants, these include pollutants such as black carbon, tropospheric ozone, methane, and hydrofluorocarbons, all of which will decay in the atmosphere on the order of days to decades. These timescales are much shorter than centennial time scale for CO_2, where about 40 percent of currently emitted CO_2 will remain in the atmosphere by 2100 and affect climate for centuries beyond. Black carbon (as a component of $PM_{2.5}$) and ozone are air pollutants with substantial health effects, and reducing their emissions can offer significant improvements in air quality and public health. In addition to the short-lived, local ozone precursors (NO_X, VOCs), methane is a global source of tropospheric ozone.

A. Continuing Evidence of Climate Change in California in Agreement with Projected Changes

Important climate change impacts are already being detected in California. California's Office of Environmental Health Hazard Assessment recently published the report, *Indicators of Climate Change in California*, which tracks trends in GHG levels, changes in the state's climate, and the impacts of climate change on California's environment and people.

Climate change is already affecting California's infrastructure, natural resources, and communities, with even larger impacts projected in the future.

Heat: More extreme hot days, fewer cold nights, and shifts in the water and growing cycles are already being observed in California. Sheridan and Kalkstein[4] project a marked increase in the number and duration of heat waves over the remainder of this century. For example, historically, in the populated areas of California, 14-day heat waves have occurred no more than once per year, with most locations not having any. By 2050, the frequency of 14-day heat waves is projected to increase up to tenfold. These increases will require a major effort to avoid heat-related death and illness, and will have a substantial effect on water and energy usage. Increases in ambient air temperature and the frequency of extreme heat events will reduce the efficiency of conventional power plants burning fossil fuels, and increase peak electricity demand for major cities for air conditioning.

Air Quality: Many Californians still experience air pollution levels that exceed health-based air quality standards. Climate warming would slow progress toward attainment of ozone air quality standards and increase pollution control costs by increasing the potential for high ozone days. A study[5] found that California could experience as many as six to thirty more days with ozone concentrations that exceed federal clean-air standards, depending on the extent of increased temperatures. In the southern California region, projected changes in ozone concentrations due

3 Wang, S.-Y., L. Hipps, R. R. Gillies, and J.-H. Yoon (2014), Probable causes of the abnormal ridge accompanying the 2013–2014 California drought: ENSO precursor and anthropogenic warming footprint, Geophys. Res. Lett., 41, doi:10.1002/2014GL059748. *http://onlinelibrary.wiley.com/doi/10.1002/2014GL059748/pdf*

4 Sheridan, S., and L. Kalkstein. 2011. A Spatial Synoptic Classification Approach to Projected Heat Vulnerability in California under Future Climate Change Scenarios. ARB contract #07-304. *www.arb.ca.gov/research/apr/past/07-304.pdf.*

5 Kleeman, M. J., S.-H. Chen, and R. A. Harley. 2010. Climate change impact on air quality in California: Report to the California Air Resources Board. *www.arb.ca.gov/research/apr/past/04-349.pdf*.

to climate change in the year 2050 could increase by 9 to 18 parts per billion. These studies reflect the increased efficiency of ozone production in a warmer climate, the potential for increased biogenic VOC emissions driven by higher temperatures, and increased tropospheric ozone levels due to higher methane emissions.

Wildfire Risks: Forest and wildland fires are becoming more frequent and intense, in part because dry seasons have started earlier and ended later. Since 1950, annual acreage burned in wildfires has been increasing in California. The three largest fire years occurred in the last ten years.[6] A recent study[7] estimated future wildfire activity over the western United States during the mid-twenty-first century (2046–2065). The results show that the fire season is expected to lengthen by 23 days in the warmer and drier climate at mid-century. Besides the damage to natural and managed systems, it was indicated that wildfire emissions would increase levels of summertime short-lived climate and air pollutants such as black carbon and $PM_{2.5}$.

Sea Level Rise: Sea levels have risen by six inches or more along much of the California coast over the last century, increasing erosion and pressure on the State's infrastructure, water supplies, and natural resources.[8] A 2012 report by the California Climate Change Center presented the state of the climate affairs in California, and discussed their impacts on the State's natural resources.[9] The report noted that, in addition to sea level rise and associated seawater intrusions, possible flooding from increased storm runoff from mountain catchments, and storm surges threaten freshwater supplies in the Sacramento–San Joaquin River Delta. Flooding also threatens existing levees and many low-lying areas in the Delta and Central Valley.[10] Critical infrastructure such as roads and highways, ports, harbors, airports, wastewater treatment facilities, and power plants are located in low-lying coastal areas. Coastal habitats such as beaches, dunes, cliffs, and bluffs could be lost to erosion, while groundwater aquifers could be impacted more widely than today by seawater intrusion and wetlands and bays could face permanent inundation.[11]

Sea level rise and increased storm frequency and intensity could also affect the operations of coastal power plants and coastal petroleum, natural gas, and transportation-related fuels infrastructure.

Agriculture: Agriculture is especially vulnerable to altered temperature, changing rainfall patterns, and new pest problems. Several scientific studies have been conducted that document the adverse impact that climate change is likely to have on crops and food supply. California agriculture is a nearly $40 billion dollar industry, and it generates at least $100 billion in related economic activity.[12]

Water Supply: Increased temperatures with decreased winter snowfall, as well as earlier snowmelt and greater rainwater runoff occurring earlier in the year, threaten the State's major water supply—the Sierra Nevada snowpack and timed downstream reservoir releases. Reduced snowpack puts greater pressure on the State's other major storage components, including water stored in reservoirs and groundwater aquifers. Lowering groundwater levels in turn create a greater energy demand to pump water from deeper wells and further reduce groundwater

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6 Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Indicators of Climate Change in California. August 2013. *www.oehha.ca.gov/multimedia/epic/2013EnvIndicatorReport.html*.

7 Yue, Xu et al. 2013. "Ensemble projections of wildfire activity and carbonaceous aerosol concentrations over the western United States in the mid-21st century." Atmospheric Environment 77: 767-780.

8 National Research Council Report. 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. National Academies Press. *www.nap.edu/catalog.php?record_id=13389*.

9 California Climate Change Center. 2012. Our Changing Climate 2012, Vulnerability & Adaptation to the Increasing Risks from Climate Change in California. California Climate Change Center. *www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdf*.

10 Knowles, N. 2010. "Potential inundation due to rising sea levels in the San Francisco Bay region." San Francisco Estuary and Watershed Science 8:1.

11 Cayan, D., M. Tyree, and S. Iacobellis. 2012. Climate Change Scenarios for the San Francisco Region. California Energy Commission. Publication number: CEC-500-2012-042.

12 Jackson, L. E., et al. 2011. "Case study on potential agricultural responses to climate change in a California landscape." Climatic Change 109 (Suppl 1): S407–S427.

contribution to rivers and streams exacerbating other impacts. Reduced Sierra Nevada snowpack and diminished runoff and water flows in late spring and summer will adversely affect hydroelectric generation and operation of the California State Water Project.[13]

As California continues to reduce GHG emissions, it is also taking steps to prepare for the impacts of climate change. In 2009, the California Resources Agency developed the first Climate Change Adaptation Strategy for California in response to Executive Order S-13-2008. The Agency released a draft of California's climate adaptation strategy in December 2013.[14] The update summarizes current science on potential climate change impacts in California and outlines possible solutions that can be implemented within and across State and local agencies.

To effectively address the challenges that a changing climate will bring, policies to reduce emissions and prepare for climate impacts should be coordinated and complementary. In fact, some of the same strategies provide both mitigation and adaptation benefits. For example, better forest management reduces the incidence of catastrophic wildfire, which reduces emissions of GHGs and also increases the carbon sequestration capacity of the forests.

B. Achieving Climate Stabilization

Scientific research indicates that an increase in the global average temperature of 2°C (3.6°F) above pre-industrial levels, which is only 1.1°C (2.0°F) above present levels, poses severe risks to natural systems and human health and well-being. Considering knowledge from the paleo-climate record with changes currently observed in the Greenland and Antarctic ice sheets, we can expect substantial sea level rise, 0.4 to 0.8 meters, with upper end uncertainties approaching one meter above present day during the 21st Century and continued substantial increase after 2100 even with stringent mitigation of emissions to achieve 2°C stabilization. Increased climate extremes, already apparent at present day climate warming (~0.9°C), will no doubt be more severe. To have a good chance (not a guarantee) of avoiding temperatures above those levels, studies focused on a goal of stabilizing the concentration of heat-trapping gases in the atmosphere at or below the 450 parts per million (ppm) CO_2-equivalent (CO_2e, a metric that combines the climate impact of all well-mixed GHGs, such as methane and nitrous oxide, in terms of CO_2).

The CO_2e target is a somewhat approximate threshold, and the exact level of CO_2e is not precisely known because the sensitivity of the climate system to GHGs has uncertainty. Different models show slightly different outcomes within this range. An example of a pre-IPCC assessment study (Meinshausen et al. 2009)[15] which has synthesized many studies on climate sensitivities, concluded that we would need to stabilize at about 400 ppm CO_2e in order to likely avoid exceeding the 2°C threshold (even at that stabilization target, there is still about a 20 percent chance of exceeding the temperature target). Further, a recent paper by an international team of scientists (Hansen et al. 2013)[16] asserts that the widely accepted target of limiting human-made global climate warming to 2°C above preindustrial levels is likely too high and may subject future generations and nature to irreparable harm. Recognizing this fact, the international community agreed in meetings in Cancun in 2012 to review, by 2015, progress to the 2°C target and consider whether it should be strengthened to a 1.5°C threshold.

What is important to recognize in these studies of warming thresholds is the critical importance of non-CO_2 gases, particularly the short-lived climate pollutants. For example, to avoid 2°C warming at a 66 percent confidence level, total carbon emissions (as CO_2e) must be kept to

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13 California Energy Commission. 2009. Potential Impacts of Climate Change on California's Energy Infrastructure and Identification of Adaptation Measures. January. CEC-150-2009-001.

14 Safeguarding California: Reducing Public Risk Plan, public draft available at *http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf*.

15 Meinshausen, M., N. Meinshausen, W. Hare, S. C. B. Raper, K. Frieler, R. Knutti, D. J. Frame, and M. Allen. 2009. "Greenhouse-gas emission targets for limiting global warming to 2 °C." Nature 458:1158 1162.

16 Hansen, J., P. Kharecha, M. Sato, V. Masson-Delmotte, F. Ackerman, et al. 2013. "Assessing 'Dangerous Climate Change': Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature." PLoS ONE 8(12): e81648. doi:10.1371/journal.pone.0081648.

1000 GtC. Considering that we have already emitted about 500 GtC, which leaves 500 GtC to be divided up among nations. If the non-CO_2 gases are included then the total CO_2e emissions are at 790 GtC, leaving only 210 GtC to be emitted. Thus, there is a compelling case to reduce the short-lived climate pollutants.

In early May 2013, the Mauna Loa monitoring station, which has been shown to provide excellent measurements of CO_2 throughout the global atmosphere, recorded atmospheric CO_2 of 400 ppm,[17] substantially higher than the 316 ppm recorded when the station made its first measurements in 1958. The monitoring station offers the longest-running record of atmospheric CO_2 measured directly from the air. This recent reading will take a few years to become the international average; however, reaching 400 ppm at Mauna Loa is significant and has surpassed a worrisome milestone.

Although stabilizing atmospheric GHG concentration below 450 ppm CO_2e is important, it does not mean that once that level is reached, temperatures will immediately level off. Because of time lags inherent in the Earth's climate, the initial warming that occurs in response to a given increase in the concentration of CO_2 ("transient climate change") reflects only about half the eventual total warming ("equilibrium climate change").

Observational data reveal that, in recent decades, some climate extremes are already increasing in response to relative modest warming; these extremes would likely increase considerably with warming of 2°C or more. While the findings suggest that even at relatively low levels of global warming the world will have to face significant sea level rise, the studies also demonstrate that the potential impacts are substantially greater if we allow warming to reach a level as high as 2°C. If they occur, changes such as these would not rapidly reverse, as even if the atmospheric CO_2 amount declines, it would take many centuries for the deep ocean to cool.

To prevent exceeding 450 ppm CO_2e, developed countries must substantially reduce their emissions in the near term. The 2008 World Energy Outlook suggests that Organisation for Economic Co-operation and Development (OECD) countries must reduce emissions by about 40 percent below 2006 levels by 2030.[18] The Union of Concerned Scientists has suggested a 2030 emissions target for the United States of 56 percent below 2005 levels (44 percent below 1990 levels).[19] A governmental study from the Netherlands finds that Europe would have to reduce emissions by 47 percent below 1990 levels and the United States would have to reduce emissions by 37 percent below 1990 levels by 2030.[20] The International Energy Agency comes to a similar conclusion, finding that the United States would have to reduce emissions by about 38 percent below 1990 levels by 2030.[21] Note that percent reductions by 2030 depend on the assumed overall trajectory of emissions, including the amount after 2030.

Because of the cumulative effects of GHG emissions and resultant changes to the earth's energy balance and the inertia in the climate system, delaying efforts to reduce emissions will likely mean that global average temperature will increase by more than 2°C, increasing the costs associated with combatting climate change. Reducing the global concentration to 450 ppm CO_2e after delaying mitigation actions for ten more years is estimated to cost an additional $3.5 trillion, compared to levels of investment needed now if low-carbon strategies were to be adopted immediately.[22]

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17 R. Monastersky (2013). Global carbon dioxide levels near worrisome milestone. Nature News: *www.nature.com/polopoly_fs/1.12900%21/menu/main/topColumns/topLeftColumn/pdf/497013a.pdf*.

18 IEA. 2008. World Energy Outlook 2008. International Energy Agency. *www.worldenergyoutlook.org/publications/2008-1994/*.

19 Cleetus, R. et al. 2009. Climate 2030: A National Blueprint for a Clean Energy Economy. Union of Concerned Scientists. May. *www.ucsusa.org/blueprint*.

20 Hof, A. et al. 2012. Greenhouse gas emission reduction targets for 2030. Conditions for an EU target of 40%. The Hague: PBL Netherlands Environmental Assessment Agency. *www.pbl.nl/sites/default/files/cms/publicaties/PBL_2012_Greenhouse-gas-emission-reduction-targets-for-2030_500114023.pdf*.

21 IEA, 2012. Energy Technology Perspectives 2013: Pathways to a Clean Energy System. International Energy Agency. *www.iea.org/etp/etp2012/*

22 IEA. 2013. Redrawing the Energy Map: World Energy Outlook Special Report. International Energy Agency. June 10. *www.worldenergyoutlook.org/energyclimatemap*.

C. Climate Pollutants

The standard definition of greenhouse gases includes six substances identified in the Kyoto Protocol – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) – plus chlorofluorocarbons and other chlorine or bromine-containing gases phased out under the Montreal Protocol. Other GHGs include synthetic gases recently added to the IPCC's AR5 report such as nitrogen trifluoride (NF_3) and sulfuryl fluoride (SO_2F_2). Tropospheric ozone (O_3), a short-lived, not-well-mixed gas, and black carbon are also important climate pollutants. Carbon dioxide is undoubtedly the most important GHG, and collectively CO_2, CH_4, and N_2O amount to 80 percent of the total radiative forcing from well-mixed GHGs.

Carbon dioxide, methane and nitrous oxide concentrations have increased in the atmosphere since pre-industrial times, and this increase is the main driver of climate change. Globally, CO_2 increased by 40 percent from 278 ppm circa 1750 to 390.5 ppm in 2011. During the same time interval, CH_4 increased by 150 percent, from 722 ppb[23] to 1,803 ppb, and N_2O by 20 percent, from 271 ppb to 324.2 ppb in 2011. The increase of CO_2, CH_4, and N_2O is caused by anthropogenic emissions from the use of fossil fuel as a source of energy, fertilizer usage, and from land use and land use change—in particular, agriculture.

For each GHG, a global warming potential (GWP) has been calculated to reflect how long emissions remain in the atmosphere and how strongly it absorbs energy on a per-kilogram basis relative to CO_2. GWP is a metric that indicates the relative climate forcing of a kilogram of emissions when averaged over the period of interest (both 20-year and 100-year horizons are used for the GWPs shown in Table 1). Other important climate-forcing species not listed under the Kyoto Protocol with large human sources are tropospheric ozone and particulate matter (PM, including black carbon and other absorbing organic carbon aerosols).

Tropospheric ozone can act as a direct GHG and as an indirect controller of GHG lifetimes. Ozone is not emitted directly into the atmosphere, but rather formed by photochemical reactions. Its average atmospheric lifetime of a few weeks produces a global distribution highly variable by season, altitude, and location. The radiative forcing of tropospheric ozone is primarily attributed to emissions of methane, but also to carbon monoxide, volatile organics, and nitrogen oxides that eventually form ozone.

Unlike other GHGs, the three main categories of fluorinated gases (HFCs, PFCs, and SF_6) have no natural sources and only come from human-related activities. Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are also potent climate-forcing fluorinated gases, but they are regulated under the Montreal Protocol because of their role in the destruction of the protective stratospheric ozone layer. The fluorinated gases are used as refrigerants, foam-blowing agents, or for a variety of industrial processes such as aluminum and semiconductor manufacturing. Many fluorinated gases have very high GWPs relative to other GHGs, so relatively low atmospheric levels can have large effects on global temperatures. They can also have long atmospheric lifetimes, lasting thousands of years in the case of SF_6. Recently, two new climate pollutants were added to the list of climate pollutants of concern in the IPCC's AR5 report. These gases are NF_3, used in the electronics industry, and SO_2F_2, used as a fumigant to replace methyl bromide. Both have rapidly increasing emissions (growing from almost zero in 1978), but they currently contribute only about 0.0001 watt per square meter (W/m^2) and 0.0003 W/m^2, respectively, to anthropogenic radiative forcing. For comparison, industrial era radiative forcing for CO_2 alone is about 1.82 W/m^2 and CO_2 is the component with the largest global mean radiative forcing.

23 Note: one part-per-million (ppm) = 1,000 parts-per-billion (ppb)

Globally, CO_2 is the fastest increasing GHG in terms of absolute CO_2-equivalents. In California, since CO_2 emissions are decreasing due to AB 32 and other regulations, the fastest growing sector of GHG emissions are the high-GWP substitutes to ozone-depleting substances, primarily the HFCs. An important outcome of conducting a state or regional specific F-gas emission inventory (rather than relying on scaled-down national estimates) was highlighted by the discovery of a regional anomaly of relatively high GHG emissions in California from sulfuryl fluoride. In 2006, the reported SO_2F_2 pesticide use in California represented 37–56 percent of the global usage estimate and 41–75 percent of the U.S. usage estimate.[24] Gallagher, et al.[25] estimated that, in 2008, SO_2F_2 contributed 4.6 $MMTCO_2e$, or nine percent of all Fgas emissions in California (51.0 $MMTCO_2e$). Nitrogen trifluoride's contribution was only 0.17 $MTCO_2E$, or 0.3 percent of all F-gas emissions in California.

Short-Lived Climate Pollutants: As mentioned above, GHGs have different atmospheric lifetimes, ranging from less than a year to thousands of years (see Table 1). Some GHGs, such as CO_2 and N_2O, are long-lived GHGs, and so contribute to long-term climate change. Other substances have shorter atmospheric lifetimes because they are removed fairly quickly from the atmosphere. Therefore, their effect on the climate system is similarly short-lived. Together, these short-lived climate forcers are responsible for a significant amount of current climate forcing from anthropogenic substances.

The differentiation between long- and short-lived GHGs is not well defined, and here we define it to be gases with lifetimes less than 20 years so that a substantial fraction of emissions (>60 percent) decays within a 20-year horizon, and thus mitigation of emissions will rapidly reduce the warming caused by these chemical species. Properties of these short-lived climate pollutants (SLCP)—including black carbon, methane, and some hydrofluorocarbons (HFCs)—are contrasted with the other Kyoto GHGs in Table 1. Key SLCPs are described in more detail in the following sections.

24 Mühle, J., J. Huang, R. F. Weiss, R. G. Prinn, B. R. Miller, P. K. Salameh,C. M. Harth, P. J. Fraser, L. W. Porter, B. R. Greally, S. O'Doherty,and P. G. Simmonds. 2009. Sulfuryl Fluoride in the Global Atmosphere. J.Geophys. Res. 114.D5: D05306.

25 Gallagher, G.; Zhan, T.; Hsu, Y-K.; Gupta, P.; Pederson, J.; Croes, B.; Blake, D. R.; Barletta, B.; Meinardi, S.; Ashford, P.; Vetter, A.; Saba, S.; Slim, R.; Palandre, L.; Clodic, D.; Mathis, P.; Wagner, M.; Forgie, J.; Dwyer, H.; Wolf, K. 2014. High-global Warming Potential F-gas Emissions in California: Comparison of Ambient-based versus Inventory-based Emission Estimates, and Implications of Refined Estimates. Environ Sci. Technol., 48, 1084–1093.

Table 1: Global Warming Potential for Selected Greenhouse Gases*

Pollutant	Lifetime (years, except for BC)	Global Warming Potential (20 year)	Global Warming Potential (100 year)*
Long-Lived			
Carbon dioxide	~100**	1	1
Nitrous oxide	121	264	265
Nitrogen trifluoride	500	12,800	16,100
Sulfur hexafluoride	3,200	17,500	23,500
Perfluorocarbons	3,000–50,000	5,000–8,000	7,000–11,000
Short-Lived (<20 years)			
Black Carbon***	days to weeks	270–6,200	100–1,700
Methane	12	84	28
Hydrofluorocarbons****	(<1 to >100)	~100–11,000	~100–12,000

* The 20- and 100-year global warming potential estimates are from the IPCC 2013 Fifth Assessment Report (AR5),[26] which includes the independent scientific assessment of the black carbon radiative forcing published early this year.[27]

** CO_2 has a variable atmospheric lifetime and cannot be readily approximated as a single number.

*** BC climate effects are highly uncertain, in large part because they depend on the conditions under which they are emitted (i.e., location and time of year). This type of uncertainty does not apply to the Kyoto greenhouse gases.

****HFCs have a wide range of lifetimes—some long, some short by this definition. Correspondingly, they have a wide range of GWPs.

Mitigation of the four SLCPs (methane, HFCs, tropospheric ozone, and black carbon), even if we are restricted to available technologies, can reduce the probability of exceeding the 2°C barrier before 2050 to less than ten percent, and before 2100 to less than 50 percent.[28,29] In addition, mitigation of CO_2 along with SLCPs can keep the twenty-first century warming below 2°C and 21th Century sea level rise below one meter.[30] However, the most immediate health and climate benefits would accrue regionally to the nations undertaking actions to mitigate SLCPs. For example, reducing black carbon emissions would help to minimize soot deposition on snowpacks and glaciers, which is known to accelerate snowmelt from the Sierra Nevada snowpack.[31,32]

26 Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura, and H. Zhang. 2013. Anthropogenic and Natural Radiative Forc¬ing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 659–740.

27 Bond, T. C., S. J. Doherty, D. W. Fahey, et al. 2013. "Bounding the role of black carbon in the climate system: A scientific assessment." Journal of Geophysical Research: Atmospheres doi:10.1002/jgrd.50171.

28 Ramanathan, V., and Y. Xu. 2010. "The Copenhagen Accord for limiting global warming: Criteria, constraints, and available avenues." Proc. Nat. Acad. Sci. 107 (18) 8055–8062. *www-ramanathan.ucsd.edu/files/pr175.pdf*.

29 UNEP/WMO. 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone. Available at *www.unep.org/dewa/Portals/67/pdf/BlackCarbon_report.pdf*.

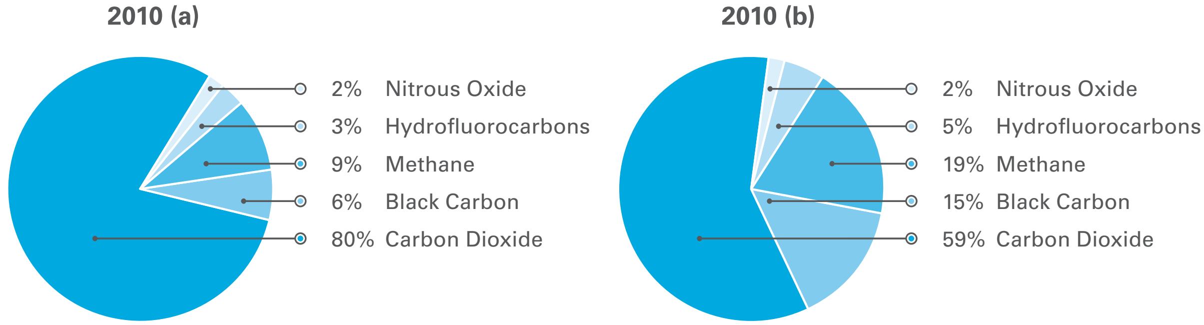
30 Hu, A., Y. Xu, C. Tebaldi, W. M. Washington, and V. Ramanathan. 2013. "Mitigation of short-lived climate pollutants slows sea-level rise." Nature Climate Change 3(5): 1–5, doi:10.1038/nclimate1869. *www-ramanathan.ucsd.edu/files/pr194.pdf*.

31 Hadley, O. L., C. E. Corrigan, T. W. Kirchstetter, S. S. Cliff, and V. Ramanathan. 2010. "Measured black carbon deposition on the Sierra Nevada snow pack and implication for snow pack retreat." Atmos. Chem. Phys. 10: 7505–7513, doi:10.5194/acp-10-7505-7513.

32 Qian, Y., W. I. Gustafson, Jr., L. Y. R. Leung, and S. J. Ghan. 2009. "Effects of soot-induced snow albedo change on snowpack and hydrological cycle in western United States based on Weather Research and Forecasting chemistry and regional climate simulations."Journal of Geophysical Research D. (Atmospheres) 114:D03108. doi:10.1029/2008JD011039.

Figure 1 shows the relative GWP-weighted contributions of 2010 California emissions of different climate pollutants for 100-year and 20-year time horizons. Note that Figure 1 does not include other SLCPs such as NO_X, CO, VOCs, and organic aerosols, which have both positive and negative GWPs, as described in the 2013 IPCC AR5. Use of a global annual average GWP for BC may significantly over- or under-estimate the contribution of California's BC emissions. Individual HFC species are aggregated according to their specific emissions and GWPs. The 20-year GWP is a better reflection of what can be achieved in the near term by mitigation.

Figure 1: Carbon Dioxide Equivalent Climate Pollutant Emissions for 2010 in California Using (a) 100-year and (b) 20-year Horizon GWPs



Many short-lived climate pollutants are already regulated by ARB, either as part of the air quality and toxics program or under the Scoping Plan. The following sections describe the major short-lived climate pollutants and ARB's past programs to reduce emissions. For many of these pollutants, ARB is proposing additional action to investigate and potentially require additional emission reductions prior to 2020. In addition to actions under way, described in Chapter IV, ARB will develop a short-lived climate pollutant strategy by 2015 that will include an inventory of sources and emissions, the identification of additional research needs, and a plan for developing necessary control measures. ARB will consult with external experts in the development of this strategy.

1. Black Carbon

Black carbon is the most strongly light-absorbing component of particulate matter (PM) emitted from burning fuels such as coal, diesel, and biomass. ARB identified diesel PM as a toxic air contaminant in 1998, and PM that can be inhaled (PM_{10} and $PM_{2.5}$) is a criteria pollutant, which is regulated by both the U.S. Environmental Protection Agency (U.S. EPA) and ARB. Black carbon contributes to climate change both directly by absorbing sunlight and indirectly by depositing on snow and by interacting with clouds and affecting cloud formation. Reducing black carbon emissions globally can have immediate economic, climate, and public health benefits.[33, 34, 35]

Short-lived species, like BC, vary spatially and, consequently, it is very difficult to quantify their global-warming forcing. Due in large part to the difference in lifetimes between BC and CO_2, the relative weight given to BC as compared to CO_2 (or other climate forcers) is very sensitive to the formulation of the metric used to make the comparison. Several leading scientists have reported

33 UNEP and WMO. 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone. United Nations Environment Programme (UNEP) and World Meteorological Organization (WMO).

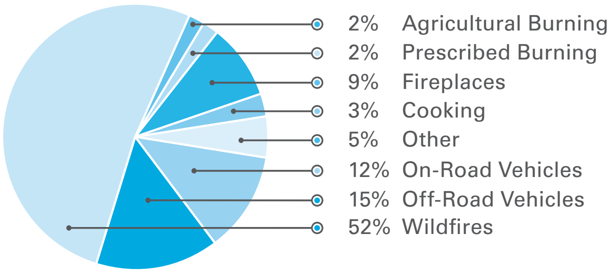
34 Shindell, D., J. C. I. Kuylenstierna, E. Vignati, R. van Dingenen, M. Amann, Z. Klimont, S. C. Anenberg, N. Muller, G. Janssens-Maenhout, F. Raes, J. Schwartz, G. Faluvegi, L. Pozzoli, K. Kupiainen, L. Höglund-Isaksson, L. Emberson, D. Streets, V. Ramanathan, K. Hicks, N. T. K. Oanh, G. Milly, M. Williams, V. Demkine, and D. Fowler. 2012. "Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security." Science 335 (6065): 183–189. doi: 10.1126/science.1210026.

35 Wallack, J., and V. Ramanathan. 2009. "The Other Climate Changes, Why Black Carbon Also Matters." Foreign Affairs Sept/Oct 2009: 105–113. *www-ramanathan.ucsd.edu/files/pr168.pdf*.

estimates of the GWP for BC emissions from different sources. Most of the regional differences in GWP are caused by differences in the lifetime of BC. In general, in the published literature, there are significant variations in the GWP values for BC emissions assigned to different regions. This indicates that the role of BC in warming requires close attention to the geography of emissions. Black carbon may also indirectly cause changes in the absorption or reflection of solar radiation through changes in the properties and behavior of clouds, e.g., BC localized warming in the lower atmosphere can prevent cloud formation.

Figure 2 shows the statewide contribution from black carbon emissions sources in 2010. The main sources of black carbon in California are wildfires, off-road vehicles (locomotives, marine vessels, tractors, excavators, dozers, etc.), on-road vehicles (cars, trucks, and buses), fireplaces, agricultural waste burning, and prescribed burning (planned burns of forest or wildlands). Wildfires are a highly intermittent but significant source—almost 50 percent of the total black carbon emissions. Emissions in this category may grow significantly in the future if climate change results in increased wildfires, as predicted in many climate model scenarios. Projections suggest that the frequency and size of forest fires is expected to increase, perhaps several fold, by the end of the century.

Figure 2: California Black Carbon Emissions Sources (2010)



California has been an international leader in reducing emissions of black carbon, with close to 95 percent control expected by 2020 due to existing programs that target reducing PM from diesel engines and burning activities.

Due to the health concerns from PM exposures, both ARB and local air districts have developed programs to reduce emissions from these sources (Table 2). These efforts have concurrently resulted in significant reductions of black carbon and GHG emissions.

ARB estimates that the annual black carbon emissions in California decreased about 70 percent between 1990 and 2010, in direct proportion to declining diesel PM emissions—a benefit of ARB's regulations on diesel fuel and engines. PM emissions from other categories of diesel engines, such as off-road (e.g., agricultural and construction equipment), building equipment, generators, ships, and harbor craft are also projected to decline significantly by 2020. Continued efforts to better manage agricultural, forest, and range land burning operations are also expected to continue to reduce black carbon emissions.

Table 2: Programs Resulting in Black Carbon Emission Reductions

Program Area	Adoption Dates
Prescribed and Agricultural Burning (ARB, Districts)	1970, 1972, 1973, 1974, 1976, 1991, 1997, 2004
Fireplaces and Fire Pits (Districts)	1986, 1993, 1995, 1996, 2004, 2006, 2008, 2013
Heavy-Duty On-Road Engine Particulate Standards (ARB, U.S. EPA)	1987, 1997, 2000, 2001
Diesel and Gasoline Fuel Specifications (ARB, U.S. EPA)	1988, 1991, 1999, 2003
Low Emission Vehicle Programs (LEV I, II, III) (ARB)	1990, 1998, 2012
Off-Road Engine Standards (ARB, U.S. EPA)	1994, 1997, 1998, 1999, 2002, 2004, 2006, 2008, 2009
Smog Check Program (ARB and Bureau of Automotive Repair)	1984,1998, and 2013
Local Commercial Charbroiling Rules (South Coast, San Joaquin Valley, and Ventura Air Districts)	1997, 2002, 2004
Diesel Clean-up Incentive Programs – Carl Moyer, AB 118 Air Quality Improvement Program, Proposition 1B (ARB, Districts)	1998, 2007
In-Use Fleet Rules (Drayage and Truck/Bus) (ARB)	2000, 2003, 2005, 2007, 2009
Ship Engine and Fuels Standards (ARB and U.S. EPA)	1999, 2002, 2007, 2008, 2010
Federal Diesel Emission Reduction Act (DERA) Incentive Programs (U.S. EPA)	2008
Federal Environmental Quality Incentives Program (EQIP) (U.S. Department of Agriculture)	2008

California is committed to continuing to reduce emissions of black carbon, to meet ongoing air quality and climate targets. Regulations requiring diesel particulate retrofits and legacy fleet turnover are critical for obtaining necessary reductions. However, advanced technologies in the freight system, including zero- or near-zero emission vehicles and fuels, will also be needed to meet future air quality and climate goals.

2. Methane

Methane (CH_4) is the principal component of natural gas and is also produced biologically under anaerobic conditions in ruminants, landfills, and waste handling. Atmospheric methane concentrations have been increasing as a result of human activities related to agriculture, fossil fuel extraction and distribution, and waste generation and processing. The radiative efficiency of CH_4 per unit concentration is relatively large in comparison to CO_2, and coupled to the significant increase in its concentration, methane is the second most important anthropogenic GHG in the atmosphere. Anthropogenic warming will likely lead to enhanced CH_4 emissions from both terrestrial and oceanic clathrates, but it is unclear if this will significantly increase atmospheric CH_4 abundances.

Methane contributes to background tropospheric ozone levels. Photo-oxidation of both methane and carbon monoxide lead to net production of global ozone. With multi-decadal full-chemistry transient simulations in the MOZART-2 global model of tropospheric chemistry model, Fiore et al[36] show that tropospheric ozone responds approximately linearly to changes in CH_4 emissions. Controlling methane emissions may be a promising means of simultaneously mitigating climate

36 Fiore, A.M., J.J. West, L.W. Horowitz, V. Naik, and M.D. Schwarzkopf (2008), Characterizing the Tropospheric Ozone Response to Methane Emission Controls and the Benefits to Climate and Air Quality , J. Geophys. Res. , 113, D08307, doi:10.1029/2007JD009162.

change and reducing global ozone concentrations.[37, 38] Tropospheric ozone can also act as a direct GHG and as an indirect controller of GHG lifetimes. Concentrations of ozone have risen by around 30 percent since the pre-industrial era and it is now considered by the IPCC to be the third most important greenhouse gas after carbon dioxide.[39]

As noted in Table 1, the current methane GWP for a time horizon of 20 years is 84 (from the IPCC 2013 Fifth Assessment Report), which, combined with its large emissions, makes it an attractive target for near-term climate mitigation policies. Although the methane GWP traditionally includes the methane indirect effects on the concentrations of ozone and stratospheric water vapor, it does not take into account the production of carbon dioxide from methane oxidation. Recent studies argue that this CO_2-induced effect should be included for fossil sources of methane, which adds about three to the GWP values for all time horizons. Boucher et al. recommend somewhat larger values for the methane GWP than suggested by the IPCC 2007 Fourth Assessment report (AR4).[40] When the methane comes from fossil sources, the 100-year GWP would be about 30. Holmes et al. also provide a new estimate of the indirect components of methane climate forcing.[41] Tropospheric ozone contributes 30–50 percent of the direct methane climate forcing, compared to 25 percent that has been used in previous IPCC assessments. Hence, accounting for the indirect effect of methane emissions could have an even larger relative impact. In the IPCC AR5 report, when feedbacks are included, the GWP for methane was increased, from 25 to 28 over a 100-year timespan, and from 72 to 84 over a 20-year timespan.

The State's largest anthropogenic methane-producing sources are enteric fermentation (belching by animals), manure management, landfills, natural gas transmission, and wastewater treatment (Figure 3). Methane emissions also come from non-anthropogenic sources such as wetlands, oceans, forests, fires, terrestrial arthropods (such as termites), and geological sources (such as submarine gas seepage, micro seepage over dry lands, and geothermal seeps). Methane gas from production and distribution is a growing source of emissions in many countries, including the United States, due to increased exploration and use of natural gas for energy.

Methane is generated in landfills during the natural process of bacterial decomposition of organic material. Many factors influence the quantity and composition of the gas generated, including the types and age of waste buried in the landfill, the quantity and types of organic compounds in the waste, and the moisture content and temperature of the waste. California has adopted several measures focused on controlling methane emissions from landfills and other sources (Table 3). Local air districts have adopted rules to implement the federal New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants for municipal solid waste (MSW) landfills, which also require installation of gas collection and control systems. These district rules target reductions in ozone precursors and hazardous air pollutants, but also provide supplemental methane reductions. In 2009, ARB adopted a regulation to reduce methane from MSW landfills. The regulation requires owners and operators of certain uncontrolled MSW landfills to install gas collection and control systems, and requires existing and newly installed gas and control systems to operate in an optimal manner. Complementary to the control of methane emissions from landfills themselves, the Mandatory Commercial Recycling Regulation

37 Anenberg S, Schwartz J, Shindell D, Amann M, Faluvegi G, Klimont Z, Janssens-Maenhout G, Pozzoli L, Van Dingenen R, Vignati E, et al. Global Air Quality and Health Co-benefits of Mitigating Near-Term Climate Change through Methane and Black Carbon Emission Controls. ENVIRON HEALTH PERSP. 2012;120 (6):831-839.

38 Shiri Avnery, Denise L. Mauzerall, Arlene M. Fiore. Increasing global agricultural production by reducing ozone damages via methane emission controls and ozone-resistant cultivar selection Glob Change Biol, Vol. 19, No. 4. (1 April 2013), pp. 1285-1299, doi:10.1111/gcb.12118.

39 Kirtman, B., S. B. Power, J. A. Adedoyin, G. J. Boer, R. Bojariu, I. Camilloni, F. J. Doblas-Reyes, A. M. Fiore, M. Kimoto, G. A. Meehl, M. Prather, A. Sarr, C. Schär, R. Sutton, G. J. van Oldenborgh, G. Vecchi, H. J. Wang. 2013. Chapter 11: Near-term Climate Change: Projections and Predictability. In: Climate Change 2013: The Physical Science Basis. Contribution of WGI to the 5th AR of the IPCC [Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K.]

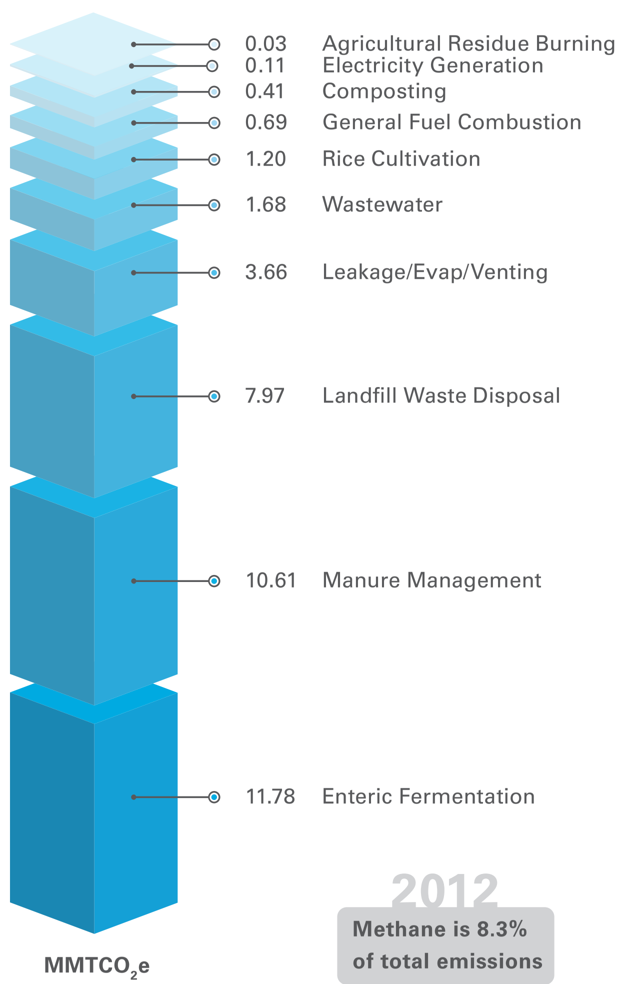
40 Holmes, C. D., M. J. Prather, O. A. Sovde, and G. Myhre. 2013. "Future methane, hydroxyl, and their uncertainties: Key climate and emission parameters for future predictions." Atmospheric Chemistry and Physics 13: 285–302.

41 Boucher, O., P. Friedlingstein, B. Collins, and K. P. Shine. 2009. "The indirect global warming potential and global temperature change potential due to methane oxidation." Environmental Research Letters, 4, 044007.

(AB 341; Chesbro, Chapter 476, Statutes of 2011) was adopted in 2012 to further reduce landfill methane emissions via upstream organic material diversion from landfill disposal. ARB and CalRecycle continue to assess new information on landfill methane emissions to determine whether additional actions in support of GHG emissions and the 75 percent goal are warranted.

Methane is also emitted from oil production and the natural gas industry. Natural gas transmission involves high-pressure, large-diameter pipelines that transport gas long distances from field production areas to distribution systems for ultimate customer use. Methane is emitted from venting and leaks of processing equipment and pipelines.

Figure 3: California Methane Emission Sources (2012)



ARB's Cap-and-Trade Program includes an offset protocol to reduce methane from dairies. The Compliance Offset Protocol Livestock Projects provides methods to quantify and report GHG emission reductions associated with the installation of a biogas control system for manure management on dairy cattle and swine farms. The protocol is designed to ensure complete, consistent, transparent, accurate, and conservative quantification of GHG emission reductions associated with a livestock digester project for generating ARB offset credits.

In addition, ARB's Low Carbon Fuel Standard incentivizes the capture and use of natural gas from landfills and digesters for transportation fuel.

Table 3: Programs Resulting in Methane Emission Reductions

Program Area	Adoption Dates
Control of landfill emissions (local air districts)	Varies
Standards of Performance for Municipal Solid Waste Landfills (U.S. EPA)	1996
Landfill Methane Control Measure (ARB)	2009
Methane inclusion in Low Carbon Fuel Standard (ARB)	2009
Dairy digester protocol for offsets in Cap-and-Trade Program (ARB)	2011
Landfill waste diversion, Assembly Bill 341 (CalRecycle)	2011
Proposed oil and gas production, processing, and storage regulation (ARB)	In progress, expected 2014

Several recent analyses of atmospheric measurements suggest that actual methane emissions may be 1.3 to 1.7 times higher than estimated in ARB's emission inventory.[42, 43] Recent research suggests that methane emissions from a broad variety of sources could be higher than previously expected, including leaks in natural gas distribution systems, oil and gas extraction facilities, and natural seeps such as the La Brea Tar Pits. Underestimations may explain the discrepancies between the inventory and atmospheric measurements. With the greater GWP assessed in recent IPCC and other studies, reductions in methane emissions will have greater benefits.

ARB is continuing to research potential sources of methane emissions to determine the source of higher-than-expected ambient methane measurements, and whether additional controls are technologically feasible and cost-effective.

42 Y.-K. Hsu, T. VanCuren, S. Park, C. Jakober, J. Herner, M. FitzGibbon, D. R. Blake, and D. D. Parrish. 2010. "Methane emissions inventory verification in southern California." Atmospheric Environment 44: 1 7.

43 S. M. Miller, S. C. Wofsy, A. M. Michalak, E. A. Kort, A. E. Andrews, et al. 2013. Anthropogenic emissions of methane in the United States. PNAS doi/10.1073/pnas.1314392110.

SUCCESS STORY

Only 24 ounces of the most commonly used automobile air conditioning refrigerant captures as much heat in the atmosphere as a ton of carbon dioxide. Thanks to California's regulations, automakers are now beginning to use a refrigerant for vehicle air-conditioning system that is 350 times less damaging to the climate. The 2004 Pavley regulations—the first standards designed to reduce GHGs from vehicles—created credits for less climate-damaging coolants. The European Union later followed suit. As a result, Du Pont developed "HFO-1234yf," a refrigerant with a global warming potential only four times that of carbon dioxide. The new refrigerant is now being introduced by General Motors and Chrysler, including models such as the 2014 Dodge Dart, Dodge Charger, Chrysler 300 and Ram 1500.

3. Hydrofluorocarbons

Hydrofluorocarbons are synthetic gases used in refrigeration, air conditioning, insulating foams, solvents, aerosol products, and fire protection. They are primarily produced for use as substitutes for ozone-depleting substances which are being phased out under the Montreal Protocol. Currently, HFCs are a small fraction of the total climate forcing (<1 percent), but their emissions are growing relatively more rapidly than those of CO_2. Recent scientific studies project substantial growth in the use of HFCs in the coming decades, primarily driven by the increased demand for refrigeration and air conditioning in developing countries. Recently, the United States, China, and 24 other countries agreed to work to phase out the use of HFCs.

ARB has implemented several measures to reduce HFC emissions (Table 4). These include low-GWP requirements for aerosol propellants, a deposit-return recycling program for small cans of motor vehicle air-conditioning (AC) refrigerant, and the Refrigerant Management Program. In addition, beginning with 2017 model year vehicles, the national Clean Cars Initiative is expected to significantly reduce motor vehicle air-conditioning refrigerant emissions.

Table 4: Programs Resulting in HFC Emission Reductions

Program Area	Adoption Dates
Semiconductor regulation (ARB)	2007
Refrigerant Management Program (ARB)	2009
High global warming potential gas ban for non-essential consumer products (ARB)	2009
Regulation for small containers of automotive refrigerant (ARB)	2009
Ozone depleting substance protocol for offsets under the Cap-and-Trade Program (ARB)	2011
Advanced Clean Car credit for mobile air-conditioning systems (ARB)	2012

D. Greenhouse Gas Monitoring Efforts

Monitoring and measurement efforts are a crucial component of the regulatory process, because they provide objective measures to identify the need for regulatory action and to verify the performance of implemented regulations.

Since the adoption of the original Scoping Plan, ARB has spearheaded and participated in various measurement-based research studies to verify statewide GHG emission inventory, identify and understand unknown GHG emission sources and under-inventoried sectors, identify possible measures for emission mitigation, and evaluate program effectiveness through monitoring long-term trends. The most significant part of these efforts is the Greenhouse Gas Research Monitoring Network that was initiated by ARB in 2010. Network participants evaluate the regional and statewide inventories to support the AB 32 program and study the regional GHG emissions trends throughout the state and provide data at a regional level to monitor AB 32-related reductions and effectiveness. The network currently has seven ARB-operated monitoring stations, and four additional stations are operated by leading researchers throughout the state. The network captures real-time GHG data throughout the state in high temporal and spatial resolution and uses high-precision analyzers to study CH_4, N_2O, and CO_2 emissions.

Data from this network have been used for monitoring and verification, and for inverse receptor-oriented modeling to estimate natural and anthropogenic sources and sinks of GHGs. These types of highly accurate and consistent measurements have been immensely valuable to evaluate and improve ARB's GHG emission inventory. For example, the results suggested that the current CH_4 inventory may be underestimated by a factor of 1.3 to 1.7, and the current N_2O inventory may be underestimated by a factor of up to 2.7. A range of research studies in the state have also identified potential sources of under-estimation in the inventory. Those studies suggest that livestock and landfills may be the largest sources of underestimated GHG emissions in California's Central Valley; whereas, the fossil fuel sector, primarily from natural gas transmission and distribution systems, may be responsible for a larger fraction of CH_4 emissions in the South Coast.

ARB is also actively participating in the Megacities Carbon Project[44], which plans to develop and test methods for monitoring GHG emissions from megacities, with the ultimate aim of establishing a global urban monitoring framework. The Megacities project relies on sustained monitoring of the various GHGs and applies scientifically robust analyses for linking monitored concentrations to emission activity. The goal is to provide decision makers with critical information for assessing the ultimate efficacy of emission mitigation policies, and to review the progress in reducing carbon emissions from cities. The Megacities team has partnered with ARB to use the GHG Research Monitoring Network data in the South Coast Air Basin. ARB is also helping the Megacities team coordinate project planning, identify potential sites for adding their monitoring locations, and analyze concentration trends.

ARB has also expanded its Mobile Measurement Platform program to monitor and measure GHGs from various under-reported and un-inventoried sources to improve the existing emissions inventories. These efforts include quantifying GHG emission fluxes from various sources in the field, developing and comparing emission factors against the inventory data, and providing emissions data for ARB inventory groups for regulatory and mitigation planning. In the recent past, this program has been successful in verifying GHG emission rates of complex sources such as natural gas compression stations and landfills. ARB is also expanding the program to include flux chambers and controlled tracer release studies to study large area sources such as landfills, wastewater treatment plants, oil and gas extraction fields, natural gas leakage from pipelines, and other fugitive emission sources. These wide-ranging collaborations and the integration of various methods will continue to provide a comprehensive approach to evaluate and validate the California GHG inventory and identify possible measures for emission mitigation in the future.

E. Adjusting the 2020 Statewide Limit

The Scoping Plan relied on the IPCC's 1996 Second Assessment Report (SAR) to assign the global warming potentials (GWPs) of greenhouse gases. Recently, in accordance with the United Nations Framework Convention on Climate Change (UNFCCC), international climate agencies have agreed to begin using the scientifically updated GWP values in the IPCC's Fourth Assessment Report (AR4)[45] that was released in 2007. ARB is beginning to transition to the use of the AR4 100-year GWPs in its climate change programs. ARB has recalculated the 1990 GHG emissions level with the AR4 GWPs to be 431 $MMTCO_2e$, therefore the 2020 GHG emissions limit established in response to AB 32 is now slightly higher than the 427 $MMTCO_2e$ in the initial Scoping Plan. More information is provided in Chapter IV, Section B(3). The IPCC AR5 was just completed (September 2013), and the scientific updates have again altered the GWPs, as discussed above. Use of AR5 GWPs will be considered in subsequent reports.

44 More information on the Megacities Carbon Project is available at: *http://megacities.jpl.nasa.gov/portal*.

45 IPCC Fourth Assessment Report (AR4), Climate Change 2007: Synthesis Report;

GWP values and lifetimes from 2007 IPCC AR4	Lifetime (years)	GWP time horizon		
		20 years	100 years	500 years
Methane	12	72	25	7.6
Nitrous oxide	114	289	298	153
HFC-23 (hydrofluorocarbon)	270	12,000	14,800	12,200
HFC-134a (hydrofluorocarbon)	14	3,830	1,430	435
Sulfur hexafluoride	3200	16,300	22,800	32,600

www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

III. California's Approach to Climate Change

California's commitment to addressing climate change is born of necessity. As described in Chapter II, our State, economy, and rural and urban communities are especially vulnerable to the impacts of climate change. Many studies have shown that the costs of inaction or delayed action to reduce GHG emissions far outweigh the costs—and come with none of the benefits—associated with reducing emissions today by deploying clean technologies, diversifying energy supplies, and strengthening and preserving natural lands. But our commitment is not just a defensive one focused on minimizing the costs or inevitable impacts of climate change within our State.

California is taking a proactive approach to climate change policy, through integrated policy and planning that will build a higher-quality, resilient economy while continually reducing GHG emissions. The State is continuing its legacy of creating a future where a strong economy, environmental protection, improved public health, and a higher quality of life increasingly reinforce one another. After decades of progress, the realization of a clean energy economy is the enviable future that we must create if we are to adequately address climate change.

California has asserted, and reasserted, its commitment to responsible climate policy and planning through the passage and implementation of AB 32, the overwhelming rejection of Proposition 23 in 2010, and through numerous other state and local policies, corporate commitments, and individual actions to reduce emissions.

Climate change is a continuous, global phenomenon, defined by cumulative emissions, rather than emissions at a given point in time. Policies and measures put in place and implemented today – and the continued implementation of already adopted measures – will affect emissions levels after 2020; additional planning is needed now to begin designing policies to continue reducing GHG emissions in order to achieve our long-term climate goals. With climate change already upon us and scientific consensus-based targets only sufficient to avert its very worst impacts, a continuum of action is needed to achieve the maximum technologically feasible and cost-effective emission reductions available at any given time—and to work toward near-zero emissions as soon as possible. Each incremental, cost-effective emission reduction puts California closer to its essential, sustainable future—where economic growth is unencumbered by environmental, resource, or health constraints.

California is not alone in its commitment to reduce emissions. Many other states— including Oregon, Washington, the northeast states in the Regional Greenhouse Gas Initiative, and others—are taking concrete steps to reduce GHG emissions. The United States is on track to meet the goals of the Obama Administration to reduce emissions to 17 percent below 2005 levels by 2020, and numerous other national and subnational governments in Canada, Mexico, China, Australia, Europe, and elsewhere are pricing carbon emissions, establishing markets for clean energy technologies, and taking other steps to reduce GHG emissions.

But California is alone in its depth of vision, scope of planning, and degree of leadership in demonstrating effective climate policies to decouple GHG emissions from economic growth and ensuring the State reduces emissions at a rate consistent with scientifically based targets on an ongoing basis. California's approach is one firmly grounded in science and public process, built from coordinated, integrated planning and cost-effective policy design, and accomplished through consistent, fair policy implementation. Continuing to build on this successful framework will foster broader action and continued progress on a global scale to address climate change—and deliver even greater benefits to California's economy, environment, and quality of life.

A. Preserve the California Lifestyle

California is a collection of farmers, surfers, factory workers, outdoor enthusiasts, tech geeks, truckers, world-class researchers, celebrity actors, and many more—who come from all around the world to live and work in one of the most beautiful, vibrant, and ecologically and culturally diverse places on Earth. We are sustained, in more ways than one, by the mountains, deserts, rivers, streams, forests, farmlands, rangelands, coastline, and temperate climate that form our natural environment and characterize our great State.

These resources, and their natural beauty, enable our continued economic and cultural growth. They attract a wide array of businesses and workers who want to live here. They are a primary reason that California is: the eighth largest economy in the world; home to the most small businesses, Fortune 500 companies, and fastest-growing businesses in the United States; the national leader in global trade and direct investment; and tops in the United States in many economic sectors, including agriculture, biotech, clean energy, entertainment, high-tech, manufacturing, tourism, and more.

Accordingly, Californians of all backgrounds and political persuasions have supported policies and planning to protect our natural environment and the high quality of life it provides. The result is a decades-long, broad commitment to ensuring clean air and water, an efficient and productive use of energy and resources, a healthy workforce, and vital cities and towns. Our collective will to protect the environment is a valuable resource in itself, whose benefits enhance economic growth and prosperity in our state and help shape California's distinct identity.

SUCCESS STORY

THE CITY OF BENICIA CALIFORNIA

The City of Benicia

How can Government work to reduce GHG emissions in a manner that does not burden business with onerous regulations? The City of Benicia has found a solution. Benicia has budgeted $625,000 to incentivize businesses to make resource and management improvements to reduce energy, water, solid waste, recycling, and fuel costs. The program furnishes businesses a comprehensive energy assessment, and if the energy savings are great enough, can provide grants and loans to help with recommended improvements. As of November 2013 the program has assisted ten businesses for annual cumulative annual savings of nearly $140,000 while reducing annual GHG emissions by 135 metric tons.

With climate change threatening our resources, economy, and quality of life, California is squarely focused on addressing it and protecting our natural and built environments. Just as California has done dozens of times before on other environmental issues, it is leading on climate change, with an approach that will enable better, lasting economic growth and allow the California lifestyle to endure.

B. Foster Resilient Economic Growth

We are addressing climate change head on because we must, but the necessity of action should not imply lost opportunity or economic compromise. The supposition that the status quo, characterized by relatively inefficient use of finite fossil resources, represents a preferred or lower-cost energy system is a false one. The imperative of climate change and an unwavering commitment to meet the challenge through innovation will drive technology development and advance social progress. They provide clear signals that encourage businesses to grow and invest in ways that do not come at the expense of future generations, but instead, provide even more opportunity for growth in the future. Investments that allow us to do more with less and unlock the availability of clean, renewable energy only push out the boundary of our future potential.

The transition to a clean energy future presents us with a tremendous opportunity to continue economic growth. In particular, since the adoption of AB 32, California's clean energy companies have grown faster and shown greater resilience than the State's overall economy.[46] We have emerged as the national dominant player in both clean energy jobs and clean energy investment.[47, 48, 49] These jobs offer better-than-average wages and provide needed employment opportunities in the construction and manufacturing sectors.[50, 51, 52] California's policy approach to climate change is supporting continued growth in these sectors, and the good, high-paying jobs that it brings.

Through AB 32 and related policies, California has implemented a suite of policies that is reducing emissions by both reducing energy demand and cleaning up energy supply. Taken together, our efficiency and clean energy policies are reducing not only GHG emissions, but also energy costs for consumers. For example, while the State moves toward 33 percent renewable energy in its electricity supply mix, it continues to outpace the rest of the country on energy efficiency. The State's building and appliance energy efficiency standards have saved Californians $74 billion in energy costs since 1977. California has the fourth lowest per-capita energy-related GHG emissions in the country and produces twice as much economic value for every unit of electricity used. California households also pay the ninth lowest electricity bills in the country (see Figure 4).

46 Next 10, 2013. 2013 California Green Innovation Index, Figure 35, Employment Growth Relative to 2001, pp. 42, 51, 55. Available at *http://next10.org/2013innovation* and *www.greeninnovationindex.org*

47 U.S. Bureau of Labor Statistics, 2013. "Employment in Green Goods and Services – 2011," USDL-13-0476. Available at *www.bls.gov/ggs*

48 Thomson-Reuters, 2012. "National Venture Capital Association Yearbook."

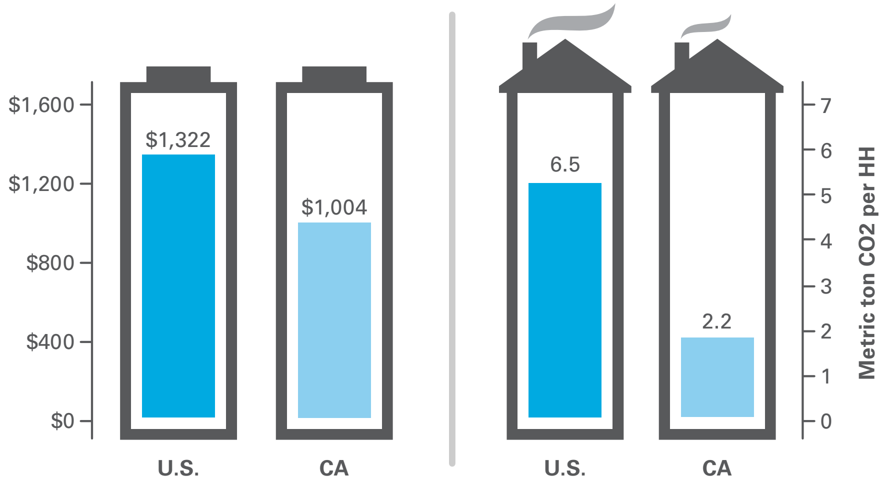
49 Pricewaterhouse Coopers, "National Venture Capital Association MoneyTree Report."

50 Brookings-Battelle, 2010. "Sizing the Clean Economy: A National and Regional Green Jobs Assessment."

51 Next 10, 2013. 2013 California Green Innovation Index, Figure 40, p. 46. Green Establishments Database, Data analysis: Collaborative Economics.

52 Collaborative Economics, 2012. "Seven Growth Sectors Driving California's Clean and Efficient Economy," May 2012. Available at *www.edf.org/sites/default/files/EDFSevenSectors-5.24.2012pdf.pdf*

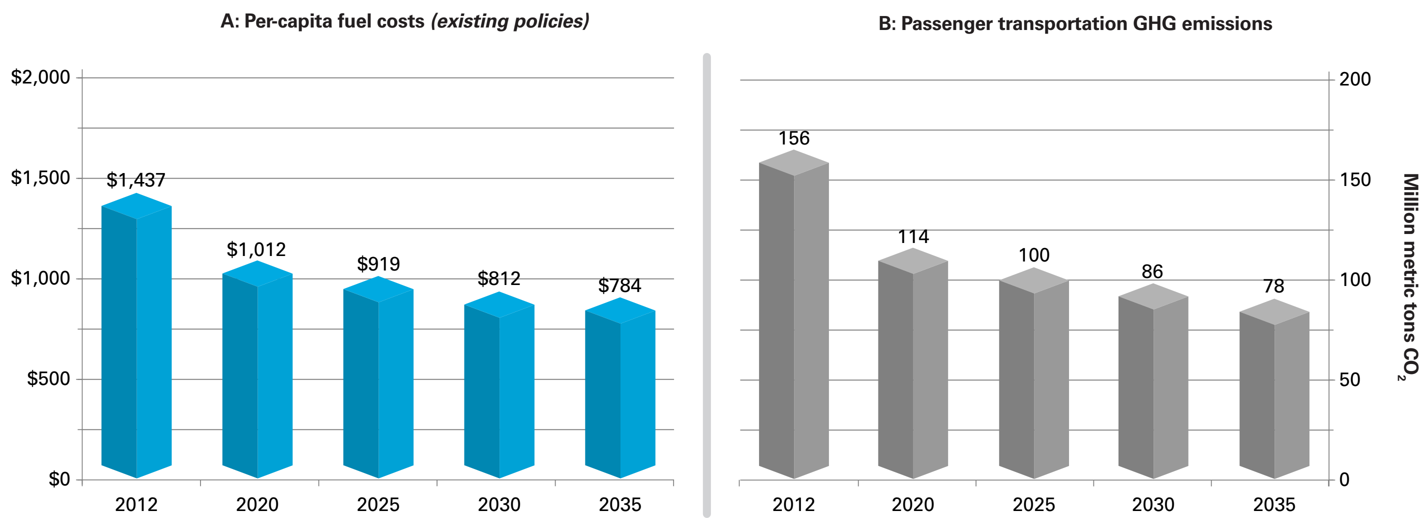
Figure 4: Average Household Expenditures on Electricity and Associated GHG Emissions in the United States and California[53]



Sources: U.S. Energy Information Administration [EIA] and ARB

The same holds true for the transportation sector. The results of California's collection of clean vehicles and fuels policies are dramatic reductions in GHG and criteria air pollution, technology innovation, and declining transportation costs. The combination of California's vehicle GHG and Zero Emission Vehicle (ZEV) standards and policies adopted under AB 32—including the Low Carbon Fuel Standard, SB 375, and Cap-and-Trade—will reduce per-capita fuel costs and GHG emissions from light-duty vehicles and fuel use by about 30 percent from current levels in 2020, and by about 50 percent in 2035 (see Figure 5). Additional measures to reduce emissions could further reduce fuel costs, as well.

Figure 5: (a) Per-Capita Fuel Costs and (b) Passenger Transportation GHG Emissions in California as a Result of the Existing Suite of California Climate Policies



53 California GHG emissions include imported electricity.

This is not to say that there are no costs associated with transitioning to clean technologies. Any technology or infrastructure change comes with initial costs. And pricing GHG emissions, as California's Cap-and-Trade Program does, inherently adds a cost at sources of pollution.

But many of the technologies needed to meet our current policies are already cost-competitive today, and prices continue to decline. In some parts of the country, new renewable power generation is competitive with new fossil generation, and in some cases, even competitive with existing fossil generation. For millions of households and businesses in California, adding rooftop solar is already reducing their energy costs. With attractive lease prices, electric vehicles are among the most affordable new cars on the market for consumers today. Multiple studies confirm that plug-in cars are already more affordable than conventional vehicles on a total cost of ownership basis.[54] And the cleaner alternatives to gasoline and diesel that are available on the market today either cost about the same as petroleum fuels (in the case of biodiesel, ethanol, and renewable gasoline and diesel), or cost far less than the petroleum fuels they replace (in the case of natural gas, renewable natural gas, or electricity).

As costs of these technologies continue to decline and additional energy efficiencies are achieved, energy costs for consumers will continue to fall, along with GHG emissions.
Avoided energy costs are pumped back into the economy elsewhere, boosting growth further.

Many more opportunities exist to capture additional efficiencies and productivity gains that will create new businesses and industries, save consumers money, and make many existing businesses and industries in California more competitive. Multiple studies show that businesses in the U.S. could collectively cut GHG emissions by more than one gigatonne (Gt) annually by 2020, representing more than 20 percent of current energy-related emissions, and generate several hundreds of billions of dollars in net savings.[55, 56] The National Academies found

54 For example, see: EPRI. 2013. Total Cost of Ownership Model for Current Plug-In Electric Vehicles. Electric Power Research Institute.

55 WWF and CDP. 2013. The 3% Solution. World Wildlife Fund and the Carbon Disclosure Project. *http://worldwildlife.org/projects/the-3-solution*.

56 McKinsey & Company. 2009. Unlocking Energy Efficiency in the U.S. Economy. McKinsey & Company. *www.mckinsey.com/client_service/electric_power_and_*

SUCCESS STORY

Anheuser-Busch InBev

Anheuser-Busch's Fairfield, California facility is covered by the Cap-and-Trade Program. Cap-and-Trade is designed to encourage energy efficiency and clean energy development. Anheuser-Busch is the world's largest operator of Bio-Energy Recovery Systems that turn the nutrients in wastewater from the brewing process into renewable biogas. The use of biogas at the Fairfield brewery accounts for 15 percent of on-site fuel needs. In addition, the Fairfield brewery has installed a large (1.5 MW) wind turbine on site and estimates about 11 percent of the plant's electricity is wind power. A planned second turbine will approximately double that supply. The turbines join a system which includes a 1.3 MW solar array. The company estimates the plant will get about 25 percent of its power from renewable sources with completion of the entire project. Over the next 20 years the shift will reduce greenhouse gas emissions by six million tons and save $2.5 million.

that U.S. manufacturing could reduce industrial energy usage by as much as 22 percent in 2020, using only technologies that yield at least a ten percent internal rate of return or a return that is greater than the company's cost of capital plus a risk premium.[57] And the Alliance Commission on National Energy Efficiency Policy has found that trillions of dollars of cost-effective energy efficiency potential is available in the United States, and that capturing it could double energy productivity by 2030, save households over $1,000 annually, add over one million jobs, and cut CO_2 emissions by one-third.[58]

Reducing GHG emissions is good business because it not only saves on energy costs, but also cuts maintenance costs, improves productivity and safety, and provides value as a hedge against future fluctuating energy prices.[59] It builds competitive, resilient businesses that are less exposed to risk from volatile energy prices and are better situated to provide lasting economic value and growth. And it diversifies energy supplies and reduces the costs that oil dependence imposes on our economy—up to half a trillion dollars per year across the United States in lost productivity and wealth transfer, alone.[60]

The Obama Administration has set a goal to double energy productivity in the United States by 2030. California is well on its way to achieve this goal as one of the most energy productive states in the country. Our commitment and approach to address climate change will continue to make our economy more efficient and productive; it will keep us ahead, while reducing emissions.

C. Strengthen the Natural Environment

In California and elsewhere, climate policy has primarily focused on reducing the energy-related GHG emissions from the built environment that account for over 85 percent of the GHG emissions in California and the United States. This includes all the buildings, cars, trucks, tractors, machines, and industrial operations that make our economy go. Accordingly, since AB 32 was passed, California has begun to build an effective framework for reducing energy-related emissions on an ongoing basis.

California has a number of policies and incentives in place to reduce emissions from agriculture, water management, and natural and working lands, as well. But additional research and policy development is needed to adequately and fairly incorporate the natural environment into an effective, lasting climate policy framework. California is committed to strengthening the role of the natural environment in climate policy. Continued work among agencies, researchers, stakeholders, and others is needed to further incorporate agriculture, natural, and working lands into the State's policy framework.

Moving forward, as energy-related emissions continue to decline in California and the developed world, the role of the natural environment in managing GHG emissions will only increase. Still, whatever its fraction of total GHG emissions, the importance of incorporating the natural environment into climate policy and planning outstrips its contribution to the State's GHG inventory. In addition to preserving California's lifestyle and economy, natural capital provided by our environment is crucial for providing safe and reliable water supplies, clean air, ecological habitat, and protection against climate change impacts. Strong and healthy coastlines, forests, waterways, marshlands, agricultural lands, and rangelands are crucial not only to support our agricultural and tourism-based economies, but also to reinforce and buffer our State from the

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natural_gas/latest_thinking/unlocking_energy_efficiency_in_the_us_economy.

57 NAS. 2009. America's Energy Future: Technology and Transformation. National Academies Press. *www.nap.edu/catalog.php?record_id=12091*.

58 ASE. 2013. Energy 2030. Alliance to Save Energy. *www.ase.org/policy/energy2030*.

59 PwC. 2013. Less and be more: better for the bottom line and the environment. 10Minutes series on eco-efficiency. *www.pwc.com/en_US/us/10minutes/assets/pwc-10minutes-eco-efficiency.pdf*.

60 Greene. 2013. "Low Carbon Transportation: A Crucial Link to Economic and National Security." *www.arb.ca.gov/research/lectures/speakers/greene/greene.htm*.

increasing impacts of climate change, including drought, flood, and forest fires. Strengthening our natural environment makes it, and consequently our economy, more resilient to the impacts of climate change and protects our built environment.

Adequately accounting for the natural environment in our climate framework requires an integrated approach that values natural resources, not just as emission sources or sinks, but also for the other values they provide. It requires coordinating plans to reduce emission impacts from the natural environment with plans to strengthen it and prepare for climate change impacts. This is the approach California will take as we continue to build our climate policy framework. The approach will not only contribute emission reductions and build emission sinks necessary to manage climate change, but also strengthen the natural environment that drives our economy and supports our quality of life.

D. Improve Public Health and Social and Environmental Justice

The impact of climate change and California's policy approach to address it reaches beyond environmental protection and economic opportunity. If done appropriately, addressing climate change provides tremendous opportunity to improve the health and well-being of all of California's citizens and to help unravel many of the patterns of environmental, health, and social inequalities within our communities.

Cleaner and more efficient power plants, industrial facilities, cars and trucks, modernized freight systems, and reduced travel demand are already greatly reducing air pollution and cancer risks in California, particularly in environmental justice communities. Strengthening our natural environment, including those areas surrounding the most impacted urban and rural communities, will further improve public health.

Ongoing planning to create more sustainable communities in the State is providing expanded mobility options, including greater access to walking and biking facilities, increased access to employment and services, and more vibrant surroundings. Energy efficiency, green buildings, and other clean energy technologies and climate policies are creating more comfortable, safer homes and transportation options, and are saving families money. Efforts to improve industrial, manufacturing, and agricultural efficiency and productivity will strengthen these sectors and make the communities and jobs they support more resilient to national or global economic downturns and climate impacts. All of these aspects of California's climate policy approach bring economic, health, and other benefits to all of California's communities.

Yet, innovative public policy brings unknowns. As California continues to lead on climate change and pioneer new policy and technology strategies to avert the worst impacts of global warming, we must continue to monitor and assess the health and environmental justice impacts of our programs and policies, making changes when necessary to maximize benefits. Capturing the opportunities of climate policy to improve health and quality of life in all of California's communities is a critical aspect of our leadership and is building a successful and lasting climate policy framework. Delivering on those opportunities will serve to expand policy action beyond the State's borders.

E. Rely on Science and Foundational Research

California's environmental policy successes are built on a strong foundation in science. Successfully addressing climate change and planning to achieve targeted emission reductions over time similarly requires a dependence on foundational research.

Climate policy in California has been supported, and advanced, by our State's world-class research institutions, which have made California perhaps the most studied region in the world when it comes to GHG emissions and climate policy. As a result, we have a strong sense of the mix of technologies needed to reduce emissions through 2050, especially in the energy sector, and a valuable research apparatus to support ongoing policy planning and implementation.

A number of studies look to 2050 in California and provide a snapshot of the mix of technologies necessary to reduce energy-related emissions in California to 80 percent below 1990 levels by 2050.[61] They share many common conclusions, including the overarching conclusion that the 2050 emissions target is achievable, mostly with technologies that are commercially available today.

Together, they show that achieving the 2050 target will require energy demand reduction through efficiency and activity changes; large-scale electrification of on-road vehicles, buildings, and industrial machinery; decarbonizing electricity and fuel supplies; and rapid market penetration of efficiency and clean energy technologies that requires significant efforts to deploy and scale markets for the cleanest technologies immediately. The studies agree that large efficiency

61 For example, see: Greenblatt, J., et al. 2011. California's Energy Future, The view to 2050: Summary report. California Council on Science and Technology (CCST). *www.ccst.us/publications/2011/2011energy.pdf*.
Williams, J. H., et al. 2011. "The Technology Path to Deep Greenhouse Gas Emissions cuts by 2050: The pivotal role of electricity." Science Express 335 (6064): 53–59. [E3] *www.sciencemag.org/content/335/6064/53*.
Wei, M., et al. 2013. "Deep carbon reductions in California require electrification and integration across economic sectors." Environmental Research Letters 7: 1–9. *http://iopscience.iop.org/1748-9326/8/1/014038/*.
[LBNL-1] Wei, M., et al. 2012. "California's Carbon Challenge (CCC): Scenarios for Achieving 80% Emissions Reduction in 2050." Lawrence Berkeley National Laboratory. October 31. *http://rael.berkeley.edu/sites/default/files/California%20Carbon%20Challenge%20Report%20Nov%201_2012.pdf*. [LBNL-2]
Jacobson, M. Z., et al. 2013. Evaluating the technical and economic feasibility of repowering California for all purposes with wind, water and sunlight. *www.stanford.edu/group/efmh/jacobson/Articles/I/CaliforniaWWS.pdf*. [Stanford]
McCollum, D., et al. 2012. "Deep greenhouse gas reduction scenarios for California – Strategic implications from the CA-TIMES energy-economic systems model." Energy Strategy Reviews 1(1):19–32. *http://www.sciencedirect.com/science/article/pii/S2211467X11000083*. [UCD-1]
Yang, et al. 2009. "Meeting an 80% reduction in greenhouse gas emissions from transportation by 2050: A case study in California." Transportation Research Part D 14. *www.internationaltransportforum.org/pub/pdf/10FP03.pdf*. [UCD-2]

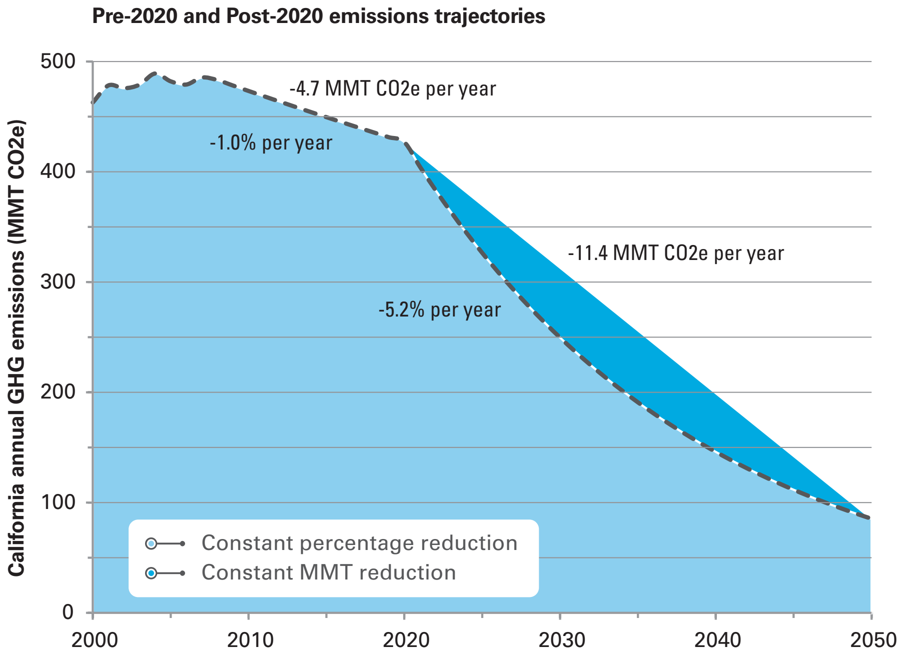
improvements can be achieved in transportation, buildings, and industry; that the electricity sector will have to be essentially zero carbon; and that electricity or hydrogen will have to power much of the transportation sector, including almost all passenger vehicles, and that near-zero carbon biofuels will have to power most other vehicles. They recognize a need for the natural environment to play an important role, providing carbon sinks to offset emissions, and a need to integrate and coordinate policy across a number of objectives and planning processes.

The studies vary in several important assumptions, however, which offer opportunities to pursue additional emission reductions or select alternative policy and technology paths forward—depending on population and economic growth in the State, technology and market development, and changing activity and behavior patterns. California will need to monitor the market and technology progress alongside emissions, and continue to rely on strong supporting research as it builds on its climate policy framework. One thing is clear; many prominent California scientists and economists support a mid-term target to meet California's long term climate goals.[62]

F. Charting a Path to 2050

Achieving the low-carbon future described in these studies will require that the pace of GHG emission reductions in California accelerate significantly. Emissions from 2020 to 2050 will have to decline several times faster than the rate needed to reach the 2020 emissions limit (Figure 6).

Figure 6: Framing the Path to 2050



Ultimately, climate change is affected by cumulative emissions. As described in Chapter II, the world must keep within scientifically determined "carbon budgets" to achieve climate stabilization. Accordingly, different paths to the same 2050 emissions levels will result in different climate impacts. Tackling global warming requires us to reduce and minimize total emissions, not just reach stated targets.

62 An Open Letter on Climate Change from California Climate Scientist and Economists: *www.arb.ca.gov/lists/com-attach/10-proposed-sp-ws-AHUFYFIgVCkEcIQw.pdf*

Appropriate action on climate change requires a continuum of action to capture cost-effective emission reductions opportunities wherever possible, on an ongoing basis. We need to meet strict, science-based targets not just in 2020 and 2050, but at every point in between, as well. California's leadership will be defined not just by its emissions level in 2050, but also by the pathway it takes to get there.

As described in Chapter IV, California will develop a mid-term target to frame the next suite of emission reduction measures and ensure continued progress toward scientifically based targets. This target should be consistent with the level of reduction needed in the developed world to stabilize warming at 2°C (3.6°F) and align with targets and commitments elsewhere. The European Union has adopted an emissions reduction target of 40 percent below 1990 levels by 2030. The United Kingdom has committed to reduce its emissions by 50 percent below 1990 levels within the 2022–2027 timeframe, and Germany has set its own 2030 emissions target of 55 percent below 1990 levels. The United States, in support of the Copenhagen Accord, pledged emission reductions of 42 percent below 2005 levels in 2030 (which, for California, translates to 35 percent below 1990 levels).

This level of reduction is achievable in California. In fact, if California realizes the expected benefits of existing policy goals (such as 12,000 megawatts [MW] of renewable distributed generation by 2020, net zero energy homes after 2020, existing building retrofits under AB 758, and others) it could reduce emissions by 2030 to levels squarely in line with those needed in the developed world and to stay on track to reduce emissions to 80 percent below 1990 levels by 2050.[63] Additional measures, including locally driven measures and those necessary to meet federal air quality standards in 2032, could lead to even greater emission reductions.

Setting a strong mid-term target that aligns with scientifically established needs is an important next step in California's climate policy leadership. Such a target will provide greater levels of market certainty in the near term, while allowing flexibility to review and adjust our course based on future technology and market conditions. Planning and effectively implementing policies to achieve a mid-term target in a manner that advances economic growth, public and environmental health, and quality of life in all of the State's communities will further demonstrate California's successful policy approach and create an enviable framework that others will look to follow.

63 Greenblatt, J. 2013. Estimating Policy-Driven Greenhouse Gas Emissions Trajectories in California: The California Greenhouse Gas Inventory Spreadsheet (GHGIS) Model. Lawrence Berkeley National Laboratory. *http://eetd.lbl.gov/publications/estimating-policy-driven-greenhouse-g*

IV. Accomplishments and Next Steps

California must continue to build on the framework established in the initial Scoping Plan as we look toward meeting our long-term climate goal of GHG emissions of 80 percent below 1990 levels by 2050. A mid-term statewide emission limit will ensure that the State stays on course to meet our long-term goal and continues the success it has achieved thus far in reducing emissions. The mid-term statewide limit will help frame the additional suite of policy measures, planning efforts, and investments in clean technologies that California will need to continue to drive down emissions and grow a cleaner, more sustainable economy.

This chapter provides a discussion of GHG emission reduction mitigation strategies for each of California's major economic sectors. It identifies the activities, policies, and other accomplishments, primarily over the last five years, that address climate change to reduce GHG emissions to meet the 2020 statewide limit. It also identifies longer-term strategies that the State must undertake to continue to reduce GHG emissions into the future to ultimately meet our long-term climate goal.

Each major sector highlighted in this chapter must play a role in supporting the statewide effort to continue to reduce emissions. Planning must begin now in order to implement our longer-term strategies. Specific recommendations for steering the State down this path are summarized, by sector, at the end of this chapter. As the statewide mid-term target is developed, sector targets will also be developed that reflect the opportunities for reductions that can be achieved through existing and new measures, actions, and investments.

A. Key Economic Sectors

The initial Scoping Plan recommended specific GHG emission reduction measures in nine major economic sectors to better define, organize, and determine control strategies for each. In this Update, six key areas of the State's economy were identified (energy, transportation, agriculture, water, waste management, and natural and working lands), along with short-lived climate pollutants, green buildings, and the Cap-and-Trade Program. The subsections below describe our progress in reducing GHG emissions and what will be required to better evaluate GHG emission reduction actions within California's broad economy to meet the State's more expansive longer-term emission reduction goals.

These key areas have overlapping and complementary interests that will require careful coordination in the State's future policies and strategies. The areas were chosen based on their ability to address concerns that underlie all sectors of the economy. As such, each focus area is not contained to a single economic sector, but has far-reaching impacts within many sectors. For example, much of the transportation sector will need to be electrified in the future. This creates demand for more electrical generation, but also provides an opportunity to take advantage of broader systems efficiencies as sectors interact in new ways.

Another example is the interaction between water delivery and energy use in California. Since water delivery is very energy-intensive, implementing programs that strongly support water conservation can reduce GHG emissions in the electricity sector by reducing the need for electricity to move, treat, and heat water. Water conservation is also critical to making the State's water supply more reliable and drought resistant. Producing electricity requires large volumes of water. Promoting a system that maximizes appropriate cooling technologies (e.g., reclaimed water and dry cooling towers), energy efficiency, and conservation can greatly reduce water demands and make those water savings available for agriculture and other essential needs. The way that communities and infrastructure are designed and built can significantly reduce California's impact on natural lands, minimize vehicle miles traveled, reduce water needs, and provide many other benefits for the State as a whole.

1. Energy

California's energy sector includes a complex system of electricity and natural gas production, transmission and distribution, utility service operations, and consumption by diverse end users—including residential, commercial, and industrial activities. Energy is a common thread that runs through all sectors of California's economy. It's also one of the State's largest contributors to GHG emissions. Presently, about 50 percent of the State's total GHG emissions are associated with the energy sector; therefore, efforts to reduce energy-related emissions are a key component of the Scoping Plan. Additionally, energy-sector emission reduction efforts will become increasingly important as more economic activities such as transportation and freight movement are electrified.

Reducing energy-sector emissions to near zero over the long-term will require wholesale changes to the State's current electricity and natural gas systems. The energy sector will generally need to adapt to a system consisting of near-zero carbon buildings (refer to Section 8 of this chapter for more discussion of zero net carbon buildings), highly efficient businesses and industry, low-carbon electricity generation, sustainable bioenergy systems, smarter and localized generation, a flexible and modernized transmission and distribution system, more compact land use, and electricity substitutes for fuels currently used for transportation, space heating, and industrial processes.

Achieving these emission reduction goals will require that a number of important administrative, financial, and technological changes are undertaken to guide energy investments and planning toward the most appropriate combination of conservation, efficiency, and clean-energy technologies to decarbonize the State's energy systems at the lowest cost.

Electricity and Natural Gas

California has made remarkable progress in developing and implementing new policies and strategies to reduce GHG emissions within the State's energy sector. California has a track record of decades of rigorously evaluated, cost-effective energy efficiency improvements across all sectors of the economy. The initial Scoping Plan continued these priorities by advancing a host of innovative and aggressive building, appliance, electronic, and water-efficiency standards that are certain to maintain California's leadership in this area.

An example of California's leadership in the energy sector is SB 1368 (Perata, Chapter 598, Statutes of 2006), which created the nation's first emission performance standard for centralized power generation. SB 1368 prevents the State's electric utilities from making long-term investments in high GHG-emitting baseload power plants. The U.S. EPA is following California's lead by proposing a GHG emission performance standard for the nation's power plants.

Consistent with the State's loading order,[64] the California Energy Commission (CEC) and California Public Utilities Commission (CPUC) have adopted several programs and regulations since 2008 that are driving efforts to reduce electricity-sector GHG emissions. Many of these programs are implemented at the local electric utility level. Below is a discussion of efforts being undertaken to reduce GHG emissions from the energy sector in accordance with the State's loading order.

Energy Efficiency

A variety of appliance (including electronics) and building energy efficiency programs and initiatives represent the State's top priority in reducing the need to develop new energy resources to meet California's electricity and natural gas demand. The CEC continues to provide a leadership role in developing and adopting new appliance and building efficiency standards for the State. Building efficiency standards were updated in 2013 and are now 25 percent more efficient for residential construction and 30 percent more efficient for non-residential construction.[65] The CEC also adopted aggressive energy efficiency standards for televisions in 2009, and first-in-the-nation energy efficiency standards for battery chargers in 2012.[66]

The CEC is currently considering additional appliance categories to cover under its appliance energy efficiency standards. Those under consideration include consumer electronics, lighting, water appliances, and several others. Future updates to these standards and collaborative work with the U.S. Department of Energy should focus on realizing both cost-effective energy savings and incorporating features that can assist in grid resilience and responsiveness.

In addition to the State's energy efficiency Standards, California's investor-owned utilities (IOUs) regulated by the CPUC have a long history of implementing energy efficiency programs that target both residential and non-residential sectors. The State's self-regulated publicly owned utilities (POUs) also have energy efficiency programs. The POU programs vary significantly between the individual utilities, but in some cases can be more aggressive than the IOU goals.

The CPUC's evaluation activities have focused on verifying utility savings claims and improving savings estimates via field-based research. Findings and recommendations from these studies have been critical to continued improvement of energy efficiency programs in the State. The CPUC has recently opened a new rulemaking in which it has signaled its intent to provide grid planners and efficiency markets with greater certainty regarding the State's commitment to these programs. Similar progress and initiatives should be made in all POU territories.

Funding from the California Clean Energy Jobs Act (Proposition 39), approved by California voters in November 2012 and subsequently refined through Senate Bill 73 (Skinner, Chapter 29, Statutes of 2013), will provide a significant source of new revenue (an estimated $2.5 billion over five years) to support energy efficiency and clean energy projects in California's public schools (K–12) and community colleges.

At the local government level, several communities have created property-assessed clean energy financing districts (PACE programs) that allow residential and commercial property owners to finance renewable on-site generation and energy efficiency improvements through voluntary property tax assessments.

Governor Brown took specific action in 2012 to improve the energy efficiency of state-owned buildings through Executive Order B-18-12, which directs State agencies to reduce their grid-based energy purchases by at least 20 percent by 2018. This Executive Order also directs State agencies to reduce the GHG emissions associated with the operating functions of their

64 The "loading order" is California's preferred sequence for meeting electricity demands: energy efficiency and demand response first; renewable resources second; and clean and efficient natural gas-fired power plants third.

65 Computed from California Energy Demand, 2012–2022 Final Forecast, June 2012, Form 2.2 on Committed Energy Impacts.

66 CEC. 2013. California Energy Commission 2012 Accomplishments. *www.energy.ca.gov/releases/2013_releases/2012_Accomplishments.pdf*.

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Kaiser Permanente

Between 2010 and 2011, Kaiser Permanente installed solar panels that increased its on-site renewable generation capacity to 11 megawatts at 12 facilities across California, creating one of the largest health care solar installations in the country. The panels generate clean, renewable energy for Kaiser Permanente hospitals and buildings, avoiding approximately 7,600 metric tons of CO_2 emissions annually since 2012. Kaiser Permanente also deployed four megawatts of natural gas-powered fuel cell generation capacity, thus avoiding approximately 5,700 metric tons of CO_2 emissions in 2012, while reducing the organization's reliance on the public electric grid and helping to diversify energy sources.

buildings by ten percent by 2015, and 20 percent by 2020.[67] State agencies have been able to achieve a four percent reduction in total energy use despite a 12 percent increase in building space since 2003.

Fifty-five percent of existing residential buildings and 40 percent of non-residential buildings were constructed before California's building energy efficiency standards were established. California's legislature recognized the opportunity and importance of upgrading existing residential and commercial buildings and passed Assembly Bill 758 (Skinner, Chapter 470, Statutes of 2009), which requires the CEC to develop and implement a comprehensive energy efficiency plan for all of California's existing buildings. The CEC is currently drafting an AB 758 Action Plan to accomplish the following:

- Improve code compliance rates with Title 24 Building Standards for existing building upgrade projects.
- Develop energy disclosure approaches and programs that build on existing efforts and expand the types of applicable buildings, including State buildings in alignment with Governor Brown's Executive Order B-18-12.
- Collaborate with the real estate and property management industries to craft aggressive, but practical, solutions to achieve efficiency upgrades in existing buildings.
- Enhance usability of Title 24 Building Standards as applied to additions and alterations of existing buil dings.

Achieving the State's zero net energy (ZNE) building goals is an important effort under way to assist with achieving climate targets. In 2008, the CPUC set forth ZNE goals in its long-term Energy Efficiency Strategic Plan and implementation roadmap for the Big Bold Energy Efficiency Strategies, which was later updated in 2011. The CPUC's Big Bold Energy Efficiency Strategies set policy goals to achieve ZNE in all new residential buildings by 2020, and all new commercial buildings by 2030.

The CEC has made progress toward achieving the State's ZNE goals for new residential and new commercial buildings through triennial updates to the State's building energy efficiency standards.

67 Executive Order B-18-12, issued on April 25, 2012. See *http://gov.ca.gov/news.php?id=17508.*

Working with the CPUC, the CEC adopted a definition for ZNE code-compliant buildings that was published in the 2013 Integrated Energy Policy Report. Building on this effort, ARB and CEC should analyze[68] zero and near-zero GHG alternatives for heating, cooking, and commercial energy use and assess the potential economic and technological barriers to switching to these alternatives. ARB is committed to building upon the recent policies and goals adopted by the CPUC and CEC and supporting the development of statewide programs, such that all new residential and commercial buildings are zero net energy by 2020 and 2030, respectively.

Recent efficiency initiatives that overlap across agencies, such as American Recovery and Reinvestment Act of 2009 (ARRA)-funded whole-house upgrades and Proposition 39 schools-focused activities, have revealed inconsistencies in the accounting and evaluation methods for estimating, verifying, and valuing energy efficiency savings across State agencies. These differences may be driven by the historic policy drivers for the energy efficiency activities. Since the methods of measuring, verifying, and valuing energy efficiency can impact the scope of future efficiency programs and the resulting GHG savings, efforts should be undertaken to improve the efficacy of these efforts by emphasizing consistency, transparency, credibility, and timeliness.

Demand Response

Demand response is also at the top of California's loading order for meeting the State's electricity demand. Demand response is provided primarily by utilities or third-party demand-response providers (DRPs), also known as aggregators, through programs or contracts that are supported by $1 billion in ratepayer funding (over three years). Demand response has traditionally been used to reduce peak demand and there is currently approximately 2,000 MW of demand-response capacity in IOU territories. Some programs are used to mitigate emergency situations, while others are used to address economic conditions, such as high wholesale energy prices

The CPUC recently initiated a new rulemaking[69] for demand response for the purpose of enhancing its role in meeting the State's resource planning needs and operational requirements. Specifically, the rulemaking states that demand response needs to improve its reliability and usefulness as the State's grid needs continue to evolve. For example, demand-response resources are not bid into California Independent System Operator (CAISO) wholesale energy markets, thereby reducing their visibility and dispatchability to CAISO's grid operators. The CPUC's rulemaking and its concurrent efforts to approve "direct participation" rules in 2014 (also known as Rule 24) are the first steps of many that will lead to the bidding of demand response resources into wholesale markets.

The rulemaking also recognizes that demand response has potential value as a flexible capacity resource for renewable integration (through increasing or decreasing demand), a balancing energy and ancillary service resource, and an alternative to transmission upgrades. Demand response as a renewable integration resource carries significant implications for GHG reduction goals. Renewable resources such as wind and solar are variable, and thus grid operators must rely on load-following resources to maintain grid stability. Those load-following resources are typically quick-start fossil-fuel generation plants. If demand response can provide the needed reliability for variable renewable resources, the State will have less need for quick-start fossil-fuel generation plants.

However, existing demand response resources do not yet have the speed, flexibility, or reliability to achieve this potential. One purpose of the CPUC rulemaking is to determine, in close collaboration with CAISO, the specific qualities demand response resources will need in order to address these new grid needs. Once these qualities have been set, market participants can then be directed to provide the "next generation" of demand-response resources through appropriate procurement mechanisms. The CAISO's Flexibility Resource Adequacy Criteria and Must-Offer

68 The CEC is required by Title 24 to use a lifecycle cost-effectiveness analysis methodology.
69 R.13-09-011, issued on September 25, 2013: *http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M077/K151/77151993.PDF*

Obligation (FRACMOO) stakeholder process and its anticipated demand response Standard Capacity Product stakeholder process are key CAISO initiatives in setting specific design and operational details for future demand response resources.

While development of DR as a renewable integration resource is a critical next step for California, the CPUC rulemaking also signals the importance of refining demand-response resources that cannot be bid into CAISO markets but are beneficial to the State's goals of reducing energy consumption during peak hours. These resources, referred to as load-modifying demand response, can reduce California's demand curve over time through strategies such as time-of-use rates and permanent load-shifting programs. The impact of these programs could potentially reduce the need for gas-fired generation resources in future planning processes. Additionally, the rulemaking will be exploring how demand response can be better coupled with other demand-side resources such as energy efficiency and distributed generation, so that retail customers see all their options and make well-informed decisions, thereby expanding demand-side resources collectively.

Renewable Energy

In 2011, the Legislature passed and Governor Brown signed a bill creating the nation's most aggressive renewables portfolio standard (RPS) program. The program requires California's investor-owned and publicly owned electric utilities, as well as all other retail sellers of electricity, to serve 33 percent of their customers' electricity needs with clean renewable energy by 2020. As part of his Clean Energy Jobs Plan, Governor Brown set an aggressive target of adding 8,000 MW of centralized, large-scale renewable facilities (of which 3,900 MW has come online since 2010) and 12,000 MW of distributed renewable generation by 2020. Of the 12,000 MW distributed renewable generation goal, 4,400 MW has already come online.

California has made substantial progress in developing new renewable resources to support the RPS and the governor's goals. The large investor-owned utilities report that they have met the 20 percent RPS goal for 2011–2013, are on track to meet the requirement of 25 percent renewables by 2016, and are well-positioned to meet the 33 percent target by 2020. The publicly-owned utilities have also contributed to meeting these targets and are progressing about as fast, and in some cases faster, than the investor-owned utilities.

Approximately 2,000 MW of new renewable capacity came online in 2012;[70] 1,600 MW of which is wind generation. Another 3,300 MW of renewable capacity is estimated to have come online statewide before the end of 2013. A total of 3,500 MW of solar (thermal and photovoltaic, or PV) and 5,700 MW of wind has been installed to date. California is now the nation's second largest producer of wind power.[71]

California leads the nation in the amount of solar PV capacity.[72] In 2012, California became the first state to install more than 1,000 MW of new solar capacity in a single year, from a combination of utility-scale projects and customer installations.[73] In 2013, the State added over 2,600 MW of solar PV; 2,300 MW from wholesale solar PV and 300 MW from self-generation PV. Solar PV programs[74] codified by Senate Bill 1 in 2006 (SB 1, Murray, Chapter 132) are driving much of the self-generation installation in California. SB 1 set a target for 3,000 MW of self-generation solar,

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70 California Public Utilities Commission. 2012. Renewables Portfolio Standard Quarterly Report, 3rd and 4th Quarter 2012. *www.cpuc.ca.gov/NR/rdonlyres/2BC2751B-4507-4A38-98F5-F26748FE6A95/0/2012_Q3_Q4RPSReportFINAL.pdf*

71 Wiser, Ryan, and Mark Bolinger. 2012. 2011 Wind Technologies Market Report. Lawrence Berkeley National Laboratories. U.S. Department of Energy. DOE/GO-102012-3472. August.

72 Dutzik, Tony, and Rob Sargent. 2013. Lighting the Way: What We Can Learn From America's Top 12 Solar States. Environment America Research and Policy Center. July. *www.environmentamericacenter.org/sites/environment/files/reports/Lighting_the_way_EnvAM_scrn.pdf*

73 Marshall, J. 2013. California Still Tops in Renewable Energy Rankings. *www.pgecurrents.com/2013/08/22/california-still-tops-in-renewable-energy-rankings/*. Accessed August 23, 2013.

74 California's solar PV programs include the CPUC's California Solar Initiative, the Energy Commission's New Solar Homes Partnership, and publicly owned utility solar incentive programs.

including solar water heating, by 2017, of which 1,570 MW have been installed. Additionally, about 300 MW were installed prior to SB 1 as result of the Emerging Renewable Program, the Self Generation Incentive Program, and POU solar incentive programs. In total, about 1,900 MW of self-generation solar was installed in California by the end of 2013.

Energy Storage

While taking steps to minimize integration needs, the State must also advance energy storage technologies to help integrate increasing amounts of renewable resources. An energy storage device is a technology capable of absorbing energy, storing it for a period of time, and dispatching the energy as needed. Energy storage devices can store energy during times of low demand or over-generation and can then provide energy stored back into the grid during times of peak demand or when the grid is stressed.

Storage technologies can be applied on transmission and distribution systems and can help maintain a reliable and efficient transmission grid. Storage can also provide load-following capabilities to manage frequent and wide variations in solar and wind energy due to their fast ramp rates (megawatts of power delivered per minute). Storage can also complement demand response programs. In October 2013, the CPUC adopted an energy storage procurement framework and design program which requires the investor-owned utilities to procure 1,325 MW of energy storage by 2024.[75]

Combined Heat and Power

Combined heat and power systems (CHP), also referred to as cogeneration, generate on-site electricity and useful thermal energy in a single integrated system. Combined heat and power systems are typically used in industrial, commercial, and institutional applications where both electricity and steam are required. Governor Brown set a goal for 6,500 MW of additional CHP capacity by 2030 as part of his Clean Energy Jobs Plan. This goal builds upon the Scoping Plan's goal for emission reductions equivalent to 4,000 MW of new CHP generation by 2020.

Through the implementation of the 2007 Waste Heat and Carbon Emissions Reduction Act (also known as AB 1613, Blakeslee, Chapter 713, Statues of 2007), the CEC and CPUC have taken steps to create efficiency guidelines and market pricing incentives for small (<20 MW) CHP system owners. The CPUC also adopted the CHP "Settlement Agreement" in 2010,

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75 CPUC. Decision Adopting Energy Storage Procurement Framework and Design Program. October 17, 2013. *http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M078/K912/78912194.PDF*.

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California's electric grid is becoming more efficient through improved communications and control software that allow operators to check energy flow every few seconds and more accurately balance supply and demand. This also improves the ability of California grid operators to bring more energy from renewable sources into the state's electricity mix. Other in-building "smart" technology developments allow for more efficient energy usage and for real-time communication between consumers, their appliances, and electricity suppliers. A study by the Pacific Northwest National Laboratory estimated that these "smart grid" improvements can reduce GHG emissions from electricity generation by as much as 12 percent by 2030.

which created a new CHP program requiring that California's three largest investor-owned electric utilities procure a minimum of 3,000 MW of CHP capacity until 2015 and reduce greenhouse gas emissions by 4.8 $MMTCO_2e$.

Despite these policy actions and incentives for CHP, significant installation barriers for CHP systems still remain and very few new CHP systems have been installed since the initial Scoping Plan was released. Indeed, due to older system retirements, the State's overall CHP capacity may be lower now than it was in 2008. ARB is committed to working with the CPUC, CEC, and CAISO to assess existing barriers to expanding the installation of CHP systems and propose solutions that help achieve climate goals. A future CHP measure could establish requirements for new or upgraded efficient CHP systems.

Industry

In the initial Scoping Plan, the industry sector was discussed in a separate sector; however, in this Update it has been included within the energy-sector discussion because its GHG emissions are primarily due to energy use.

California industry includes a broad and diverse range of sources, including cement plants, refineries, power plants, glass manufacturers, and oil and gas production facilities. Industrial sources play a significant role in the State's vast economy and accounted for about 20 percent of California's total GHG emissions.

Most emission reductions from industry will be realized through California's Cap-and-Trade Program, which includes large industrial sources (i.e., sources emitting more than 25,000 $MTCO_2e$ per year). (See Section 9 of this chapter for a discussion of the Cap-and-Trade Program.) As with other activities covered by the Cap-and-Trade Regulation, ARB also assessed the potential for direct regulation measures that could be implemented at these facilities. In addition, fugitive emissions from industrial facilities (primarily methane emissions) are not part of the Cap-and-Trade Program. Therefore, direct regulations were also considered for industrial sources with significant fugitive GHG emissions—oil and gas extraction, natural gas transmission, and refineries.

Carbon capture and sequestration (CCS) is another option to reduce emissions from electricity generation and industrial emitters. ARB is currently working with researchers from the Lawrence Berkeley National Laboratory (LBNL) to evaluate existing quantification methodologies related to the sequestration portion of CCS in the context of California geological and regulatory considerations. ARB will continue to work with the Division of Oil, Gas & Geothermal Resources (DOGGR), CEC, and CPUC for future development of a quantification methodology for California GHG emissions sources.

In 2010, ARB approved the energy efficiency assessment regulation requiring California's largest industrial facilities to conduct a one-time assessment of the facility's fuel and energy consumption and emissions of GHGs, criteria pollutants, and toxic air contaminants. The assessments were to include the identification of potential energy efficiency improvement projects. ARB subsequently received assessment reports from 43 industrial facilities covering five industrial sectors: refinery, cement, hydrogen production, power generation, and oil and gas/mineral production. ARB is currently developing public reports for each industrial sector, summarizing the information provided by the facilities. ARB will use these findings to identify the best approaches to secure energy efficiency improvements and the associated emission reductions at California's largest facilities.

Regarding fugitive emissions, ARB undertook a survey of the oil and gas extraction sector, on items such as compressor seals, storage tanks, valves, flanges, and connectors, to improve the emission inventory. The key findings of this survey are influencing ARB's approach to developing a new measure in 2014 to reduce fugitive GHG emissions from these operations.

Current data indicate that methane emissions in California may be undercounted and that one potential source of these emissions is the natural gas transmission and distribution system. Based on a 2008 survey, the vast majority of the GHG emissions from this sector are expected to come from distribution pipeline leaks. Field measurements of fugitive emissions from natural gas distribution pipelines in California are currently being conducted to update the emission factors for this sector. The field study is expected to be completed by 2015. ARB will use the study results to determine the cost-effectiveness of developing a regulation to reduce fugitive GHG emissions from these operations.

Methane has historically been exempt from the local air districts' volatile organic compound (VOC) regulations, such as refinery leak detection and repair regulations, because it has very low photochemical reactivity and, thus, does not contribute significantly to smog formation. However, because methane is a powerful GHG and short-lived climate pollutant, ARB is working with local air district staff to determine the benefits of incorporating amendments to their existing leak detection and repair rules to include methane leaks from refineries and other industrial sources with a potential for fugitive methane emissions.[76]

Oil and Natural Gas Production

California has a significant oil and natural gas industry. Currently, our existing rules (LCFS, Cap-and-Trade and others) and proposed new measures, such as for hydraulic fracturing (fracking), oil and gas production, and other short-lived climate pollutants measures, will lead to best-in-industry practices to minimize GHG, criteria and toxic pollutant emissions associated with the production and refining of oil and gas.

Maintaining Momentum

California will be unable to achieve the needed GHG emissions within the energy sector by simply continuing or modestly expanding upon current energy conservation, efficiency, and generation decarbonizing program efforts. In addition, no single agency or entity has complete responsibility for the energy sector. As previously noted, a reworked and comprehensive State program will be required that addresses all affected energy entities and is specifically designed to ensure that the proposed emission reductions are achieved.

For example, in addition to calling for more localized generation and smart grid technologies, the energy sector should support "smarter generation." This includes advanced energy technologies and distributed generation, as well as regional grid management to allow for pooling of diverse resources. Planning for regional (west-wide) grid management is occurring through the Energy Imbalance Market (EIM), led by CAISO. It allows California to use a regional approach to increase grid reliability by allowing the State's energy system to pull from a more diverse set of resources to meet demand and renewable integration needs.

At the electricity distribution level, actions to expedite the deployment of small-scale storage systems, as well as microgrid and "smart-grid" technologies, are essential to maximize renewable and distributed resource integration. Strengthening and expediting California's policies for ZNE homes and businesses and maximizing energy conservation and demand-response participation in the consumer electricity market should also be a priority. The role and functions of utilities may need to evolve as California increasingly shifts toward more renewable and distributed energy integration.

The State will need a comprehensive and aggressive (but flexible) program to drive energy utilities toward providing zero and near-zero GHG energy resources. At the same time, the State will need to ensure that new or expanded economic development activities are designed to incorporate the most advanced energy-efficient technologies and energy-conserving practices.

76 In addition, CEC is mandated by AB 1257 (Bocanegra, Chapter 749, Statutes of 2013) to identify strategies for evaluating the lifecycle GHG emissions from the natural gas sector every four years.

State agencies should collaborate toward developing a comprehensive and enforceable GHG emission reduction program for the State's electric and energy utilities. The CEC, CPUC, and ARB will all have a role in developing and implementing the most technologically appropriate and cost-effective suite of strategies to achieve the State's emission reduction goals.

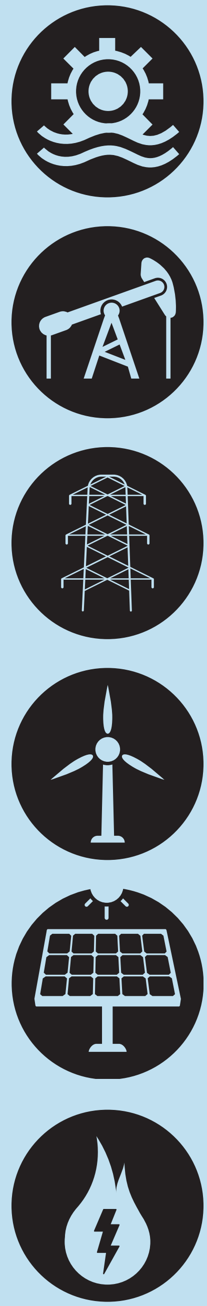
The program should maintain consistency with the State's broader energy policies, such as those articulated in the loading order and the initial Scoping Plan, and be designed to further advance key State energy programs and needs such as energy efficiency and demand-response efforts, renewable energy development, energy storage systems, smart-grid and microgrid deployment, and distribution and transmission system upgrades and expansion.

The program should contain monitoring mechanisms to ensure reasonable progress is being made in achieving emission reduction goals and broader energy policies. The program should include mid-term targets (including a GHG emission target and other targets that support meeting broader energy policies) designed to spur and gauge progress toward meeting a final 2050 GHG emission target and broader energy policies. The program should be established through a process which includes extensive stakeholder and public input.

In addition to facilitating the creation of the comprehensive emission reduction program, the State's energy agencies should pursue a series of key proceedings to further advance energy efficiency and conservation programs that hold great potential for reducing GHG emissions within the energy sector.

Several key actions are summarized below to drive the State toward developing and deploying the most appropriate market, resource, technology, and design options to achieve longer-term GHG emission reductions within the energy sector.

Key Recommended Actions for the Energy Sector



State agencies will develop comprehensive and enforceable GHG emission reduction requirements for the State's electric and energy utilities to achieve near-zero GHG emissions by 2050. Program development to be completed by end of 2016, and incorporate the following principles:

- Thoroughly account for the carbon intensity and air quality impacts of various energy resources, generation technologies, and associated fuels.
- Maximize local and regional benefits of energy facilities.
- Minimize emissions of criteria and toxic air pollutants.
- Avoid disproportionate impacts to disadvantaged communities.
- An enforceable program for all energy and electricity service providers.
- Recordkeeping and reporting mechanisms to monitor and enforce the GHG emission reduction requirements.

State's energy agencies pursue a series of key proceedings, including the following:

- Develop criteria and rules for flexible demand response resources to participate in wholesale markets and integrate variable renewable resources, reducing the need for new flexible fossil generation.
- Expand participation of regional balancing authorities in the CAISO Energy Imbalance Market and other potential methods of balancing authority cooperation, which provide low-cost, low-risk means of achieving real-time operational efficiency and flexibility needed for greater penetration of variable renewable resources, while ensuring support for greenhouse gas emission reduction programs.
- Through the AB 758 process, CEC will develop a plan to encourage energy assessments—particularly when done at the time a building or unit is sold or by a predetermined date—as well as energy use disclosure requirements.
- Enhance energy efficiency and demand response programs, including development of education/outreach programs, and develop robust methodologies to monitor and evaluate the effectiveness of these programs. Methodologies developed by end of 2015 with the enhanced program proceedings completed by end of 2016.
- A CPUC proceeding to continue to streamline state jurisdictional interconnection processes to create a ministerial low-cost interconnection process for distributed generation completed by the end of 2015. The CEC to explore similar streamlined processes for interconnecting distributed generation in publicly owned utility systems. The CPUC and CEC consult as appropriate with the CAISO as part of these proceedings.
- ARB will assess existing barriers to expanding the installation of CHP systems and propose solutions (in consultation with the State's energy agencies) to achieve the Governor's objectives and that of the initial Scoping Plan for CHP to reduce GHG emissions. A future CHP measure could establish requirements for new or upgraded efficient CHP systems.
- Evaluate the potential for CCS in California to reduce emissions of CO_2 from energy and industrial sources. Working with DOGGR, CEC and CPUC, ARB will consider a CCS quantification methodology for use in California by 2017.

2. Transportation: Vehicles/Equipment, Sustainable Communities, Housing, Fuels, and Infrastructure

California's transportation system accounts for about 36 percent of California's GHG emissions and is the primary source of smog-forming and toxic air pollution in the State. Mandatory regional criteria pollutant reduction targets will be established in the 2016 State Implementation Plans (SIPs) with expected reductions on the order of 90 percent below 2010 levels in the South Coast and similar reductions in the San Joaquin Valley by the year 2032. Many of the strategies employed to reduce GHG emissions will also work to meet the national ambient air quality standard for ozone in 2032.

Achieving California's long-term criteria pollutant and GHG emissions goals will require four strategies to be employed: (1) improve vehicle efficiency and develop zero emission technologies, (2) reduce the carbon content of fuels and provide market support to get these lower-carbon fuels into the marketplace, (3) plan and build communities to reduce vehicular GHG emissions and provide more transportation options, and (4) improve the efficiency and throughput of existing transportation systems.

As one of the most significant sources of GHG and criteria pollutant emissions, the transportation system represents one of the greatest needs for emission reductions in California, and one of the greatest opportunities to build an economy that aligns stable economic growth with the need for ever-improving public health and environmental protection. Reducing transportation emissions, including those from heavy-duty diesel engines, will have dramatic air quality and public health benefits—especially in many of California's environmental justice communities. Improving vehicle efficiency will continue to cut consumer fuel bills. Diversifying fuel supplies will further decouple economic growth in California from volatile global oil prices and keep more of Californians' fuel expenditures in our own communities. Planning and building communities to reduce travel demands and designing more productive transportation systems will cut transportation costs for California's workers and make the State's freight distribution system more competitive in the global marketplace.

Building on California's Existing Policy Framework

California already has many of the elements necessary for an effective framework to address transportation emissions. The actions identified in this Update represent a natural extension of existing policies, including targeted investment, strategic market support, and coordinated planning for more sustainable development. These recommendations are based on technologies currently available or expected in the near term, and on planning and investment steps that can be taken now. However, to achieve the needed transportation GHG emission reductions and the corresponding 2032 ozone standards, the market uptake of advanced technologies will need to be accelerated. Additional strategies are needed over the next five years to define the paths for longer-term change. As all these actions and policies are implemented, they will need to be consistent with principles and criteria, as recommended by the Environmental Justice Advisory Committee (EJAC), that ensure access, equity, and benefits to vulnerable communities.

To illustrate these additional paths toward significant emission reductions, a number of forward-looking strategies are described in this chapter. These paths envision the use of technologies that require further development. In addition, the market structures, investment strategies, businesses models, regulatory actions, and financial resources to support the very large-scale transition to these technologies need to be identified and put in place.

California's regulatory programs and planning efforts provide a basic foundation to build lasting markets where vehicle/equipment manufacturers, suppliers, and fuel providers who make large, smart investments are handsomely rewarded for developing leading technologies. Standards should drive technologies to higher volumes, lower prices, and ultimately, become market-winning solutions, rather than compliance approaches.

Efficient Vehicle and Engine Technology and Zero Emissions Technology Development

California has made tremendous progress pushing clean vehicle technologies. This progress has led to emission reductions throughout the United States and has pushed market development for clean and zero emission technologies throughout the world. California was the first state in the nation to require reductions of GHGs from motor vehicles when, in 2004, ARB adopted what is commonly referred to as the Pavley regulations resulting from Assembly Bill 1493 (Pavley, Chapter 200, Statutes of 2002). These regulations formed the foundation for the federal GHG and fuel-economy programs for light-duty vehicles for the 2012–2016 model years.

California continues its leadership through ARB's Advanced Clean Cars program, which was developed in part through collaboration with the U.S. EPA and National Highway Traffic Safety Administration (NHTSA). This set of regulations will reduce GHG emissions from new light-duty vehicles by about 4.5 percent per year, from 2017–2025, such that by 2025 a new vehicle will emit about half the GHG compared to today's fleet mix. The Advanced Clean Cars program also included tighter criteria pollutant requirements which, in 2025, will result in cars emitting 75 percent less smog-forming pollution than the average new car sold today.

SUCCESS STORY

Broadband Internet service is now used to save vehicle miles driven for medical care in the South Lake Tahoe area. The California Telehealth Network (CTN), a service available statewide, has collaborated with the UC Davis Health System to upgrade broadband and bring telemedicine equipment to Barton Memorial Hospital. CTN now averages more than 200 patient consultations each month.

As part of the Advanced Clean Cars program, the Zero Emission Vehicle (ZEV) Regulation requires about 15 percent of new cars sold in California in 2025 to be a plug-in hybrid, battery electric, or fuel cell vehicle. Ten other states have adopted California's ZEV Regulation, increasing the reach of California's policy to about a quarter of the U.S. vehicle market. California currently has 60,000 ZEVs (primarily light-duty vehicles, including battery electric, plug-in hybrid, and fuel cell vehicles) on its roadways—more than any other state. Continuing to support and develop zero emission vehicle markets within California and elsewhere is critical to achieving California's emissions reduction requirements. California has outlined several steps in the State's *ZEV Action Plan*,[77] to further support the market and accelerate its growth. Committed implementation of the actions described in the plan will help meet Governor Brown's 2012 Executive Order (EO) B-16-12, which—in addition to establishing a more specific 2050 GHG target for the transportation sector of 80 percent from 1990 levels—called for 1.5 million ZEVs on California's roadways by 2025.

Continuing progress on light-duty vehicles beyond the scope of the Advanced Clean Cars program with a LEV IV standard targeted at achieving additional GHG emission reductions of about five percent per year beyond 2025 would reduce new vehicle emission standards to about 125 grams of carbon dioxide equivalent per mile (gCO_2e/mi) in 2030 and to below 100 gCO_2e/mi by 2035. Furthermore, commercially available technologies, such as fuel efficient passenger vehicle tires, can be utilized by both new and in-use vehicles in the near-term to achieve GHG emission reductions. Deployment of fuel efficient vehicle tires for in-use vehicles could include limited incentives, followed by ratings and then standard setting to permanently shift the market.

Achieving our long-term climate goal and 2032 ozone standards will require a much deeper penetration of ZEVs into the fleet. As outlined in the 2009 ZEV Review[78] and the 2012 Vision for

77 The ZEV Action Plan can be found at *http://opr.ca.gov/docs/Governor%27s_Office_ZEV_Action_Plan_%2802-13%29.pdf*.

78 *www.arb.ca.gov/msprog/zevprog/2009zevreview/2009zevreview.htm* (Refer to Attachment B)

Clean Air,[79] and several independent studies (See Chapter III), the light-duty vehicle segment will need to become largely electrified by 2050 in order to meet California's emission reduction goals.

For the heavy-duty segment, ARB recently approved a regulation establishing GHG emission reduction requirements for all medium- and heavy-duty vehicles and engines manufactured for use in California, harmonizing with the GHG emission reduction rule adopted by the U.S. EPA in 2011. For Class 8 heavy-duty vehicles, this "Phase I" GHG standard will reduce new vehicle emissions by four to five percent per year from 2014–2018.

ARB is working with U.S. EPA on Phase 2 GHG standards for heavy-duty vehicles to continue these reductions beyond 2018. U.S. EPA is planning to finalize Phase 2 standards in 2016. ARB believes additional annual improvements of around five percent through 2025 can be achieved from Class 8 heavy-duty vehicles using commercially available technologies and advanced transmissions, hybridization, improved trailer aerodynamics, and other technologies. In addition, significant, ongoing vehicle efficiencies can be achieved in Class 3–Class 7 trucks during the same time frame. These efficiencies will be partly enabled by improvements in light-duty vehicles; the challenge is to move these technologies from the light-duty sector to the heavy-duty on-road and off-road sectors in order to reach commercialization in the necessary time frame. ARB is working to ensure Phase 2 standards are set at the lowest feasible levels, to accelerate the introduction and deployment of the advanced technologies necessary to meet the State's air quality and climate policy objectives.

While the Phase 2 standards will be an important next step in reducing GHG emissions from heavy-duty trucks, significantly greater reductions will be needed to meet California's climate change goals. To continue reducing emissions, zero and near-zero emission technologies will need to be deployed in large numbers. In addition to clean NG trucks, BEV and FCV technology could be deployed in urban fleet applications and medium-heavy classifications. This is particularly true for fleets that have a central fueling hub. For the heavier classifications with moderate range, strategies could include plug-in hybrid technology with catenary electric infrastructure along transport corridors. For heavy, long-range applications where electrification is not practical, low-carbon sources of energy, such as renewable fuels and hydrogen FCVs, will be necessary.

For successful implementation of these strategies, California needs to make similar commitments to develop zero emission vehicle markets for heavy-duty vehicles and equipment. Many zero emission technologies for trucks have progressed at least to the demonstration phase, and in the case of smaller trucks, battery-powered vehicles are available commercially in small volumes. However, ZEV technology for Class 7 and 8 vehicles, which account for most of heavy-duty vehicle emissions, has not progressed as far as it has for light-duty vehicles. Where the technology is available or being demonstrated, near-term challenges exist in terms of cost, vehicle range, payload, and the need for associated infrastructure. ARB is proposing larger efforts to demonstrate, pilot, and deploy ZEV technologies for heavy-duty vehicles with Cap-and-Trade auction proceeds.

Low-Carbon Fuels

California has an effective, scalable framework in place for fuels to ensure ongoing emission reductions. The Low Carbon Fuel Standard (LCFS), adopted in 2009, requires the carbon intensity of transportation fuels to be reduced by at least ten percent in 2020. While the primary goal is reducing carbon intensity and concomitant greenhouse gas emissions, implementation will also necessarily diversify the fuel portfolio, reducing the economic impact in California from gasoline and diesel price spikes resulting from volatile global oil price changes. As a result of California's leadership, other states and countries are pursuing the development of carbon-intensity fuel measures. In addition, fuels will come under California's Cap-and-Trade Program in 2015. Together, LCFS and Cap-and-Trade provide a structure to ensure that necessary emission reductions are achieved and provide an effective market signal to accelerate innovation and

79 *www.arb.ca.gov/planning/vision/vision.htm*

development of cleaner fuels. Continuing these policies beyond 2020 will ensure that fuel carbon intensity continues to decline and that low-carbon alternatives to petroleum are available in sufficient quantities in the long term. Research that further refines our understanding of fuel carbon intensity is similarly important and should include an assessment of methane emissions from natural gas systems. Achieving the GHG and air quality goals will require a renewable portfolio of transportation fuels—including electricity and hydrogen—well beyond the current policy trajectories. Accordingly, in 2014 ARB will consider extending the LCFS, with more aggressive targets for 2030.

Transportation, Land Use, and Housing

As a result of Senate Bill (SB) 375 (Steinberg, Chapter 728, Statutes of 2008), the Sustainable Communities and Climate Protection Act of 2008, California has developed a critical, unique policy mechanism for reducing transportation-sector GHG emissions. Regional and local planning agencies are responsible for developing Sustainable Communities Strategies (SCS) as part of the federally required Regional Transportation Plan (RTP), and also responsible for developing State-required general plan housing elements to help meet these targets. The goal of SB 375 is to reduce GHG emissions from passenger vehicles through better-integrated regional transportation, land use, and housing planning that provides easier access to jobs, services, public transit, and active transportation options.

Sustainable Communities Strategies promote more travel and housing choices through greater access to alternative forms of transportation (including public transit, biking, and walking) and development patterns where people can live, work, and play without having to drive. All seven metropolitan planning organizations (MPOs) that have adopted SCS so far have met or exceeded the ARB-set targets. Successful implementation of these SCS is the critical next step in achieving the associated GHG emission reductions.

Implementation of these strategies hinges on local actions to realize the GHG emission reductions envisioned in the regional SCS. The State must encourage new and targeted strategies to reduce emissions throughout California's diverse communities. The State's role is to provide ongoing support, through access to financial resources and incentives, guidance documents, housing element certification, planning tools, and other forms of technical assistance. California has a number of important planning tools available to reduce vehicle travel demand, expand mobility options, and improve goods movement; however, these tools will need to be enhanced and new tools will need to be developed, including but not limited to land use models, health models, and scenario planning tools. With appropriate coordination among local and State agencies—including ARB, the California Department of Transportation (Caltrans), the Strategic Growth Council (SGC), and the Department of Housing and Community Development (HCD)—California can ensure that the expected GHG emission reductions are achieved or exceeded. The State must also support integration of the planning, development, and funding of transportation systems, including recognition of the impacts and interactions between passenger and freight transportation.

In 2014, ARB will review the advancements in data, models, analytical methodologies, and technologies that have taken place since 2010 to inform the need for and timing of revised MPO targets. This technical review will provide the foundation for a future target revision, consistent with each MPO's time frame for updating its RTP under federal law. Future updates to SCS targets, along with other new transportation strategies, will help provide further emission reductions needed to achieve long-range reductions in transportation-related emissions.

Coordinated, comprehensive planning is critical to achieving deep emission reductions in the transportation sector, and must include the development of the 2014 California Freight Mobility Plan (Caltrans), the 2014 Sustainable Freight Strategy (ARB), the 2040 California

Transportation Plan in 2015 (Caltrans), the 2016 SIP (ARB, SCAQMD,[80] SJVAPCD[81]), and all future regional sustainable community strategy and Regional Transportation Plan development and implementation. These planning efforts will need to identify the infrastructure, including fueling and intelligent transportation infrastructure, needed to support full-scale deployment of advanced technologies, improved throughput, and expanded access to rail, public transit, and active transportation.

As State agencies proceed with GHG emission reduction planning, it is necessary to integrate the need for significant NO_x reductions by 2032 to meet the national ambient air quality standards for ozone. Tools developed to support these planning efforts should emphasize the needs of vulnerable communities, as recommended by EJAC. These needs include, but are not limited to: access to affordable public transit, electric vehicle charging, or other low-carbon fueling infrastructures; accessible affordable housing; and localized public health benefits.

California is implementing a large-scale rail modernization program, which includes the nation's first true high-speed rail (HSR) system. Europe's experience with high-speed rail is illustrative of its mode-shift potential; after high-speed rail launched in Europe, air trips were cut in half from Paris to London. In Spain, for the 315-mile trip from Barcelona to Madrid, more than 60 percent of air travelers have switched to the 2½-hour rail ride. The first construction contract to begin California's high-speed rail system was awarded in August 2013, for work in the Central Valley. Additionally, environmental work is proceeding to electrify the Caltrain corridor in the Bay Area by 2019 as part of the high-speed rail system. High-speed rail will provide a new, clean, interregional transportation option and increase ridership on integrated regional rail and local transit systems, reducing single-occupancy vehicle trips.

Systems Efficiencies

California is at the forefront of developing additional strategies to reduce emissions from existing vehicles and systems. In fact, many system efficiency strategies identified in the initial Scoping Plan have been implemented or are still under development such as ship electrification at ports, tire pressure, fuel-efficient tires, and low friction motor oils. These strategies go beyond just vehicle improvements; for example, Caltrans has initiated several strategies that achieve GHG emission reductions from the existing system, including modification to concrete specifications, alternative asphalt pavements, and adoption of the Caltrans Complete Streets Implementation Action Plan[82], which spurred a series of comprehensive edits to its Highway Design Manual.

However, California must do more to capture significant potential emission reductions from existing systems that could also improve safety, reduce congestion, and improve economic productivity and workforce and businesses competitiveness. For example, improved pavement engineering—including surface smoothness, rigidity, and durability—can reduce GHG emissions through improved fuel efficiency. Smart phone and vehicle "apps" that provide real-time travel information and eco-routing or eco-driving suggestions can reduce emissions from existing vehicles. Coordinating signal timing and providing real-time information to drivers about signal status can reduce emissions in urban driving by up to ten percent. Utilizing adaptive cruise control, a global positioning system (GPS), and camera technologies to enable truck "platooning" can reduce GHG emissions and fuel consumption from those vehicles by about 15 percent.

Myriad existing and emerging technologies will lead to an increasingly connected and automated transportation system and could have dramatic efficiency and emissions benefits. Many automakers and others have committed to bring varying levels of automation to new vehicles over the next five years, and the NHTSA is beginning to take steps to enable vehicle-to-vehicle and vehicle-to-infrastructure communications. The degree to which markets for these vehicles grow—and how local, State and federal rules shape and support them—will determine the

80 South Coast Air Quality Management District
81 San Joaquin Valley Air Pollution Control District
82 *www.dot.ca.gov/hq/tpp/offices/ocp/complete_streets_files/CompleteStreets_IP03-10-10.pdf*

level of emissions impact from these technologies. Early studies show that vehicle automation could enable dramatic emissions decreases, or emissions increases, depending on the level of increased vehicle and systems efficiency they enable, how the vehicles integrate with an alternative fuels infrastructure, and the degree to which they may induce additional vehicle travel.

Over the next five years, it will be critical to begin planning for these vehicles on our roads and to maximize their benefits and potential for GHG emission reductions. California is already a leader in this emerging space, and the California Department of Motor Vehicles has issued the nation's first draft rules regulating the testing of autonomous vehicles on California's roads, pursuant to Senate Bill 1298 (Padilla, Chapter 570, Statutes of 2012). Many are also looking to California's I-710 corridor to begin demonstrating and deploying intelligent transportation system technologies for heavy-duty trucks. Additional research is needed to better understand the impacts these vehicles will, or can, have on GHG emissions in California's transportation sector, and how to best integrate automated vehicles within the State's existing and evolving vehicle, fuel, and planning policy framework. The next Scoping Plan Update will include additional detail on the role of existing systems improvements and vehicle automation in meeting California's transportation-sector emissions reduction goals.

Integrated Policy Planning in the Sustainable Freight Strategy

California has already made significant progress reducing emissions from its freight system, while supporting our ports and goods movement industries as some of the most critical to the State's economy. Through regulations, incentives, enforcement agreements, port and industry initiatives, project mitigation and land use decisions, California has reduced diesel PM emissions—along with the associated health risks—by 70 percent at the largest ports and about 50–70 percent at the highest-risk railyards since 2005. However, much more needs to be done to continue to reduce the impacts from air pollution, including diesel PM at the local level, ozone at the regional level, and GHGs at the global level. The ongoing planning, policy foundation, financial incentives, and state commitment to reduce PM and NO_x emissions from the freight system provide a foundation from which to develop a similar framework to reduce GHG emissions.

Over the past decade, public and private stakeholders across California have increasingly recognized the need to plan and implement multi-pollutant emission reduction strategies that achieve transformational changes resulting in significant reductions of near-source toxic, regional criteria pollutant, and global GHG emissions. SB 375 uses this integrated, multi-pollutant approach to reduce passenger vehicle GHG emissions through strategies that impact land use and housing decisions, transportation infrastructure funding, and regional criteria pollutant analyses.

A parallel effort to SB 375 needs to reside in the freight sector, with its highly complex international logistics system and incredibly diverse set of stakeholder groups. To achieve our multi-pollutant goals, over the long-term California must transition from a diesel-dependent system into one with significant numbers of zero and near-zero emission engines for trucks, locomotives, cargo-handling equipment, ships, and aircraft. California must also support the parallel development of the necessary supporting infrastructure, and implement logistical/efficiency improvements to reduce the emissions impact of moving freight. In short, the freight sector must become a system that is efficient, reliable, clean, and low carbon.

The Sustainable Freight Initiative[83] (Initiative) is a broad, multi-decade effort to develop, fund, and implement the changes necessary to achieve a sustainable freight system. The Initiative will be informed by an ongoing, transparent process that engages all freight stakeholders. These include, but are not limited to: industry (such as retailers and other cargo owners, shipping, trucking, rail, and warehousing), ports, labor, environmental groups, business leaders, venture capitalists, community representatives, technology developers, air districts, and representatives from local, State, and federal government.

83 *www.arb.ca.gov/gmp/sfti/sfti.htm*

The 2014 Sustainable Freight Strategy (Strategy) is a concentrated, one-year effort to produce a document developed in the context of the broader Initiative and represents the next milestone in defining what is necessary to move California toward a sustainable freight system. Building a coalition of freight stakeholders is a primary focus of the Strategy, and will ultimately be a significant driving force behind affecting change in areas outside of ARB's sphere of influence, including advocating at the federal level and acquiring public and private funding for implementation.

The South Coast Zero-Emission Freight Transport Technology Symposium and ARB's Haagen-Smit Symposium in mid-2013 provided early input into the sustainable freight effort. Currently, there are a number of existing venues led by both public and private entities where California freight issues are being discussed. These are critical to ARB's public process for the sustainable freight effort, and were some of the earliest points of engagement in the process.

ARB will work with stakeholders on the Strategy throughout 2014, with the ultimate goal of setting California on the path to move freight more efficiently and with zero/near-zero emissions. This work must recognize the equally important priorities of transitioning to cleaner, renewable energy sources, providing reliable velocity and expanded system capacity; integrating with the national and international freight system; and supporting clean air and healthy communities. The Initiative should also recognize the value of: keeping California's ports and logistics industry competitive; supporting the delivery of California's products locally and to other states and countries; creating jobs in California and training local workers to support the new transport system; increasing energy security; and improving mobility.

The 2014 Strategy will include several key elements that together will provide a holistic look at the freight system and identify actionable next steps through 2020. The Strategy will: identify near-term actions resulting from assessments of each of the freight sectors and the system, prioritize efficiency improvements, include principles and criteria for transportation infrastructure projects, and begin to answer the following questions:

- What actions and changes must take place within California's freight system to address air quality and climate requirements?
- What are the technology gaps?
- What research and demonstration is needed?
- What incentives are needed to drive technology, infrastructure and efficiency improvements?

To that end, ARB is working with agency partners to expand upon existing and ongoing technology assessments in all the major freight-related source categories, including: trucks, locomotives, ocean-going vessels, commercial harbor craft, cargo equipment, and air cargo/airports. These assessments will draw from technology expertise in the public and private sector, and will lay the framework for identifying and prioritizing the next steps, including accessing and leveraging funding, near-term implementation strategies, and longer-term actions that could be included as measures in upcoming SIPs.

This technical effort will also provide an opportunity to evaluate the types and availability of data and how they could be collected and ultimately used to quantify the emission reduction potential of future measures for each sector. Technology-specific objectives include, but are not limited to, the following:

- Accelerate the introduction and deployment of zero and near-zero emission trucks, including trucks capable of zero-emission miles.
- Continue improving the efficiency of trucks (both engines and vehicles).
- Support development and introduction of locomotives capable of zero emission track miles.
- Accelerate cleanup of the existing locomotive fleet.

- Increase near-dock rail in Oakland/Los Angeles/Long Beach.
- Reduce GHGs and criteria pollutants from ocean-going vessels.
- Build on the work done by the U.S. Department of Defense on cleaner fuels/aircraft design to reduce GHGs and criteria pollutants from air cargo.
- Identify efficiency improvements on all levels (equipment, sector, and system).
- Showcase strategies and best practices.

In addition, ARB will develop principles and criteria that seek to establish air quality and climate benefits as equal to established transportation/mobility metrics in determining the priority of freight-related transportation projects and recommend inclusion of these principles and criteria in the 2014 Freight Mobility Plan. ARB is participating on the California Freight Advisory Committee and will coordinate with Caltrans staff to reflect the outcome of this effort in the California Freight Mobility Plan.

Moreover, the Strategy process provides the opportunity to begin evaluating the feasibility of a systemwide efficiency metric(s) that could track upstream and downstream impacts of implemented emission reduction and efficiency strategies. The metric could be used to set targets, prioritize funding, evaluate projects, evaluate programs, and gauge performance or progress across modes. To complement a metric, ARB will seek advice on actions that government could take to support efficiency improvements. ARB will also begin efforts to define criteria and principles for new and expanded freight infrastructure projects as a tool for local land use decision makers and community residents.

Supporting Planning and Market Development through Targeted Investments

Incentive funding is essential to encourage use of alternative transportation modes, develop and deploy low-carbon fuels, spur fleet turnover, and continue to develop advanced technologies. Through the Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer), Proposition 1B program for goods movement, and AB 118 Air Quality Improvement Program (AQIP), ARB provides funding, directly or through the air districts for technologies that reduce criteria pollutant and air toxic emissions, often with concurrent climate change benefits. A subset of these funds, about $283 million to date, are utilized for advanced technologies that achieve GHG emission reduction benefits, which include: rebates for light-duty clean cars, vouchers for hybrid and zero emission heavy-duty trucks, grants for installation of shore-based electrical power for ships, and technology demonstrations such as hybrid tugboat retrofits.

In 2013, the State extended fees for AQIP until 2024 which is expected to provide about $25 million annually for advanced technologies. Most recently, the Governor's proposed budget for Fiscal Year 2014–15 would direct $200 million from Cap-and-Trade auction proceeds to ARB for low-carbon transportation to respond to the increasing demands for incentives of these technologies and for pre-commercial demonstration of advanced freight technology. In addition, the CEC's AB 118 Alternative and Renewable Fuel and Vehicle Technology Program invests $100 million annually (also extended until 2024) to develop and deploy alternative and renewable fuels, fueling infrastructure, vehicles, and workforce skills necessary operate and maintain these new technologies. Finally, Senate Bill 99 creates an active transportation program to increase funding of bicycle and pedestrian infrastructure, which is funded at an annual level of $129 million.

These current efforts will need to be enhanced or expanded beyond currently allocated resources. To implement this, protocols that outline funding priorities will need to be reviewed and metrics should be developed for evaluating investment opportunities. For example, existing State rebates for light-duty zero emission and plug-in hybrid vehicles are consistently oversubscribed, yet continued public commitment is necessary at this time to support full-scale commercialization and consumer acceptance of these vehicles. Furthermore, the vehicle regulations and incentives for both light- and heavy-duty vehicles must be supported through parallel investments in infrastructure and additional policies to ensure that value is returned to consumers. These policies include setting reasonable electricity rates that encourage electrification and vehicle charging rates that strongly encourage off-peak charging or are responsive to grid operational needs and policies that manage charging to facilitate renewable energy uptake. They also include streamlining local permitting, siting, and utility interconnection for fueling infrastructure.

Additional investments will be necessary for advanced technology freight demonstration projects and pilot deployments of advanced heavy-duty vehicles and equipment in a variety of vocations. Near-term focus areas for these projects include, but are not limited to: zero emission port trucks for near-dock rail pilot projects; pilot projects to deploy zero emission and hybrid vehicles and equipment at distribution centers located in areas most affected by air pollution; and development and demonstration of advanced technology locomotives, marine vessels, and cargo handling equipment.

Investment throughout California in projects that modernize the passenger rail system and link seamlessly to local public transit systems will continue to build public transit ridership and shift travelers from single-occupancy vehicles to public transport. As a start, in 2008, voters approved Proposition 1A, authorizing nearly $10 billion in state bonds for the United States' first high-speed rail line, which would connect the San Francisco Bay Area with Los Angeles. Rail modernization in California will increase benefits for passengers, including improved mobility and safety, with a reduced carbon footprint. Prior to 2030, high-speed rail will reduce GHG emissions by providing a cleaner alternative to air and private car travel. It is projected to realize GHG emission reductions its first year in operation, with annual increases in GHG emission reductions as the system expands.[84]

Rail modernization infrastructure investments must be coordinated with local and regional planning to be mutually supportive. As part of the early development of high-speed rail, commuter and urban rail systems are being upgraded and expanded to provide connectivity to the future high-speed rail system. In addition, work has begun on shared-use investments that high-speed rail will ultimately access, such as the electrification of the Caltrain corridor between San Francisco and San Jose, which is scheduled to be operational in 2019. Coordination among regional and urban rail providers on issues such as schedules and integrated fare mechanisms will provide increased service, speed, and amenities that will grow this clean mode of travel and encourage transit-oriented development and infill around station locations.

Furthermore, ongoing investments are needed for local communities to plan and implement sustainable community development, including integrated public transit and high-speed rail, incentivizing transit utilization, and to address both passenger and freight transportation infrastructure needs. Active transportation and public transit alternatives, including zero-emission transit buses, are increasingly in demand and are necessary to meet ongoing emission reduction targets. Caltrans, working with local and regional agencies, will need to coordinate on transportation infrastructure funding (including construction, operation, and maintenance costs) and consider lifecycle benefits and impacts (including environmental, construction, operation, and maintenance costs) for transportation infrastructure projects.

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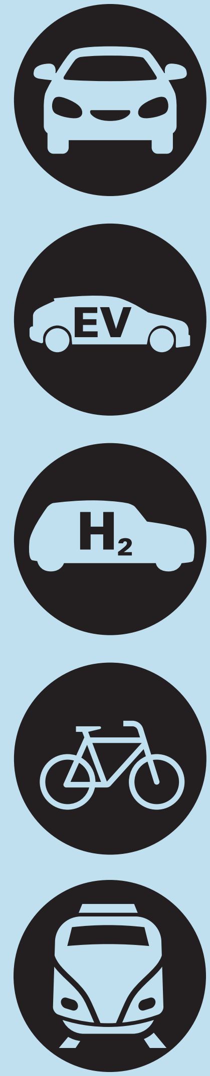
84 *www.hsr.ca.gov/docs/programs/green_practices/HSR_Reducing_CA_GHG_Emissions_2013.pdf*

Key Recommended Actions for the Transportation System



Vehicle Technology

- The 2017 mid-term review for Advanced Clean Cars, where ARB, U.S. EPA, and NHTSA will conduct a technical assessment of vehicle technology trends, will inform future light-duty vehicle standards targeted at continuing to achieve GHG emission reductions of about five percent per year through at least 2030.
- In 2016, ARB will propose rules and/or incentives, including the “Phase 2” heavy-duty vehicle GHG standards in conjunction with U.S. EPA and NHTSA with a goal of achieving new vehicle GHG emission reductions of at least five percent per year.
- For completion by 2017, ARB will engage the Office of Planning and Research (OPR) and other stakeholders to expand upon the 2013 ZEV Action Plan for medium- and heavy-duty ZEVs.

Fuels

- In 2014, ARB will propose enhancements to strengthen the LCFS. ARB will also consider extending the LCFS beyond 2020 with more aggressive long-term targets, such as a 15 to 20 percent reduction in average carbon intensity, below 2010 levels, by 2030.
- By 2018, the CPUC, CEC, California Department of Food and Agriculture (CDFA), and ARB will evaluate and adopt the necessary regulations and/or policies to further support commercial markets for low-carbon transportation fuels, including but not limited to:
  - Reducing off-peak demand charges for electricity and plug-in vehicle charging rates that strongly encourage off-peak charging both at home and at public chargers;
  - Development of large-scale renewable and low-carbon production facilities through continued funding for infrastructure;
  - Development and adoption of performance and quality standards;
  - Streamlined local permitting and siting for hydrogen fueling and charging infrastructure and utility interconnection for charging infrastructure; and
  - Research.

Transportation, Land Use, and Housing

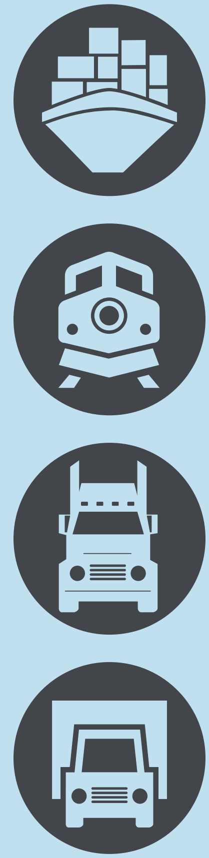
- In 2014, ARB will complete a technical review that will inform the need for and appropriate timing of revisions to the SB375 regional targets established in 2010.
- The High-Speed Rail Authority will work with other rail and mass transit providers to increase transit ridership both regionally and inter-regionally.
- The High-Speed Rail Authority will continue construction of the HSR system, beginning with completion of all station-area planning by 2017 followed by completion of the initial operating segment in 2022. By 2029, HSR will run from San Francisco to Los Angeles.
- ARB, Caltrans, SGC, and HCD, along with other State, local, and regional agencies, will coordinate planning and support to ensure that the expected GHG emission reductions from approved SCS are achieved or exceeded.

Sustainable Freight Strategy

- In 2014, ARB will complete the first phase of the Sustainable Freight Strategy, which will identify and prioritize actions through at least 2020 to move California towards a sustainable freight system.

Investments

- Leverage available public money to scale-up clean technology markets and strategies and ensure necessary infrastructure investments, including the following:
  - ARB, CEC, CPUC, and CDFA will support growing markets for clean passenger transportation, advanced technology trucks and equipment, and low-carbon transportation fuels and energy, including any necessary infrastructure.
  - Caltrans, working with local and regional agencies, will consider lifecycle benefits and impacts (including environmental, construction, operation, and maintenance costs) for transportation infrastructure projects.
  - Caltrans and regional transportation agencies will increase investment in expanded transit and rail services, active transportation, and other VMT-reduction strategies in their next regional transportation plans.
  - SGC will support SCS implementation, including, for example, integration of the regional transportation and Regional Housing Needs Allocation planning, as well as provision of local assistance for transit, active transportation, and affordable transit-oriented housing development; therefore offering more efficient consumer choices.
- State agencies, including ARB and Caltrans, will incorporate into ongoing GHG planning efforts strategies that help achieve significant NO_x reductions by 2032 to meet the national ambient air quality standards for ozone. The 2016 SIPs will outline attainment strategies through 2032.



3. Agriculture

Agriculture in California provides a safe, reliable, and affordable food source to support growing local, State, national, and global populations. It is also a key economic driver in the State. California has a range of climatic regions that allow for the production of a diverse variety of annual crops (such as vegetables and grains), perennial crops (such as fruits and nuts), and livestock and dairy products. As one of only five Mediterranean growing regions on Earth, California is a major contributor to the global food supply; particularly of fruits, nuts, vegetables, and dairy products.

California's agricultural GHG emission inventory includes on-site emissions from enteric fermentation (by animals), manure management, rice cultivation, energy use (including fuel combustion), crop residue burning, and soil management practices (fertilizer and manure applications). The primary GHG emissions from agriculture include methane (CH_4), carbon dioxide (CO_2), nitrous oxide (N_2O), and black carbon. In 2012, agricultural sources accounted for about eight percent of California's total GHG emissions. In addition to being a GHG emissions source, agriculture can also be a carbon sink, where carbon is stored (sequestered) in both crops and soil.

Many of the strategies to reduce GHG emissions or increase sequestration in the agriculture sector overlap and have synergies with other sectors. For example, agricultural operations are the largest water users in the State. Because water use is a significant source of GHG emissions (due to the electricity used to pump water), conservation and water delivery efficiency improvement efforts employed in agricultural operations would support GHG emission reduction goals in the water sector. Agricultural operations can also contribute to the strategies for reducing GHG emissions in the energy sector by providing biomass feedstock resources for bioenergy production (for both fuels and electricity). Reduction strategies described in the transportation, land use, fuels, and infrastructure sector could also be realized through agricultural land conservation efforts, and through operational efficiency improvements that reduce transportation emissions and fuel use.

Due to the wide diversity of crop and livestock production, the agricultural sector presents unique challenges to controlling GHG emissions. The initial Scoping Plan considered voluntary steps to reduce GHG emissions in this sector in place of regulatory measures, due primarily to costs and scientific uncertainty in measuring GHGs in many agricultural systems.

The installation of manure digesters to reduce methane emissions was included as a voluntary strategy for the agricultural sector in the initial Scoping Plan. However, voluntary installation of anaerobic digesters at dairies in California has not increased as expected. This is due to the recent economic recession, increased feed and fuel prices, lack of sufficient financial incentives, and insufficient utility contracts. ARB is working with federal, State, and local agencies, as well as with industry stakeholders, to remove obstacles to digester installations. Critical to this is the continued effort to evaluate the many co-benefits of manure management through digesters. The evaluation will examine the potential for successful voluntary efforts to be more widely adopted in California. As new information becomes available, ARB will work with stakeholders to determine whether and how the program should become mandatory and/or more strongly incentivized.

The initial Scoping Plan also called for research on baseline nitrous oxide (N_2O) emissions from the use of fertilizers to improve the GHG inventory. ARB, CEC, and CDFA have been coordinating and funding research to determine baseline N_2O emissions from a variety of soil types, crops, and farming techniques used throughout California. Research began in 2009 and is expected to be completed by the end of 2014.

A number of other potential voluntary GHG-reduction activities were mentioned in the initial Scoping Plan, including improvement of agriculture water use efficiency, increasing the efficiency of or electrification of agricultural water pumps, using biomass-based fuels, and increasing carbon sequestration on agricultural lands.

The CDFA, in partnership with scientists at the University of California (UC) at Davis, and with funding from the CEC, are evaluating the economic, beneficial environmental factors and costs of biofuel feedstock crops. Outcomes will focus on cropping systems for California with best management practice recommendations; estimates of direct environmental costs such as water use, input levels, and effects; and potential off-farm environmental consequences. The CDFA is working with ARB to expand use of biomass-based transportation fuels as a regulatory pathway under the Low Carbon Fuel Standard.

The CDFA is also supporting projects that address GHG mitigation through its Specialty Crop Block Grant Program (SCBGP). Results of funded research projects provide knowledge and tools to help growers reduce GHG emissions and increase carbon sequestration.

As discussed in Chapter II, there is increased recognition of the significant role that short-lived climate pollutants have on climate change. In response, the importance of methane emissions from agricultural operations, particularly from rice and cattle operations, has increased. Consequently, there is a need for enhanced efforts to secure additional methane reductions from agricultural operations.

Maintaining Momentum

There are many GHG emission reduction and carbon sequestration opportunities that could be realized in the agriculture sector. However, because of limited research, and the wide variety of farm sizes, animals, and crops produced, there are few one-size-fits-all emission reductions or carbon sequestration strategies for the agriculture sector.

Agricultural operations throughout the State are variable, there are a number of potential GHG sources at each operation, and a number of potential co-beneficial management practices can be used for each source. To address this complexity, one approach to reducing GHG emissions from agriculture in California is to develop agriculture-sector mid-term and long-term 2050 GHG emission reduction planning targets.

To meet GHG emission reduction planning targets, farmers and ranchers could assess their on-farm GHG emissions and determine which GHG emission reduction management practices work best for their particular situation. In many cases, pursuing the GHG emission reduction practices would build on existing efforts already in use to increase operational efficiency, reduce criteria pollutant emissions, and reduce costs.

The sections below detail some of the areas with potential emission reduction/sequestration opportunities, as well as areas that need additional research. These opportunities may yield multiple co-benefits, including cost and resource savings, to growers.

Nitrogen Management

Nitrogen fertilizers applied to crops release N_2O, a significant source of agricultural GHG emissions. Obtaining more specific data on statewide fertilizer use in agriculture

SUCCESS STORY

The broadband Internet technology driving the information revolution is also driving revolutions in energy efficiency and GHG reductions for farming. So-called M2M (machine-to-machine) technology now allows precision farming technology to more efficiently apply fertilizers and pesticides, helping reduce GHGs and other air pollutants. Wireless soil moisture sensors reduce water use, saving electricity costs for pumping and moving the water. Some growers claim crop yield increases as a result of more effective monitoring and timing of irrigation—a benefit appreciated all the more during a drought.

and nitrogen deposition on land would help ARB determine baseline emissions and improve the GHG N_2O inventory. This information would also help guide the development of potential GHG emission reduction measures. Existing nitrogen tonnage reports and new reporting requirements under development by the Regional Water Quality Control Board (RWQCB) could be utilized to improve the existing GHG N_2O inventory for fertilizer. Further examination of these data will help determine if broader statewide fertilizer use reporting is needed.

There are several practices that have been shown to reduce emissions of N_2O in agriculture, including the use of nitrification inhibitors, fertigation (the application of fertilizer through irrigation systems), and other approaches. When fertigation is combined with precision drip irrigation there are opportunities to both reduce water and nitrogen fertilizer use. Additional research is needed to evaluate the potential for GHG emission reductions.

Manure Management

Livestock manure is a significant source of methane, and approximately half of the methane generated from livestock comes from manure storage lagoons. The methane generated from those lagoons can be captured by covering the lagoons and can be used to produce energy or renewable fuel (e.g., with the use of a digester).

Soil Management Practices

Historically, tilling (loosening and turning) of soil has been a fundamental agricultural practice to suppress weeds and loosen compacted clay soils. However, tillage releases large quantities of CO_2 and N_2O from the soil into the atmosphere. Several alternative methods, including changing tillage or cropping patterns, may reduce the release of GHGs. Some soil management practices, such as reduced tilling, can also result in reduced fuel consumption by farm equipment, providing additional permanent reductions in GHG emissions, including short-lived climate pollutants.

Water and Fuel Use

A new generation of technologically advanced tools, such as remote irrigation systems, will play an important role in water conservation efforts, maximizing operational efficiency and optimizing resources that can also reduce GHG emissions. In addition, the application of precision irrigation to crops can reduce water use (in turn, reducing the GHG emissions associated with the energy needed to deliver the water), which may also reduce fertilizer use—both of which can reduce emissions and costs.

Greenhouse gases and other emissions from the operation of internal combustion engines that power farm equipment and water pumps are a concern from a regional air quality and climate change perspective. To reduce emissions, the cleanest, most-efficient, and well-maintained equipment should be used for agricultural operations.

The agriculture sector can also play an important role in producing fuels. Biofuel production is a renewable energy resource that reduces reliance on fossil-based fuels. Fueling equipment with biofuels generated on-site or nearby can also reduce emissions and fuel costs.

Land Use Planning to Enhance, Protect, and Conserve Lands in California

Recent research has shown that GHG emissions from urban areas are much greater than those from agricultural lands on a per-acre basis. As California's population increases, pressures to convert agricultural croplands and rangelands to urban and suburban development also increase. Conservation of these lands will be important in meeting our long-term climate goals. Farmland and open space conservation can be an important policy to support the objectives of the Sustainable Communities Strategies, including reducing vehicle miles traveled. This could be accomplished by using incentives for conservation easements, supporting urban growth boundaries, and maintaining agricultural zoning.

As also described in the Natural and Working Lands Sector section below, to meet the State's GHG reduction goals it is important to take an integrated and coordinated approach to local land use planning that considers all land types, including urban, agricultural, and natural and working lands, within and across jurisdictions, to create interconnected land areas and ecosystems. Local and regional land use planning actions and policies need to more fully integrate and emphasize land conservation and avoided conversion of croplands, forests, rangelands, and wetlands, as well as expansion and promotion of urban forestry, urban agriculture, and green infrastructure.

Highly Efficient Conventional and Organic Agriculture Systems

Highly efficient management systems (precision agriculture) for both conventional and organic farming may provide climate benefits through reduced GHG emissions and increased carbon sequestration. To realize such systems, a host of agricultural management practices might be required. In addition to potentially reducing GHG emissions, these strategies may also have co-benefits such as reductions in energy and fossil fuel use and improvements in soil carbon content and water quality.

Research, Technical Assistance, and Incentives

Over the past several years significant progress has been made in understanding agricultural GHG emissions and the strategies that can provide climate benefits. Through research, technical assistance, and financial incentives, farmers and ranchers have implemented many successful GHG emission reduction strategies. Priority should be placed on continued coordination and leveraging of funding between State, local, and national conservation programs to help farmers and ranchers implement GHG emission reduction practices.

Key Recommended Actions for the Agriculture Sector

- In 2014, convene an interagency workgroup that includes CDFA, ARB, CEC, CPUC, and other appropriate State and local agencies and agriculture stakeholders to:
    - Establish agriculture sector GHG emission reduction planning targets for the mid-term time frame and 2050.
    - Expand existing calculators and tools, to develop a California-specific agricultural GHG tool for agriculture facility operators to use to estimate GHG emissions and sequestration potential from all on-farm sources. The tool would include a suite of agricultural GHG emission reduction and carbon sequestration practices and would allow users to run different scenarios to determine the best approach for achieving on-farm reductions.
    - Make recommendations on strategies to reduce GHG emissions associated with the energy needed to deliver water used in agriculture based on the evaluation of existing reporting requirements and data.
- The Dairy Digester Workgroup will develop recommendations for a methane capture standard by 2016.
- Conduct research that identifies and quantifies the GHG emission reduction benefits of highly efficient farming practices, and provide incentives for farmers and ranchers to employ those practices.
- By 2017, evaluate the data reported to the RWQCB's Long Term Irrigated Lands Regulatory Programs to determine if the reported fertilizer data are adequate to establish a robust statewide GHG N_2O inventory for fertilizer used in agriculture. If existing data are not adequate to develop an inventory, then develop a mechanism to collect the necessary data.
- In 2015, OPR, the California Natural Resources Agency (CNRA), the California Environmental Protection Agency (CalEPA), CDFA, and ARB will convene an inter-agency workgroup to engage local and regional land use planning agencies in establishing a coordinated local land use program to develop recommendations and targets for incorporating farmland conservation in local and regional land use planning.
- CDFA will strengthen technical assistance programs and associated financial incentives to help agricultural operators develop carbon plans and implement GHG emission reduction practices.
- In 2015, the Bioenergy Interagency Working Group will:
    - Strengthen, refine, and implement actions contained in its Bioenergy Action Plan to promote the input of digester biogas into natural gas pipelines and bioenergy onto the electric grid.
    - Evaluate the potential biomass energy generation capacity.
    - Develop methods to quantify biomass life-cycle GHG flux.

4. Water

In addition to being an essential element for all life, a reliable, clean, and abundant supply of fresh water is a critical component of California's economy. The State's developed surface and groundwater resources support a variety of residential, commercial, industrial, and agricultural activities. Therefore, the development and management of the State's water resources has implications for each of the focus areas evaluated in the updated Scoping Plan.

More than 40 percent of California's total fresh water supply (or about 80 percent of developed water resources) is used to support the State's extensive agricultural industry and, therefore, has critical ramifications for the agricultural focus area. A significant amount of water is also used to support residential, commercial, and industrial activities within California's extensive metropolitan and suburban areas. Therefore, a reliable water supply also has important ramifications for future population growth and economic development as examined within the transportation, fuels, and land use focus area. Water is also used to cool power plants and produce hydropower, and therefore has important implications for the energy focus area.

California's water system includes a complex infrastructure that has been developed to support the capture, use, conveyance, storage, conservation, and treatment of water and wastewater. Greenhouse gas emissions from the water sector come primarily from the energy used to pump, convey, treat, and heat water. As such, water sector emission reductions are primarily associated with reducing the amount of electricity and natural gas used within the water sector.

The storage, conveyance, and treatment of water in California consume large amounts of electricity. Approximately 19 percent of the electricity and 30 percent of non-power plant natural gas consumption is used by the water sector. Water is used to grow crops, support urban and industrial needs, and produce energy. Therefore, most of the water measures included in the Scoping Plan focused on the GHG emission benefits derived from reduced energy use, and the emission benefits are reflected in those sectors.

The State is currently implementing several targeted, agricultural, urban- and industrial-based water use efficiency, recycling, and conservation programs as part of an integrated water management effort that achieves GHG emission reductions within the water sector. California's water community is continuing collaborative efforts to reduce its carbon footprint while improving water supply reliability, drought resilience, and public safety; fostering environmental stewardship; and supporting a stable State economy.

California's 2009 Water Conservation Act (Senate Bill x7-7) specifically addresses urban and agricultural water conservation. The Act's key urban provision established an aggressive statewide goal to reduce per capita water use by 20 percent by 2020. To date, 400 urban water agencies have prepared water management plans, which cover close to 80 percent of California's population.

The State has also set ambitious goals for development of alternative water sources such as recycled water and stormwater. The State Water Resources Control Board (SWRCB) adopted recycled water and stormwater goals through a stakeholder-driven process. Recycled water usage is to be increased above the 2002 usage levels by at least one million acre-feet per year by 2020 and by at least two million acre feet per year by 2030. Stormwater usage is to increase above the 2007 usage levels by at least 500,000 acre-feet per year by 2020 and by at least one million acre-feet per year by 2030. Grant and loan programs have provided over $1.15 billion for recycling and stormwater capture infrastructure, and projects are coming online.

In addition, the State has invested $1.5 billion to support 48 regional collaborative efforts to develop water management plans, diversify regional water portfolios, and increase regional water supply self-reliance to support future growth and development. Governor Brown has also taken action to permanently reduce water use consumption by directing State agencies and departments to reduce their overall water use by ten percent by 2015 and 20 percent by 2020.[85]

85 See Executive Order B-18-12, issued on April 25, 2012.

The ongoing drought in California affects energy management as well as water systems. Reduced snowpack decreases hydroelectricity production, and reduced surface flows create additional demands for groundwater pumping. These relationships highlight the need for closer coordination between water and energy managers. Coordinated water and energy investments can be coordinated to maximize GHG emission reductions, if local and State agencies work together to identify project designs that best serve both purposes.

Maintaining Momentum

The primary mechanisms to reduce water-related energy use are energy efficiency and water conservation strategies. Many water and wastewater agencies are already leading the way through conservation-adjusted business plans, investments in efficient infrastructure, reuse of wastewater, and self-generation of renewable energy; but more work is needed. Achieving industry-wide shifts will require sustained State leadership and new policy and regulatory frameworks that account for water supply, water and energy use, water quality standards with regional flexibility and funding, and effective data collection and analysis. Reducing GHG emissions from the water sector will require close coordination between water agencies and energy agencies. Greater attention will need to be paid to the water-related impacts of land use and development. Most important, the State and local water agencies will need to play a key role in three areas:

- Prioritizing investments in conservation.
- Adopting rate structures and pricing that maximize conservation.
- Promoting less-energy intensive water management, such as a comprehensive groundwater policy.

Additional gains in water conservation, especially use reductions in both agricultural and urban landscape irrigation, are critical not only for meeting GHG emission reduction goals, but also for resilience to more frequent and severe droughts. Many local agencies throughout California have invested in water conservation and water use-efficiency activities. The State should encourage and facilitate local water conservation projects that achieve co-benefits of energy efficiency and greenhouse gas emission reductions.

Establishing a conservation-first policy for water-sector investment and action would help to sustain declining per-capita usage. This policy would be similar to the State's "loading order" policy for energy, which prioritizes investments in energy efficiency ahead of developing new power supplies. The conservation-first policy could be implemented through legislation or joint-agency action. (The State's Energy Action Plan, for example, was jointly approved by the CEC, CPUC, and CAISO).

Pricing policies are another key tool to deter waste, encourage efficiency, and require those who use the most to pay the costs of assuring the water supply. It is important that such policies also protect the ability of low-income households to purchase minimum necessary water supplies. While water rates are set at the local level, the State can use financial and regulatory incentives to promote widespread adoption of strong and equitable price signals to maximize conservation. These incentives could be made available within State grants and loans, or through applicable regulatory relief processes such as water rights applications.

California must also develop policies that thoroughly and accurately reflect the economic, social, and environmental value of water, to ensure the effectiveness of future water management practices, and to evaluate competing water use demands and trade-offs. For example, in the California Water Action Plan, the State proposed a comprehensive groundwater policy to reduce overdraft and energy-intensive pumping from deep underground. This policy will require collaboration between the SWRCB, Department of Water Resources (DWR), Department of Food and Agriculture, and other agencies.

Successfully meeting the water sector goals will also require balancing multiple policy objectives, such as flood protection, sustainable food production, and renewable energy development. Interagency coordination, such as the recent efforts of the SWRCB to develop the Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling (once-through cooling), shows interagency coordination is possible without a drastic overhaul of regulatory responsibilities. Nevertheless, additional challenges posed by the changing climate and economic pressures to successfully achieve mitigation goals across multiple economic sectors must be addressed. Multiple policy objectives must be balanced across a wide spectrum of State water and climate planning documents, such as the AB 32 Scoping Plan, the Safeguarding California Plan, the California Water Plan, the Delta Plan, the Bay Delta Conservation Plan, and the Integrated Regional Water Management Strategic Plan. The California Water Action Plan provides some guidance on the relationship between the priorities established in these water and climate planning documents by establishing priorities for the next five years.

State agency collaboration and policy alignment requires a foundation of information sharing and feedback. Both agency staff and executives will need to devote more time to inter-agency dialogue to ensure that policy differences are resolved with a full understanding of the consequences of decisions taken. In addition, achieving efficient and aligned policies across agencies may require alterations to existing agency authorities and decision-making procedures.

Key Recommended Actions for the Water Sector

Funding

- DWR and SWRCB to give priority to funding integrated management plans that include robust existing or proposed water and energy conservation and efficiency and measures that achieve GHG emission reductions. Conservation programs should include numeric targets.

Technology

- CEC to implement new water-related energy conservation measures and efficiency standards.
- CPUC to complete water-energy nexus rulemaking by 2016 and to continue implementation of joint water-energy utility efficiency programs and partnerships
- SWRCB and CPUC to incent resource-recovering wastewater treatment projects by 2015.
- SWRCB and RWQCB by 2016 to implement green infrastructure permits to treat and capture urban runoff for local use.

Administration

- As directed by the California Water Action Plan, the DWR, the SWRCB, CPUC, CEC, CDFA, and ARB to guide adoption of GHG emission-reducing policies for water sector investments and action by 2015. Conservation measures and regulations to reduce GHG emissions and maintain water supply reliability during drought periods will be a centerpiece of this administration action.
- As directed by the California Water Action Plan, DWR, SWRCB, CPUC in consultation with the CDFA, to identify and incent implementation of rate structures that accurately reflect the economic, social, and environmental value of water in California while maintaining affordability for basic services.
- As directed by the California Water Action Plan, the SWRCB to develop a comprehensive groundwater management strategy, and the DWR and CDFA to provide technical and financial assistance to exceed SBx7-7 targets.
- SWRCB and RWQCBs by 2016 to modify State and regional water board policies and permits to achieve conservation, water recycling, stormwater reuse, and wastewater-to-energy goals.

Education

- As directed by the California Water Action Plan, DWR, SWRCB, CPUC, CEC, and CAISO to promote water-energy conservation outreach and education.

5. Waste Management[86]

The Waste Management Sector covers all aspects of solid waste and materials management, including the recycling, reuse, and remanufacturing of recovered material; composting and anaerobic/aerobic digestion; municipal solid waste (MSW) thermal operations (waste-to-energy); biomass management (combustion, composting, chip and grind); and landfilling. This sector also includes market development programs, such as the State's environmentally preferable and recycled-content product purchasing program. The primary source of GHG emissions from this sector is the direct emission of methane from the decomposition of organic material in landfills. However, recycling, reuse, and reduction of waste materials will reduce upstream GHG emissions associated with the production and transport of products. Although many of these upstream GHG emissions happen outside of California, California's waste policies can help reduce both local and global GHG emissions and create jobs within the State.

California has a robust waste management system in place, with established programs that reduce air emissions through activities such as gas collection systems from landfills and stringent recycling mandates. California adopted landmark legislation in 1989 (Assembly Bill (AB) 939) that required cities and counties to reduce the amount of waste going to landfills by 50 percent in 2000 and has surpassed this mandate to achieve 66 percent in 2012. This action has resulted in diverting nearly 60 million tons per year of material from landfills to reuse, recycling, composting, and other beneficial uses.[87] These reductions could not have been achieved without the waste industry, local jurisdictions, affected business, and the public working diligently and cooperatively to meet the goal of AB 939. In doing so, we achieved a co-benefit of substantial GHG emission reductions due to the energy savings associated with the use of recovered materials in place of new raw materials.

However, California still disposes about 30 million tons of solid waste in landfills each year. To address this and recognize the role waste management can play in GHG emission reductions, the legislature adopted AB 341 (Chesbro, Chapter 476, Statutes of 2011) in 2011. This legislation set a clear mandate to achieve more significant waste reductions by 2020, setting a goal that 75 percent of the solid waste generated be reduced, recycled, or composted by 2020. It is estimated that achieving the AB 341 waste reduction goal will result in a yearly GHG reduction of about 20 to 30 $MMTCO_2e$.[88]

The initial Scoping Plan identified several activities that would continue to move California forward in enhancing this integrated system for addressing waste-related issues and further reduce GHG emissions from this sector. These activities include landfill methane emission reductions, reduction in waste generation, and shifting waste to more beneficial uses. In 2009, ARB adopted the Landfill Methane Control Measure to further reduce methane emissions from landfills. And, in 2012, CalRecycle adopted the Mandatory Commercial Recycling regulation to further increase recycling programs throughout the State.

ARB approved two resolutions to work with CalRecycle and other stakeholders to characterize emission reduction opportunities for different options for handling solid waste, including recycling, remanufacturing of recovered materials, composting and anaerobic digestion, waste-to-energy, landfilling, and the treatment of biomass. In addition, ARB is to develop a comprehensive approach for the most appropriate treatment of the Waste Sector under the Cap-and-Trade Program, based upon the analysis of emission reduction opportunities.

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86 ARB and CalRecycle have prepared six technical papers: Recycling, Reuse, and Remanufacturing; Composting and Anaerobic Digestion; Biomass Conversion; Municipal Solid Waste Thermal Technologies; Landfilling of Waste; and State Procurement which are the basis for the information summarized here. The technical papers are available at *www.arb.ca.gov/cc/waste/waste.htm*.

87 This also includes the use of green material as alternative daily cover at landfills and some materials sent to transformation facilities.

88 Most of the estimated emissions benefits will be outside of California, since the majority of the recyclable commodities are currently reprocessed outside the State.

Meeting the AB 341 75 percent recycling goal is the best path forward to maximizing GHG emission reductions from the Waste Management Sector and putting California on the path for even greater GHG emission reductions in the future. In the future, net zero GHG emissions are achievable in a mid-term time frame. By 2050, direct GHG emissions from waste sector activities could be reduced by 25 percent, creating a net negative GHG footprint for the waste sector.

To achieve these goals, California must take greater ownership and responsibility for the waste generated within its borders. Shipping of waste, even recyclable products, to other states or nations is not a viable, long-term, environmentally appropriate waste management practice for California. Furthermore, exporting waste denies California the economic opportunity of significant job growth that would result if these materials were processed and remanufactured in California. While California cannot control exports, implementing the principle of owning our own waste will allow California to develop new, state-of-the-art waste management facilities/system which can be emulated by other states and nations.

Maintaining Momentum

California will need to maximize recycling, composting, and anaerobic digestion (instead of landfilling) and expand current waste management infrastructure to accommodate the increases in recycling and remanufacturing of waste material that is expected. This would mean constructing more composting and anaerobic digestion facilities that can use organics from the waste stream, as well as building more remanufacturing facilities for recyclable commodities such as fibers and resins.

Financing and permitting infrastructure development will be critical elements to achieving the Waste Management Sector goal. Financing, funding, and incentive mechanisms will be needed to support the development of the in-state infrastructure. Mechanisms to be considered will include Cap-and-Trade Investment Plan; loan, grant, and payment programs; Low Carbon Fuel Standard pathways; Public Utility Commission programs (e.g. biogas from anaerobic digestion and Renewable Market Adjusting Tariff); and offset protocols. Actions will also be needed to address permitting challenges and streamlining the multi-agency review of new and expanded infrastructure.

As increasing amounts of materials are diverted and recovered from the landfills, the markets for the recycled, reused, and remanufactured materials must grow. The State can take a leadership role in market development by having public agencies increase procurement of products with low-waste or no-waste attributes. In addition, greater producer responsibility for end-of-life product management, along with product design changes that minimize impacts on human health and the environment at every stage, will be increasingly important.

The State will need to explore opportunities for additional methane control at new and existing landfills either through amendments to the Landfill Methane Regulation and/or moving landfills into Cap-and-Trade or prohibiting/phasing out landfilling of organic materials.

The comprehensive nature of the waste sector has important ramifications for other focus areas. For example, efforts to divert green waste or biomass from the waste stream complements goals within the energy sector to further develop biomass resources for renewable electricity generation. Expanding agricultural waste diversion through composting and anaerobic digestion may affect policies within the agricultural focus area. Efforts to expand urban-based waste recycling and reuse programs may have implications for the transportation, fuels, and land use focus area.

Enhanced collaboration with State and local agencies is necessary, as California's waste-related issues are diverse and interconnected. Determining the best use of recycling alternatives, examining ways to increase the use of collected wastes and expanding their potential markets, providing funds to build needed infrastructure, and undertaking additional research are all important steps to reach the State's 2050 GHG emission goals.

In summary, to achieve the vision for the waste management sector, certain overarching actions are recommended. Actions to identify opportunities to further expand and maximize various waste management alternatives with California's own borders will need to be pursued. This could include the implementation of regulatory or statutory actions to phase out organic materials at landfills; including landfills in the Cap-and-Trade Program; and implementation of "best management" practices. Financial incentives to build adequate in-state infrastructure and incentivize activities to accomplish GHG and waste reduction goals are critical. Collaboration with other agencies, districts, and jurisdictions to streamline the permitting process and address conflicting requirements, including cross media issues, will permit a sustainable waste management system to grow in California. Additional research will also be needed to better characterize emissions for various materials and processes, and identify the best waste management alternatives.

Key Recommended Actions for the Waste Sector

- ARB and CalRecycle will lead the development of program(s) to eliminate disposal of organic materials at landfills. Options to be evaluated will include: legislation, direct regulation, and inclusion of landfills in the Cap-and-Trade Program. If legislation requiring businesses that generate organic waste to arrange for recycling services is not enacted in 2014, then ARB, in concert with CalRecycle, will initiate regulatory action(s) to prohibit/phase out landfilling of organic materials with the goal of requiring initial compliance actions in 2016.
- ARB and CalRecycle will identify and execute financing/funding/incentive mechanisms for in-State infrastructure development to support the Waste Management Sector goals. Mechanisms to be considered will include the Cap-and-Trade Investment Plan; loan, grant, and payment programs; LCFS pathways; CPUC proceedings (e.g. biogas from anaerobic digestion and Renewable Market Adjusting Tariff); and offset protocols.
- ARB will lead a process of identifying and recommending actions to address cross-California agency and federal permitting and siting challenges associated with composting and anaerobic digestion. As the first step, ARB convened a working group in 2013 made up of representatives from CalRecycle, SWRCB, and local air districts to identify challenges and potential solutions. A working group report will be released in mid-2014.
- ARB will explore and identify opportunities for additional methane control at new and existing landfills, and increase the utilization of captured methane for waste already in place as a fuel source for stationary and mobile applications. If determined appropriate, amend the Landfill Methane Regulation and/or move landfills into the Cap-and-Trade Program (2016/17).
- ARB and CalRecycle will develop new emission reduction factors to estimate GHG emission reduction potential for various recycling and remanufacturing strategies. To the extent data are available, these factors will include upstream and downstream emissions impacts.
- CalRecycle and the Department of General Services will need to take the lead in improving the State procurement of recycled-content materials through the State Agency Buy Recycled Campaign reform. Recommended improvements need to be identified by 2014, along with a plan for implementing the identified improvements.

6. Natural and Working Lands (Formerly Referred to as Forest Sector)

Three-quarters of California's landmass comprises biologically diverse landscapes such as forests, woodlands, shrublands, grasslands and wetlands. In this section's discussion, working lands includes rangelands but not agricultural croplands which are addressed in the Agriculture Sector. The initial Scoping Plan included a measure on sustainable forests and also identified additional strategies such as urban forestry and fuels management. This Scoping Plan update recognizes the key role that forests and all natural and working lands must play in meeting California's GHG emission reduction goals.

Natural and working lands act as both a source of GHG emissions and a carbon sink that removes CO_2 from the atmosphere. For example, vegetation growth and associated carbon sequestration in response to favorable growing conditions in one year can be followed by reduced growth or mortality during extended periods of drought. Emissions from wildfire, pest, and disease, are all natural ecosystem processes that can fluctuate from year to year and greatly influence the relationship between source and sink. However, when sustainably managed, the potential for natural and working lands to reduce GHG emissions and sequester carbon is significant and will be critical to reaching California's long-term climate goals.

Efforts to reduce GHG emissions and enhance carbon sequestration on natural and working lands also have significant economic, social, and environmental co-benefits, and can aid progress on efforts to prepare for climate change risks. A few key co benefits include protection of water supply and water quality, air quality, species habitat, recreation, jobs, wood and related products, flood protection, nutrient cycling and soil productivity, reduced heat-island effect, and reduced energy use. However, to ensure resilience, carbon management of these lands must be integrated with a broader suite of resource management objectives for those lands.

The initial Scoping Plan included a Sustainable Forest Target. The goal of this target was to maintain net carbon sequestration on forest lands. This was to be achieved using the mechanisms provided by the Forest Practice Rules, timberland conversion regulations, fire safety requirements, forest improvement assistance programs, and the California Environmental Quality Act (CEQA), which requires avoidance or mitigation of impacts affecting forest site productivity or forest carbon losses to conversion. The initial Scoping Plan also identified other opportunities to realize additional GHG emission reductions and increase sequestration, including the following:

- Preventing the conversion of forestlands through publicly and privately funded land acquisitions.
- Maintaining and enhancing forest stocks on timberlands through forest management practices subject to the Forest Practice Act.
- Planting trees on lands that were historically covered with native forests.
- Establishing forest areas where the preceding vegetation was not forest.
- Planting trees in urban areas.
- Using urban forest wood waste for bioenergy.
- Reducing vegetative fuels that could feed wildfires and using this waste for bioenergy.

The Board of Forestry and Fire Protection (BoF) has been evaluating the adequacy of existing forest regulations and programs for achieving GHG emission reductions and ensuring carbon sequestration on forest lands. In 2010, amendments to CEQA guidelines led to the requirement that timber harvest proponents subject to State regulations must analyze GHG emissions when applying for CAL FIRE permits.

The initial Scoping Plan recognized the need for continued research to improve estimates of ecosystem carbon stocks and GHG flux associated with stock change on forests and other natural lands. In 2011, ARB contracted with researchers from UC Berkeley to develop a new methodology for assessing carbon stock changes for all California's lands except agricultural and urban areas. The researchers have developed a new emissions assessment approach based on field measurements (Forest Inventory and Analysis data) and satellite remote sensing data and methods. The methodology includes an emissions assessment of forests, woodlands, grasslands, shrublands, and wetlands.[89]

Healthy forests and lands returning to forest are an important source of carbon sequestration. The UC Berkeley research is showing, however, that loss of forests and other natural lands through fire, natural ecosystem succession and conversion of forests and woodlands to other uses represent significant CO_2 release, potentially significantly greater than previously estimated and may outpace carbon sequestration, possibly by substantial amounts. This information underscores the importance of managing our forests and other natural and working lands to maximize the net benefits—increasing sequestration while reducing conversion and carbon stock losses, and maximizing associated co-benefits.

Application of the new research methodology will enable the monitoring of changes on the land over time and periodic quantification of the GHG flux associated with changes in ecosystem carbon stocks. As source data improves and methods are refined, ARB's GHG inventory for forests and other lands will be updated. This new inventory information can help identify the steps needed to reverse adverse trends and inform efforts to manage natural and working lands for net climate benefits.

The methodology developed by UC Berkeley does not include tree-covered urban areas. However, CAL FIRE, in conjunction with the U.S. Forest Service and researchers at UC Davis, is also developing GHG inventory data for urban forests and is continuing to refine and update those data over time. Improvements to ongoing GHG reporting systems will include refinements to methods and incorporation of additional relevant data sets (such as information on vegetation, forest stand treatments, and other activities) that are collected by CAL FIRE and other agencies.

On September 11, 2012, Governor Brown signed Assembly Bill 1492 (AB 1492; Blumenfield, Chapter 289, Statutes of 2012), with the first major changes in forest sector legislation in ten years. Among other things, AB 1492 set into motion a fee on certain types of lumber and wood products in California that now help fund forest management programs related to timberlands. One of the provisions of this new law is the requirement for the State to evaluate ecological performance measures, which are likely to include an evaluation of practices that may directly or indirectly affect GHG emissions.

Maintaining Momentum

While ongoing efforts are being made to reduce GHG emissions and increase carbon sequestration in California's forests, additional work is necessary, and incorporating other land types into our planning will become increasingly important as we move beyond 2020. With appropriate investments and sound science-based policy, natural and working lands in California can provide a tremendous opportunity to meet the State's climate goals. Over time, efforts in the Natural and Working Lands Sector will achieve many other important public and environmental benefits, such as protection of water supply and quality, air quality, and species habitat, as well as providing recreational opportunities and jobs.

Timing is critical for actions in this sector. Activities to enhance carbon storage on natural and working lands, such as reforestation or restoration, will require time to fully realize carbon benefits. For example, planting trees today will maximize their sequestration capacity in 20 to 50 years. In addition, trees in urban environments, or "urban forests," provide significant shading

89 Battles, J., Gonzalez, P., Robards, T., Collins, B., Saah, D., Jan 2014, California Forest and Rangeland Greenhouse Gas Inventory Development, Final Report, California Air Resources Board Agreement 10-778; *www.arb.ca.gov/cc/inventory/sectors/forest/forest.htm*

and other cooling benefits. As the trees mature they reduce urban temperatures and energy needs. Near-term investments in activities such as planting trees will help us reach our 2020 limit, but will also play a greater role in reaching our mid-term and longer-term 2050 targets especially if action is taken in the near-term.

Some actions to reduce emissions and enhance carbon storage in the long-term may result in temporary, short-term reductions in carbon sequestration. For instance, actions taken to address forest health concerns or to reduce wildfire risks may result in temporary reductions in carbon stock, but they are necessary to maintain healthy forests that are more efficient at GHG sequestration and more resilient to future climate conditions. It's important to manage our forests to maximize net climate benefits, increasing sequestration while reducing losses due to fire or other processes, while also considering the broader range of environmental services that forests and other natural lands provide.

There may also be additional benefits beyond carbon that can only be realized if actions are taken early enough. For instance, in some cases restoring tidal wetland can offer flood protection that is able to keep pace with sea level rise through the growth of root mass over time, but such naturally growing flood protection enhancements are only possible if restoration activities are initiated early.

Through implementation of GHG policies, actions, and strategic investments identified below, efforts to enhance, protect, and conserve natural and working lands in California can result in important climate benefits, as well as a more resilient California that is better prepared for climate risks such as more frequent and severe wildfires, changing water availability, and stressors on species and natural communities.

Research and Emission Inventory Updates

Inventory development and improvement are critical for informing carbon management activities in California. Recently developed tools will enable ARB to generate geospatially explicit estimates of ecosystem carbon stocks and GHG flux associated with stock change across a variety of land categories. Though additional work is needed, these tools, along with regularly updated input datasets will allow tracking of changes over time and provide a new method to update the GHG inventory.

The sources and methods for quantifying ecosystem carbon and GHG flux in this sector are complex. Additional work is needed to evaluate the data provided by the UC Berkeley research, to incorporate additional new data, and to identify further research needed to expand use of these tools. Continued refinements will advance carbon quantification, attribution of GHG flux by disturbance process, and reduce uncertainty, all of which will help inform effective carbon management activities. There is also a need to prioritize and conduct additional research on outcomes of specific practices to maximize carbon uptake on natural and working lands in California.

Integrating Biological Systems

Natural and working landscapes in California are composed of widely varied, vibrant, and often interconnected biological systems. Moving forward, it is important to begin looking at these lands in a more holistic and integrated way to ensure that we maximize opportunities to achieve biological carbon benefits across the range of California's natural lands, while also ensuring the health and resiliency of these lands to provide ongoing ecosystem services.

Forest Planning and Actions

California forests must be managed to ensure that they provide net carbon storage even in the face of increased threats from wildfire, pests, disease, and conversion pressures. Quantitative planning targets must be set to increase net forest carbon storage in California in the near-term, mid-term, and by 2050, while ensuring forest resilience, health, and continued ecosystem services. Forest carbon inventory and assessments should be continually maintained and refined to support this effort, and appropriate measures, funding, and incentives must also be established.

Specific actions to meet these planning targets for increasing carbon storage in California forests will be laid out in a "Forest Carbon Plan" (Plan). The Plan will be developed by a joint inter-agency workgroup and will necessitate engaging our federal partners with respect to federal lands in the State. The Plan should also include input from expert resources and stakeholders such as academia, non-governmental organizations, working forest owners, and local planning groups, to inform policy decisions. Additionally, the Plan should work synergistically with other State planning policies where GHG emission reduction strategies and co-benefits intertwine such as in the Water Action Plan, State Wildlife Adaptation Plan, and Safeguarding California. A resource economics study may be necessary to support the development of the Forest Carbon Plan; funding for such a study would be needed.

The Forest Carbon Plan will, at a minimum, set mid-term and long-term planning targets; identify actions to meet those targets; and provide recommendations on funding those actions. Development of the Plan should include a review of Forest Practice Regulations and recommendations for best management practices and potential additional regulatory measures or amendments needed to minimize GHG emissions and enhance carbon storage associated with silvicultural treatments. For example, a requirement for Sustained Yield Plans to demonstrate that activities not only maintain the current level of carbon sequestration, but actually increase carbon sequestration over the 100-year planning horizon.

Funding recommendations in the Plan should include but not be limited to the following:

- Recommendations regarding the development and implementation of market-based mechanisms applicable to large forest land owners for the purpose of ensuring that forests in California provide net carbon storage.
- Recommendations regarding the development and implementation of a competitive grant program.
- Recommendations regarding types of climate investments that might be supported by varying levels of funding support from Cap-and-Trade auction revenues or other sources.
- Recommendations regarding the process for dedicating a portion of Yield Tax Revenue to fund forest climate investments.
- Recommendations pertaining to property tax restructuring or other financial incentives to attract more interest in active forest management by nonindustrial timberland owners.

Another forest action is to incentivize the sustainable use of biomass obtained from forest management practices to produce energy. This strategy diverts raw materials from being burned in open piles, and reduces criteria and GHG pollutant emissions. Open burn piles create particulate emissions, which can exacerbate health problems and interfere with attaining State and federal ambient air quality standards. In addition, open burning contains black carbon, which is a short-lived climate pollutant (SLCP). As discussed in Chapter II, SLCPs have a shorter lifetime in the atmosphere and have a higher pound-for-pound warming potential than CO_2, and as such, during these shorter lifetimes they are very potent. Because SLCPs are removed from the atmosphere rather quickly, reducing their emissions results in immediate climate and air quality benefits. Cross-sector coordination is needed between the energy, waste, water, natural and working lands, and agriculture focus groups to develop recommendations for addressing economic, infrastructure, and regulatory hurdles regarding the input of bioenergy into the electricity grid from both small-scale and utility-scale biomass energy facilities.

Development of a carbon life cycle analysis for wood products could also be considered. When utilizing wood products for construction, manufacturing, and sale of goods in California, the location of the initial raw wood should be considered along with an analysis of the associated carbon emissions from the processing and transport of wood products through the various steps of the supply chain. Guidelines could be established that would identify and incentivize wood products that reduce carbon emissions–taking into account GHG emissions from transportation to the mill, from the mill to the production facility, and finally to the retailer. For example, wood harvested in California and transported and utilized locally for construction and manufacturing would have a lower carbon impact than wood that has been harvested and manufactured outside the State, shipped from overseas, or processed and reintroduced within California as a finished wood product.

Rangelands and Wetlands Planning and Actions

In the absence of comprehensive California rangeland and wetland carbon data, these lands should be protected from conversion pressures and degradation that could result in significant carbon emissions. In addition, restoration and improved management practices to increase carbon storage should be incentivized. This is true particularly where such enhancement, protection, and conservation action provide other important climate benefits, such as improving watershed conditions and flood protection, and providing habitat and connectivity for climate-stressed species.

Land Use Planning to Enhance, Protect, and Conserve Lands in California

As described under the Agricultural Sector, an integrated and coordinated approach to local land use planning that considers all land types is important in meeting the State's GHG reduction goals. Urban, natural and working lands, and agricultural croplands within and across jurisdictions must all be considered to create interconnected land areas and ecosystems. Local and regional land use planning actions and policies need to more fully integrate and emphasize land conservation and avoided conversion of croplands, forests, rangelands, and wetlands—as well as expansion and promotion of urban forestry, urban agriculture, and green infrastructure.

Urban Forests

Expansion and support is needed for urban forest programs, particularly in environmental justice communities. Urban forests can significantly reduce the disproportionate environmental impacts on California's environmental justice communities through increased green infrastructure investments that reduce GHG emissions. These investments benefit communities and result in environmental benefits such as reduced storm water runoff and clean air; health benefits from motivating active transportation and reducing urban heat island effects; and economic benefits such as reduced energy demand through cooling and increased land values. Utilizing local groups, such as the Local Conservation Corps, to implement urban forest and urban greening projects in these areas can provide dual benefits by also providing experience, training, and opportunity for at-risk youth.

Funding Needs

Funding is critical to address the needs in this sector, yet it is far below historic levels and in some cases does not exist. Outcomes of actions on natural and working lands often occur on a decadal scale. Action within the next ten years is critical so long-term benefits can be fully realized in the 2050 time frame. Funding sources must be identified, particularly where funds from existing sources can be leveraged effectively.

Funding across the sector is needed for further inventory improvements, research on effective GHG reduction and sequestration practices, and direct on-the-ground activities known to reduce GHG emissions and increase sequestration.

To further define and describe these needs, a natural and working lands climate investment working group will be convened to produce a report that outlines funding needs and opportunities for the Natural and Working Lands Sector as a whole. The GHG inventory, Forest Carbon Plan, local land use planning efforts, and other statewide efforts should be considered in development of the report.

To the extent feasible, the report should include strategic prioritization guidelines for investments in forests, rangeland, or wetlands. As different governmental entities and stakeholders actively manage forest, rangelands, and wetlands, separate prioritization guidelines should be developed for each land type and for the sector as a whole, if possible.

Key Recommended Actions for Natural and Working Lands

- The California Natural Resources Agency (CNRA) and CalEPA will convene an inter-agency forest climate workgroup to prepare and publish a "Forest Carbon Plan" in 2016. The Forest Carbon Plan will:
  - Set quantitative near-term, mid-term, and long-term planning targets to ensure an increase in net forest carbon storage in California commensurate with the State's long-term GHG reduction goals, and in light of recent research that suggest that forests in California may be a source of GHG emissions rather than a carbon sink.
  - Identify near-term and long-term actions necessary to meet quantitative planning targets while ensuring forest resilience and health, ecosystem services, conservation of the forest land base, and continued economic opportunities.
  - Evaluate GHG emission and carbon sequestration trends for different forest land ownership types and consider sector sub-targets for each type.
  - Develop specific recommendations regarding approaches for funding actions to ensure that forests in California provide net long-term carbon storage.
- In 2016, through AB 1504, CAL FIRE and BOF will evaluate methods to develop a life cycle analysis to track carbon in wood products; this work should be coordinated with ARB's forest inventory and support the Forest Carbon Plan.
- The Bioenergy Interagency Working Group will continue to work with stakeholders and relevant agencies to:
  - Strengthen, refine, and implement actions contained in its Bioenergy Action Plan related to use of forest biomass.
  - Evaluate the potential biomass energy generation capacity.
  - Develop methods to quantify biomass life-cycle GHG flux.
- In 2015, OPR, CNRA, CalEPA, CDFA, California Department of Fish and Wildlife (CDFW), CAL FIRE, and ARB will convene an inter-agency workgroup to engage local and regional land use planning agencies in establishing a coordinated local land use program. The program will set planning targets that identify, prioritize, and incentivize land conservation; increase urban forestry canopy cover; bolster development of green infrastructure; and limit the conversion of both agricultural croplands and natural and working lands.
- In 2015, CNRA, CalEPA, CDFA, CDFW, CAL FIRE and ARB will convene a natural and working lands climate investment working group to draft a report outlining funding needs, opportunities, and priorities for the Natural and Working Lands Sector.
- Expand urban forestry and green infrastructure programs and investments, particularly in California's environmental justice communities.
- Continue to analyze the UC Berkeley research methodology and data to develop GHG inventory updates, incorporate more recent data into the newly developed tools for carbon quantification, and invest in and expand monitoring and research to reduce uncertainty in carbon quantification and attribution of GHG flux by disturbance process.

7. Short-Lived Climate Pollutants

Mitigation of short-lived climate pollutants (SLCPs)—which include black carbon, methane, tropospheric ozone, and some hydrofluorocarbons (HFCs)—produces immediate climate benefits and is an important complement to efforts to reduce emissions of CO_2. Many short-lived climate pollutants are already regulated by ARB, either as part of the air quality and toxics program or under the Scoping Plan. For example, black carbon levels in California will be reduced by 95 percent from the late 1960s to 2020, primarily due to diesel controls and burning restrictions. Peak urban ozone levels have also been reduced by more than 75 percent since the 1960s; however, substantial further reductions are needed to comply with federal requirements to meet the National Ambient Air Quality Standard by 2032. ARB is mitigating methane and HFCs from various sources through the implementation of control measures identified in the initial Scoping Plan and will develop a more aggressive short-lived climate pollutant strategy by 2015 that will include an inventory of sources and emissions, the identification of additional research needs, and a plan for developing necessary control measures. ARB will consult with external experts in the development of this strategy.

Several recent analyses of atmospheric measurements suggest that actual methane emissions may be 1.3 to 1.7 times higher than estimated in ARB's emission inventory. California and federal agencies, universities, and national laboratories have put into place a comprehensive set of research studies to determine the sources of these higher-than-expected methane emissions, and whether additional controls are technologically feasible and cost-effective. In March 2014, the Obama Administration released the Climate Action Plan - Strategy to Reduce Methane Emissions[90] identifying actions to improve methane emission estimates and develop methane emission control measures. The Strategy identifies key agencies that will be responsible for evaluating and implementing methane reduction strategies for various sources including landfills, agriculture operations, coal mines, and oil and gas production. Strategies that address methane emissions in this Update are identified in the preceding sector discussions on energy, agriculture, and waste.

Short-lived climate pollutants have a subcategory of compounds that are considered to have an even higher significance on climate change on a per-ton emission basis than other SLCPs. These compounds are called high global warming potential (GWP) gases. High-GWP gases are those that, on a per-ton basis, contribute to global warming at a level many times greater than carbon dioxide (GWPs of 150 or higher). These gases are manufactured, have no natural sources, and have been in use for decades, primarily in refrigerators, air conditioners, and foam insulation. A majority of the emissions are comprised of hydrofluorocarbons (HFCs), with a smaller percentage from perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). Although emissions of high-GWP gases are only three percent of today's statewide GHG inventory, they are the fastest-growing GHG source in California as HFCs are replacing ozone-depleting substances (ODSs) in response to the Montreal Protocol mandates. Significant efforts will be needed to control these emissions as the ODSs are phased out. The ODSs are primarily chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), and all the fluorine-containing gases are collectively known as F-gases. Figure 7 shows California's F-gas emission trends from 1990 to 2050.

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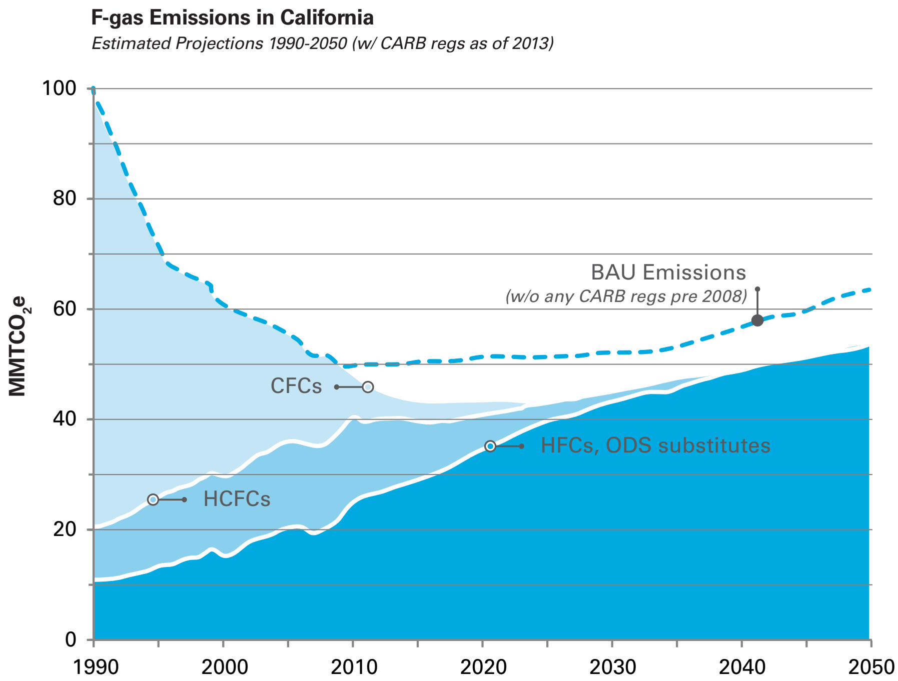
90 *www.whitehouse.gov/sites/default/files/strategy_to_reduce_methane_emissions_2014-03-28_final.pdf*

Figure 7: Fluorinated gas (F-gas) Emissions in California (1990–2050)



Note: The blue dashed line represents business-as-usual F-gas emissions if no CARB regulations had been adopted to reduce high-GWP emissions. The dark blue area represents business-as-usual (BAU) emissions, including reduction measures adopted as of December 2013.

Due to the phase-out of ODSs, total F-gas emissions have been reduced by 57 percent since 1990. However, HFCs continue to increase as they replace the ODSs that are banned by the Montreal Protocol. Even with the current regulations that are in place, HFC emissions are expected to increase by about 40 percent (from 18 to 25 $MMTCO_2e$) between 2012 and 2020. With no additional control measures, HFC emissions in California are expected to more than double by 2050, to 43 $MMTCO_2e$ annually, accounting for approximately half of California's long-term GHG emission target.

While high-GWP gases are not a discrete sector of California's economy, the Scoping Plan addressed them as a sector to organize and track emissions, sources, and emission reduction strategies. The focus of the Scoping Plan measures was primarily on HFC emission reduction programs. These measures focused on two central themes to achieve five $MMTCO_2e$ of GHG emission reductions by 2020: (1) use of lower-GWP alternatives for certain consumer products and new motor vehicle air conditioning systems, and (2) avoiding releases of currently used high-GWP gases, using gas recovery options, such as those for electrical transmission and particle accelerators, and leak tightness specifications.

Implementation of the Scoping Plan measures has reduced emissions from a variety of sources. The biggest reductions of high-GWP gases are expected to come from ARB's Refrigerant Management Program, which requires facilities with refrigeration systems to inspect and repair leaks, maintain service records, and in some cases, report refrigerant use. Significant reductions are also expected to come from a motor vehicle air-conditioning (AC) credit program for vehicle models 2017 and beyond. This measure is part of the Low Emission Vehicle (LEV III) regulation that has been aligned with a new federal Clean Cars program.

In spite of ARB efforts, significant obstacles remain for further reductions of HFCs, due to the diverse nature of sources. Substantial progress has been made in recent years in the development of low-GWP alternatives in the refrigeration and foam industries that can achieve significant reductions in the high-GWP sector. Low-GWP refrigerants and insulating foam are currently under evaluation to better understand their technical feasibility and cost-effectiveness in various applications. Based on further analysis, ARB may develop programs to require low-GWP insulating foam materials and refrigeration systems that use either low-GWP alternatives or significantly reduced amounts of HFCs.

California's efforts can help support a national or international phase-down of HFC production and consumption. On June 8, 2013, the United States and China entered into a preliminary agreement to phase down the production and consumption of HFCs between the two countries. For the first time, the United States and China will work together and with other countries to use the expertise and institutions of the Montreal Protocol to phase down the consumption and production of HFCs, among other forms of multilateral cooperation.

Maintaining Momentum

There are several potential approaches to further reduce high-GWP F-gases. These include:

High-GWP F-gas Phasedown

California to work with the U.S. EPA to establish national standards in alignment with the European Union (EU) proposed F-gas phasedown of HFC production and import to just 21 percent (based on CO_2-equivalents) of baseline annual usage (years 2008 – 2011) by the year 2030. Some sector-specific prohibitions are included within the proposed EU phasedown, including a ban on refrigerants with a GWP greater than 2,500 used in new equipment.

Low-GWP Requirements

Low-GWP substitutes for ODSs and HFCs are becoming increasingly feasible and cost-effective. As such, it will be vital to require that low-GWP compounds be used for commercial refrigeration and air conditioning, residential appliances and air conditioning, insulating foam, motor vehicle air conditioning, transport refrigeration, aerosol propellants, metered dose inhalers, solvents, fire suppressants, sulfur hexafluoride uses, and structural pesticide fumigants if California is to meet its mid-term GHG goals and long-term GHG emission reduction goal of 80 percent below 1990 levels by 2050.

ODS Recovery and Destruction

The Montreal Protocol has reduced ODS emissions significantly (by almost 60 percent) by reducing the production and consumption of ODSs. However, it appears that end-of-life emissions from legacy equipment are still significant. Due to higher demand and therefore higher value of recovered ODSs, there is currently less incentive for ODS destruction. More than 80 percent reduction in ODS emissions (approximately 20 $MMTCO_2e$) can be obtained by 2030 by incentivizing recovery and destruction of ODSs at the end-of-life. This can be done by a combination of strategies, including adjustments to current ODS destruction protocols, implementing a mitigation fee, and/or using cap-and-trade revenue to help pay for higher costs.

High-GWP Fee

An upstream mitigation fee on sales of high-GWP gases would incentivize a faster transition to low-GWP substitutes, and could further incentivize improved refrigerant recovery practices. The fee would also be applied to sales or import of equipment pre-charged with high-GWP gases. The mitigation fee would complement rather than replace downstream high-GWP regulations currently in effect or being developed. As sources comply with regulatory measures, affected entities would reduce their emissions and therefore the fees they would need to pay. A high-GWP fee would address high-GWP gases in a consistent manner, on a carbon dioxide equivalent basis, and serve to change behavior, induce new low-GWP alternative products, and provide revenue that can be used to mitigate GHG emissions.

Key Recommended Actions for Short-Lived Climate Pollutants

- Develop a comprehensive strategy for mitigation of short-lived climate pollutants by 2015.
- Continue diesel controls that will reduce black carbon emissions by 95 percent from the late 1960s to 2020.
- Reduce emissions of smog-forming pollutants by about 90 percent below 2010 levels by 2032 to meet the National Ambient Air Quality Standard for ozone.
- Create a collaborative agreement with the U.S. EPA to establish national standards in alignment with the European Union (EU) proposed F-gas phasedown of HFC production and importation to just 21 percent (by CO_2-equivalents) of baseline annual usage (years 2008-2011) by the year 2030.
- Require low-GWP gases where feasible and cost-effective.
- Incentivize recovery and destruction of ODSs at the end-of-life by a combination of strategies, including adjustments to current ODS destruction protocols, and/or implementing a mitigation fee.
- Set an upstream mitigation fee on sales of high-GWP gases and sales or import of equipment pre-charged with high-GWP gases.

8. Green Buildings

Buildings represent the second largest source of statewide GHG emissions, when accounting for electricity, natural gas, and water consumption. However, there are additional GHG emissions related to buildings that have not yet been fully accounted for as part of the Statewide GHG emission inventory. For example, additional GHG emissions could be accounted for under a lifecycle emissions analysis approach such as estimating emissions resulting from the mining, harvesting, processing, and transportation of materials used to construct new buildings, as well as products consumed over the life of a building. The siting and integration of buildings into communities may also affect transportation patterns and infrastructure needs and result in GHG benefits. Green buildings are designed, constructed, operated, and maintained to maximize energy efficiency, conserve water, and minimize waste. They also are strategically located to encourage people to walk, bike, or take public transit rather than drive cars.

Green buildings offer a comprehensive approach to support California's climate change goals across multiple sectors, including energy, water, waste, and transportation while protecting the environment and public health. Green buildings utilize an integrated process to improve the design and construction of new buildings, as well as to retrofit, maintain, and operate existing buildings. By supporting current initiatives and expanding the long-term focus toward zero carbon buildings, green buildings represent a fundamental shift toward a cross-sector and integrated climate policy framework. In the last five years, California has solidified its commitment to green building; leading the way with State buildings, improving building standards, continuing to raise the bar with voluntary programs at the local level, and greening existing buildings.

Leading the Way with State Buildings

Governor Brown took a leadership role by signing Executive Order B-18-12 in April 2012. The Executive Order directs State agencies and departments to take immediate action for state government buildings to serve as models for green buildings. New and renovated State buildings shall achieve Leadership in Energy and Environmental Design for New Construction (LEED-NC) "Silver" certification or higher. All existing State buildings over 50,000 square feet shall complete LEED for Existing Buildings: Operations and Maintenance (LEED-EB: O&M) certification by 2015. In addition, the Order provides that 50 percent of new State facilities beginning design after 2020 shall be zero net energy (ZNE) buildings, and all new State buildings and major renovations starting design in 2025 shall be ZNE buildings. Already, over 100 State buildings have been able to achieve LEED certification. Nearly half of those certifications are for LEED-NC, 35 percent are for LEED-EB: O&M, and about 20 percent are certified to the LEED for Commercial Interiors (LEED-CI) rating system.

In addition, by the end of 2014, there will be 46 megawatts of on-site solar photovoltaic systems at State facilities, plus about 33 megawatts at University of California campuses, and 11.3 megawatts at California State University campuses.

California Green Building Standards

Reducing GHG emissions from construction is being accomplished through continuous updates to the California Green Building Standards (CALGreen) Code. Originally adopted in 2008, the CALGreen Code included all voluntary standards that went beyond the basic building code requirements and introduced new standards for reducing water use, provisions for reducing and recycling construction and demolition waste, criteria for site development to locate buildings near public transit, and measures for improving indoor air quality to protect the health of building occupants. In 2010, the CALGreen Code became mandatory on a statewide basis. The 2010 code, as amended, included provisions for additions and alterations for non-residential buildings, but it still only applied to new construction for low-rise residential buildings. For the 2013 code, effective January 2014, the scope of the CALGreen Code was expanded to all residential buildings, including high-rise residential, as well as to additions or alterations with increases in conditioned space. In addition to mandatory standards, the CALGreen Code still includes voluntary standards, also known as Tiers, that offer model building code language available for local adoption.

Voluntary Programs at the Local Level

Local governments are helping to reduce GHG emissions as they adopt green building standards that include targets to exceed minimum State building standards for new construction. Over 100 local governments have adopted "beyond code" green building standards. Twenty of those cities adopted building standards to exceed the Building Energy Efficiency Standards by 15 or 30 percent; IOUs supported the adoption of these local "reach" energy standards through technical analysis and funding, as overseen by the CPUC. About 50 cities and counties have standards exceeding the minimum CALGreen Code Tiers. Over 60 local governments have mandated all new construction to achieve third-party green building certification, such as the GreenPoint Rated program and the LEED rating system. Similarly, school districts are pursuing high performance standards for greening public schools. About 40 school districts have mandated minimum Collaborative for High Performance Schools (CHPS) certification for all new construction and major modernization. Since 2008, nearly 200 schools in California have been recognized as CHPS schools.

The State's higher education systems are also leaders in designing and constructing green buildings on their campuses. For example, the University of California system has taken a proactive role in reducing GHG emissions in its buildings and in 2013; President Janet Napolitano declared an initiative for the University of California to achieve carbon-neutrality in its operations by 2025.[91] As of 2011, the California State University system had 36 buildings that were LEED certified with an additional ten buildings expected to qualify for some level of LEED certification.[92] Finally, California's Community Colleges have made remarkable progress toward conserving energy and making their campuses more energy efficient.[93]

Greening Existing Buildings

While building standards for new construction, additions, and alterations are useful to reduce the impacts of climate change, major renovations and sustainable operation of existing buildings offer the greatest potential to reduce building-related GHG emissions. Over 500 buildings have been certified to the LEED-EB: O&M rating system, which certifies that a building's operations follow rigorous green building standards and practices. To maintain momentum for greening existing buildings, progressive programs that accelerate the uptake of proven strategies are needed to reduce not only energy impacts, but also water, waste, and transportation impacts of the existing building stock. To this end, California must begin to develop a process to implement a portfolio of green building requirements to reduce GHG emissions at time of sale or using other trigger mechanisms.

Maintaining Momentum

Zero Net Carbon Buildings

Zero net carbon buildings will be key as we continue to pursue an integrated approach to reduce new and existing building-related impacts that combine climate and air quality programs. To this end, the State will be developing new emission reduction programs for State buildings, schools, homes, and commercial buildings. It will be essential to expand upon the Energy Sector zero net energy building goals and establish goals to achieve zero net carbon buildings. Achieving these goals would result in zero net carbon emissions over the course of a year from all GHG emission

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91 *http://sustainability.universityofcalifornia.edu/documents/carbon-neutrality2025.pdf*.
92 *www.calstate.edu/pa/documents/CSU_Sustainability_Report_2011.pdf*
93 *http://extranet.cccco.edu/Portals/1/CFFP/Sustainability/BOG_Energy_Sustainability_Policy_FINAL.pdf*

sources associated, directly and indirectly, with the use and occupancy of buildings. Zero net carbon buildings could utilize high-performance design solutions, generate renewable energy and heating on-site or locally, and employ other techniques to eliminate or offset GHG emissions from all GHG impacts (i.e., energy, water, waste, and transportation) associated with a building. Zero net carbon buildings are the next generation of buildings and could contribute significantly to achieving our long-term GHG emission goals.

The key actions summarized below would support the State's efforts to realize the 2020 emission reduction limit while helping to drive California toward developing and implementing additional strategies to achieve emission reductions from green buildings.

Key Recommended Actions for Green Buildings

Develop a comprehensive GHG emission reduction program for new construction, existing building retrofits, and operation and maintenance of certified green buildings. Program development to be completed by end of 2017 and incorporate the following principles:

- Achieve Executive Order goals for State buildings.
- Build on California's existing zero net energy building goals and activities by 2015.
- Continue research activities to better quantify GHG emission reduction potential of certified green buildings by 2016.
- Strengthen the next two triennial editions (2016 and 2019) of the Green Building Standards Code with mandatory provisions that reduce GHG emissions by 2017 and 2020 respectively.
- Build on AB 758 Action Plan implementation activities, and explore opportunities to implement a portfolio of green building retrofit requirements at time-of-sale or other trigger mechanism by 2017.
- Explore methodologies to quickly but accurately quantify direct and indirect GHG emissions from new and existing buildings by 2017.
- By 2017, establish target dates and pathways toward transitioning to zero net carbon buildings that expand upon and complement ZNE goals.
- By 2018, implement a mechanism to track progress toward achieving statewide green building goals.

9. Cap-and-Trade Regulation

The Scoping Plan recommended the development of a California Cap-and-Trade Program that links with other Western Climate Initiative partner programs to create a regional market system. On January 1, 2013, ARB launched the second-largest GHG Cap-and-Trade Program in the world. The Cap-and-Trade Regulation ensures progress toward the near-term 2020 statewide limit, while providing businesses the greatest flexibility to reduce emissions at the lowest possible cost.

The Cap-and-Trade Program is a vital component in achieving both California's near-and long-term GHG emissions targets. California's Cap-and-Trade Regulation is purposely designed to leverage the power of the market in pursuit of an environmental goal. It opens the door for major investment in emission-reducing technologies and sends a clear economic signal that these investments will be rewarded. The Cap-and-Trade Regulation establishes a hard and declining cap on approximately 85 percent of total statewide GHG emissions. Under the Cap-and-Trade Regulation, ARB issues allowances equal to the total amount of allowable emissions over a given compliance period and distributes these to regulated entities. One allowance equals one metric tonne of greenhouse gases. Each regulated entity must hold allowances or other compliance instruments equal to its emissions.

The Cap-and-Trade Regulation gives companies the flexibility to trade allowances with others or take steps to cost-effectively reduce emissions at their own facilities. Companies that emit more have to turn in more allowances or other compliance instruments. Companies that can cut their GHG emissions have to turn in fewer allowances. But as the cap declines, aggregate emissions must be reduced. Companies can meet a limited portion of their compliance requirement by surrendering offset credits, which are rigorously verified emission reductions that occur from projects outside the scope of the Cap-and-Trade Regulation. The offset program was included in the Cap-and-Trade Regulation because it is an important cost-containment mechanism. The Cap-and-Trade Regulation currently recognizes offset protocols for four project areas: forestry, urban forestry, manure digesters, and the destruction of ozone-depleting substances. ARB recently adopted a compliance offset protocol for the capture and destruction of fugitive mine methane, and is developing a protocol to reduce GHG emissions from rice cultivation. ARB will continue to evaluate additional offset protocols with an emphasis on in-state opportunities.

With just the envisioned six compliance offset protocols, it is clear there will not be enough offsets to meet the 2013–2020 maximum offset demand if every entity chose to use the maximum number of allowable offsets. It should be noted that the Cap-and-Trade Program is designed so that offsets will play a larger role in cost containment in the later years of the program. As ARB continues to work to identify additional compliance offset protocols, there will be challenges, particularly for in-state offset protocols. California has a history of identifying and regulating emissions when it is feasible and cost-effective. Under AB 32, offsets must be additional to any regulatory requirement and beyond business-as-usual. California's focus on regulations limits opportunities for California offsets. This preference for regulatory solutions—which are mandatory under a regulation as opposed to voluntary under an offset protocol—ensures maximum emission reductions. However, it limits opportunities for offsets both in- and out-of State.

The Cap-and-Trade Regulation is being implemented in two stages. Electric generating utilities, electricity importers, and large industrial facilities became subject to the program beginning in 2013, and fuel distributors are brought under the cap in 2015.

The Cap-and-Trade Regulation is different from most of the other measures in the Scoping Plan. The regulation sets a hard cap, instead of an emission limit, so the emission reductions from the program vary as our estimates of "business as usual" emissions in the future are updated. In addition, the Cap-and-Trade Program works in concert with many of the direct regulatory measures—providing an additional economic incentive to reduce emissions. Actions taken to comply with direct regulations reduce an entity's compliance obligation under the Cap-and-Trade Regulation. So, for example, increased deployment of renewable electricity sources reduces a utility's compliance obligation under the Cap-and-Trade Regulation. Finally, the Cap-and-Trade

Regulation provides assurance that California's 2020 limit will be met because the regulation sets a firm limit on 85 percent of California's GHG emissions.

Under the Cap-and-Trade Regulation, a portion of the allowances required for compliance are auctioned by the State. The first auction of emission allowances occurred in November 2012. To date, ARB has held five successful auctions.

The State's portion of the proceeds from these auctions is to be used to fund projects to reduce GHG emissions. A three-year investment plan was submitted to the Legislature in May 2013, identifying the State's GHG emission reduction goals and priority programs for investment of the action proceeds. More discussion of auction proceeds and other investments is included in Chapter V.

Because the Cap-and-Trade Program applies only to California entities, ARB designed the regulation to minimize emissions leakage. ARB continues to conduct ongoing leakage assessment studies that are based on an evaluation of industry emissions and trade exposure.

ARB is considering several amendments to improve the Cap-and-Trade Regulation in 2014. In particular, ARB proposes to provide additional transition assistance in the form of free allowances to industrial producers while the new leakage studies are being conducted. In addition, ARB is proposing mechanisms to keep allowance prices within an acceptable range by allowing a limited number of future allowances to be used for compliance should prices get too high. The continuation of the Cap-and-Trade Program will enhance the effectiveness of the new cost containment mechanism proposal.

California linked its program with the Canadian Province of Québec in January 2014. California and Québec have worked together to harmonize their regulations and coordinate on a joint auction platform and tracking system. ARB provided a report on the status of linkage implementation to the governor and CalEPA in November 2013.

As part of the Cap-and-Trade Regulation, the Board also approved an Adaptive Management Plan[94] to track unintended consequences of the Cap-and-Trade Regulation. The Plan requires ARB to develop systems to track and respond to: (1) potential adverse localized air quality impacts that might be caused by the Cap-and-Trade Regulation, and (2) potential adverse impacts that might be caused by the Compliance Offset Protocol U.S. Forest Projects (Protocol). ARB is working with the local air districts to determine the most effective path forward for gathering and evaluating permit data, GHG data, and other information needed for tracking potential localized impacts. As part of this effort, ARB has amended the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions to collect information on GHG emission increases and decreases from covered entities. ARB has contracted with the University of California, Davis, and is working with forestry experts from around the country to develop an approach to understand potential forest impacts resulting from implementation of the Protocol under Cap-and-Trade.

Maintaining Momentum

The Cap-and-Trade Program will continue to be a vital component in achieving California's longer-term climate change goals. As the cap continues to decline, the Cap-and-Trade Program incentivizes emission reductions associated with the production of energy and goods and encourages consumers to reduce emissions. Sending the market a signal that the Cap-and-Trade Program will continue in the long-term is critical to fully realizing the benefits of the program. Continuing the program and establishing an emission cap beyond 2020 will also reduce the costs of the program as California industry and households make long-term capital and investment decisions. A clear path forward will lead to a lower-carbon California.

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94 The 2011 Adaptive Management Plan for the Cap-and-Trade Regulation is available at *www.arb.ca.gov/cc/capandtrade/adaptive_management/plan.pdf*.

As the Cap-and-Trade Program continues to help achieve our long-term climate goals, it will be increasingly important to bolster the offset program. As noted above, there are real challenges to identifying in-state offset protocols, but ARB is committed to pursuing those that are workable. Part of the strategy to ensure sufficient offsets are available is to continue to consider international sector-based offset programs. The Cap-and-Trade Regulation already includes a placeholder for potential international sector-based offsets from programs designed to Reduce Emissions from Deforestation and Forest Degradation (REDD) through a future rulemaking. To that end, the REDD Offset Working Group, an ad hoc technical expert working group, labored for two years to develop technical and policy recommendations that were provided for consideration in final form to ARB, Acre (Brazil), and Chiapas (Mexico) in July 2013.[95]

Carbon capture and sequestration (CCS) is another option to reduce emissions under both the Cap-and-Trade Program and the Low Carbon Fuel Standard (LCFS). Successful development and deployment of CCS in California would provide in-State GHG emission reductions, lower an entity's compliance obligation under Cap-and-Trade, and potentially lower an entity's carbon intensity under LCFS.

B. Progress to Date

The initial Scoping Plan laid out an ambitious plan for reducing GHG emissions from a combination of direct regulatory measures, incentives, and market-based approaches. The Cap-and-Trade Program establishes an overall limit on GHG emissions from most of the California economy—the "capped sectors." Within the capped sectors, some of the reductionvvs are being accomplished through direct regulations, such as improved building and appliance efficiency standards, the LCFS, and the 33 percent RPS. Whatever additional reductions are needed to bring emissions within the cap is accomplished through price incentives posed by emissions allowance prices. Together, direct regulation and price incentives assure that emissions are brought down cost-effectively to the level of the overall cap. Reductions in the remainder of the economy—the "uncapped sector"—are being accomplished through specific measures, such as those for high-GWP gases and fugitive emissions from industrial sources.

Over the last five years, ARB has worked with other State and local agencies to implement the climate change programs outlined in the Scoping Plan and to ensure their smooth implementation. The State's progress on measures included in the Scoping Plan and other complementary activities have put California on the path to achieve the statewide GHG emissions limit of 1990 levels by 2020, and to achieve the maximum technologically feasible and cost-effective reductions over the long-term. Today, many of the State's GHG emission reduction measures and initiatives set forth in the initial Plan have been adopted and are in the early stages of implementation. Full implementation of all adopted measures by 2020 will not only allow us to reach our near term GHG goals but will also provide numerous additional public health and environmental benefits.

We measure progress toward the 2020 statewide limit in two ways:

- **Evaluating the expected emission reductions from ongoing regulations and programs**: ARB and other State agencies are implementing numerous programs to reduce GHG emissions. The California Greenhouse Gas Report Card is an annual report that summarizes state agency activity to reduce greenhouse gases.[96] To assess whether California will meet the 2020 limit, it is necessary to estimate the expected emission reductions from these measures in 2020 based on the regulatory requirements.

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95 REDD Offset Working Group. 2013. California, Acre and Chiapas – Partnering to Reduce Emissions from Tropical Deforestation: Recommendations to Conserve Tropical Rainforests, Protect Local Communities and Reduce State-Wide Greenhouse Gas Emissions. Available at *http://greentechleadership.org/documents/2013/07/row-final-recommendations-2.pdf*.

96 The State Agency Greenhouse Gas Reduction Report Card is available at : *www.climatechange.ca.gov/climate_action_team/reports/2013_CalEPA_Report_Card.pdf*.

- **Evaluating emission trends**: Each year, ARB updates the statewide GHG emission inventory. This information provides a retrospective look at emissions and is based on actual data, either reported directly to ARB or to other regulatory agencies. The emission inventory is useful for evaluating progress in sectors that are affected by many different programs. For example, the electricity sector is affected by the Renewable Energy Standard, energy efficiency programs implemented by utilities, appliance efficiency standards, building codes, and numerous other programs. One way to assess progress in this sector is to retrospectively examine whether actual emission trends are consistent with our expectations.

ARB used both of these methods to evaluate progress toward the 2020 statewide limit in this Update. As the Scoping Plan is in the early stages of implementation, this evaluation will be ongoing.

1. Key Accomplishments

California has undertaken a number of notable groundbreaking climate change initiatives. These include the first in the nation economy-wide Cap-and-Trade Program, the Low Carbon Fuel Standard, a 33 percent Renewable Portfolio Standard, and an Advanced Clean Cars program that has been adopted at the federal level. ARB has also worked closely with our local and regional partners to implement the Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375). Strategies developed under this program integrate land use, housing, and transportation planning to reduce regional passenger vehicle GHG emissions.

In addition to these efforts, additional actions include Building and Appliance Energy Efficiency Standards, the California Solar Initiative (i.e., Solar Hot Water Heaters and Million Solar Roofs), Water Efficiency, Mandatory Commercial Recycling, and High-Speed Rail.

2. GHG Emissions Trends

In 2006, Assembly Bill 1803 mandated that ARB prepare, maintain, and update California's statewide GHG emission inventory. The GHG emission inventory serves as the foundation for tracking the State's emission trends and progress toward California's GHG emission reduction goals. The GHG inventory provides estimates of the amount of GHGs emitted to the atmosphere by human activities within California. The inventory includes estimates for carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs), which are often referred to as the "six Kyoto gases," plus nitrogen trifluoride (NF_3). The emission estimates of the seven gases are typically expressed in terms of million tonnes of carbon dioxide equivalents ($MMTCO_2e$). The emissions of the non-carbon dioxide gases are converted in CO_2e units based on their global warming potential relative to that of carbon dioxide.

The California statewide GHG emission inventory is structured and aligned with the Guidelines for National Greenhouse Gas Inventories developed by the IPCC (2006). Emission estimates rely primarily on state, regional, or national data sources. The inventory also incorporates methodology and data from the Inventory of U.S. Greenhouse Gas Emissions and Sinks, published by the U.S. EPA.[97] Starting in 2008, facility-level data from ARB's Mandatory GHG Reporting Program have been used to compile statewide emissions from electricity generation facilities, refineries, cement plants, and lime and nitric acid production facilities.

ARB regularly publishes updated versions of California statewide GHG emission inventory on its Greenhouse Gas Emission Inventory website.[98] A technical support document detailing the data sources and methods used to develop the inventory is also available for download from the same website. The current inventory compiles statewide anthropogenic GHG emissions from 2000 through 2012, using consistent sets of data and methods to allow for the detection of trends over time (Figures 8a and 8b). ARB updated the GHG emission inventory in this Update to be based on GWPs in the IPCC's Fourth Assessment Report.

97 *www.epa.gov/climatechange/ghgemissions/usinventoryreport.html*)
98 *www.arb.ca.gov/cc/inventory/inventory.htm*.

Figure 8a: California Total and Per Capita GHG Emissions (2000-2012)

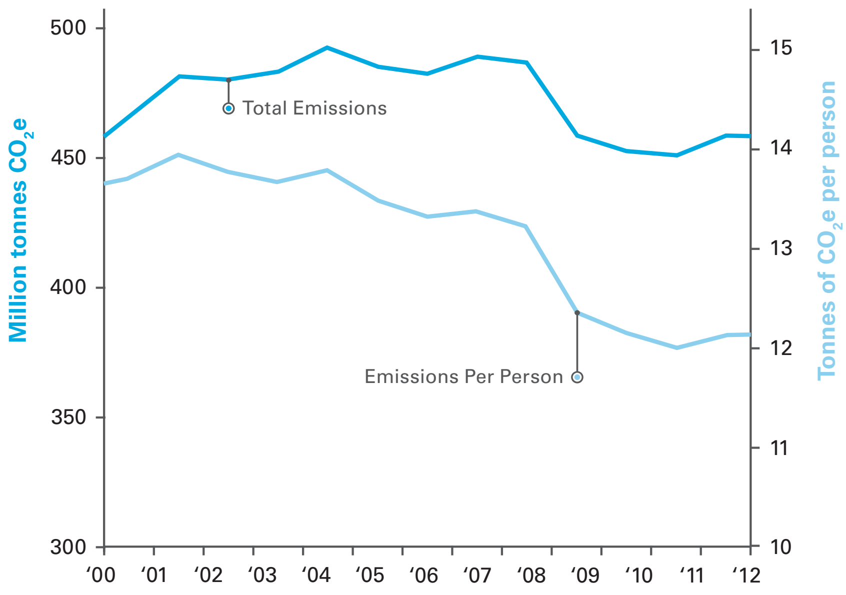
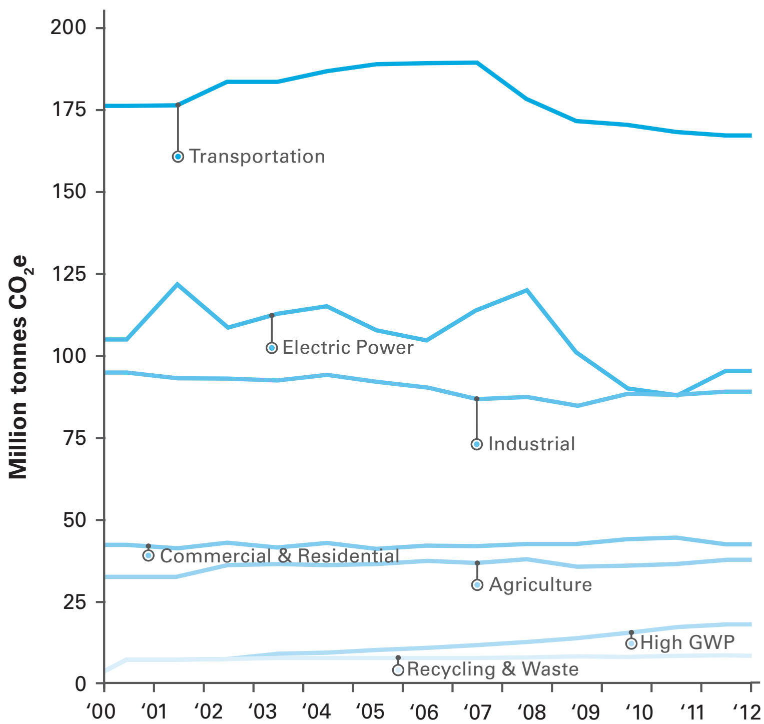


Figure 8b: California Sectoral GHG Emissions (2000-2012)



Over the last decade, the total statewide GHG emissions decreased from 466 $MMTCO_2e$ in 2000 to 459 $MMTCO_2e$ in 2012—a decrease of 1.7 percent. The emissions in 2012 increased for the first time in the five-year period since 2007. This increase was driven largely by the increased natural gas-generation of in-state electricity due to the closure of the San Onofre Nuclear Generating Station (SONGS) as well as dry hydrological conditions in 2012 (drought) causing a drop in the in-state hydropower generation. California's population grew by 11.3 percent between 2000 and 2012. As a result, California's per capita GHG emissions have decreased by 11.6 percent. The recent recession had a major impact on GHG emissions between 2008 and 2009, when emissions decreased by almost six percent. Other changes reflect ongoing early implementation of Scoping Plan measures, energy efficiency actions, renewable power requirements, and hydrology (rain and snow fall). In 2012, emissions from the transportation sector continued to decrease while emissions from the electric power sector increased from the previous year. Emissions from all other sectors remained relatively constant since 2000.

A summary of the trends in emissions observed for each of the major sectors of the statewide GHG inventory is provided below.

Transportation Sector: The transportation sector remained the largest source of GHG emissions in 2012, constituting more than 36 percent of California's GHG emission inventory. Emissions decreased by five percent between 2000 and 2012. Emissions from on-road vehicles constituted over 92 percent of the transportation sector. These emissions have declined each year since 2007, with the greatest decrease occurring at the time of the recession. In the summer of 2008, fuel prices reached a historic maximum, followed by a dramatic decrease in the consumption of gasoline and diesel fuel. Total transportation fuel consumption declined in 2008, and even with modest increases in 2009 and 2010, on-road emissions continued to decrease, remaining below pre-recession levels as the economy improved.

Electric Power: Greenhouse gas emissions from electricity generation have decreased by 9 percent from 2000 to 2012, in spite of the shutdown of the San Onofre Nuclear Generating Station (SONGS) and low hydro-power generation due to the drought, both of which caused an increase in emissions for 2012. California produces almost 70 percent of its electricity within the State and imports the rest. Emissions from in-state electricity generation decreased by more than 13 percent between 2000 and 2012. During that period, electricity consumption grew from 265.8 terawatt-hours (TWh) in 2000 to 282.1 TWh in 2012, with a peak of 288.0 TWh in 2008.

Over the last twelve years, on average, hydropower provided 13 percent of California's electric power generation. The amount of hydropower produced is dependent on rainfall and was highest in the two wettest years, 2006 and 2011. Hydropower production, as well as other non-emitting sources of energy, affects the GHG intensity of electricity generation (the amount of CO_2e emitted per megawatt-hour [MWh] generated). The GHG intensity of California electricity peaked in 2001 and reached a low point in 2011, a particularly wet year. Both the GHG intensity of in-state generation and that of electricity imports have been reduced since 2008, with in-state intensity showing a slight increase in 2012 due to the double impacts of the SONGS shutdown and the low hydro-power output caused by the drought.

Industrial Sector: Industrial emission sources include refineries, oil and gas extraction, cement plants, and other stationary sources that consume fuel. Emissions from the industrial sector have declined overall, decreasing by six percent between 2000 and 2012. Associated with the recession, a decline of three percent was observed in 2009. However, emissions grew by four percent from 2009 to 2010. Emissions from cement plants, made up of fuel combustion and clinker process emissions, peaked in 2005, with a decrease beginning in 2006 and continuing through 2010. Between 2005 and 2010, cement plant emissions declined 44 percent, reflecting a large decrease in demand due to the crisis in housing and construction, as well as the closure of three cement plants in the State over the period. Cement production has begun to recover, showing a 24 percent increase in emissions in 2012 from its 2010 low.

Commercial and Residential Sectors: Emissions from the commercial and residential sectors are driven by the combustion of natural gas and other fuels for household use and heating and for providing energy for commercial businesses. Emissions remain flat over the past twelve years between 2000 and 2012.

Emissions from residential fuel combustion showed a decline of five percent over the last twelve years, with its lowest point of 28.1 million tonnes occurring in 2012. At the same time, the number of housing units grew steadily, from 12.2 million units in 2000 to slightly over

13.7 million in 2012, resulting in a sharp decline in the fuel consumption per housing unit. The commercial sector emissions increased 16 percent between 2000 and 2012, but at the same time commercial use of floor space has increased slightly faster, resulting in slightly reduced emissions per unit of floor space.

Agricultural Sector: Agricultural emissions represent the sum of emissions from agricultural machinery fuel use, residue burning, soil management and fertilization, enteric fermentation, manure management, and rice cultivation. Emissions (primarily methane emissions from livestock) increased by 16 percent between 2000 and 2012. Agricultural fuel use was the only category that saw a GHG emissions decrease from 2000 to 2012, decreasing by three percent over that period. On the other hand, emissions from manure management increased 29 percent during the same period, reflecting the growth of the number of animals in agriculture in California.

High-GWP Gases: High Global Warming Potential (high-GWP) gases included in the inventory consist primarily of substitutes for ozone-depleting substances. Emissions from this sector increased by 129 percent between 2000 and 2012. This growth is driven by the increasing substitution of these gases to replace ODS gases in refrigeration, air conditioning, aerosols, and other applications over the last decade.

Recycling and Waste: Emissions from the recycling and waste sector consist of methane and nitrous oxide emissions from landfills and from commercial-scale composting, which increased by 16 percent between 2000 and 2012.[99] Emissions from landfills constitute about 94 percent of the total emissions of this sector. In 2000, 37 million tons of solid waste was deposited in California's landfills; deposits grew to 42 million tons by 2005, followed by a steady decline to 29 million in 2012. The decrease in annual landfill deposits has not yet resulted in a landfill emissions trend decline however, since the total waste-in-place not yet decomposed that has accumulated from the landfills' opening continues to drive the increasing amount of landfill gas generated.

3. Emission Reductions to Meet the 2020 Statewide Limit

Assembly Bill 32 required ARB to determine California's 1990 statewide GHG emissions level, which would become California's near-term statewide emissions limit to be achieved by 2020. ARB developed a California statewide GHG emission inventory for years 1990–2004 to support the effort of determining the 1990 level and 2020 emissions limit. In December 2007, the Board approved a total statewide GHG 1990 emissions level and 2020 emissions limit of 427 $MMTCO_2e$, based on the IPCC's Second Assessment Report. As discussed in Chapter II, most national and international climate change organizations are moving to the IPCC's Fourth Assessment Report, which updated the global warming potential of GHGs, especially methane and HFCs. ARB is proposing to update the number for the 2020 limit, weighting the 1990 emissions with 100-year GWPs from the IPCC's Fourth Assessment Report. The new 2020 statewide limit is 431 $MMTCO_2e$—an approximately one percent increase from the 427 $MMTCO_2e$ limit adopted by the Board in 2007. In addition, to assess progress toward the limit in a consistent manner, ARB is using GWPs from the Fourth Assessment Report to update projections of the emission reductions that adopted and anticipated Scoping Plan measures will achieve.

ARB maintains the statewide GHG emission inventory to track California's progress toward the 2020 statewide emissions limit. To determine the amount of GHG emission reductions needed to reduce to 1990 emissions, ARB developed a forecast of 2020 emissions in a business-as-usual scenario (2020 BAU),[100] which is an estimate of the emissions expected to occur in the year 2020 if none of the foreseeable measures included in the Scoping Plan[101] were implemented. ARB

99 See the Recycling and Waste sector discussion earlier in this chapter for a discussion of additional GHG emission reductions associated with upstream activities.

100 *www.arb.ca.gov/cc/inventory/data/forecast.htm*.

101 *www.arb.ca.gov/cc/inventory/data/tables/reductions_from_scoping_plan_measures_2010-10-28.pdf*.

subtracts the estimated reductions from adopted and anticipated measures in 2020 to determine whether the 2020 limit is within reach (Table 5). The Cap-and-Trade Regulation provides a firm cap, ensuring that the 2020 statewide emission limit will not be exceeded. Thus, the estimated emission reductions attributed to the Cap-and-Trade Program depend on the emissions forecast. For example, if the emissions forecast increases, the reductions associated with the Cap-and-Trade Program will increase.

Table 5: Meeting the 2020 Emissions Target

Category	2020 ($MMTCO_2e$)**
AB 32 Baseline 2020 Forecast Emissions (2020 BAU)	509
Expected Reductions from Sector-Based Measures	
Energy	25
Transportation	23
High-GWP	5
Waste	2
Cap-and-Trade Reductions	23*
2020 Limit	431

* Cap-and-Trade emission reductions depend on the emission forecast.
** Based on AR4 GWP values.

C. Next Steps

Since the initial Scoping Plan was released, California has put in place a number of measures that have already led to significant emission reductions, and a transformation to a strong, stable low-carbon economy in California is under way. It is critical that California continues to develop and implement a successful climate policy. Planning must begin now to transition the State toward meeting our longer-term GHG emission reduction goals. Table 6 summarizes the recommended actions the State should take in each of the sectors discussed earlier in this chapter to meet our climate change goals.

Table 6: Summary of Recommended Actions by Sector

All Sectors		
Set mid-term targets to meet a State mid-term GHG emission reduction goal when defined.		
Energy Actions	**Lead Agency**	**Expected Completion Date**
Develop a comprehensive and enforceable GHG emission reduction program for the State's electric and energy utilities.	ARB CEC CPUC CAISO	2016
Develop criteria and rules for flexible demand response resources to participate in wholesale markets and integrate variable renewable resources.	CPUC CAISO	TBD
Expand participation of regional balancing authorities in CAISO Energy Imbalance Market and other methods of balancing authority cooperation.	CAISO	Ongoing
Through AB 758 process, develop a plan to encourage energy assessments and energy use disclosure requirements.	CEC	2016
Enhance energy efficiency and demand-response programs, and develop robust methodologies to monitor and evaluate the effectiveness of these programs.	CEC CPUC CAISO	Methodologies by 2015/ Enhanced program proceedings by 2016
Develop ministerial, low-cost interconnection process for distributed generation.	CPUC CEC CAISO	2015
Assess existing barriers to expanding the installation of CHP systems and propose solutions that help achieve climate goals. A future CHP measure could establish requirements for new or upgraded efficient CHP systems.	ARB CEC CPUC CAISO	2016
Continue development of statewide programs that could require new residential and commercial construction to meet ZNE standards.	ARB CPUC CEC	TBD
Develop cost-effective, on-site reductions for large industrial facilities, consistent with the audit findings under the Energy Efficiency and Co-Benefits Audits for Large Industrial Sources Measure.	ARB	TBD
Develop measures to control fugitive methane and carbon dioxide emissions from oil and gas production, processing, and storage tanks.	ARB	2014
Develop measures to reduce fugitive emissions from natural gas transmission and distribution pipelines and associated facilities (e.g., compressor stations).	ARB CPUC	TBD in the SLCP Plan
Work with the local air districts to evaluate amendments to their existing leak detection and repair rules for industrial facilities to include methane leaks.	ARB	Ongoing
Evaluate the potential for CCS in California to reduce emissions of CO_2 from energy and industrial sources. Working with Division of Oil, Gas and Geothermal Resources, CEC and CPUC, ARB will consider a CCS quantification methodology for use in California	ARB	2017

Transportation Actions	Lead Agency	Expected Completion Date
Propose "Phase 2" heavy-duty truck GHG standard standards.	ARB	2016
Expand upon 2013 ZEV Action plan for medium- and heavy-duty ZEVs.	OPR	2017
Enhance and strengthen the LCFS with more aggressive long-term targets.	ARB	2014
Adopt the necessary regulations and/or policies to further support commercial markets for low-carbon transportation fuels.	ARB CPUC CEC CDFA	2018
Evaluate updating the SB 375 regional targets established in 2010.	ARB	2014
Ensure GHG emission reductions from approved SCS are achieved or exceeded through coordinated planning.	ARB Caltrans SGC HCD Local & Regional	Ongoing
Construct HSR system • Complete all station-area planning. • Complete Caltrain component of HSR. • Complete initial operating segment of HSR. • Run HSR from San Francisco to Los Angeles.	High-Speed Rail Authority	 2017 2019 2022 2029
Complete the first phase of the Sustainable Freight Strategy, which will identify and prioritize actions through 2020 to move California towards a sustainable freight system.	ARB	2014
Provide expanded markets for clean passenger transportation, advanced technology trucks and equipment, low-carbon transportation fuels and energy, and related infrastructure.	ARB CEC CPUC CDFA	TBD
Consider lifecycle benefits and impacts for transportation infrastructure projects	Caltrans	TBD
Increase Caltrans and regional transportation agencies' investments in expanded transit and rail services, active transportation, and other VMT reduction strategies in regional transportation plans.	Caltrans & Regional Transportation Agencies	TBD
Support Sustainable Communities Strategies to provide more efficient consumer choices.	SGC	Ongoing
Incorporate into ongoing GHG planning efforts strategies that help achieve significant NO_x reductions by 2032 to meet the national ambient air quality standards for ozone. The 2016 SIPs will outline attainment strategies through 2032.	ARB Caltrans	2016

Agriculture Actions	Lead Agency	Expected Completion Date
Convene an interagency workgroup whose purpose is to: (1) establish agriculture-sector GHG reduction planning targets for the mid-term time frame and 2050; (2) develop a California-specific agricultural GHG tool to estimate GHG emissions and sequestration potential from all on-farm sources; (3) strategies to reduce GHG emissions associated with energy in agricultural water use.	CDFA ARB CEC CPUC	2014
Develop a methane capture standard.	Dairy Digester Workgroup	2016
Evaluate data reported to Long Term Irrigated Lands Programs, to determine if the reported fertilizer data are adequate to establish a robust statewide GHG N_2O inventory for fertilizer used in agriculture.	RWQCB	2017
Develop recommendations for a coordinated local land use program.	OPR CNRA CalEPA CDFA ARB	2015
Implement actions in Bioenergy Action Plan to promote the input of digester biogas into natural gas pipelines and bioenergy onto the electric grid, evaluate the potential biomass energy generation capacity, and develop methods to quantify biomass life-cycle GHG flux.	Bioenergy Interagency Working Group	Ongoing

Water Actions	Lead Agency	Expected Completion Date
Give priority to funding integrated management plans that include robust existing or proposed water and energy conservation and efficiency, and measures that achieve GHG emission reductions. Conservation programs must include numeric targets.	DWR SWRCB	2014
Implement new water-related energy conservation measures and efficiency standards	CEC	2015
Complete water-energy nexus rulemaking and continue implementation of joint water-energy utility efficiency programs and partnerships.	CPUC	2016
Incent resource-recovering wastewater treatment projects.	SWRCB CPUC	2015
Implement green infrastructure permits to treat and capture urban runoff for local use.	SWRCB RWQCB	2016
Guide adoption of GHG emission-reducing policies for water sector investments and action. Conservation measures and regulations to reduce GHG emissions and maintain water supply reliability during drought periods will be a centerpiece of this administration action.	DWR SWRCB CPUC CDFA ARB	2015
Identify and incent implementation of rate structures that accurately reflect the economic, social, and environmental value of water in California while maintaining affordability for basic services.	DWR SWRCB CPUC CDFA	TBD
Develop a comprehensive groundwater management strategy and provide technical and financial assistance to exceed SBx7-7 targets.	SWRCB DWR CDFA	TBD
Modify State and regional water board policies and permits to achieve conservation, water recycling, stormwater reuse, and wastewater-to-energy goals.	SWRCB RWQCB	2016
Promote water-energy conservation outreach and education.	DWR SWRCB CPUC CEC CAISO	TBD

Waste Management Actions	Lead Agency	Expected Completion Date
Eliminate the disposal of organic materials at landfills.	CalRecycle ARB	2016
Implement financing or incentive mechanisms for in-State infrastructure development to support Waste Sector goals.	CalRecycle ARB	TBD
Develop actions to address cross-California agency and federal permitting and siting challenges associated with composting and anaerobic digestion.	ARB	2014
Identify opportunities for additional methane control at new and existing landfills, and use of captured methane as a fuel source for stationary and mobile applications.	ARB	TBD in the SLCP Plan
Develop new emission reduction factors to estimate GHG emission reduction potential for various recycling and remanufacturing strategies.	ARB CalRecycle	TBD
Identify improvements to the procurement of recycled-content materials through the State Agency Buy Recycled Campaign reform.	CalRecycle DGS	2014
Natural and Working Lands Actions	**Lead Agency**	**Expected Completion Date**
Convene an inter-agency forest climate workgroup to prepare and publish a "Forest Carbon Plan."	CNRA CalEPA	2016
Evaluate methods to develop a life cycle analysis to track carbon in wood products.	CAL FIRE BOF	2016
Implement actions in Bioenergy Action Plans related to use of forest biomass, evaluate the potential biomass energy generation capacity, and develop methods to quantify biomass life-cycle GHG flux.	Bioenergy Interagency Working Group	Ongoing
Develop recommendations for a coordinated local land use program.	OPR CNRA CalEPA CDFA CDFW CAL FIRE ARB	2015
Convene an interagency workgroup to draft a report outlining funding needs, opportunities, and priorities for Natural and Working Lands.	CNRA CalEPA CDFA CDFW CAL FIRE ARB	2015
Expand urban forestry and green infrastructure programs and investments, particularly in California's environmental justice communities.	CAL FIRE	Ongoing

Short Lived Climate Pollutants Actions	Lead Agency	Expected Completion Date
Develop a comprehensive strategy for mitigation of short-lived climate pollutants, including methane.	ARB	2015
Continue diesel controls that will reduce black carbon emissions by 95 percent from the late 1960s to 2020.	ARB	2020
Reduce emissions of smog-forming pollutants by about 90 percent below 2010 levels by 2032 to meet the National Ambient Air Quality Standard for ozone.	ARB	2032
Create an agreement with U.S. EPA to establish national standards for the proposed F-gas phasedown of HFC production.	ARB	2030
Require low-GWP gases where feasible and cost-effective.	ARB	TBD in the SLCP Plan
Incentivize recovery and destruction of ODS at end of life by a combination of strategies.	ARB	TBD in the SLCP Plan
Set an upstream mitigation fee on sales of high-GWP gases and sales or import of equipment pre-charged with high-GWP gases.	ARB	TBD in the SLCP Plan
Green Building Actions	**Lead Agency**	**Expected Completion Date**
Build on California's existing zero net energy building goals and activities.	CEC CPUC	2015
Continue research activities to better quantify GHG emission reduction potential of certified green buildings.	ARB	2016
Strengthen the next two triennial editions of the Green Building Standards Code with mandatory provisions that reduce GHG emissions.	CBSC	2016 & 2019
Building on AB 758 Action Plan implementation activities, explore opportunities to implement a portfolio of green building retrofit requirements at time-of-sale or other trigger mechanism.	CEC	2017
Explore methodologies to quantify direct and indirect GHG emissions from new and existing buildings.	TBD	2017
Establish target dates and pathways toward transitioning to zero net carbon buildings that expand upon and complement ZNE goals.	ARB CPUC CEC	2017
Implement a mechanism to track progress toward achieving statewide green building goals.	ARB CPUC CEC	2018
Cap and Trade Actions	**Lead Agency**	**Expected Completion Date**
Develop a plan for a post-2020 Cap-and-Trade Program, including cost containment, to provide market certainty and address a mid-term emissions target.	ARB	2017

Evaluation Actions	Lead Agency	Expected Completion Date
Develop a plan for an Ex Post Assessment of Realized Cost and Benefits of AB 32.	ARB	2014
Assess the effects of AB 32 programs on disadvantaged communities	ARB	2014 (Phase I)
Develop guidance for agencies administering Cap-and-Trade auction proceeds, including actions to fulfill the requirements for investments to benefit disadvantaged communities.	ARB	2015
Report annually to the Legislature on auction proceeds investment results and benefits to disadvantaged communities.	ARB DOF	Ongoing
Update the three-year Cap-and-Trade Auction Proceeds Investment Plan, identifying funding gaps and new investments needed for GHG emission reductions and other environmental and public health benefits.	ARB	2016

V. Achieving Success

Climate change presents an unprecedented set of challenges for California that cuts across sectors and policy areas. These emerging challenges are increasingly unifying policy planning across government agencies and jurisdictions, allowing us to do more with less – achieving multiple goals more quickly and effectively than if we address separate priorities in isolation.

Successfully delivering on California's climate policies and realizing the full benefits of California's leading approach to climate change requires careful policy planning and implementation, diligent monitoring, and evaluation of policies (Chapter VI). We are integrating climate thinking and sustainability programming into the range of actions we take to grow the economy, protect the environment, and plan for the future. Increasingly, we must coordinate planning to ensure that the way we design and grow our communities for the future allows us to meet all of our goals – including those related to economic growth, equity, climate change and resiliency, air quality, water quality and reliability, mobility, public health, and others. Of course, achieving success requires targeted investment and market support, to launch commercial markets for the cleanest technologies and build the infrastructure we need to support continued economic growth in California that is increasingly free of pollution and consequence for disadvantaged communities or future generations. And it requires active outreach to share our successful approach and expand global action to address climate change.

With strategic investment and coordinated policy-making, California can slash emissions from trucks and trains while at the same time building a world-class goods movement and freight-delivery system. We can modernize our rail and passenger transportation systems to move people in ways that both reduce greenhouse gases and increase mobility options and safety. We can take actions to cut emissions of potent short-lived climate pollutants that will also deliver key public health benefits. And we can align strategies that both support reduction goals and bolster our ability to deal with the impacts of climate change already underway.

The imperative of climate change can push action to advance priorities that affect every aspect of our built and natural environments, and quality of life. Effectively implementing California's climate plan will not just chart the path in the fight against climate change, but also to cleaner air, better health, and lasting, equitable growth.

A. Integrate and Coordinate Planning

California faces many critical, and equally important, planning objectives. In order to most effectively meet each of them, minimize costs, and maximize and accelerate benefits, the State is focused on integrating planning objectives and ensuring that limited investments advanced as many objectives as possible. The strategies we pursue to cut greenhouse gas emissions from our cars, trucks, buses, trains and industries can support ongoing efforts to improve air quality up and down the state, especially in our most heavily impacted communities. Efficiency and conservation programs in the water sector needed to cut emissions will also drive critically needed efforts to enhance supply and reliability priorities. We can cut emissions from our waste stream while also increasing home-grown sources of low-carbon energy and fuels. And we can manage our natural lands and valuable agricultural resources in ways that both achieve climate goals and enhance their long-term sustainability.

The nexus between air quality and climate is a key example. The South Coast and San Joaquin Valley Air Quality Management Districts, together home to more than half of the State's population, must reduce emissions of smog-forming pollutants by about 90 percent below 2010 levels by 2032 to meet the National Ambient Air Quality Standards. Many of the technologies and strategies to reduce smog-forming pollution or GHG emissions are the same. Advancing progress on climate change should advance progress on air quality, and vice versa. By effectively integrating our planning to do so, as California has done through its Vision modeling exercise and Sustainable Freight Plan (among other activities), we can accelerate progress to meet both air quality and climate change objectives.

Amid dire drought, the availability, reliability, and quality of water are taking center stage. Water efficiency, conservation, and storage are connected to energy efficiency and supply, food supply, land use and housing, and economic growth of our agricultural and other sectors. The phase-out of once-through cooling in the State's power plants links energy supply with water availability, quality, and habitat. As we respond to the drought, develop an increasingly clean and reliable energy supply system, and build upon California's climate framework, we must ensure that our efforts in one area recognize and reinforce the objectives in the others. To that end, DWR has developed a Climate Action Plan. The State Water Board is developing a Guidance Document on Climate Change. Together with other efforts being led through the Climate Action Team and those identified in this Update, California is increasingly focused on integrating objectives for climate and water policy planning.

Increasingly, technologies and planning objectives are converging across sectors. Electrification in the transportation and building sectors must coincide with decarbonization of electricity supply. New electricity loads from these sectors, as well as increasing levels of renewable generation, will change the operational requirements of the electricity grid, which in turn affects emissions and operations for electric transportation. Changes in the energy sector will affect the water and agricultural sectors due to the significant amount of energy used to move water throughout the State and the important role and evolving role of hydropower in the electricity system. Green and net zero energy buildings create new accounting requirements and interactions between utilities and customers and buildings and the electricity grid. The growing role of bioenergy for transportation fuels, heat production, and electricity generation will impact the agricultural, natural lands, water, and waste management sectors. All of this will have direct or indirect effects on land use that will require integrated planning and a closely coordinated effort with locally driven GHG emission reduction initiatives. State agencies are addressing each of these cross-cutting issues and others through standing, interagency working groups that all keep climate change as an overarching or integral theme.

Integrating planning to achieve multiple objectives inherently requires coordination among planning agencies across sectors, systems, and governmental jurisdictions. Already, climate change is serving as a unifying objective that is bringing unprecedented levels of collaboration among government agencies. California state agencies meet routinely and work very collaboratively as part of the Climate Action Team or other climate-related working groups. ARB is working with Caltrans, the South Coast Air Quality Management District, and many other agencies and stakeholders to develop the Sustainable Freight Strategy. SB 375 has created new relationships and coordinated planning between state and local planning agencies. The Desert Renewable Energy Conservation Plan is a unique collaboration among state and federal agencies. And this Scoping Plan Update is key example of the level of coordination happening among California State agencies to address climate change.

State Plans that Will Assist the State in Meeting Its GHG Goals

- California Climate Adaptation Strategy
- Safeguarding California Plan (Update to 2009 Adaptation Strategy)
- California's Clean Energy Future
- ARB's Vision for Clean Air
- California Agricultural Vision
- DWR Climate Action Plan
- CEC Integrated Energy Policy Report
- California Transportation Plan
- Strategic Fire Plan for California
- Water Action Plan
- Environmental Goals and Policies Report
- Zero Emission Vehicle (ZEV) Action Plan
- Caltrans Interregional Blueprint
- Climate Research Plan
- Vision California
- State Implementation Plan
- CDFW Vision for Confronting Climate Change in California
- Extreme Heat Adaptation Guidance Document
- AB 341 75% Plan (in development)

California's state agencies are collaborating to achieve the State's climate change goals and broader environmental protection goals, in concert with achieving their own individual agency's goals. It will be necessary to maintain and strengthen this collaborative effort, and to draw upon the assistance of regional and local governments and private institutions, to achieve the State's near-term and longer-term emission reduction goals and improve its ability to adapt to potential climate change impacts.

The Governor's Office provides leadership to set priorities and to ensure a coordinated effort is taken among the numerous State agencies and departments in pursuing GHG emission reductions. To this end, Governor Brown has overseen the development of the Zero Emission Vehicle Plan and Bioenergy Action Plan, and has set distributed generation and combined heat and power goals for the State in his California Clean Jobs plan. The Governor's Office of Planning and Research (OPR) has hosted several stakeholder conferences and participated in research efforts on issues including climate change adaptation risks and strategies, zero emission vehicles and infrastructure planning, strategies to increase renewable and distributed energy integration, GHG emission assessments in CEQA, and streamlining criteria. OPR is also providing outreach and technical assistance to regional and local government transportation and land use planning agencies.

Climate change, like many issues, crosses economic sectors, policy areas, and governmental jurisdictions. Recognizing this, the State has established interagency workgroups to provide coordinated policies and strategies in various key areas where GHG emission reductions are needed to meet California's 2020 limit. For example, the Water-Energy Team of the Climate Action Team (WET-CAT), consisting of over two dozen State agency and academia representatives, is tasked with coordinating efforts on both GHG emission reductions and adaptation actions affecting the portion of the energy sector that supports the storage, transport, and delivery of water in California while ensuring that the State continues to maintain water quality and adequate water supplies. Part of the WET-CAT effort has been to provide recommendations to pertinent agencies on water and energy policies and actions.

This Update is California's plan for future actions to reduce climate-changing emissions. Other State agencies have already developed plans and actions specific to their priorities that will assist California in fulfilling the vision set forth in the Scoping Plan and this Update, and are expected to continue to do so. Some plans are interagency plans, developed in coordination with numerous State agencies' policies and priorities. Future State agency planning tools must incorporate mechanisms to help the state meet California's GHG emission reduction goals.

Action plans have been developed in concert with adaptation planning and climate research. State environmental goals and objectives should be integrated and framed to align State agency decision-making toward attaining these goals, as proposed in the Governor's Environmental Goals and Policies Report.

B. Transportation, Land Use, and Housing Planning Development

One of the most critical, cross-cutting issues for addressing climate change and other integrated policy priorities is land use and development.

Over the past 60 years, growth in automobile ownership, development of the highway system, and the rise of suburban neighborhoods has dominated the landscape in much of California and the United States. This development pattern has created a dispersed network of cities and towns, which can be difficult to serve efficiently with transportation and other necessary public services. In the same way that past policies have shaped today's built environment, actions taken today will establish the foundation for a more sustainable future.

For the first time, State law (SB 375) requires an integrated approach to planning our transportation system and land use. Metropolitan planning organizations and local governments are collaborating to evaluate alternative future scenarios that could make land use development patterns and supportive transportation systems more sustainable. Regional planning agencies that are responsible for forecasting growth and preparing transportation plans to accommodate that growth are already responding to significant demographic and market shifts that call for changes in the way we plan our housing and transportation

SUCCESS STORY

Local Governments in Action

In 2013, the City of Palo Alto switched to 100 percent renewable energy. To support this, the city authorized solar power purchases totaling 182,500 MWh of solar a year—enough to power the city's 65,000 residents and more.

The City of Tulare in central San Joaquin Valley has implemented extensive building retrofit and residential solar programs, created a 100 percent green-powered wastewater treatment facility by installing a 900 kilowatt (kW) fuel cell system, one MW of solar power, and much more. Through these improvements, Tulare is expected to save more than $13.9 million in energy costs and avoided capital and operation costs.

In 2010, the Metropolitan Transportation Commission awarded $33 million in grants to promote: innovative, breakthrough techniques to reduce GHG emissions; purchase electric vehicles for public agencies and tribes, and to electrify City CarShare; bringing shore power to the Port of Oakland; implementation of bike-detecting traffic signals; and more.

In December 2012, the City of Glendale launched the use of "smart meters" for all 120,000 residents, which will result in considerable electricity savings over the next 15 years through energy efficiency, increased options for time-of-use electricity rates, and real-time user consumption data to encourage conservation.

Sonoma County's Energy Independence Program (SCEIP) is an innovative voluntary financing program that uses the property tax system to fund permanent energy efficiency, water-efficiency, and renewable-energy improvements. Since 2009, SCEIP provided $64 million in funding to more than 1,900 property owners in the county.

infrastructure. Recently adopted regional sustainable community strategies (SCS) are designed to respond to shifts in the way future generations of Californians will live, work, recreate, and travel. As residential development constitutes the largest share of urbanized and land uses, changes in housing development are particularly critical to influencing travel patterns, energy use, and emissions. Location-efficient, affordable transit-oriented development (TOD), for example, has been estimated to yield VMT reductions of 20 to 40 percent over households in non-TOD locations. In large urban regions of California, the demand for more livable cities with smaller dwelling units located close to activity centers and more transportation options are creating momentum for more sustainable community development. As transit ridership is highest among lower-income households, many of whom already reside in transit-rich areas, the preservation and upgrading of affordable housing in these locations is also important.

Traffic congestion and higher gasoline prices are forcing consumers to consider the financial ramifications of longer commutes and continued use of fossil-fueled vehicles. Recent demographic trends predict a shift toward lower vehicles miles traveled both in-state and nationally, along with changing attitudes toward driving automobiles. For example, nationally, young people between 16 and 34 drove 23 percent fewer miles on average in 2009 than they did in 2001.[102] Those born between 1983 and 2000 are more likely to want to live in urban and walkable neighborhoods and are more open to public transportation than older Americans. These trends are expected to continue beyond 2020.

Metropolitan areas are beginning to change and trend toward more dense urban development designed to minimize energy consumption, waste output, air pollution, and water pollution. Business districts are encouraging more infill development that offers a mix of residential space, entertainment, restaurants, shopping, and other amenities within close proximity, which reduces dependence on private vehicles. These trends create opportunities for developers to satisfy changing consumer desires and for land- use planners to establish policies for more sustainable development patterns. It takes decades for changes in land use and transportation policies to result in tangible changes, including GHG emission reductions. The next generation of regional integrated plans is expected to result in climate benefits well beyond the 2035 time horizon.

Integrated regional planning efforts under SB 375 enable communities to understand the differences between alternative development patterns and to make choices accordingly. Recently approved SCSs reflect regional goals for a more sustainable form of community development that brings with it economic, social, and environmental benefits. The implementation of these regional goals through individual action by local governments and the development community will be essential to meeting the State's ongoing climate objectives. The success of efforts to reduce GHG emissions within other economic or resource sectors such as water, energy, and transportation will be greatly improved by a transition to more sustainable land use practices in the years ahead.

Similarly, California must pursue integrated planning in the freight sector, recognizing that passenger vehicles and trucks share the same transportation system.

C. Investments

Investments in financial incentives and direct funding are critical components for successful implementation of GHG emission reduction strategies. These investments combine with California's regulatory and market-based programs to provide an environment where businesses that make smart investments can be rewarded for developing advanced technologies. Targeted, performance-based standards and technology-forcing rules can kick-start markets and drive technologies to higher volumes, lower prices, and ultimately, to become market-winning solutions, rather than compliance approaches. Strategic financial investments and policy support can accelerate market transitions to cleaner technologies.

102 Dutzik, T., and P. Baxandall. 2013. A New Direction: Our Changing Relationship with Driving and the Implication's for America's Future. U.S. PIRG Education Fund and Frontier Group. Spring.

The initial Scoping Plan contained a comprehensive array of strategies to reduce GHG emissions in California and acknowledged the important role that strategic investments and financial incentives play in moving the State toward the 2020 goal. The initial Plan noted that funding, combined with effective regulatory policies, should help to foster an economic environment that promotes California-based investment and the development of new clean energy. Many of the initial Plan's measures relied on incentives and funding to achieve the full benefits, including energy efficiency, forestry management, and local land use planning.

The State has existing, but limited, incentive programs and it is critical to use these resources effectively to leverage private-sector investment and build sustainable, growing markets for clean and efficient technologies. Some examples include: millions of dollars in rebates for Californians that purchase or lease electric or fuel cell cars; millions of dollars for grants to help diesel truck owners buy cleaner trucks; billions of dollars in assistance to help improve the energy efficiency of homes and businesses; and the potential use of Cap-and-Trade revenue to promote growing clean energy markets.

There are many existing funding programs that work in tandem at the Federal, State, and local levels to achieve GHG emissions reductions and help foster the transition to a clean energy economy. For example, since 2008, the CEC has administered the Alternative and Renewable Fuel and Vehicle Technology Program, authorized under AB 118 (Núñez, Chapter 750, Statutes of 2007) to fund alternative and renewable fuels and advanced transportation technologies and help meet California's climate change goals. The program invests $100 million annually to develop and deploy advanced technology fuels, build fueling infrastructure, purchase clean vehicles, and provide the workforce training that is needed to operate and maintain these new technologies. In addition, ARB administers the Air Quality Improvement Program (AQIP) which is also authorized under AB 118 and continues to provide incentives for zero-emission passenger vehicles, zero-emission and hybrid trucks, and advanced technology demonstrations. These AB 118 programs are critical to meeting California's long-term air quality and climate change goals and have recently been reauthorized through 2023[103] providing about $1 billion in public investments over the next decade to reduce GHG, criteria, and toxic emissions.

Table 7 highlights some of the existing federal, State, and regional incentive programs.

103 Assembly Bill 8, (Perea, Chapter 401, Statutes of 2013).

Table 7: Existing Regional, State, and Federal Incentive Programs

Regional Programs
• Clean truck and bus grants/incentives from local air districts • Urban greening and sustainable development grants from metropolitan planning organizations and local governments • Utility rebates/incentives for energy efficiency and renewable energy • Transit assistance from local governments and transit operators • Water efficiency and wastewater diversion projects via local air, water and sanitation agencies
State Programs
• ARB incentives for clean cars and buses, fuel infrastructure, equipment electrification, and RD&D of sustainable freight technology • CEC incentives, via the Electric Program Investment Charge (EPIC) Program and AB 118, for alternative and renewable energy, alternative fuel technology, energy efficiency, waste-to-energy, and applied research and development for innovative energy technology • CPUC and CSD* energy efficiency, weatherization, and solar projects • Climate dividends for electricity ratepayers • Energy efficiency projects for schools and clean energy jobs via Proposition 39 • SGC/DOT/HCD** grants for sustainable community planning and development • CalRecycle incentives for waste reduction, recycling, and composting, including infrastructure • CAL FIRE/CDFW support for natural resource protection • HCD Transit Oriented Development Housing Program (TOD) • CDFA funding for RD&D of environmentally sound fertilizing materials
Federal Programs
• U.S. EPA incentives reducing mobile source emissions, encouraging smart growth and increasing multi-modal transportation options • U.S. DOE funding for energy efficiency, renewable energy, alternative fuels and vehicles, and alternative fuel infrastructure • U.S. DOT incentives for increased transit opportunities, cleaner fuels, congestion reduction, and multi-modal transportation options • U.S. Department of Housing and Urban Development (HUD) funding for residential energy efficiency and affordable infill development • U.S. Department of Agriculture (USDA) support for rural electricity and bioenergy programs

* (CSD) Community Services & Development, **(HCD) Housing and Community Development;

While the funding resources shown above represent existing programs, the initial Scoping Plan focused on potential State proceeds from the auction of allowances under the Cap-and-Trade regulation. The initial Plan also identified a number of possible investments, including funding energy efficiency and renewable resource development, providing incentives to local government, delivering rebates to consumers, and funding research, development, and deployment.

In 2013, the Brown Administration developed an Investment Plan to guide the investment of State proceeds from Cap-and-Trade auctions—expected to be one of the largest State sources of funding for climate mitigation programs. The Investment Plan was developed to meet the requirements of AB 1532, SB 535, and SB 1018, which provide a framework for how the auction proceeds will be administered, including requirements to spend a percentage of the proceeds within disadvantaged communities and to benefit disadvantaged communities. The Administration's first three-year Investment Plan, which continues through the 2015–16 fiscal year, contained the following investment principles to guide the expenditure of auction proceeds:

- Emphasize investments in existing programs in sectors which have the greatest GHG emissions—transportation, energy, waste, and natural resources—with investments commensurate with relative emissions.
- Maximize economic, environmental, and public health benefits to the State.
- Foster job creation, through promotion of in-state GHG emission reductions carried out by California workers and businesses.

- Complement efforts to improve air quality.
- Direct investments toward the communities and households disproportionately burdened by multiple sources of pollution.
- Provide additional opportunities to businesses, public agencies, nonprofits, and other community institutions to participate in and benefit from statewide efforts to reduce GHG emissions.
- Lessen the impacts and effects of climate change on the State's communities, economy, and environment.

ARB will outline multi-year auction proceeds investment strategies every three years as part of the required updates to the Cap-and-Trade Auction Proceeds Investment Plan.

Building upon the results of the public process and multi-agency effort for the first three-year Investment Plan, the Governor's proposed January budget for fiscal year 2014-2015 (Proposed Budget) presented auction proceeds investments in existing State programs that support California's ongoing effort to reduce GHG emissions and promote a more energy-efficient California. The Proposed Budget included a balanced portfolio of $850 million in initial investments for GHG emission reductions and benefits to disadvantaged communities, as directed by SB 535 (De León, Statutes of 2012), in the transportation, energy, waste, and natural resources sectors.

An important element of auction proceeds investment will be identifying and funding projects that meet or exceed the requirements in SB 535, which states that at least 25 percent of funding provide benefits to disadvantaged communities and at least ten percent of funding be allocated to projects located in disadvantaged communities. Over the last year, the Administration has received comments with varying interpretations of how an investment can benefit disadvantaged communities. To ensure consistent implementation of SB 535, ARB will develop guidance for administering agencies, including what qualifies as a benefit to disadvantaged communities. ARB will solicit public input on this guidance and the SB 535 specific elements. Informed by the public process, ARB will also work with implementing agencies to define how those benefits can be quantified, tracked, and reported. Table 8 provides a preliminary timeline for the SB 535 implementation process.

Table 8: Proposed SB 535 Implementation Process

Activities	Preliminary Timeframe
• Develop preliminary guidance, including what it means for an investment to benefit a disadvantaged community • Solicit public input on SB 535 implementation	Summer 2014 to Winter 2015
• Quantify and report on benefits to disadvantaged communities • Revise SB 535 guidance as needed and as new investments are made	Each year

Continued investment in existing programs with established success in reducing GHG emissions will help maintain the 2020 limit. However, extensive additional innovative strategies and funding sources are needed in sustainable community planning and development, clean transportation, clean energy, energy efficiency, water efficiency, agriculture, natural resources, and waste diversion to achieve deeper emissions reductions.

For the near-term, funding is needed to fill information gaps and analyze the trade-offs associated with different policy choices and technologies. These strategic investments can be made now to demonstrate and identify projects with long-term environmental and economic benefits for California. For example, investment in research to develop improved fertilizer management practices has the potential to result in larger-scale strategies that can reduce GHG emissions while maintaining or enhancing crop yields.

On the transportation side, as part of 2013-14 State Budget, Governor Brown charged the California State Transportation Agency with identifying California transportation needs and long-term funding sources. Per this direction, in April 2013, the California State Transportation Agency formed the California Transportation Infrastructure Priorities Workgroup (CTIP) to help set priorities for transportation spending and explore long-term funding options to support California's infrastructure needs. In February 2014, the CTIP released a visioning document for the next ten years of California's transportation infrastructure that recognized the need to continue to seek consensus and implementation on viable long-term, dedicated, funding such as increased local revenue, mileage-based user fees, toll facilities and lanes, and others.

The availability of dedicated and long-lasting funding sources, such as those identified by the CTIP, helps provide certainty and additional partnership opportunities at the State, regional, and local levels for further investing in projects that have the potential to reduce millions of metric tons of GHGs, such as sustainable communities, transit infrastructure, energy conservation, renewable energy, and natural resources projects.

Funding available to support AB 32, whether from short or long-term sources, should be primarily focused on programs that (1) reduce GHGs or short-lived climate pollutants, (2) are consistent with state climate strategies, and (3) provide co-benefits such as job creation and better air quality. As an example, investments in urban forestry projects administered by Local Conservation Corps are identified in the Investment Plan and can provide economic and educational co-benefits combined with long-term carbon sequestration and GHG emission reductions. Table 9 describes the types of funding that support the purposes of AB 32 and provide valuable co-benefits.

Table 9: Funding of Specific Areas to Support AB 32

- Expansion of established programs:
    - affordable transit-oriented development (TOD) and infill housing development that cut VMT
    - local, regional, and state funding programs supporting transit, infrastructure, active transportation (walking/biking), land-use changes, and other projects that place a priority on reducing VMT and GHG emissions and are identified in the Sustainable Community Strategies or Regional Transportation Plans
    - rebates and grants for zero and near-zero emission vehicles, trucks, and buses
    - funding for goods movement and other mobile source advanced technology demonstration/deployment projects
    - residential energy efficiency financing mechanisms
    - weatherization and building energy efficiency upgrades
    - residential solar retrofits
    - incentives for small-scale energy storage systems and smart-grid technology to support zero-net energy buildings
    - water efficiency/conservation
    - industrial and agricultural operational energy efficiency
    - diesel pump replacement and electrification
    - Recycling Market Development Zones loans
    - organic waste reduction, recycling, and increased composting to turn waste into a resource

- Infrastructure investments that are integrated with sustainable community plans, maximize transit trips, and cut VMT
- Partnerships with local programs, such as the California Green Business Program, which promote and improve environmental practices within businesses to reduce GHG emissions
- Rail modernization efforts that grow transit ridership, improve mobility across the State, and reduce GHG emissions
- Wide-scale implementation of sustainable freight transport strategies and other mobile source strategies
- Research, development, and deployment for projects that have the potential to further reduce or sequester GHG emissions, such as low-emission distributed generation, advanced energy storage, renewable/low carbon fuels, and carbon capture, utilization, and sequestration
- Low carbon bioenergy, including developments in second-generation biofuels
- Urban forestry, forest, and biomass energy projects that result in a net increase in carbon stocks
- Agricultural and rangeland efforts to reduce or minimize GHG emissions through fertilizer and amendment strategies, soil management practices, and land conservation and management aligning with SB 375 and AB 32 goals
- Water conservation and efficiency
- Wetlands, rangelands, and other land use efforts to minimize GHG emissions or increase net sequestration
- Commercialization of low-/lower-GWP gas alternatives for existing high -GWP gases

Looking forward, the State will need to make targeted, priority investments with the limited funding available. California will need to continue coordinating and utilizing funding sources such as the Greenhouse Gas Reduction Fund[104] (auction proceeds), the Alternative and Renewable Fuel and Vehicle Technology Program (AB 118), Electric Program Investment Charge (EPIC) Program, and the Proposition 39: Clean Energy Job Creation Fund to expand investments in California's clean economy and further reductions in both GHG emissions and short-lived climate pollutants. For example, the State can use auction proceeds to provide rebates that encourage consumers to purchase zero- and near-zero emission vehicles. This effort can be coordinated with CEC AB 118 investments for the installation of charging infrastructure to help meet the objectives of AB 32 and move the State to the widespread adoption of zero-emission vehicles needed to achieve ongoing climate and air quality goals.

D. Expanding Climate Actions

California's achieved success of reducing emissions while supporting economic growth and improving quality of life creates another leading policy regime in California that others necessarily want to follow.

Engaging with other governments is critical to expanding action to address global climate change and maximizing benefits to California. Fostering broad action on the global scale is critical to minimize the impacts of climate change on California, reach sectors that California policy has a hard time affecting, and scale markets for clean technologies, including California products. California and other leading national and subnational jurisdictions are working to expand action to reduce emissions and combat climate change and share best practices in order to maximize the efficiency and benefits of doing so.

Successful climate action does not start or end with government, however. It depends on how we interact with our built and natural environments. It depends on how businesses create value and interact with customers. Ultimately, it depends on the choices we each make. A critical element of California's strategy to achieve climate policy success is remaining flexible, facilitating local and private sector leadership, and providing a greater array of choices for consumers that include cleaner technologies and lower carbon lifestyles.

1. Support Sustainable Choices by Households and Businesses

The choices that we make—where we live, how we travel, what we purchase—have significant impacts on energy use and GHG emissions. Individuals and businesses play critical roles in addressing climate change. According to a recent Lawrence Berkeley National Laboratory (LBNL) study,[105] changes in behavior can result in 8 to 17 percent energy savings. Moving forward, it will be essential to expand the range of options Californians have to live sustainable, healthy lives.

Through policies implemented under AB 32, California is offering consumers more choices. This is materializing in just about every area of our lives that is touched by the way we use energy and is illustrated by the examples below:

- **Cars and trucks**: We have an expanding array of choices in the cars and trucks that we drive. There is now a wide, and growing, range of efficient and zero emission vehicles in showrooms.
- **Alternatives to driving:** Those who want an alternative to driving or vehicle ownership are finding more alternatives, as local governments design their communities to accommodate more walking, biking, and public transportation and businesses pioneer new mobility models.
- **Fuels**: Drivers can now pick from fossil or bio-based gasoline and diesel, ethanol, electricity, natural gas, renewable natural gas, or hydrogen.

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104 AB 1532 (Pérez, Chapter 807), SB 535 (De León, Chapter 830), and SB 1018 (Senate Budget Committee, Chapter 39) established the GHG Reduction Fund to receive Cap-and-Trade auction proceeds.

105 Wei, M., J. H. Nelson, M. Ting, and C. Yang. 2012. California's Carbon Challenge: Scenarios for Achieving 80% Emissions Reduction in 2050. Lawrence Berkeley National Laboratory.

- **Energy in the home**: Homes and appliances are more energy efficient, delivering more comfort for less cost. Consumers have more control over how and when they use energy, how much it costs, and where it comes from. New home buyers can pick among an array of energy options, including various levels of efficiency and solar.
- **Business productivity**: Businesses are improving productivity and delivering more value with lower energy use and emissions. They have more options for cutting their energy costs and getting products to market quickly and efficiently. And they are leading on distributed generation deployment and clean energy investment.

Always, California's climate policies and programs need to leverage and enable its citizens and businesses to innovate and further reduce GHG emissions.

2. Enable Local and Regional Leadership

California's local and regional governments are critical partners in meeting the State's GHG goals. They have broad influence and, in some cases, sole authority over activities that contribute to GHGs and air pollutants, including industrial permitting, land use and transportation planning, zoning and urban growth decisions, implementation of building codes and other standards, and control of municipal operations.

Local and regional governments are uniquely positioned to collaborate to affect GHG emission reductions on a larger scale. As cities and counties fall into a larger regional framework, they are working together to create synergistic relationships for reductions through land use and transportation networks, as well as within specific sectors, such as energy.

Local air pollution control and air quality management districts (districts) have a key role to play in reducing regional and local sources of GHG emissions. Because many actions to reduce air pollutants also reduce GHG emissions, many districts are actively integrating climate protection into air quality programs. Districts also support local climate protection programs, by providing technical assistance and data, quantification tools, and even funding. In addition, districts can be key players in regional cross-media collaborations to mitigate and adapt to climate change. The California Air Pollution Control Officers' Association, and its 34 local air district members, prepared a detailed discussion of local and regional efforts to mitigate climate change; this document is included as Appendix D.

Since the approval of the Scoping Plan, local and regional governments throughout California have increasingly pursued efforts to reduce GHG emissions across sectors. The passage of SB 375 has accelerated regions toward the development of more integrated, sustainable regional transportation plans that, if implemented, could reduce passenger vehicle emissions and bring about substantial co-benefits. So far, each of the major metropolitan planning organizations (MPOs) that have adopted SCSs has demonstrated that it could meet its region's emission reduction targets under SB 375.

Local governments have initiated efforts to reduce GHG emissions beyond those required by the State. Local governments are improving their municipal operations by upgrading their vehicle fleets, retrofitting government buildings and streetlights, purchasing greener products, implementing waste-reduction policies, and more. In addition, they are adopting more sustainable codes, standards, and general plan improvements to reduce their community's emissions. For instance, localities are implementing landscaping ordinances to reduce water use, streamlining permitting for small-scale renewable energy systems, requiring commercial buildings to be retrofit on resale, and updating General Plans to improve transportation mobility options and land use decisions. Regions throughout California are also supporting innovative programs and technologies—supporting the accelerated adoption of advanced vehicle technologies and programs, creating innovative financing options for residents to retrofit their homes, and pursuing their own alternative energy sources. To maximize success in reducing

GHG emissions and promoting sustainability within communities, local governments are creating integrated planning processes and are developing innovative regional collaborations that extend beyond government agencies to include utilities, universities, labor, and leadership from business and community groups.

While the Scoping Plan encouraged local governments to adopt GHG emission reduction goals consistent with those of statewide targets, many local governments had already initiated their own locally driven climate action efforts. By late 2011, 27 percent of California's cities and counties—representing 50 percent of the state's population—were signatories to the U.S. Conference of Mayors Climate Protection Agreement or the Sierra Club's "Cool Counties" program.[106] By September 2013, 76 California local governments had joined the International Council for Local Environmental Initiatives' Climate Protection Campaign—representing 57 percent of the State's population.[107] Today, locally driven climate actions continue to increase among local governments. According to a recent survey, roughly 70 percent of California jurisdictions have either completed policies or programs to reduce GHG emissions or are in the process of adopting them.[108] While many local governments have become leaders in sustainability, there remains significant opportunity for many local governments to take meaningful action.

A number of tools and resources have been developed to assist local climate action planning. These include:

- The local Government Operations Protocol, which provides a standard GHG emission inventory methodology for municipal operations.
- The U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions.
- Climate action plan templates and monitoring and tracking tools developed through the Statewide Energy Efficiency Collaborative in coordination with ARB and OPR.

Many of these tools can be found on the *CoolCalifornia.org* website, which also houses climate action tools and resources for businesses, schools, and individuals.

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106 Bedsworth, L. W., and E. Hanak. 2013. "Climate policy at the local level: Insights from California." Global Environmental Change 23: 664–677.

107 ICLEI Local Governments for Sustainability membership status as of September 2013.

108 Office of Planning and Research. 2012. Annual Planning Survey Results 2012. *www.opr.ca.gov/docs/2012_APSR.pdf*.

SUCCESS STORY

COOLCALIFORNIA
CITY CHALLENGE

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CoolCalifornia City Challenge

To engage communities in reaching the State's climate goals, the Air Resources Board sponsored a pilot project, the CoolCalifornia Challenge. Conducted by the University of California, Berkeley, the Challenge was a yearlong competition between California cities to reduce the carbon footprints of residents and build more vibrant and sustainable communities. Using lessons from successful community-based social marketing programs that motivate individuals to take climate action through peer-to-peer capacity building and leadership, the Challenge inspired over 225 metric tons of greenhouse gas emission reductions by over 2,600 participants in its eight participating cities, equivalent to taking 95 California homes off the electrical grid for one year.

To enable local and regional leadership to further reduce GHG emissions beyond State programs and policies, California must always provide a supportive framework to advance community-wide, voluntary efforts. In addition to reducing emissions across sectors, many of these activities also can bring benefits to households and businesses, create more sustainable lifestyles, and help our communities thrive.

Community-wide Emissions Reduction Target

Recognizing the important role local governments play in the successful implementation of AB 32, the initial Scoping Plan called for local governments to set municipal and community-wide GHG reduction targets of 15 percent below then-current levels by 2020, to coincide with the statewide limit. As California continues to build its climate policy framework, there is a need for local government climate action planning to adopt mid-term and long-term reduction targets that are consistent with scientific assessments and the statewide goal of reducing emissions 80 percent below 1990 levels by 2050. Local government reduction targets should chart a reduction trajectory that is consistent with, or exceeds, the trajectory created by statewide goals. Improved accounting and centralized reporting of local efforts, including emissions inventories, policy programs, and achieved emission reductions, would allow California to further incorporate, and better recognize, local efforts in its climate planning and policies.

Local Government Financing Mechanisms and Incentives

The development of long-term revenue streams and creative local financing mechanisms and incentives can accelerate emission reductions. For instance, local financial incentives can spur retrofits of the existing building stock, net-zero energy or carbon projects, and other voluntary GHG emission reductions. The expansion of PACE financing programs, the creation of incentive opportunities under various policies and planning efforts, and the formation of new mechanisms are all options that should be explored to continue progress toward reducing emissions across our communities.

3. Coordinate with Subnational, Federal, and International Partners

California has established itself as a national and international leader in addressing and combatting climate change. The release of the initial Scoping Plan strengthened the State's commitment to address climate change, but California is not alone. Reducing the risks of climate change requires effective action among all the world's major GHG emitters. Recognizing the interconnected and multi-jurisdictional nature of climate change, California has established a wide range of partnerships, both within and beyond its borders, to promote its own best practices and learn from others while further leveraging the State's leadership in climate protection.

California's efforts on clean energy and climate policy have been successful in leveraging action at the interstate, federal, and international levels. Through collective efforts such as the Western Climate Initiative (WCI) and other alliances of states, California is taking action to expand emission reduction programs and build resiliency against climate change impacts. At the federal level, many of California's policies and programs have served as models for action. California has developed climate solutions with key federal agencies, including the U.S. Department of Energy (U.S. DOE), U.S. EPA, U.S. Department of Transportation (U.S. DOT), and others. Internationally, California is engaged in consultation and collaboration with both national and subnational jurisdictions to share best practices, build capacity, and pioneer new policy tools. These activities are assisting in implementing and strengthening a variety of climate programs around the world.

Efforts in all of these areas are consistent with the State's long-standing leadership in environmental protection and leadership. Coordinating and promoting climate action at the interstate, federal, and international levels is necessary to adequately address climate change, expand clean energy and economic development, and enhance the competitiveness of the State's businesses, workers, and economy.

Interstate Partnerships

California has a long history of working with other states on environmental protection. Continuing this practice and recognizing the value in broad collaborative action to reduce GHG emissions, the State has reached beyond its borders to enlist its neighbors in joint climate-change efforts and promote interstate action.

With the adoption of the initial Scoping Plan, California became the first state in the nation to formally approve a comprehensive GHG emission reduction plan that involves every sector of the economy. Today, several states and cities are following suit and achieving real emission reductions and gaining valuable policy experience as they take action on climate change.

Through participation in interstate initiatives and partnerships with other states, California continues to promote its own best practices and learn from others while finding solutions to reduce GHG emissions, develop clean energy sources, and achieve other environmental and economic goals. Specific examples of these ongoing efforts include:

- Coordination with the WCI on Cap-and-Trade.
- Ongoing consultation with the Regional Greenhouse Gas Initiative, a forum for leadership and information sharing and a common voice on issues faced by the region.
- An agreement with the Pacific Coast Collaborative partners (California, Oregon, Washington and British Columbia) to develop coordinated approaches to reduce GHG emissions, including setting mid-term climate targets, pricing carbon, developing Low Carbon Fuel Standards, and developing an alternative fuels plan for the heavy-duty sector.

Federal Collaborations

In June 2013, President Obama approved the nation's first Climate Action Plan that lays out a series of executive actions to reduce carbon pollution, prepare the nation for the impacts of climate change, and lead international efforts to address global climate change.

California has worked closely with key federal agencies to ensure that the federal approach is consistent with California's stringent standards, as well as the programs in other states that have been leaders in climate protection. Examples of successful collaboration between California and the federal government include the following:

- ARB worked with U.S. EPA and NHTSA to harmonize federal light-duty vehicle standards with California's existing standards through 2016.
- ARB worked with U.S. EPA and NHTSA to develop the first-ever federal GHG standards for medium- and heavy-duty vehicles.
- ARB and U.S. EPA routinely coordinate on advanced transportation and fuels, including the relationship between the federal Renewable Fuels Standard and California's LCFS.
- ARB and the U.S. Department of State routinely coordinate on common issues between California's climate programs and the negotiations under way at the United Nations Framework Convention on Climate Change.
- In January 2012, Governor Brown signed a memorandum of understanding (MOU) with U.S. Department of Interior Secretary Ken Salazar to expand a state and federal partnership that has paved the way for more than a dozen utility-scale solar energy projects and more than 130 renewable power projects in California.

Currently, California is engaging with U.S. EPA and others in the development of national GHG emission standards for power plants under the federal Clean Air Act. As U.S. EPA moves forward to set standards, California is well positioned to respond based on our pioneering actions on climate and air quality.

California is committed to working with the federal government as it implements the President's Climate Action Plan. This commitment includes ensuring that actions the State has already taken to cut emissions will be reflected in subsequent federal actions.

International Engagement

As one of the largest economies in the world and a leader on addressing climate change, California is committed to working at the international level to reduce global GHG emissions. As part of this effort, California has engaged in consultation and collaboration with both national and subnational jurisdictions to share best practices, build capacity, and pioneer new policy tools. These activities are successfully assisting in implementing and strengthening a variety of climate programs around the world, in turn supporting the ability of both developing and developed countries to make more meaningful climate commitments under both the United Nations Framework Convention on Climate Change and bilateral agreements.

California also engages in multi-lateral forums that help develop the policy foundation and technical infrastructure for GHG regulations in multiple jurisdictions. Recognizing that many efforts were under way around the world to use market forces to motivate GHG emission reductions, California worked with other governments to establish the International Carbon Action Partnership (ICAP) in 2007. The ICAP provides a forum for sharing experiences and knowledge among jurisdictions that have already implemented or are actively pursuing market-based GHG programs.[109]

Similarly, and recognizing the need to address the substantial GHG emissions caused by deforestation and degradation of tropical forests, California worked with a group of subnational governments to form the Governors' Climate and Forests Task Force (GCF) in 2008.[110] The GCF is currently comprised of 22 different subnational jurisdictions, including states and provinces from Brazil, Indonesia, Mexico, Nigeria, Peru, Spain, and the U.S. that are contemplating low-emissions development policies and programs, such as REDD. These include addressing forest-related emissions and sharing experiences on how such programs could potentially interact with carbon markets, including California's Cap-and-Trade Program. Ongoing engagement between California and its GCF partners, including with more advanced jurisdictional programs, such as Acre (Brazil), and emerging programs in Chiapas (Mexico) and elsewhere, as well as ongoing discussions with other stakeholders, will provide lessons on how such programs could fit within California's Cap-and-Trade Program. Furthermore, REDD is a key topic within the United Nations Framework Convention on Climate Change and between national and subnational jurisdictions, including through collaboration between California and the U.S. Department of State. Continued evaluation of REDD and other sector-based offset programs further demonstrates California's ongoing climate leadership and could result in partnering on other mutually beneficial climate and low emissions development initiatives, particularly those in Mexico.

In April 2013, Governor Brown led a delegation of California government and business leaders to Beijing and several Chinese provinces. California signed Memorandums of Understanding (MOUs) pledging direct cooperation in developing clean technology, pollution reduction, and climate mitigation policies and markets with the Beijing Environmental Protection Bureau, the Ministry of Environmental Protection, and Guangdong Province. In June 2013, California and Shenzhen, China, signed an MOU to work together to share policy design and early experiences from their climate trading programs. In July 2013, California and Australia signed an MOU to guide collaboration between the agencies in addressing the global issue of climate change.

More recently, Governor Brown signed the first agreement of its kind between a subnational entity and China's National Development and Reform Commission to expand bilateral cooperation on climate change. The Memorandum of Understanding is intended to boost

109 International Carbon Action Partnership Website: *http://icapcarbonaction.com/*.
110 Governors' Climate and Forests Task Force Website: *www.gcftaskforce.org/*.

bilateral cooperation on climate, clean energy, and development, and sharing of low-carbon programs and policies. In his 2014 State of the State address, the Governor announced his intention to work with Mexico on climate change.

As California continues to engage at all these levels and share its experiences, policy programs, and leading approach to climate change, we will also seek new partners to expand global action to address climate change, minimize its impacts, and deliver benefits to our State.

VI. Evaluations

Continuing to effectively build upon California's climate framework and ensuring successful implementation of the State's policies requires periodic monitoring and program evaluation, so that programs can be built upon, adapted, and enhanced – as appropriate – to continue driving down emissions well into the future. California will continue to evaluate the economic, environmental, and public health impacts of its set of climate policies to inform its ongoing activities to reduce emissions. Importantly, the State is committed to ensuring an equitable distribution of benefits from its climate programs, and will continue monitoring impacts in environmental justice communities and target programs and investments where appropriate to enhance benefits in disadvantaged communities.

This chapter discusses the economic, public health, and environmental justice evaluations that will be conducted as the Scoping Plan continues to be implemented. It also discusses the environmental analysis that was prepared of this Update.

A. Economic Analysis

In California, the implementation of Scoping Plan measures is under way but still in the early stages, presenting challenges in the ongoing assessment of the economic impacts of AB 32. While comprehensive in regulatory scope and scale as indicated below, the net impact of AB 32, even after full implementation, is estimated to be small in relation to the $2 trillion California economy,[111] making it difficult to isolate its economic impact. In addition, the global recession and California's subsequent recovery complicate the evaluation of the economic impact of the suite of regulatory measures that are being implemented under AB 32. This challenging economic landscape requires careful analysis of the costs and benefits of AB 32 on industries and individuals in California. The assessment can inform the design and refinement of cost-effective actions California can take toward its long-term climate goals.

As California emerges from the recession, the overall impact of AB 32 remains unclear, and many questions remain unanswered. How has AB 32 impacted economic growth? Has AB 32 spurred innovation and economy-wide growth? How have the impacts of Scoping Plan measures been distributed among businesses and Californians? These questions and others are critical in the accurate assessment of the economic impacts of AB 32 and are the driving force in a multi-pronged approach to the analysis of the economic costs and benefits of AB 32.

Prior to the implementation of regulatory measures under AB 32, the anticipated micro- and macroeconomic costs of the suite of regulatory measures were estimated. Now California turns to the next stage of analysis that consists of estimating the aggregate costs of measures already implemented and analyzing their distributional impacts across businesses and individuals in California and beyond.`

111 Center for Continuing Study of the California Economy. *www.ccsce.com/PDF/Numbers-July-2013-CA-Economy-Rankings-2012.pdf*.

Moving forward, the assessment of the economic impact of AB 32 is divided into two phases: (1) the continued estimation of regulatory costs as measures are implemented, and (2) an ex post analysis of the macro- and microeconomic impacts of AB 32. As California prepares for a retrospective ex post analysis in subsequent Scoping Plans, the State continues to assess whether the economic costs of the implementation of AB 32 are in line with ex ante estimates of costs. In the first phase of the assessment, State agencies are monitoring the costs of AB 32 regulatory measures. In the second phase of the assessment, State agencies will collaborate with external economic experts, researchers, and stakeholders in the design, development, and implementation of rigorous micro- and macroeconomic assessments of the ex post economic impact of AB 32.

The following sections outline the assessments of economic impacts that occurred prior to the implementation of AB 32, the assessments that will occur once AB 32 measures are more fully implemented, and the assessments of economic impacts that are currently under way.

Ex Ante Assessment of Potential Costs and Benefits

Section 38561 of AB 32 requires State agencies to evaluate the total potential costs, as well as the total potential economic and non-economic benefits of the Scoping Plan using the best available economic models and emission estimation techniques.[112] Pursuant to AB 32, ARB conducted two full-scale analyses, as part of the 2008 Scoping Plan and 2010 Updated Economic Analysis of the Scoping Plan, to assess the potential economic impacts of the portfolio of Scoping Plan measures on the California economy. In addition, four external general equilibrium analyses have been conducted.

The two internal and four external macroeconomic analyses estimated the overall potential impact of AB 32 on California gross state product to range from an increase of 1.0 percent to a decline of 2.2 percent in 2020.[113] The models and modeling approaches underlying the

112 The AB 32 text is available at *www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf*.

113 The six analyses include analyses conducted by ARB, David Roland-Holst, the Electric Power Research Institute, and Charles River Associates. These analyses can be accessed at: ARB. 2008. Climate Change Scoping Plan. *www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf*;

SUCCESS STORY

California Local Governments

Local governments are in many ways the "boots on the ground" for meeting California's climate change goals, beginning with their local planning efforts. Municipalities use a number of frameworks to outline their goals and implementation strategies for reducing greenhouse gases. According to 2012 OPR's Annual Planning Survey, about 90 local governments have adopted policies and/or programs to address climate change, often in the form of Climate Action Plans. Moreover, over 270 local governments reported they were making progress towards adopting climate change policies. As of October, 2013, 135 California mayors have voluntarily signed the U.S. Conference of Mayors Climate Protection Agreement, which strives to meet or beat the Kyoto Protocol reduction targets.

six analyses vary in terms of structure and inputs, yet they yield a generally similar conclusion on the economy-wide impact of AB 32.[114] The analyses also identified the impacts of AB 32 on certain industrial sectors in California. These results led to program modifications—most notably the inclusion of output-based allocation for industrial entities in the Cap-and-Trade Program.

In addition to identifying the impact of AB 32 when all implemented measures achieve expected emission reductions, in the 2010 Updated Economic Analysis of California's Climate Change Scoping Plan ARB estimated the economic impact of reaching the near-term emission limit in 2020 should measures not provide anticipated GHG emission reductions.[115] Within the five sensitivity cases developed in the analysis, the overall costs of reaching the near-term emission limit in 2020 were minimized when all measures, as currently being implemented, achieve their anticipated GHG emission reductions. Scenarios in which AB 32 measures related to energy efficiency, transportation, and renewable energy fall short of expected emission reductions result in an increase in the overall cost of AB 32, as additional, less cost-effective emission reductions are required from the remaining measures to meet the 2020 emission limit. This sensitivity analysis highlights the need to monitor the GHG emission reductions and costs of individual measures to identify the overall costs of the suite of AB 32 regulatory measures.

While robust analyses have estimated the potential, or ex ante, economic impacts of AB 32 prior to implementation, more data and analysis is necessary to determine the realized, or ex post, impacts of the regulatory measures on California's industries, businesses, and consumers. In addition, the range of potential economic impacts identified in the six macroeconomic analyses highlights the challenge in parsing the effects of AB 32 from other macroeconomic conditions in the California economy. The recent economic recession and recovery, as well as the presence of overlapping local, State, and federal regulations present challenges in the identification of a "business as usual" baseline against which to evaluate the impacts of AB 32.

The macroeconomic ex ante analyses provide important information; however, the models used in these assessments are often highly aggregated and lack specific detail about individual industries or technologies. Greater detail is important for assessing the potential economic impact of individual regulatory measures that is required under the Administrative Procedure Act (APA). Section 11346.2 of the APA requires as part of the Initial Statement of Reasons (ISOR) an assessment of the benefits and costs of any proposed or amended regulation.[116] For regulatory measures adopted under AB 32, assessments of the costs and benefits have been included as part of the regulatory package. These assessments require gathering sector-specific information regarding the engineering and economic costs of regulatory compliance on businesses and estimating the indirect and induced impacts of these costs, as well as the corresponding expected environmental benefit. While the scale, scope, and assumptions used in these assessments are regulation-specific, these industry-level calculations provide additional data outlining the projected costs and benefits of AB 32.[117]

ARB. 2010. Updated Economic Analysis of California's Climate Change Scoping Plan. *www.arb.ca.gov/cc/scopingplan/economics-sp/updated-analysis/updated_sp_analysis.pdf*; Roland-Holst, David. 2008. Economic Analysis of California Climate Policy Initiatives Using the Berkeley Energy and Resources (BEAR) Model (Appendix G-III). *www.arb.ca.gov/cc/scopingplan/document/appendices_volume1.pdf*; Roland-Holst, David. 2010. Climate Action for Sustained Growth: Analysis of ARB's Scoping Plan. *www.arb.ca.gov/cc/scopingplan/economics-sp/meetings/042110/rolandholst.pdf*; Electric Power Research Institute. 2007. An Updated Macroeconomic Analysis of Recent California Climate Action Team Strategies. *www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001015510*; Charles River Associates. 2010. Analysis of the California ARB's Scoping Plan and Related Policy Insights. *http://crai.com/uploadedFiles/analysis-of-ab32-scoping-plan.pdf*.

114 The internal ARB and external analyses differ, most notably, in assumptions related to emissions leakage, the rate of technological change, input substitution, costs of VMT, and economic growth in the "Business as Usual" scenario.

115 Table 12 outlines the sensitivity cases considered in the analysis and is available at: *www.arb.ca.gov/cc/scopingplan/economics-sp/updated-analysis/updated_sp_analysis.pdf*

116 The APA text is available at *www.leginfo.ca.gov/cgi-bin/displaycode?section=gov&group=11001-12000&file=11346-11348*.

117 Regulatory documents are available through ARB's Climate Change Programs at *www.arb.ca.gov/cc/cc.htm*.

Ex Post Assessment of Realized Costs and Benefits

In the years since the analyses of potential economic impacts were conducted, California has moved from the assessment of projected impacts to the implementation of measures outlined in the Scoping Plan and planning the ex post estimation of realized costs and benefits. California has two objectives in the assessment of the ex post economic impacts of AB 32: (1) estimating the overall costs and benefits of the suite of AB 32 measures on the California economy, and (2) identifying the distribution of impacts on industry, small businesses, households, environmental justice communities, and the public sector. California agencies are currently designing a work plan to guide this two-prong approach, including the time line, data requirements, and appropriate methodology for the objective. The work plan will be developed and made publicly available in 2014.

The overall economic impact of AB 32 on the California economy is dependent in large part on the performance of specific measures, including the Renewables Portfolio Standard (RPS), Advanced Clean Cars, Low Carbon Fuel Standard (LCFS), high global warming potential gas measures, and the Cap-and-Trade Program. The costs and benefits of these measures will be fully realized only after the measures reach full stringency. Thus, while the ex post work plan is under development, the full ex post analysis will be conducted in the coming years. As economic impacts may not be immediately realized upon implementation, delaying the assessment also allows for the analysis of lagged economic indicators such as structural changes in employment and production, including the global competiveness of California businesses.

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In pursuit of guidance, ARB has engaged a group of Economic Advisors to assist in the development of the work plan to achieve the first objective and estimate the ex post economic impact of AB 32. The Advisors are helping to identify the metrics and methodologies that are best suited to identify the overall costs and benefits of AB 32. More details on macroeconomic modeling of the overall impact of AB 32 and ex post analysis will be included in future updates to the Scoping Plan.

During the implementation of AB 32, California has been collecting data toward the second objective of the ex post assessment—identifying the distributional impacts of AB 32. Through mandatory requirements and voluntary reporting, facility-level data are being collected, and California is beginning the process to analyze, both internally and externally though contracted researchers, how putting a price on carbon changes the behavior and economic health of California businesses and individuals. The data will be used to inform microeconomic models estimating the direct and indirect costs of AB 32, including expenditures on energy, capital, and labor. This analysis will allow the impacts of AB 32 to be quantified over a variety of time horizons, geographic regions, industrial sectors, and income groups, and will provide flexibility in the interactions of regulatory policies. Further, California will continue to track technological developments and the various pathways that industries use to comply with environmental regulations in order to better understand program costs.

The ex post assessment of economic impacts will also inform the design of California's long-term climate change regulatory portfolio. Estimating the economic impact of the current suite of AB 32 measures will provide guidance in establishing long-term emission targets. Assessing the costs and environmental benefit of each regulatory measure over time can lead to modifications of specific measures as well as the mix of programs within AB 32. This will ensure that the interaction of regulatory measures achieves the goals of AB 32. Thus, the ex post assessment can inform the scope, scale, and stringency of measures in the climate change mitigation portfolio to achieve California's long-term emission targets.

Ongoing Economic Assessment

In addition to the longer-term objectives of the ex post assessment, there are analyses under way to estimate the facility-level regulatory costs and benefits of AB 32 on specific sectors, to inform near-term regulatory modifications. Currently, two analyses are under way at ARB to assess the ability of industrial entities in the Cap-and-Trade Program to maintain competitiveness while incorporating the carbon price into their production processes. In each analysis, external researchers are reevaluating the leakage classification, a measure of the energy intensity and trade exposure of an industrial sector, of California producers using facility-level data on energy consumption, trade flows, and market transfers.[118] The results of the leakage analyses will be used to inform the level of transition assistance needed to minimize leakage in the industrial sector in the third compliance period of the Cap-and-Trade Program. Results are expected by 2016.

External research has also informed the longer-term design of measures under AB 32— most notably the Cap-and-Trade Program and the LCFS—to identify the link between program design and the California economy. For example, the Market Simulation Group (MSG) was established under contract to inform ARB on issues pertaining to market rules and efficiency. It has provided input in assessing program costs, as well as the supply and demand for allowances in the Cap-and-Trade Program.[119] In addition, ARB co-sponsored a symposium in 2012 that brought together economic researchers and regulators to identify the metrics required for the effective analysis of the Cap-and-Trade Regulation.[120] Academic researchers are also providing input to ARB on the design of the LCFS and the near-term cost of compliance.[121] Discussions between regulators and expert economists has spawned ongoing research that is helping to inform the work plan for the ex post analysis of AB 32.

California agencies have also actively engaged the general public and stakeholders to ensure that the economic costs of AB 32 measures are not overly burdensome to specific sectors or income groups. ARB has conducted workshops on the economic costs of LCFS and the Cap-and-Trade Program and solicited comments on internal white papers discussing potential options for cost containment.[122] Gaining insight into the economic market conditions faced by stakeholders allows for the more accurate modeling of economic impacts under AB 32 and provides a measure of some of the compliance costs faced by covered entities.

Along with the collection of data and the active engagement of researchers and stakeholders, ARB is also monitoring the impact of AB 32 on the supply and demand of energy in California. Partnering with the Federal Energy Regulatory Commission (FERC) and CAISO, ARB is monitoring energy and fuel markets to identify the impact of AB 32 on energy markets and the wholesale energy costs faced by industrial, commercial, and residential consumers.[123] These analyses will assist ARB in identifying areas in which to improve the design and stringency of Scoping Plan measures in order to achieve AB 32 emissions goals with minimal economic impact.

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118 Stephen Hamilton of Cal Poly San Luis Obispo and a team of researchers from UC Berkeley are conducting an analysis on the food processing sector, while Meredith Fowlie of UC Berkeley and a team of researchers from Stanford, Resources for the Future, and Clark University are conducting an analysis that covers all remaining industrial sectors. The results of these analyses will be publically available on the ARB website upon completion.

119 The draft analysis is available at *http://ei.haas.berkeley.edu/pdf/Forecasting%20CA%20Cap%20and%20Trade.pdf*.

120 More information is available at *www.bren.ucsb.edu/events/AB32.htm*.

121 The analysis of the LCFS and compliance costs is available at *www.des.ucdavis.edu/faculty/Lin/California_LCFS.pdf*.

122 The LCFS white paper is available at *www.arb.ca.gov/fuels/lcfs/regamend13/20130522ccp_conceptpaper.pdf*; the Cap-and-Trade Program white paper is available at *www.arb.ca.gov/cc/capandtrade/meetings/062513/arb-cost-containment-paper.pdf*.

123 More information is available at *www.caiso.com/Documents/2013SecondQuarterReport-MarketIssues_Performance-Aug2013.pdf* and *www.ferc.gov/EventCalendar/Files/20121220111740-A-4-Presentation.pdf*.

Achieving Near-Term and Long-Term Goals

The Cap-and-Trade allowance price can be used as a proxy for the cost of some GHG emission reductions (those that remain after reductions from the other AB 32 regulatory measures have occurred). By projecting the allowance price through 2020, models estimate the overall cost of a portion of the emissions abatement required under AB 32. Recent analyses suggest that the allowance price in 2020 will likely be near the price floor at the time, around $17 per metric ton.[124] These analyses highlight the uncertainty inherent in the projection of future market conditions, as well as the critical need to identify a "Business as Usual" emissions baseline. While there is much uncertainty in these analyses, the projected allowance prices are lower than the allowance price projected by ARB in the 2010 Updated Economic Analysis to the Scoping Plan.[125] ARB estimated that the 2020 emissions limit could be met with an allowance price of $21 per metric ton and an associated 0.1 to 0.2 percent change in Gross State Product relative to the forecasted 2020 "Business as Usual" baseline.

The similarity of the external estimates of the 2020 allowance price and the projected allowance price in the 2010 Updated Economic Analysis to the Scoping Plan may offer evidence that the assessment of the projected economic impacts of AB 32 is reasonable and that California can reach the near-term 2020 emissions limit without sacrificing economic stability.

The assessment of economic impacts will continue as California develops a climate mitigation portfolio to achieve its long-term climate change mitigation goals. The assessment of the overall economic impacts of the current suite of AB 32 measures will inform the design of the long-term regulatory portfolio as well as the analysis of its impact. However, extending the time horizon of the assessment of economic impacts will present new challenges. Regulatory and climate uncertainty, as well as the performance and costs of existing AB 32 measures, will need to be incorporated in the estimation of potential economic impacts of the long-term climate change mitigation portfolio.

Isolating the specific macroeconomic effects of AB 32 from other economic volatility will continue to present a significant challenge as California looks to the future and achieving long-term climate goals. Long-term economic shifts will need to be incorporated into the assessment of economic impacts. For example, household energy demand and vehicle miles traveled will be influenced by demographic changes in the California population, changes in land use, and the built environment. These issues are the direct focus of regional planning agencies and sustainable community legislation and will require the inclusion of policy interaction and jurisdictional overlap in the long-run modeling of policies affecting energy demand.

Challenges will also arise in estimating the long-term effects of AB 32 across sectors, jurisdictions, and natural resources. The promulgation of climate change mitigation and adaption policies worldwide has highlighted the importance of understanding the far-reaching impacts, both in terms of costs and co-benefits, of climate change and climate change regulations. In 2011, ARB acknowledged the importance of analyzing the impact of the Cap-and-Trade Regulation on localized air quality impacts, special status species, sensitive habitats, and federally protected wetlands in the Adaptive Management Plan. Measuring the long-term impacts of AB 32 will require new methodologies to parse the impacts of individual climate mitigation polices across sectors, jurisdictions, and natural resources. Accounting for the co-benefits and the economic costs of AB 32 will allow California to maximize emission reduction towards long-term climate change mitigation targets while also maximizing the benefits, through improved air quality and natural resources for all Californians.

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124 In $US 2013 (the price floor is currently at $11.34 and rises five percent plus inflation each year). See, for example, the MSG report linking in footnote 105.

125 The projected allowance price of $21/ton ($US 2007) corresponds to -0.2 percent change in gross state product in 2020. Available at *www.arb.ca.gov/cc/scopingplan/economics-sp/updated-analysis/updated_sp_analysis.pdf*.

ARB will continue to consult with external experts to develop new analytical tools and methods to incorporate these issues in the assessment of economy-wide and distributional impacts of California's long-term climate change mitigation portfolio.

B. Climate Change and Public Health Assessment

Climate change has been identified as the greatest health threat of the twenty-first century.[126] As described in Chapter II, in California, climate change is expected to increase temperatures, change precipitation patterns, increase the frequency and severity of extreme weather events, and increase wildfires and sea level rise—all of which could have significant impacts on the health of California's residents.

Efforts to reduce GHGs minimize the impacts that climate change will have on human health. In addition to combatting climate change and its subsequent health impacts, many of these efforts have additional direct and indirect public health impacts. It is challenging to assess the magnitude of health impacts that result specifically from AB 32 mitigation measures. However, assessing the directionality of the relationship between many mitigation actions and health based on current empirical literature indicates that overall, the State's climate control program has many health co-benefits, particularly for chronic diseases. In the instances in which mitigation measures may be at odds with positive health outcomes, California must ensure that positive health outcomes are maximized as we address climate change. Local governments, and in particular local public health departments, are important partners in this work.

Assessing the Health Impacts of AB 32 Implementation

As with economic impacts, efforts to fully quantify the health impacts due to Scoping Plan measures remain challenging and are complicated by many factors. Communities and individuals are influenced by a multitude of factors, including socioeconomic conditions, occupational and environmental exposures, the natural and built environments, and personal choices. The influence of all these factors impairs the ability to assign causation between a discrete set of policies, such as the State's climate program, and quantified health impacts. In addition, the long time scale over which certain health impacts may appear—particularly for chronic diseases—complicate attribution to specific actions. Efforts to quantify health impacts by modeling the reduction of co-pollutants to estimate health impacts associated with reductions of GHG measures are difficult because they rely on assumptions about what would have happened if those measures had not been implemented. Assessing the magnitude of health impacts that result specifically from AB 32 mitigation measures remains challenging; however, the directionality of the relationship between many mitigation actions and health can be evaluated using current empirical literature. Efforts are now under way to develop health co-benefit modeling tools to be used in conjunction with regional transportation demand models used by California's Metropolitan Transportation Organizations to help quantify health co-benefits of active transport in future Sustainable Community Strategies (Table 10). For instance, the Strategic Growth Council has convened a Technical Advisory Committee to provide recommendations on the development and use of a health module as part of the Urban Footprint model—a scenario development and modeling tool designed to inform planners on the impacts of development decisions. In addition, CDPH has advanced a model—the Integrated Transport and Health Impact Modeling tool (ITHIM)—that quantifies the health impacts of active transportation and low carbon driving scenarios. The ITHIM model is currently being evaluated by MPOs for use in their regional planning processes.

126 Costello, A., et al. 2009. "Managing the health effects of climate change." The Lancet 373: May 16, 2009. *www.ucl.ac.uk/global-health/project-pages/lancet1/ucl-lancet-climate-change.pdf*.

Table 10: Current Models Designed to Quantify Health Co-Benefits of Sustainable Community Strategies

Model	Timeline
Urban Footprint	SGC Advisory Committee recommendations anticipated Spring 2015
Integrated Transport and Health Impact Modeling Tool (ITHIM model)	Under evaluation by MPOs

Health Impacts of Unmitigated Climate Change

Left unchecked, climate change will affect health in a number of ways. Increasing temperatures from climate change will increase the severity and frequency of heat waves. As California saw in the 2006 heat wave, which resulted in over 650 excess deaths, over 16,000 excess emergency department visits and almost 1,200 excess hospitalizations,[127, 128] extreme heat events create a significant risk of adverse health effects and heat-related mortality. Older adults with chronic health problems, and agriculture, construction, and other outdoors workers are particularly at high risk for adverse effects of extreme heat. Increasing temperatures may exacerbate air pollution in California; in particular, ozone and fine particulate matter.[129] In addition to increasing air pollutants directly, higher temperatures will also likely increase and intensify wildfires in the State, exacerbating poor regional air quality.[130] An increase in air pollution can increase the number of cases of exacerbation of asthma, allergies, and cardiovascular and respiratory diseases, as well as incidents of cancer, neurological and reproductive disorders, and premature death.[131] These impacts are especially felt among our most vulnerable populations, including children, elderly, people with cardiovascular or respiratory diseases, low-income communities, and people without access to health insurance.[132] Changes in climate can also affect the prevalence and geographic location of food-, mosquito-, and vector-borne diseases. While hard to predict, it is possible for infectious diseases like West Nile Virus and Lyme disease to become more prevalent in California as the climate changes.[133] Extreme weather events can lead to both physical and mental health problems.[134] In addition, climate change is associated with higher pollen levels, which contribute to allergies and asthma attacks.[135] Additional climate change impacts, including changes in precipitation patterns, can threaten the quality and supply of water, endanger agriculture production, and lead to many other health-impacting consequences.

The impacts of climate change will not affect everyone the same way. Climate change is expected to more seriously affect the health and well-being of the communities in our society that are the least able to prepare for, cope with, and recover from its impacts. For instance, low-income communities and communities of color are expected to be hit harder by extreme heat, extreme weather events, and worsened air pollution; and are more sensitive to the economic stresses associated with climate change, like increased prices for basic needs and threat of job loss in the agricultural and tourism sectors.[136] If this "climate gap" is not addressed, climate change will exacerbate many of the health and social disparities among California residents. Fortunately,

127 Hoshiko, S., P. English, D. Smith, and R. Trent. 2010. "A simple method for estimating excess mortality due to heat waves, as applied to the 2006 California heat wave." Int J Public Health 55(2): 133–7.
128 Knowlton, K., M. Rotkin-Ellman, G. King, et al. 2009. "The 2006 California heat wave: Impacts on hospitalizations and emergency department visits." Environ Health Perspect 117(1): 61–7.
129 Drechsler, D. M. 2009. Climate Change and Public Health in California.
130 Ibid.
131 CARB. ARB Fact Sheet: Air Pollution and Health. *www.arb.ca.gov/research/health/fs/fs1/fs1.htm*.
132 Shonkoff, S., R. Morello-Frosch, M. Pastor, and J. Sadd. 2009. Environmental health and equity impacts from climate change and mitigation policies in California: A review of the literature. California Climate Change Center. *www.energy.ca.gov/2009publications/CEC-500-2009-038/CEC-500-2009-038-D.PDF*.
133 Drechsler, D. M., N. Motallebi, M. Kleeman, D. Cayan, K. Hayhoe, L. S. Kalkstein, N. Miller, S. Sheridan, J. Jin, and R. A. VanCuren. 2005. Public health-related impacts of climate change in California.
134 CDC. 2013. CDC's Climate Change and Health Program: *www.cdc.gov/nceh/information/climate_and_health.htm*.
135 Ibid.
136 Ibid.

many of the actions that reduce GHG emissions also improve the health and well-being of these vulnerable communities, providing an opportunity to address many of our current environmental and health disparities.

Health Impacts of AB 32 Mitigation Measures

Climate change mitigation efforts not only help combat the direct adverse health impacts of climate change, many of the strategies laid out in the Scoping Plan have additional health co-benefits—many of which can improve existing health disparities. In addition, these climate strategies have implications for chronic disease—which accounts for the vast majority of ill health in California. Chronic disease and injury account for 80 percent of deaths in California, and affect the lives of millions of Californians. Chronic disease is also the key driver of health inequities, lost workforce productivity, and rising health care costs.[137]

The strategies California has employed to reduce GHG emissions from the transportation sector include cleaner and more fuel-efficient vehicles and land use strategies that reduce vehicle miles traveled and promote active transport (bicycling and walking—alone and in combination with public transit.) Putting cleaner and more fuel-efficient vehicles and heavy-duty trucks on the road is reducing GHGs and criteria air pollutants and toxics, including NO_x (which forms ozone and $PM_{2.5}$) and directly emitted $PM_{2.5}$ (which includes toxic diesel PM). Since statewide monitoring efforts began in 2000, $PM_{2.5}$ levels have decreased by an average of four percent each year.[138] Strategies that will help us achieve our 2050 climate goals, including zero emission vehicles and increased electrification of goods movement, will further reduce air pollutants and bring health co-benefits throughout the State. These improvements will particularly benefit many low-income communities of color, who are disproportionately exposed to traffic-related air pollutants.[139]

The impact that our built environment—including land use decisions, transportation systems, and our buildings—has on human health and well-being has long been recognized.[140] Statewide efforts to reduce GHG emissions through integrated land use and transportation planning will fundamentally change our communities, bringing with it public health benefits. The Sustainable Community Strategies (SCSs) adopted by Metropolitan Planning Organizations are planning for communities in a way that reduces travel demand per person, provides greater mobility options, increases access to employment and services, and creates more vibrant surroundings. Reducing vehicle travel will reduce GHG emissions and improve regional air quality. For instance, Southern California's 2012–2035 Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS) is expected to result in a 24 percent reduction in total pollution-related health incidences, saving over $1.5 billion per year in total costs.[141] In an effort to improve mobility options for California residents, the RTP/SCSs are also increasing opportunities for residents to use bicycling and walking as travel alternatives. Active transportation increases physical fitness and improves mental health.[142, 143] The health benefits of physical activity are extensive and well documented: physical activity—even in modest amounts—has been linked with a decreased risk of cardiorespiratory diseases, type 2 diabetes, breast and colon cancer, depression, cognitive

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137 CDPH. 2013. The Burden of Chronic Disease and Injury. *www.cdph.ca.gov/programs/Documents/BurdenReportOnline%2004-04-13.pdf*.

138 ARB staff analysis.

139 Shonkoff, S., R. Morello-Frosch, M. Pastor, and J. Sadd. 2009. Environmental health and equity impacts from climate change and mitigation policies in California: A review of the literature. California Climate Change Center. *www.energy.ca.gov/2009publications/CEC-500-2009-038/CEC-500-2009-038-D.PDF*.

140 U.S. EPA. 2013. Our Built and Natural Environments. A Technical Review of the Interactions Among Land Use, Transportation, and Environmental Quality. Second Edition, *www.epa.gov/smartgrowth/pdf/b-and-n/b-and-n-EPA-231K13001.pdf*.

141 SCAG. 2012–2035 RTP/SCS; American Lung Association Analysis: *www.lung.org/associations/states/california/assets/pdfs/advocacy/smart-growth/smart-growth-analysis.pdf*.

142 Atkinson, M., and L. Weigand. 2008. A Review of Literature: The Mental Health Benefits of Walking and Bicycling. *www.pdx.edu/ibpi/sites/www.pdx.edu.ibpi/files/Mental%20Health%20Benefits%20White%20Paper.pdf*.

143 Ewing, R., T. Schmid, et al. 2008. "Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity." Urban Ecology 567–582.

decline, all-cause mortality, and improved musculoskeletal health.[144] These regional plans are not just providing more travel options, they also have implications for other health-related factors, like improved access to health services and employment opportunities and safer, more cohesive neighborhoods. The SCS plans created by regions are key mechanisms for improving factors that have indirect but broad implications for the health and well-being of California's communities.

Climate change strategies that also reduce urban heat islands improve public health and help build climate change resiliency. Increasing urban tree canopy and green space combats climate change directly through sequestration of GHGs and indirectly by reducing ambient air temperatures[145] and reducing the energy needed to heat and cool buildings.[146] The cooling effects of urban trees reduce urban heat islands and can lessen the severity of extreme heat events. Additional health-related benefits of urban trees include reduced air pollutants,[147] reduced noise from traffic,[148] and other psychological and social benefits that help decrease stress and aggressive behavior.[149, 150, 151] Cool roofs and cool pavements also combat climate change while cooling our communities.[152]

Strategies to build more energy-efficient, green buildings—if done right—also can have public health benefits. Improving indoor air quality through source reduction and strategies such as high-efficiency air filtration can greatly improve indoor air quality and occupant health. The State's green building code (CALGreen) includes both required and voluntary measures that improve public health. A number of these measures help assure healthful indoor air quality, such as those addressing chemical emissions from composite wood products, carpets, resilient flooring materials, paints, adhesives, sealants, and insulation, as well as those addressing ventilation. ARB has been active in improving building indoor air quality by sponsoring and conducting research, regulating indoor air cleaners and consumer products, and helping to develop green building standards and guidelines that both reduce GHG emissions and protect indoor air quality.

Reducing the use of nitrogen fertilizers can reduce GHG emissions and improve water quality. Many Californians live in agricultural areas that have water nitrogen levels well above national health-based standards.[153] Central Valley residents in areas with contaminated drinking water must also spend far more than average to purchase safe water, reducing the ability to spend on other health-protective necessities such as food and housing.[154]

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144 PAGAC. 2008. Physical Activity Guidelines Advisory Committee Report, 2008. U.S. Department of Health and Human Services.

145 Trees can lower outdoor air temperatures by as much as 9°F (5°C) through evapotranspiration: EPA. 1992. Cooling our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing. U.S. Environmental Protection Agency, Office of Policy Analysis, Climate Change Division. p. 32.

146 Akbari, H., D. Kurn, S. Bretz, and J. Hanford. 1997. "Peak power and cooling energy savings of shade trees." Energy and Buildings 25:139–148. (Accessed via Reducing Urban Heat Islands: Compendium of Strategies - Trees and Vegetation, p. 5)

147 Nowak, D. J., D. E. Crane, and J. C. Stevens. 2006. "Air pollution removal by urban trees and shrubs in the United States." Urban Forestry and Urban Greening. 4(2006):115–123. (Accessed via Reducing Urban Heat Islands: Compendium of Strategies - Trees and Vegetation, p. 6)

148 Nowak, D. J., and J. F. Dwyer. 2007. Understanding the Benefits and Costs of Urban Forest Ecosystems. In: Kuser, J. E. Handbook of Urban and Community Forestry in the Northeast. New York: Kluwer Academic/Plenum Publishers. 25–46. (Accessed via Reducing Urban Heat Islands: Compendium of Strategies - Trees and Vegetation, p. 9)

149 Wolf, K. 1998. Urban Nature Benefits: Psycho-Social Dimensions of People and Plants. Center for Urban Horticulture, College of Forest Resources, University of Washington, Fact Sheet #1. Seattle, Washington. (Accessed via Reducing Urban Heat Islands: Compendium of Strategies - Trees and Vegetation, p. 9)

150 Laverne, R. J., and K. Winson-Geideman. 2003. "The Influence of Trees and Landscaping on Rental Rates at Office Buildings." Journal of Arboriculture 29(5): 281–290. (Accessed via Reducing Urban Heat Islands: Compendium of Strategies - Trees and Vegetation, p. 9)

151 Kuo, Francis E., and W.C. Sullivan. 2001. "Environment and Crime in the Inner City: Does Vegetation Reduce Crime?" Environment and Behavior 33(3): 343–367. (Accessed via Reducing Urban Heat Islands: Compendium of Strategies - Trees and Vegetation, p. 9)

152 U.S. EPA. No date. Reducing Urban Heat Islands: Compendium of Strategies — Cool Roofs.

153 UC Davis. 2011. Addressing Nitrate in California's Drinking Water. *http://groundwaternitrate.ucdavis.edu*.

154 Pacific Institute. 2001. The Human Costs of Nitrate-contaminated Drinking Water in the San Joaquin Valley. *www.pacinst.org/wp-content/uploads/2013/02/nitrate_contamination3.pdf*.

Ongoing Evaluation

As California looks beyond 2020, there will be many opportunities to address long-standing air quality and public health issues through the implementation of sustainable community strategies, the expanded deployment of zero and near-zero emission vehicles in the light- and heavy-duty sectors, and the more efficient use of electricity and natural gas. But we must be mindful of how current and future strategies are implemented, so that they maximize the health benefits while minimizing unintended negative health impacts. For instance, pursuing more compact, transit-oriented development will help reduce GHG emissions and regional air pollutants; however, without appropriate preventative measures, it may have the potential to displace current residents who are disproportionately from low-income and minority communities, as well as to increase near-roadway exposure for some individuals. Additional efforts are needed to prevent any adverse health impacts that may be exacerbated by future land use and transportation decisions. ARB is pursuing research to help improve health impacts from near-roadway exposure.

While the Cap-and-Trade Regulation is designed to reduce GHG emissions, co-benefits such as reductions in criteria and toxic air pollutants, are expected to follow. However, concerns have been raised that these reductions in criteria and toxic air pollutants may not occur in some areas, or that the Cap and Trade Program may exacerbate some localized air pollution impacts. To address these concerns, ARB is working with CAPCOA to design elements of a Cap-and-Trade adaptive management process to identify and respond to concerns about the potential for localized emission increases due to the Cap-and-Trade Regulation. The effort will involve a transparent process to collect, review, and evaluate data to determine if any potential adverse localized air quality impacts might have occurred as a result of implementing Cap-and Trade. If a potential impact is identified through this process, ARB is committed to developing appropriate responses through a public process, including consideration and approval by the Board as necessary.

Despite the difficulties in quantifying the health impacts that result from AB 32 implementation, additional action can be taken to better understand the relationship between climate control measures and health impacts. Several efforts undertaken by the California Department of Public Health will aid in this endeavor, including the development of land use/transportation health impact assessment tools and the development of health community data and indicators to facilitate monitoring and tracking of progress. Additional effort will be needed to advance the development and adoption of tools to evaluate the health benefits of land use and transportation planning, as well as to better educate policymakers, local officials, and the public of these impacts. Moving forward, ARB will continue to monitor and track statewide air pollution levels and community pollutant levels to ensure that our policies and programs continue to improve air quality for all Californians. In addition, ARB will continue to ensure that efforts to reduce GHG emissions through the building sector continue to simultaneously improve indoor air quality and occupant health and safety. Continued research and analysis is needed on the short- and long-term health co-benefits of climate strategies to help communities maximize the positive impacts of local actions.

Federal air quality requirements could be an important driver in influencing how and when California achieves mid-term climate targets. The South Coast and San Joaquin Valley Air Quality Management Districts, together home to more than half of the State's population, must reduce emissions of smog-forming pollutants by about 90 percent below 2010 levels by 2032 to meet the National Ambient Air Quality Standards. Since many of the technologies to reduce smog-forming pollution are the same as those to reduce GHG emissions, and recognizing that it is imperative to integrate planning to meet multiple objectives, complying with federal air quality standards will likely accelerate climate action in California.

In addition, ARB will continue to evaluate ways to monitor the public health of disadvantaged communities. As with economic impacts, communities and individuals are subjected to a multitude of factors that affect their health; consequently, teasing out the impacts of one discrete set of policies, such as the climate program, is very challenging.

C. Environmental Justice and Disadvantaged Communities

State law defines environmental justice as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. ARB is committed to considering environmental justice in every program and process.

In 2001, ARB adopted Policies and Actions for Environmental Justice (Policies) to provide a framework for incorporating environmental justice into its programs. The Policies apply to all communities in California, but recognize that environmental justice issues have been raised mostly in the context of low-income and minority communities. These Policies are intended to promote the fair treatment of all Californians and cover the full spectrum of ARB activities. The Policies recognize the need to engage community members as ARB develops and implements its programs. ARB is committed to work closely with all stakeholders, environmental and public health organizations, industry, business owners, other State and local agencies, and all other interested parties, to successfully implement these Policies.

Climate change will present additional challenges to those that environmental justice communities are already facing. Climate change has both direct and indirect impacts on health. These health effects disproportionately impact vulnerable individuals—the young, elderly, and people with chronic illness—and people in environmental justice communities.

Climate change will affect human health, infrastructure, and transportation systems, as well as energy, food, and water supplies. Environmental justice communities may face greater challenges to adapting to climate change due to limited resources. To the extent feasible, the State should work to identify and address any adverse effects of the State's climate programs, policies, and activities on environmental justice communities. In addition, the State must ensure that its climate programs, policies and actions also result in benefits to environmental justice communities.

Potential Impacts and Benefits to Environmental Justice Communities

The implementation of air pollution control programs in California at the federal, State, and local levels targeting GHGs, criteria pollutants, and air toxics will together result in a reduction of air pollution throughout the State. These statewide emission reductions are intended to improve the health of all of California's residents. Specifically, the implementation of the Scoping Plan will result in significant GHG emission reductions in California, accompanied by criteria and toxic pollutant emission reductions at the State and local level. ARB will work to ensure that implementation of the Scoping Plan and all of its programs do not adversely affect environmental justice communities. ARB will continue to work closely with the local air districts to monitor air pollution to ensure that emission reductions at the State, local, and regional levels are occurring as intended, and that environmental justice communities are also sharing in the benefits of cleaner air.

In addition, as part of a focused effort, ARB will continue to work with CAPCOA to design elements of a Cap-and-Trade adaptive management process to identify and respond to concerns about the potential for localized emission increases due to the Cap-and-Trade Regulation. The effort will involve a transparent process to collect, review, and evaluate data to determine if any potential adverse localized air quality impacts might have occurred as result of implementing Cap-and-Trade. If a potential impact is identified through the process, ARB is committed to developing appropriate responses through a public process, including consideration and approval by the Board as necessary.

Environmental justice communities will also benefit directly from the expenditure of Cap-and-Trade auction proceeds. SB 535 requires CalEPA to identify disadvantaged communities based on geographic, socioeconomic, public health, and environmental hazard criteria for purposes of expending Cap-and-Trade auction proceeds. SB 535 also requires that at least 25 percent of Cap-and-Trade auction proceeds be allocated to projects that benefit these communities, and at least ten percent of the proceeds be allocated to projects located in the communities.

To the extent feasible, all State, regional, and local government agencies with a role in implementing AB 32 should employ available data sources to help target resources, programs, incentives, and enforcement efforts to ensure that residents of EJ communities receive benefits from climate-related efforts and to guard against worsening conditions or creating new environmental justice problems.

Assessing the Effects of AB 32 Climate Change Programs in Environmental Justice Communities

ARB, in coordination with CalEPA and the Office of Environmental Health Hazard Assessment (OEHHA), is working on developing a method to assess the effects of California's climate change mitigation efforts on environmental justice communities. AB 32 requires that, to a feasible extent, ARB must ensure that activities undertaken to address climate change do not disproportionately impact disadvantaged communities and that those communities also benefit from statewide efforts to reduce GHG emissions.

The Environmental Justice Advisory Committee, formed pursuant to AB 32, has expressed significant interest in the development of metrics for tracking, assessing, and quantifying the potential impacts and benefits of the State's climate programs, policies, and actions on California's economy, environment, and public health, particularly with respect to environmental justice communities.

Tools such as CalEnviroScreen (released by CalEPA and OEHHA) have been developed to evaluate multiple indicators of environmental and socioeconomic vulnerability in disadvantaged communities. These tools do not show the impacts of any single program, but are intended to evaluate a community's vulnerability to pollution's adverse effects.

In contrast, the effort discussed here attempts to focus on the impacts of AB 32 programs that reduce GHGs and other climate change pollutants. Any effort to track the effects of AB 32 will require, at a minimum, the identification of indicators that could be tied to the programs of interest and a method for assessing those indicators. An effective and meaningful evaluation of AB 32 programs must rely on indicators expected to fluctuate with government, community, and industry actions to implement climate change mitigation programs.

Project Concept

ARB staff, in coordination with CalEPA, OEHHA and other agencies, is undertaking an effort to assess the effects (benefits and potential impacts) of AB 32 programs on disadvantaged communities. The key objective is to develop a quantitative mechanism to gauge the effectiveness of AB 32 programs with respect to disadvantaged communities. Specifically, to help address the question "Is the implementation of AB 32 programs fulfilling the statutory responsibility to provide benefits and avoid disproportionate harmful impacts to the extent feasible in those communities?"

ARB is developing a multi-phase approach, beginning with identifying sources of existing available and accessible data. This first phase would look at changes in emissions of multiple air pollutants at individual facilities and include a visual tool to support ready public access to those data. ARB will rely on a process of extracting and reviewing criteria and toxics emissions information, developed by and in concert with the local air districts, in order to understand localized impacts. The next phase would expand in scope to encompass entire disadvantaged communities (per SB 535), reflecting emissions from both facilities and mobile sources in each area. In a later phase, we would include relevant emission reduction and economic data from projects funded through the investment of Cap-and-Trade auction proceeds to benefit disadvantaged communities. Table 11 below describes the phases of the proposed approach. The Scoping Plan Economic Advisors, other State agencies (like OEHHA), and local air districts may aid ARB by supplementing these data and analyses, which would provide an expanded view.

Existing data sources include the following:

- California Electronic Greenhouse Gas Reporting Tool (Cal e-GGRT)
    - Cal e-GGRT is California's Mandatory Greenhouse Gas Emissions Reporting Program that provides quality assured and third-party verified emissions data from sources that contribute the most to Statewide GHG emissions.
- California Emission Inventory Development and Reporting System (CEIDARS)
    - CEIDARS data are the result of facility reports to air districts that are passed to ARB. CEIDARS provides facility criteria and toxic emissions data.
- EMissions FACtors for emissions from California's on-road vehicles (EMFAC)
    - EMFAC is California's model for estimating GHG, criteria and toxic emissions from on-road vehicles operating in California.
- Off-Road Motor Vehicles and Equipment
    - Category-specific methods and inventory models are being developed for specific regulatory support projects to replace the OFFROAD model. The following ARB website lists the categories that have been or are being updated with new methods and data: *www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles*.

The goal is to provide an evaluation of the effects of AB 32 programs, considering multiple variables, including greenhouse gases, criteria pollutants, and toxic air contaminants. This assessment would not only meet the goals of the Cap-and-Trade Adaptive Management Plan but would also include impacts not otherwise attributed to Cap-and Trade. The results of this assessment would provide an evaluation of the effects of all AB 32 programs on disadvantaged communities. Data collected could provide information needed for ARB to plan and implement investment, regulatory, or policy responses to any identified adverse localized impacts on specific disadvantaged communities.

Staff intends to present this effort as part of the Cap-and-Trade Adaptive Management Plan public workshops scheduled for mid-2014. Additionally, staff anticipates that with the Cap-and-Trade Adaptive Management Plan, an update on the progress of this effort will be presented to the Board before the end of 2014.

Table 11: Project Phases for Assessing the Effects of AB 32 Programs on Disadvantaged Communities

Phase	Description
Phase 1 Collect and Make Available Facility Data	The focus will be on facilities that are required to report consistent with ARB's Mandatory Reporting Regulation. We will compile several years of climate, criteria pollutant, and air toxics emissions data for these facilities. We will also make this information available for review and analysis by the public, including communities, academics, and government.
Phase 2 Evaluate Facility Emissions Data	Analyze the information collected in Phase 1. We intend to utilize the data evaluation process developed for the Cap-and-Trade Adaptive Management Plan and annually provide a summary of findings for public review.
Phase 3 Collect and Make Available Community Data	The focus will be on disadvantaged communities as defined by CalEPA under SB 535. We will integrate "community-level" mobile source emission data and investment data from Cap-and-Trade auction proceeds. In this phase, we will also quantify trends and provide data biennially for public review and analysis.
Phase 4 Evaluate Community Data	Conduct a detailed analysis of the information collected in Phase 3. We will summarize our findings and biennially release results for public review.
Phase 5 Respond to Evaluations in Scoping Plan	Respond to Phase 4 results and discuss project progress in the next Update to the Climate Change Scoping Plan.

Outreach and Community Capacity Building

As climate policy and programs are developed and implemented, community capacity building through education and outreach efforts—as well as integration of community members into the decision making process—are critical components of helping to ensure that the needs of these communities are known and addressed. Additional effort is needed in communities that are geographically, linguistically, and/or economically isolated. Collaboration with trusted sources of information, such as community-based organizations, regional climate collaboratives, and culturally appropriate messaging techniques, are recommended.

Environmental Justice Advisory Committee

To ensure environmental justice needs and concerns are integrated into the State's climate programs, ARB reconvened the Environmental Justice Advisory Committee (Committee) to advise the Board on the Update. On March 21, 2013, the Board appointed members based on nominations received from environmental justice organizations and community groups.

Environmental Justice Advisory Committee		
Martha Dina Argüello	Physicians for Social Responsibility	Los Angeles
Nicole Capretz *(Served on EJAC until August 2013)*	Environmental Health Coalition	San Diego
Gisele Fong	End Oil	Los Angeles
Tom Frantz	Association of Irritated Residents	Central Valley
Kevin Hamilton	Clinica Sierra Vista	Central Valley
Rey León	Valley LEAP	Central Valley
Penny Newman *(Appointed to EJAC but unable to serve)*	Center for Community Action and Environmental Justice	Inland Empire
Luis Olmedo	Comite Civico Del Valley	Imperial Valley
Susan Riggs *(Served on EJAC until March 2014)*	San Diego Housing Federation	San Diego
Kemba Shakur	Urban Releaf	Bay Area
Mari Rose Taruc	Asian Pacific Environmental Network	Bay Area
Monica Wilson	Global Alliance for Incinerator Alternatives	Bay Area
Ryan Briscoe Young *(Served on EJAC until April 2014)*	The Greenlining Institute	Statewide

The Committee met four times from June 2013 to April 2014 to discuss the Update. The Committee focused their discussions on each Scoping Plan sector and developed comprehensive recommendations that ARB considered in drafting this Update. The Committee's "Final Recommendations on the Proposed AB 32 Scoping Plan" provided recommendations for each Scoping Plan sector and overarching environmental justice policy. The final recommendations included the need for monitoring and assessing potential impacts of the State's climate programs; a call for a 2030 target of, at a minimum, 40 percent reduction from 1990 levels and a 2040 target of, at a minimum, 60 percent reduction from 1990 levels; a call for California to reduce its energy use and transition to 100 percent renewable energy; financial support for transportation in disadvantaged communities; and amendments to the Cap-and-Trade Regulation that would exclude direct allocation and offset credits. The Committee's final recommendations can be found in Appendix E.

D. Environmental Analysis

ARB prepared an environmental analysis (EA) of the Scoping Plan Update pursuant to its regulatory program certified by the Secretary of the Natural Resources Agency (14 CCR 15251(d); 17 CCR 60000–60008). The draft EA is included as Appendix F. In accordance with Public Resources Code section 21080.5 of CEQA, public agencies with certified regulatory programs are exempt from certain CEQA requirements, including but not limited to those preparing environmental impact reports, negative declarations, and initial studies (14 CCR 15250). The resource areas from the CEQA Guidelines Environmental Checklist are being used as a framework for assessing the potential for significant impacts (17 CCR 60005(b)).

A draft EA was released for a 45-day public review on March 15, 2014. ARB summarized and responded in writing to all comments submitted on the EA in a supplemental response document for the Board to consider for approval along with the Update.

VII. Conclusions

California is forging a path forward in the fight against climate change. By expanding on existing policies and developing new ones, we are steadily bending the arc of economic growth in our state in a cleaner, more sustainable direction. And while climate change demands it, the steps we are taking to cut emissions are the very actions we should be taking anyway to build for the future in California.

Sustainability and climate action have increasingly become part of the DNA of who we are and how we, as Californians, see ourselves. It is now as inconceivable to pump unlimited amounts of carbon pollution into the atmosphere as it was once to spew mercury, lead, sulfur dioxide, or arsenic into the air.

Day by day, in steady steps of visible progress, we are seeing the emergence of a clean energy future. Solar panels are commonplace, whether on roofs, commercial warehouses, or in shiny ground-based arrays across the State. Thousands of wind turbines have become part of the California clean energy panorama, their blades describing slow graceful arcs as they generate more than 4,000 megawatts of pollution-free energy.

Electric vehicles are a common sight on our streets and highways, and each day brings more charging stations to parking structures and shopping malls. Biofuel is available at retail outlets. Even big-rigs are getting a climate makeover as trailer skirts, low-rolling resistance tires, and aggressively aerodynamic cabs mean less wind resistance, lower fuel costs, and fewer emissions.

These efforts aren't just cutting greenhouse gases. They are cleaning our air; helping to better preserve water, and agricultural lands, and other critical natural resources; powering the growth of new long-term economic drivers in the state; and helping to pull together and better align public policy priorities across programmatic silos.

As California takes these steps, public support for action also continues to grow. Recent polls show that 79 percent of Californians believe global warming is happening, and a majority want to see more action by the State; 73 percent say corporations and industry need to do more; 70 percent feel they, themselves, should be doing more to address the issue.

This public consensus aligns with the dictates of science, which tell us unequivocally that we must continue on the path we are on, and even accelerate our efforts in the coming years.

That is exactly what this Update does. It builds on California's framework for climate action with a range of strategies that will keep pushing our state toward a cleaner, more sustainable future. It is a continuation of what we have already begun. Now is the time to make it a reality.

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CALIFORNIA
ENERGY
COMMISSION

INVENTORY OF CALIFORNIA GREENHOUSE GAS EMISSIONS AND SINKS: 1990 TO 2004

STAFF FINAL REPORT

December 2006
CEC-600-2006-013-SF

Arnold Schwarzenegger, *Governor*

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State of California **The Resources Agency of California**

Memorandum

To: Linda C. Murchison, PhD
Division Chief
Planning and Technical Support Division
Air Resources Board

Date: January 23, 2007

Telephone: (916) 654-4628

From: **California Energy Commission -- Rosella Shapiro, Deputy Director**
Fuels and Transportation Division
1516 Ninth Street
Sacramento CA 95814-5512

Subject: REVISIONS TO THE 1990 TO 2004 GREENHOUSE GAS EMISSIONS INVENTORY REPORT, PUBLISHED IN DECEMBER 2006 (CEC-600-2006-013)

As we finalized the technical report titled *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004* in late December 2006, my staff discovered a need to change greenhouse gas (GHG) emissions estimates for in-state electricity production. They discussed the need for these changes with both Peggy Taricco and Webster Tasat of your staff. They requested that we document these changes as we transmit them to the Air Resources Board.

Enclosed in this package is the published version of Table 6 from the referenced report, a revised version of Table 6 showing the needed changes for GHG emissions from in-state electricity production, and a detailed description of the specific changes needed. Gerry Bemis of my staff is available to assist your staff to provide whatever additional assistance may be needed to implement these changes. He will also provide your staff with a final version of all GHG inventory files.

December 20, 2006 Changes Identified for
In-State Electricity GHG Emissions

1. Refinery Self-Generation
   The Energy Balance (Assembly File) has an entry on Row 22 under "Transfer, Oil Refineries". This was erroneously thought to be "Refinery Self-Generation" and was listed as such in both the GHG inventory published in 2005 and the one published in 2006. These values should be removed from all years, but entries for 1990 to 1992 were zero, so those years are not affected. This reduces GHG emissions values published in 2006 by 0.7 to 4.3 $MMTCO_2E$, depending on year.

   Change Needed:
   Remove all columns of Row 178 from Table A-4 in the main file[1] including removing this row from the equation in Row 172. Also remove all columns of Row 184 from the Fossil Fuel CO2 tab and the summary equation in Row 178 of this tab.

2. Coal
   There was an error made in multiplying Thousand Short Tons of coal by the energy content of the coal. This was a simple mechanical error, which shows up in the GHG inventory published in 2006, but was not in the 2005 GHG inventory.

   Changes Needed:

   On "Appendix B in the main file, Columns "G" through "U":
   a) Change Row 193 to read as follows:
   ='[assembly(July 2006 Update).xls]COAL'!C16*'[assembly(July 2006 Update).xls]Conv Energy'!**C49**/10^3 (change "C13" to "C49")

   b) Change Row 194 to read as follows:
   ='[assembly(July 2006 Update).xls]COAL'!C17*'[assembly(July 2006 Update).xls]Conv Energy'!**C50**/10^3 (change "C14" to "C50")

   c) Change Row 195 to read as follows:
   ='[assembly(July 2006 Update).xls]COAL'!C19*'[assembly(July 2006 Update).xls]Conv Energy'!**C52**/10^3 (change "C16" to "C52"; see below for "C19")

   For changes a) through c), change each column correspondingly to apply the change to each year, 1990 through 2004.

3. Merchant Power (natural gas)
   On the "Appendix B" tab in the main file, Row 195 had the wrong reference cell for BTUs used by Merchant Power facilities. This is another mechanical error which appears in the 2006 GHG inventory but not in the 2005 GHG inventory.

[1] 2005 GHG Inventory (1990 to 2004).xls

Change Needed:
Change the first term from “COAL’C18” to “COAL’C19” as indicated above for Row 195. Make this change for all columns, “G” through “U”.

Changes #2 and #3 taken together increase values above those published in 2006 for GHG emissions from coal-based electricity generation by 1.0 to 2.5 MMTCO$_2$E, depending on year.

4. “Other” Petroleum Products
These fuel uses were left off of both the 2005 and 2006 GHG inventories. This was an oversight. To fix this problem and because the Energy Balance (Assembly File) did not identify “Other Petroleum Products” fuel uses by fuel type, it was necessary to use an Energy Information Administration (EIA) database, specifically the one for EIA Form 906. This database provides fuel use for in-state fuel consumption to produce electricity.

There is a separate file for each year from 2001 through 2005. Each file was data-filtered for California, then data-filtered for each fuel and each sub-category of fuel use as listed in Appendix B of the main file. End results of filtering for natural gas and coal (after making the adjustments above) match very closely to Energy Balance (Assembly) values when comparing physical units (TCFs and BBLS). This shows that the proper sub-categories (Utility, Merchant Plant, etc) were identified in the Form 906 database. Corresponding values for BTU equivalents to the physical units were also close, but differed slightly because the Form 906 database has monthly values for conversion from physical unit to BTUS, while the Energy Balance uses a yearly approximation. The corrections below include using BTU values from the Form 906 database for natural gas and coal (years 2001 to 2005) because they are viewed to be slightly more accurate than Energy Balance BTUs. The results of filtering, done for each year, are in new files for each year and a summary file titled “Electric GHG Emissions” within a new folder “EIA Electricity Data”.

This process yields in-state electricity fuel uses for distillate oil, residual fuel oil and petroleum coke, each of which has a tab in the Energy Balance (Assembly file) which was empty. The process also yields a modest amount of “Other Organic Gases” from the EIA 906 database, which could not be identified. For purposes of making emissions calculations, these were assumed to be refinery still gas for purposes of calculation. These Other Organic Gases are calculated to contribute 0.6 to 1.3 MMTCO$_2$E. If the carbon content of these unknown gases is different from refinery still gas, their correct emissions are likely to be similar.

Rows were added to the “Fossil Fuel CO2” tab (new file, Rows 189 to 194) to accommodate this change. Row 177 was also revised to include Row 189, the subtotal for petroleum. Table 2 was likewise expanded to add a subtotal for petroleum under Electricity Generation (In-State).

Changes Needed (as described in the revised main file[2]):
Add Rows 410 to 462, column “A” through “U” to Fossil Fuel CO2 tab in the main file. These new cells link to a new file “Electric GHG Emissions” within a new folder “EIA Electricity Data” where new calculations are made from EIA forms.

Link these new cells to corresponding cells in “Electric GHG Emissions” file. Then make the following changes to Fossil Fuel CO2 file:

[2] 2005 GHG Inventory (12-20-06 edits--1990 to 2004).xls

(Note: no changes needed for rows 178 to 188, columns “F” through “P”)

a) Make new summary Row 189 for petroleum subtotal and new Rows 190-194.

b) For Columns “F” through “P”:
Make Row 190 = Row 450
Make Row 191 = Row 451
Make Row 192 = Row 452
Make Row 193 = Row 453
Make Row 194 = Row 454

c) For Columns “Q” through “U”:
Make Rows 179-184 = Rows 415-420, respectively;
Make Rows 186-188 = Rows 423-425, respectively;
Make Row 190 = row 430;
Make Row 191 = Rows 441+445;
Make Row 192 = Rows 431+437+442+446+447;
Make Row 193 = Rows 428+435;
Make Row 194 = Rows 429+436+440

Add Row 189 to the equation in Row 177, for all columns.

One effect of these changes is to make slight modifications for years 2001 through 2004 in the natural gas data. This was possible because the Form 906 file has monthly values for fuel energy content, so the revised annual BTUs are slightly different. Coal data were revised as discussed above. The change discussed here will be limited to natural gas GHG emissions, which increase by 0.9 $MMTCO_2E$ in 2002 and 2003, and 2.1 $MMTCO_2E$ in 2004.

The second effect of these changes is to add petroleum fuel GHG emissions in years 1990 to 2005 (2005 shown for information). These changes add 2.5 to 4.6 $MMTCO_2E$ depending on year.

The net effect of all these changes is to increase emissions from in-state electricity production. The maximum increase is in 2004, +8.0[3] $MMTCO_2E$. The smallest increase is in 2003, +1.8[4] $MMTCO_2E$.

5. <u>Electricity Imported to California</u>
Staff are still in the process of updating the method used to estimate out-of-state emissions for electricity imported into California. However, if the current method continues to be used, GHG emissions should be increased to account for transmission line losses which were not included in the previous calculation. The Energy Commission uses an overall bulk average of 7.5% for transmission line losses, but this includes all sources, local and imported. In-state line losses are implicit in the existing methodology, which is based upon fuel used, not electricity used. In the methodology currently being used, GHG emissions from imported electricity are computed from imported electricity, not fuel use, and this method should have included an estimate of transmission line losses. This can be done by multiplying the computed results by 1.075, if 7.5% is the appropriate value. However, imported electricity would travel over greater distances than

[3] 2004 value increases 1.8 for natural gas, 2.6 for coal and 3.6 for petroleum fuels, all $MMTCO_2E$.
[4] 2003 value decreases 3.4 for natural gas, and increases 2.0 for coal and 3.2 for petroleum fuels, all in $MMTCO_2E$.

in-state electricity and thus may have larger transmissions losses than the bulk average. The bulk average transmission losses (7.5%) can be determined from Form 1.2 of the document *California energy Demand 2006-2016, Staff Energy Demand Forecast, Revised September 2005*, CEC-400-2005-034-SF-ED2, September 2005.

The above change was not made in the December 20, 2006 revisions because the entire methodology is expected to change.

ABSTRACT

This report provides estimates of California's greenhouse gas emissions over the 1990 to 2004 time period. Emissions estimates in the report are derived from data provided by the U.S. Energy Information Administration and additional data collected by the California Energy Commission. Analysis in the report uses protocols established for country-level greenhouse gas emissions inventory reporting as established by the Intergovernmental Panel on Climate Change and the U. S. Environmental Protection Agency. The report includes both in-state emissions and emissions from electricity imported into California. These emissions and emissions from international fuel uses are shown at the bottom of the inventory to allow the reader to decide whether to include them.

California's greenhouse gas emissions are large in a world-scale context and growing over time. If California was considered to be an independent country, its emissions would rank seventeenth largest.

This report also includes projections of California greenhouse gas emissions to 2020. These projections are based upon forecasts adopted by the Energy Commission in its *2005 Integrated Energy Policy Report*. This report also includes an estimate of reductions needed to meet 2010 and 2020 greenhouse gas emissions reduction targets established by California's Governor, Arnold Schwarzenegger.

KEYWORDS

Greenhouse gas emissions inventory, climate change, carbon dioxide, methane, nitrous oxide, high global-warming potential gases

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EXECUTIVE SUMMARY

This report updates California's statewide inventory of greenhouse gas (GHG) emissions to support evaluation of state policies that address climate change and climate variability or more commonly known as global warming. Information in this report extends the inventory period through 2004, which is the most recent year that data are available from the California Energy Commission (Energy Commission) or the United States Department of Energy's (DOE's) Energy Information Administration. This inventory reports GHG emissions from out-of-state electricity used in California along with in-state generation GHG emissions and estimates future emissions trends using fuel demand and other forecast data from the Energy Commission's *2005 Integrated Energy Policy Report*.

California's economy experienced the second largest percentage growth in terms of gross state product (in dollars, not adjusted for inflation) of any state in the country from 1990 to 2003.[1] During that period, California's GSP grew 83 percent while its GHG emissions grew more slowly at 12 percent. This demonstrates the potential for uncoupling economic trends from GHG emissions trends.

Nonetheless, California's GHG emissions are large and growing. As the second largest emitter of GHG emissions in the United States and twelfth to sixteenth largest in the world,[2] the state contributes a significant quantity of GHGs to the atmosphere.

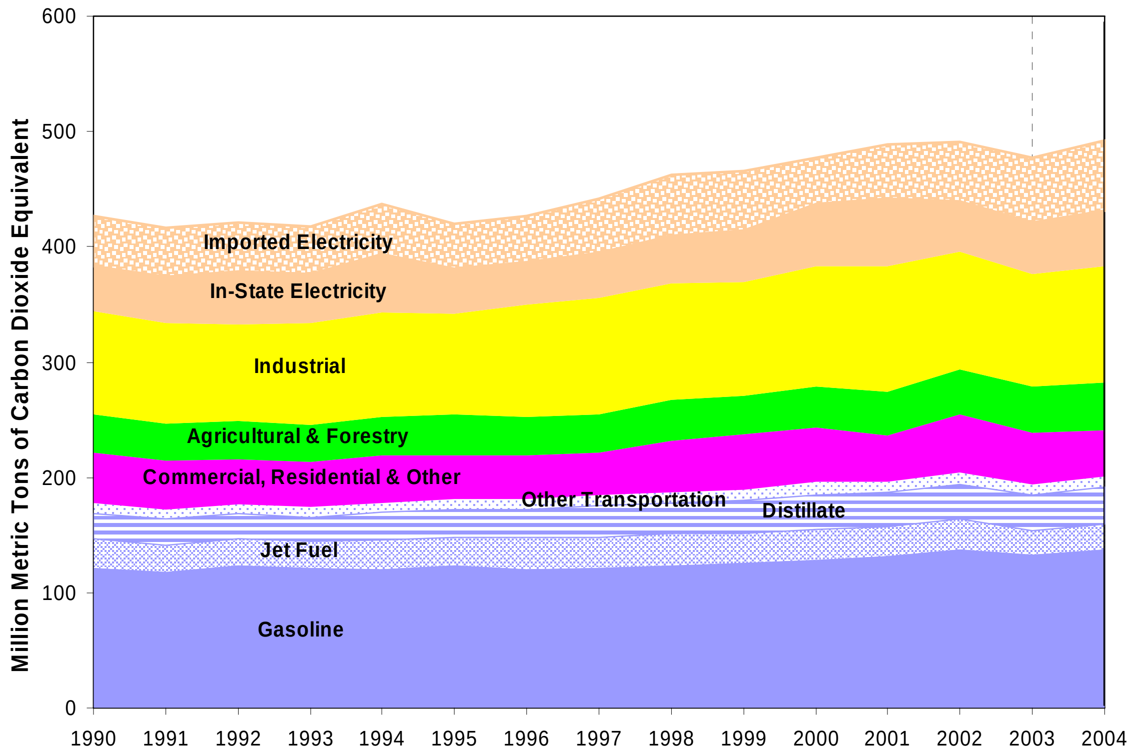
California's ability to slow the rate of growth of GHG emissions is largely due to the success of its energy efficiency and renewable energy programs and a commitment to clean air and clean energy. In fact, the state's programs and commitments lowered its GHG emissions rate of growth by more than half of what it would have been otherwise.[3] Moreover, California's energy programs and policies have had multiple benefits that include not only reducing GHG emissions, but reducing energy demand and improving air quality and public health.

Although California's total GHG emissions are larger than every state but Texas, California has relatively low carbon emission intensity. In 2001, California ranked fourth lowest of the 50 states in carbon dioxide emissions per capita from fossil fuel combustion and fifth lowest of the 50 states in carbon dioxide emissions from fossil fuel combustion per unit of gross state product. Emission trends per unit of gross state product are encouraging; most states have reduced their emissions per unit of gross state product over the 1990 to 2001 period.

In 2004, California produced 492 million gross metric tons of carbon dioxide-equivalent[4] GHG emissions, including imported electricity and excluding combustion of international fuels and carbon sinks or storage.

Figure 1 shows year-by-year trends in GHG emissions for the major energy sectors. Values differ yearly due to changes in fuel uses, meteorological variations, and other factors.

Figure 1 -- California's Gross GHG Emissions Trends



Source: California Energy Commission

The transportation sector is the single largest category of California's GHG emissions, producing 41 percent of the state's total emissions in 2004. Most of California's emissions, 81 percent, are carbon dioxide produced from fossil fuel combustion.

This California GHG emissions inventory excludes all international fuel uses, reporting them separately. Including these international emissions would increase total emissions by 27 to 40 million metric tons of carbon dioxide–equivalent GHG emissions, depending on the year.

Electricity generation is the second largest category of GHG emissions (behind transportation). In particular, out-of-state electricity generation has higher carbon intensity than in-state generation. While imported electricity is a relatively small share of California's electricity mix (ranging from 22 to 32 percent of total electrical energy used), out-of-state electricity generation sources contribute 39 to 57 percent of the GHG emissions associated with electricity consumption in California. Electricity imported to California from the Southwest has a significant percentage that is coal-based generation, while imports from the Pacific Northwest have a significant portion that is hydroelectricity.

Because GHGs affect the entire planet, not just the location where they are emitted, policies developed to address climate change should include an evaluation of emissions from the entire fuel cycle whenever possible.

Staff recommends the following steps to further improve the accuracy and utility of the California GHG emissions inventory:

- Update fuel use and other emissions-related activity data.

- Perform a more detailed review of industrial uses of fossil fuels to classify when they are used as fuel versus when they are used as a process input and not released into the atmosphere at that step in their usage chain.

- Add industrial wastewater emissions. These occur from processing fruits and vegetables, red meat and poultry, and pulp and paper. Methane and nitrous oxide emissions from these activities are not yet included in this inventory and should be added since California is a major producer of these products.

- Study in more detail landfill methane emissions. Values in this inventory represent a facility-by-facility review of emissions by local air quality district staff; as of July 2006, local air quality districts are updating their data but have yet to finish this work. Also, landfill emissions are being studied by the Energy Commission's Public Interest Energy Research Program but results are not expected before 2008. Improved data for landfill emissions are expected to result from both of these efforts.

- Develop California-specific data for sulfur hexafluoride emissions from electric utilities for the 1990-to-present time period.

- Develop California-specific emission factors for methane and nitrous oxide from enteric fermentation and manure management.

INTRODUCTION

This report updates California's statewide inventory of GHG emissions, using the most current data available from the EIA and the Energy Commission. The report also adds two years to the period covered by the inventory, extending it from 2002 to 2004. Major changes from the previous state inventory are summarized in Appendix D.

The California GHG emissions inventory is an estimate of anthropogenic[5] emissions of carbon dioxide (CO_2), methane, nitrous oxide, and various high global warming potential (GWP) gases that contribute to warming of the earth's atmosphere and oceans. All these gases have been identified as forcing the earth's atmosphere and oceans to warm above naturally occurring temperatures.[6]

The last State of California inventory of anthropogenic GHG emissions was reported in *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update.*[7] It covered the period from 1990 to 2002, and was prepared by Energy Commission for the *2005 Integrated Energy Policy Report*.

In November 2002 the Energy Commission published a previous State of California GHG emissions inventory in a report titled *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999*.[8] It covered the period from 1990 to 1999 and was prepared under contract to the Energy Commission by ICF Consulting of Washington, D.C.

All three GHG inventories are based on guidance documents also prepared by ICF Consulting for the U.S. Environmental Protection Agency (EPA).[9]

Because they provide a comprehensive and consistent data source without significant gaps or overlap, where available, U.S. Energy Information Administration (EIA) fuel data were used in the 1990-1999 inventory and for subsequent updates. These EIA fuel data were supplemented with Energy Commission fuel data in a report titled *California Energy Balances Report (Energy Balance)*[10] prepared by Lawrence Berkeley National Laboratories for the Energy Commission's Public Interest Energy Research (PIER) Program. For non-fuel emissions, a variety of sources are used as documented later in this report.

The new inventory relies heavily upon data sources and procedures used by ICF Consulting in preparing the 1990-1999 California inventory and the national GHG emissions inventory.[11] In some instances, staff used newer data available from the Energy Commission and the California Air Resources Board (ARB), which allow for a more refined treatment. These changes are explained in the body of this document.

This report presents the methodology and approach used in the current inventory update. Where a change is made in either data or analysis, staff has provided information in this report to fully document the change. The 1990-1999 inventory provides full technical documentation. All changes are applied over the entire time span of the inventory to more properly show GHG inventory trends.

The report next provides a summary of California's GHG emissions, followed by a discussion of projected GHG emissions trends. The trend section ends with a comparison of California GHG emissions to those of other states. This discussion is limited to CO_2 emitted from fossil fuel combustion because it was not possible to get 50-state data for the non-fossil fuel emissions.[12] Fossil fuels produce more than 80 percent of California's GHG inventory and are responsible for large, but varying, percentages of GHG emissions for the other states.

After the CO_2 trend analysis, the report summarizes the methods used to estimate California's inventory of GHG emissions. Next, this report discusses ways to improve future versions of the California GHG emissions inventory.

Appendix A provides documentation for improvements made to the California GHG inventory. Appendix B provides a table showing energy used in fossil fuel combustion in California, largely derived from the California Energy Balance. Appendix C provides a comparison of alternative methods of estimating GHG emissions from imported electricity. Appendix D compares the 1990 to 2002 inventory to the 1990 to 2004 inventory for the years that match. Appendix E provides the methane speciation profile used by ARB to calculate methane emissions for the categories for which they provided data. Finally, Appendix F compares the CAT emissions inventory and projections to the 1990 to 2004 GHG inventory and projections using the *2005 IEPR*.

Early California GHG Inventories

In October 1990, the California Energy Commission published[13] the first inventory of GHG emissions for the State of California. This inventory was only for one year (1988) and only for CO_2, with results expressed in million short tons of carbon. Table 1 shows a summary of these emissions estimates in the units originally used and converted into million metric tons of carbon dioxide equivalents ($MMTCO_2E$). Gross GHG emissions are shown, which means that CO_2 sinks are not included.

Table 1 – 1988 Gross California GHG Emissions (Million Tons) (Published October 1990)

	Million Short Tons of Carbon	Million Metric Tons CO_2E
In-state	125.1	416
Out-of-state	19.4	64.5
Total	144.5	480.5

In March 1997, the Energy Commission published[14] its second inventory of GHG emissions for the State of California. This second inventory was also only for one year (1990) but included an estimate for methane and nitrous oxide, in addition to CO_2. It used a 100-year GWP[15] of 11 for methane (this report uses 21) and 270 for nitrous oxide (this report uses 310). Both these weighting factors are values multiplied by the weight of the gases emitted to convert them to CO_2 equivalents. Results were expressed in short tons of CO_2 equivalent, using the GWPs to obtain the CO_2 equivalents for methane and nitrous oxide. These estimates included international bunker fuels.[16] Gross California emissions (excludes CO_2 sinks) for this second inventory are summarized in Table 2.

Table 2 – 1990 Gross California GHG Emissions (Million Tons) (Published March 1997)

	Million Short Tons of Carbon Dioxide Equivalent	Million Metric Tons of Carbon Dioxide Equivalent
In-state	482.3	437.5
Out-of-state	16.0	14.5
Total	498.3	452.0

In January 1998, the Energy Commission published[17] its next GHG inventory. This inventory covered 1990 through 1994 and included methane and nitrous oxide in addition to CO_2. It used 100-year GWPs of 21 for methane and 310 for nitrous oxide, as did subsequent GHG inventories. Results were expressed in short tons of CO_2 equivalent. The report includes an estimate for out-of-state GHG emissions only for 1990. This 1990 value was estimated from Figure 5 of the 1990 to1994 GHG inventory report. Thus, the “Total” row in each of the two tables below is left empty except for 1990. Table 3 shows a summary of gross California emissions from this inventory in the original short tons of CO_2 equivalent units. Table 4 shows the same inventory converted to million metric tons of CO_2 equivalents to facilitate comparison to other inventory vintages.

Table 3 – 1990 Gross California GHG Emissions (Million Short Tons CO_2 Equivalent) (Published January 1998)

	1990	1991	1992	1993	1994
In-state	456.3	440.7	443.6	435.6	458.2
Out-of-state	59 (est.)	N.A.	N.A.	N.A.	N.A.
Total	515.3				

Table 4 – 1990 Gross California GHG Emissions (Million Metric Tons CO_2 Equivalent) (Published January 1998)

	1990	1991	1992	1993	1994
In-state	414.0	399.8	402.4	395.2	415.7
Out-of-state	53.5 (est.)	N.A.	N.A.	N.A.	N.A.
Total	467.5				

From Tables 3 and 4 one can see that emissions decrease beginning in 1990 and then rebound to values slightly above 1990 levels by 1994. The trend is consistent in subsequent California GHG inventories, including the 1990 to 2004 GHG inventory.

As information on activity levels and GHG emissions estimating techniques improve over time, estimated emissions for a selected year can and will change. It is accepted practice to improve and recalculate historical emissions inventories even if the end result causes a change in reported emissions and trends.[18] Table 5 below shows estimated gross emissions levels from five California GHG emissions inventories published by the Energy Commission, their dates of publication, and total estimated 1990 California emissions in million metric tons of carbon dioxide, including both in-state and imported electricity.

Table 5 – Various Estimated 1990 Gross California GHG Emissions

CEC Publication Number	Date Published	Million Metric Tons of Carbon Dioxide Equivalent
P500-97-004	March 1997	452
P500-98-001V3	January 1998	468
P600-02-001F	November 2002	425
CEC-600-2005-025	June 2005	439
CEC-600-2006-013	October 2006	427

The first two rows of Table 5 are from Tables 2 and 4 above, respectively. The next two rows of Table 5 are 1990 values from the referenced reports and the last row of Table 5 is from Table 6 of this report. As can be seen from Table 5, estimated 1990 GHG emissions range from a low of 425 million metric tons of carbon dioxide equivalent to a high of 468 million metric tons of carbon dioxide equivalent. The "exact" value for 1990 will always remain unknown.[19]

Legislative Requirements for Inventory Updates

In 2000, the California Legislature required the Energy Commission to update the state's inventory of GHG emissions in consultation with other agencies. Senate Bill (SB) 1771 (Sher, Chapter 1018, Statutes of 2000) required the Energy Commission to update the inventory in January 2002 and every five years after that. The next GHG inventory update required by this legislation is due in January 2007.

The Energy Commission prepared its first statewide GHG inventory in response to SB 1771 and published it in a report titled, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999*,[20] based on the best information available at the time of publication. The inventory was developed using guidelines adopted by the Intergovernmental Panel on Climate Change (IPCC) and was consistent with the methods being used by the EPA. An update[21] to this inventory was prepared and published in June 2005 to incorporate newer information and to allow policy makers to use the most current information and data available.

Summary of California's 2004 GHG Emissions

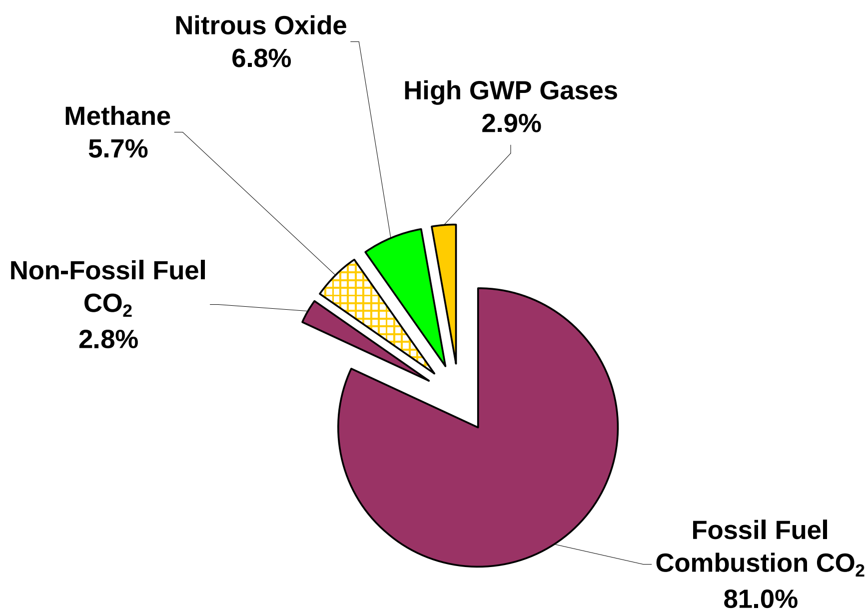
In 2004 California produced 492 million metric tons of CO_2-equivalent GHG emissions, including emissions associated with imported electricity. As shown in Figure 2, 81 percent were emissions of CO_2 from fossil fuel combustion, 2.8 percent were from other sources of CO_2, 5.7 percent were from methane, and 6.8 percent were from nitrous oxide. The remaining source of GHG emissions was high GWP gases, 2.9 percent.

The percentage of climate change associated with each specific gas is similar for each year over the 1990 to 2004 period. However, high GWP gas percentages are rising somewhat.

Composition of California's GHG Emissions

CO_2 emissions represent about 84 percent of California's total GHG emissions in 2004. CO_2 emissions are mainly associated with carbon-bearing fossil fuel combustion with a portion of these emissions attributed to out-of-state fossil fuel used for electricity consumption within California. Other activities that produce CO_2 emissions include mineral production, waste combustion, and land use and forestry changes. Some anthropogenic activities lead to a reduction in atmospheric concentration of CO_2. These are called "CO_2 sinks."

Figure 2 -- California GHG Composition by Type of Gas in 2004
(Includes electricity imports and excludes international bunker fuels)



Source: California Energy Commission

Methane emissions also contribute to global warming and they represented 5.7 percent of total GHG emissions in 2004. Methane emissions are reported in CO_2-equivalent units to reflect their GWP compared to CO_2. Agricultural activities (enteric fermentation and manure management) and landfills compose the major sources of these emissions.

Another gas that contributes to global warming is nitrous oxide (N_2O). Agricultural soil management activities and mobile source fuel combustion compose the major sources of these emissions. After using the appropriate GWP adjustment, N_2O emissions comprised 6.8 percent of California's overall GHG emissions in 2004.

A class of gases called "high GWP gases" makes up the final set of gases that contribute to global warming,[22] composing about 2.9 percent of total emissions in 2004. These are composed mostly of gases used in industrial applications to replace gases associated with ozone depletion over the Earth with an additional modest contribution from sulfur hexafluoride (SF_6) used as insulating materials in electricity transmission and distribution.

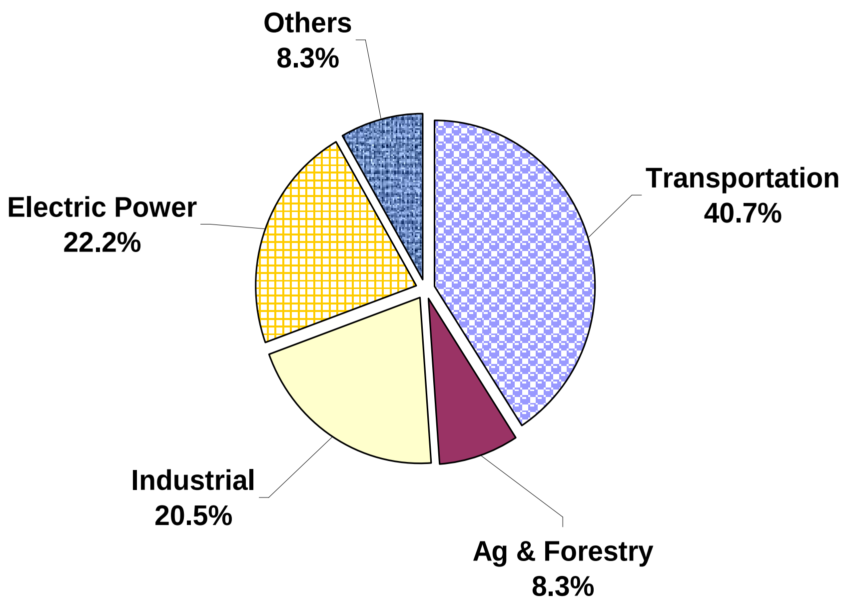
High GWP gases compose a low percentage of overall GHG emissions over this time period, although the estimated emissions are difficult to quantify and are less certain than other emissions categories. Although small in magnitude, emissions of these gases are increasing at a faster rate than other GHGs. In California, high GWP gases are largely composed of refrigerants, although electric utility transmission and distribution equipment are also sources.

End-Use Sectors Contributing to California's GHG Emissions

As shown in Figure 3, fossil fuel consumption in the transportation[23] sector was the single largest source of California's GHG emissions in 2004, with electric power from both in-state and out-of-state sources second, and the industrial[24] sector as the third largest source category. Agriculture,[25] forestry,[26] commercial,[27] and residential[28] activities composed the balance of California's GHG emissions.

Care must be exercised when looking at emissions from different sectors of the economy. For example, the GHG inventory identifies cement production from clinker manufacturing in a stand-alone category and fuel used to heat the cement production process within the industrial fuel category. Thus, CO_2 from clinker production does not represent total GHG emissions from cement production. Likewise, the GHG inventory reports landfill methane emissions in the methane portion of the inventory and CO_2 sinks associated with landfills in the CO_2 portion of the inventory. Taken together, the landfill CO_2 sinks approximately offset the landfill methane emissions. However, there are additional fuel related GHG emissions from transporting wastes to landfills, and these emissions are included in transportation fuels.

Figure 3 -- Sources of California's 2004 GHG Emissions (By End-Use Sector)
(Includes electricity imports and excludes international bunker fuels)



Source: California Energy Commission

Historical GHG Emissions Trends

This section discusses historical trends in California's gross GHG emissions. The values discussed in this section do not account for CO_2 sinks from forest, rangelands, or landfill and yard trimming disposal.

This section also excludes international aviation and marine vessel uses of jet fuel, residual oil,[29] and distillate oil because they are international fuel uses and the standard GHG emissions inventory protocol excludes them. Domestic aviation gasoline, jet fuel, residual oil, and distillate oil uses are included in the analysis.

The trends discussed in this section include carbon emissions from imported electricity, including out-of-state coal-fired power plants owned by California electric utility companies that provide electricity to California.

California's GHG emissions are large and growing as a result of population and economic growth and other factors. From 1990 to 2004 total gross GHG emissions rose 14.3 percent; they are expected to continue to increase in the future under "business-as-usual" unless California implements programs to reduce emissions.

Trends in California GHG Composition

In 1990, fossil fuel-related CO_2 emissions composed 81 percent of California's total GHG emissions, including CO_2 emissions from electric power imported to the state.[30] This percentage held steady at 81 percent in 2004. Non-fossil fuel CO_2 contributed 2.2 percent in 1990 and increased to 2.8 percent in 2004.

Methane emissions composed 6.4 percent of California's total GHG emissions in 1990. The percentage decreased to 5.7 percent in 2004. Nitrous oxide emissions trends held steady, representing 6.7 percent of total emissions in 1990, increasing slightly to 6.8 percent in 2004. High GWP gas emissions composed 2.0 percent of California's total GHG emissions in 1990, increasing to 2.9 percent in 2004.

Trends in California's GHG Emissions End-Use Categories

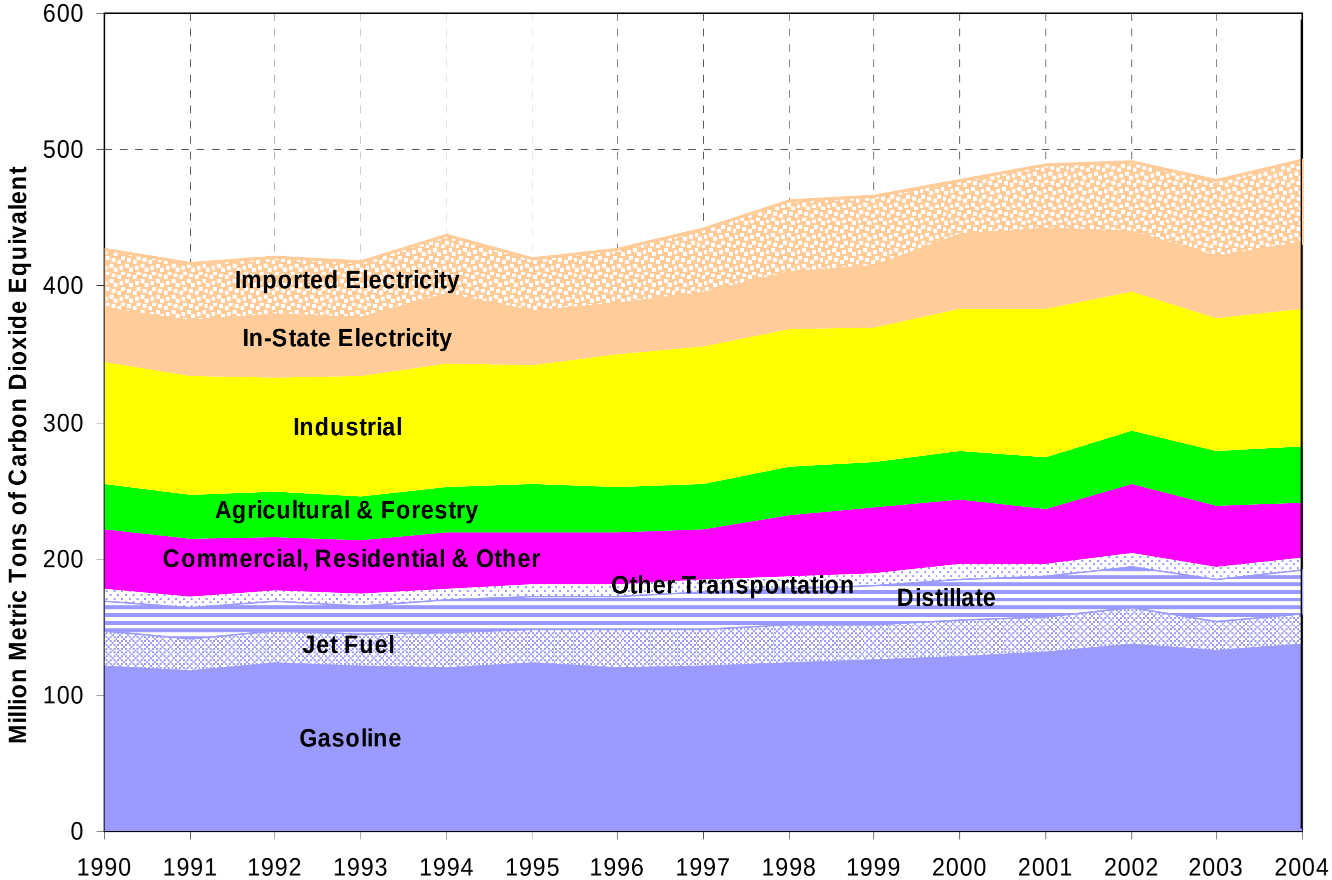
Figure 4 shows year-by-year trends in GHG emissions from transportation (gasoline consumption, jet fuel consumption, distillate fuel consumption, and other transportation fuel use); commercial, residential and other fuel use; agricultural and forestry fuel use; industrial fuel use; and electricity production (both in-state and imported electricity). These data represent gross GHG emissions.

Transportation

The bottom band in Figure 4 shows the 1990 to 2004 trends for CO_2, methane, and nitrous oxide emissions from gasoline consumption in California. The second band from the bottom shows trends for the same three gases from domestic jet fuel consumption, the third band shows trends for CO_2 emissions from distillate fuel use, including diesel, and the fourth band shows trends for the same three gases due to other[31] transportation fuel uses. The four bands together show trends for total transportation fuel consumption.

These data show a modest increase over the 1990 to 2004 period, 12.6 percent overall. Gasoline emissions increased 12.3 percent; jet fuel emissions decreased 8.4 percent. Jet fuel actually increased 11.0 percent from 1990 to 2000, but then declined in 2001-2004, likely due to the events of September 11, 2001. Distillate (includes diesel) emissions increased by 41.0 percent, while other emissions decreased 0.4 percent.

Figure 4 -- California's Gross GHG Emissions Trends (Includes electricity imports and excludes international bunker fuels)



Source: California Energy Commission

Commercial, Residential, Agricultural, Forestry, and Industrial Sectors

GHG emissions from fuel use in the commercial, residential, and other[32] end-use sectors are also shown in Figure 4. These emissions are composed mostly of CO_2 but include small amounts of methane and nitrous oxide gases. These emissions both increase and decrease over the 1990 to 2004 period, with an overall decrease of 9.7 percent by 2004.

GHG emissions from the agricultural and forestry sectors are composed mostly of nitrous oxide from agricultural soil management, CO_2 from forestry practice changes, methane from enteric fermentation, and methane and nitrous oxide from manure management. These emissions also both increase and decrease over the 1990 to 2004 period, with an overall increase of 23.8 percent.

GHG emissions from the industrial sector are produced from many industrial activities. For example, CO_2 is produced from fossil fuels, with the major contributions from oil and natural gas extraction; crude oil refining; food processing; stone, clay, glass, and cement manufacturing; chemical manufacturing; and cement production.

Other industrial activities produce methane emissions, with the major contributions from petroleum and natural gas supply systems and wastewater treatment. Still other industrial activities produce nitrous oxide emissions with the major contributions from nitric acid production and municipal wastewater treatment. The industrial sector also includes a category of emissions comprised of high GWP gases, comprised mostly of gases used to replace ozone-depleting[33] gases. The apparent spike in emissions in 2002 is due to a significant increase in non-specified natural gas usage in that year. This appears to be caused by not being able to attribute the use of the gas to a particular end-use sector rather than an error in data input since the trend for total natural gas use from year-to-year does not show the spike.

Industrial sector GHG emissions both increased and decreased over the 1990 to 2004 period, with an overall increase of 10.1 percent by 2004.

GHG Emissions from Electricity Generation

The top two bands of Figure 4 show GHG emissions from electricity produced for use in California. The solid band includes emissions from electricity production within California, and the stippled band shows emissions from electricity produced outside California that is used within California. Although values vary from year-to-year, California's longer-term electricity gross generation (includes transmission line losses and private supplies) has grown modestly, increasing from 248,135 gigawatt-hours in 1990, to 292,927 gigawatt-hours in 2004, an overall increase of 18 percent in 13 years.[34]

In-state emissions are composed of CO_2 from natural gas combustion in utility power plants, combined heat-and-power facilities and merchant power plants, and from coal[35] combusted in combined heat-and-power facilities. In-state emissions also include SF_6 emissions associated with operation of power switching equipment and transformers. In-state emissions peaked in 2001, and then decreased in 2002 due to a reduction in natural gas use for electricity production compared to 2001. Then in-state emissions gradually increased in 2003 and 2004. These trends are most likely associated with the unstable period when electricity market deregulation made some market participants less eager to import power into California.

In-state electricity generation emissions decreased by 7.2 percent in 1996 and increased as much as 53 percent in 2001 over 1990 emissions. Overall, in-state electricity emissions increased by 29 percent over the 1990 to 2004 period.

Out-of-state emissions are composed of CO_2 emissions, mostly from coal-fired power plants. Although out-of-state electricity composes only about 22 to 32 percent of California's total electrical energy consumption, it composes 39 to 57 percent of the total GHG emissions associated with electricity use in California. Some out-of-state emissions are from coal-fired electric power plants owned by California electric utility companies. Out-of-state emissions increased and decreased annually relative to1990, with an overall increase of 40.4 percent by 2004.

Out-of-state electricity generation has shown higher carbon intensity than in-state generation in the past. Since 1990, in-state electricity produced 187 to 280 metric tons of CO_2 per gigawatt-hour, while imported electricity from fossil fuels produced 544 to 735 metric tons of CO_2 per gigawatt-hour.[36] This carbon intensity variation is affected by the year-to-year availability of hydropower and other factors.

GHG Emissions Intensity[37] *Trends*

This section places California's GHG emissions into context with its population and its level of economic activity as measured by its gross state product (GSP). Because all 50 states are included, only in-state emissions are addressed in this section. Due to limited availability of data, this section addresses only CO_2 from fossil fuel combustion for the 1990 to 2001 period.

CO_2 emissions from fossil fuel combustion compose 58 to 90 percent of the total GHG emissions of individual states,[38] and the trends that follow should be viewed within this context. Although some states indicate that CO_2 emissions from fossil fuel combustion is much less than 90 percent of total GHG emissions, total emissions from these states are modest in magnitude. On a national average, CO_2 emissions from fossil fuel combustion composed 80 percent of total GHG emissions in 2004.

To mitigate some of the effects of its large and growing population and expanding economy, California began in the 1970s to aggressively implement energy efficiency measures for fuel-burning equipment and electricity use. Both of these policies have significantly reduced fuel consumption and associated GHG emissions. Compared to other states, California has relatively low carbon use intensity due to the success of state air quality and energy efficiency programs.

Another factor that has reduced California's fuel use and GHG emissions is its mild climate compared to that of many other states. The mild climate reduces the use of heating fuel during winter but somewhat increases electricity use for summer air conditioning. This mild climate, combined with a complex topography and meteorology, also produced some of the nation's worst air pollution over the past quarter century, which has led to aggressive pollution reduction efforts. As a direct result, California uses relatively low carbon intensity fuels in its power plants and other industrial sectors.

Over the 1990 to 2000 period, California's population grew by 4.1 million people, the largest increase in the United States; however, California ranks only eighteenth from the largest when its population growth is measured in percent increase.

Correspondingly, California's economic base, measured by GSP, grew from $788 billion in 1990 to $1.1 trillion in 2000, the largest GSP growth in the United States;[39] however, California ranks only thirtieth when its GSP growth is measured in percentage increase.

Figure 5 shows in-state CO_2 emissions from fossil fuel combustion in each of the 50 states over the 1990 to 2001 period, as calculated by the EPA. Year 2001 is the most current year available from EPA.

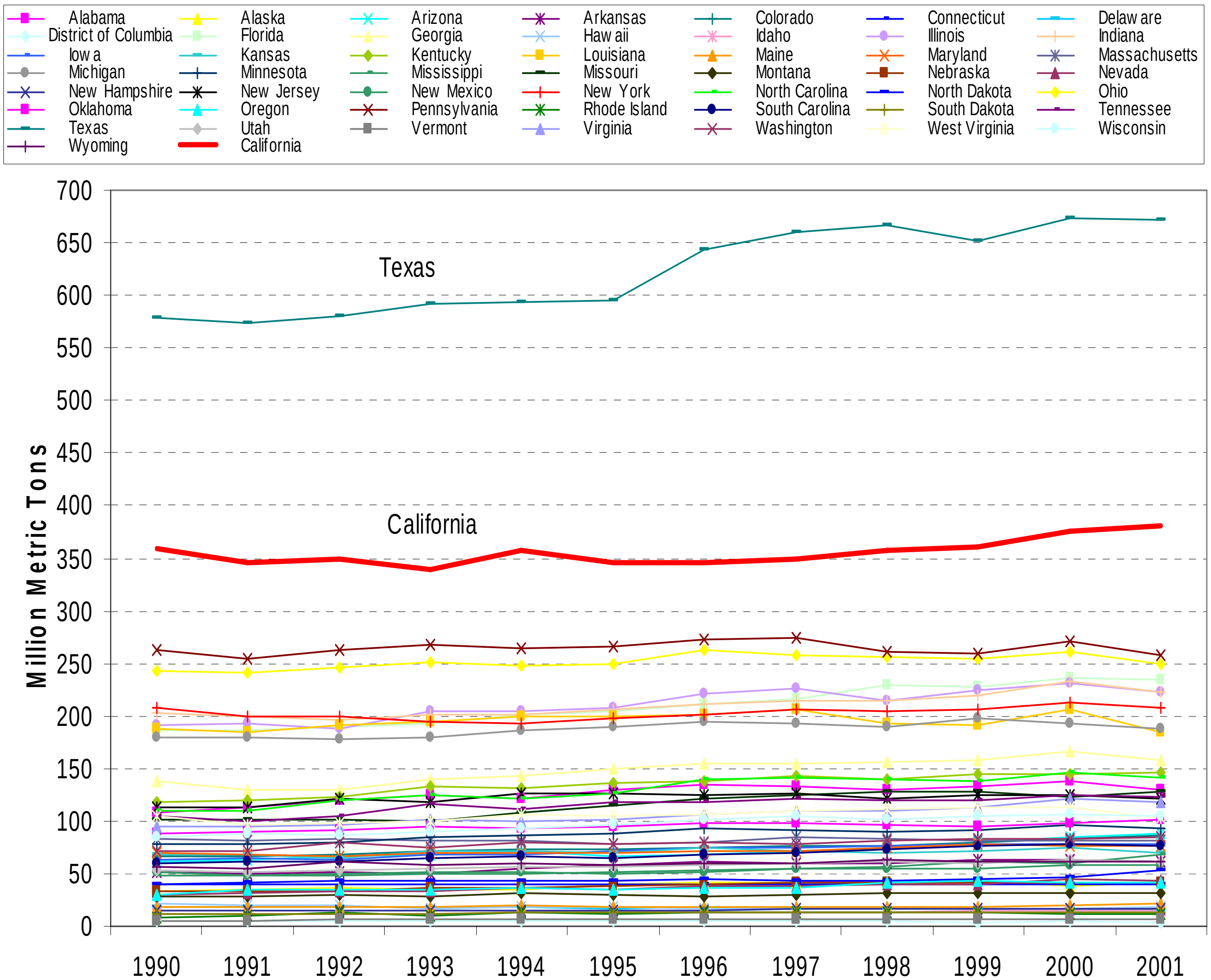
Although it is difficult to identify individual states, several factors are apparent from Figure 5: (1) most states show a fairly stable trend over the 1990 to 2001 period; (2) Texas has the highest in-state CO_2 emissions from fossil fuel combustion and shows a rising trend; and (3) California has the second highest emissions, which are fairly stable over the time horizon.

California has about half as much CO_2 emissions as Texas. However, Texas' emission growth rate ranks twenty seventh out of the 50 states, and California's growth rate ranks forty fourth when measured in percentage increase. Emissions from other states are all so similar to one another that they need not be individually identified; for the most part they are all considerably lower than Texas or California.

Figure 6 shows in-state fossil fuel CO_2 emissions per person for each of the 50 states. This figure was developed by dividing the population of each state into the fossil fuel emissions from Figure 5. Again, individual states are difficult to identify although several trends are apparent from the figure. First, Wyoming and North Dakota have the highest emissions per capita, not Texas or California. California is difficult to identify, near the bottom of the figure. It is second lowest in the nation in per capita CO_2 emissions from fossil fuel combustion with only the District of Columbia lower. Second, emissions per capita show a fairly flat trend for most states. This means that population growth and CO_2 emissions from fossil fuel combustion are well correlated for most states. In terms of per capita emissions, most states show remarkably stable emissions over the 1990 to 2001 period.[40]

Figure 7 shows fossil fuel CO_2 emissions per GSP[41] unit for each of the 50 states. In this figure, once again individual states are difficult to identify, but trends are apparent. Wyoming has the largest emissions in terms of CO_2 emissions from fossil fuel combustion per unit of GSP and North Dakota ranks second. Texas ranks near the bottom one-third, and California ranks near the bottom.

Figure 5 -- CO_2 Emissions from Fossil Fuel Combustion



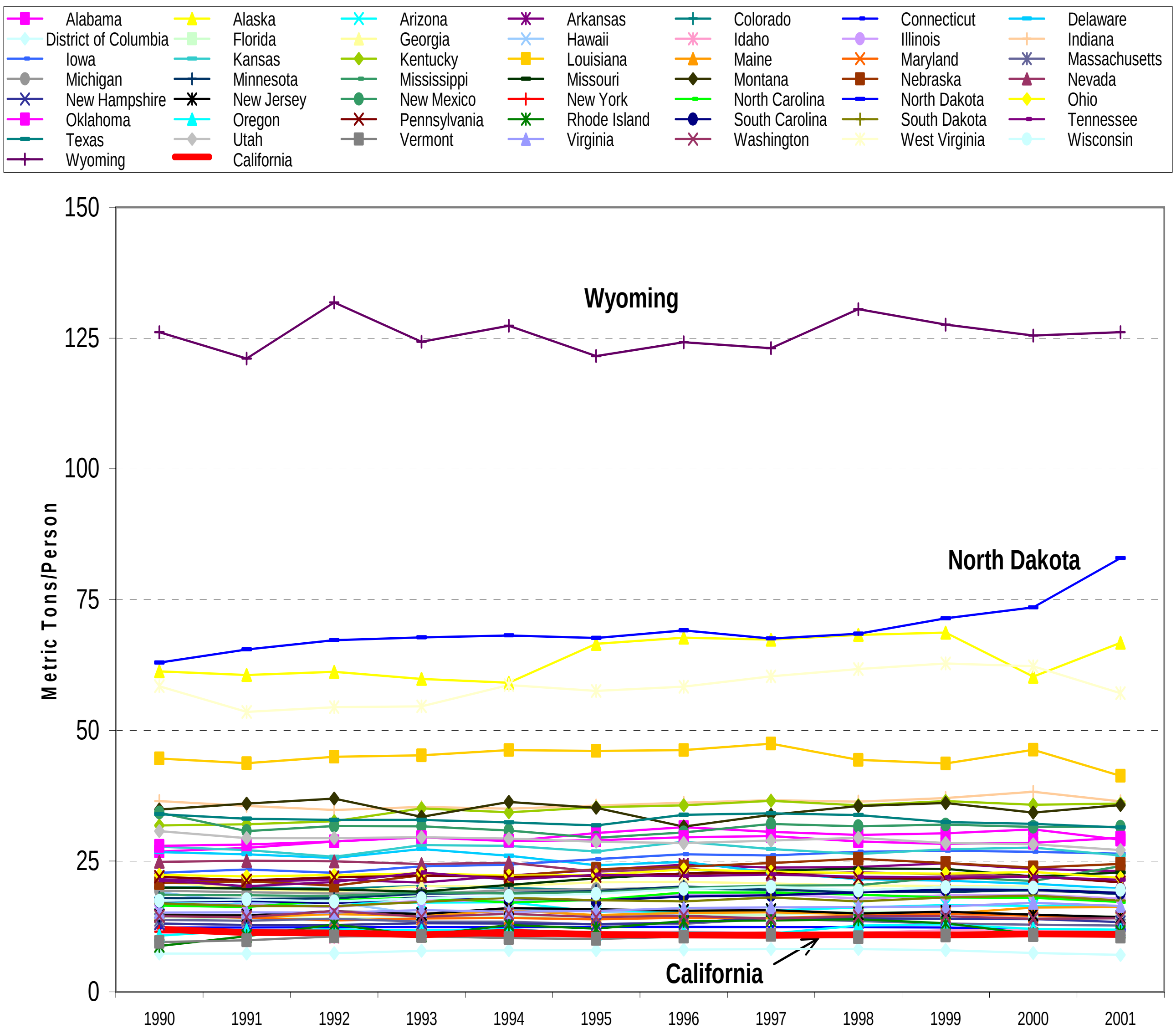
Source: California Energy Commission

This figure shows a trend of reduced GHG emissions per million dollars of GSP for most states. In general, GSP increases while CO_2 emissions from fossil fuel combustion remain steady over the same time period, as shown in Figure 5. In Figure 7, each state shows a reduction over time because the increase in GSP is greater than the increase in CO_2 emissions from fossil fuel combustion. This means that most states are successfully decreasing the carbon intensity of their economic base. The District of Columbia and the states of Connecticut, New York and

California have the lowest CO_2 emissions from fossil fuel combustion per unit of GSP.

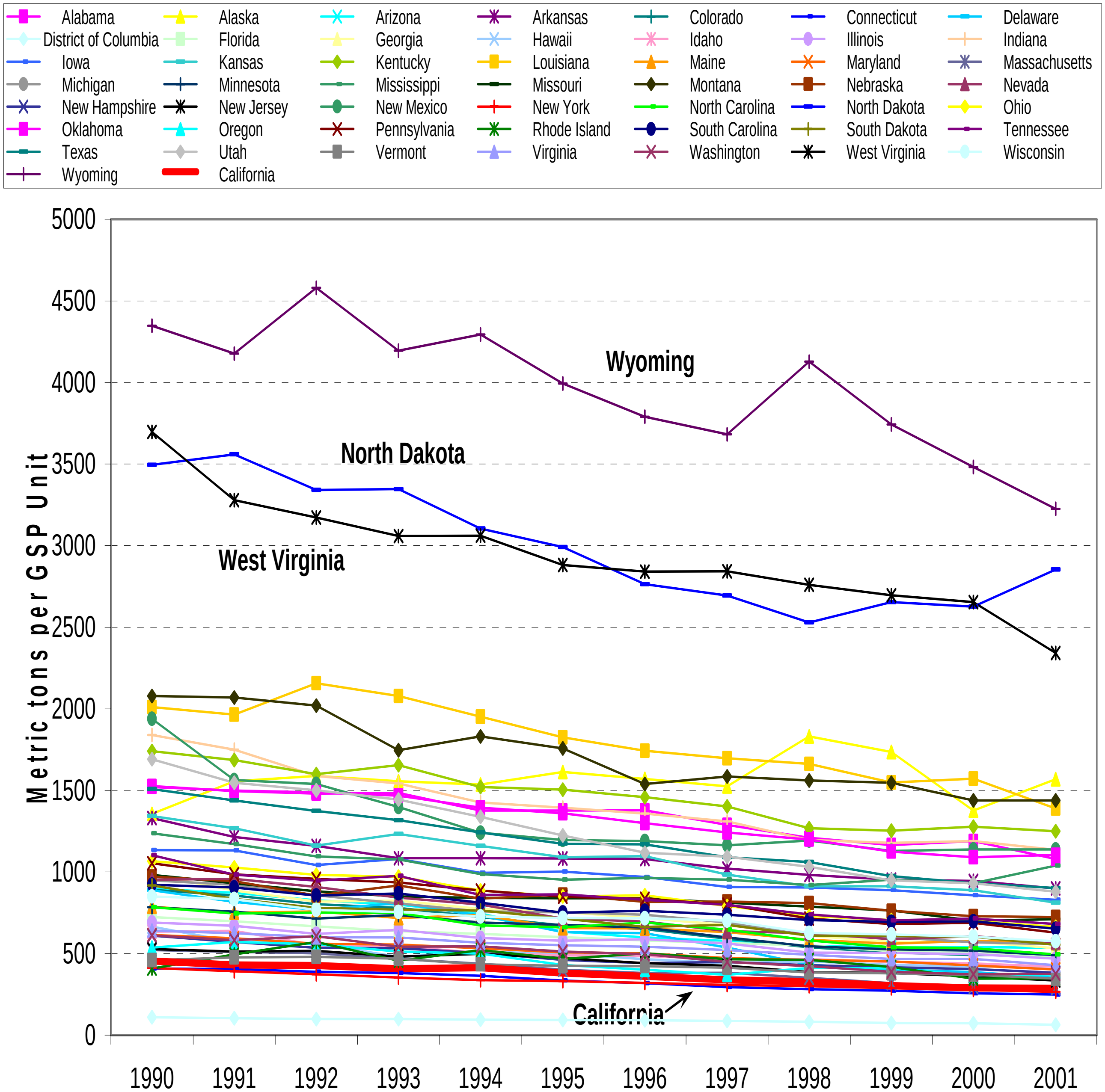
Figures 5, 6, and 7 all show a similar result in terms of relative ranking by state, regardless of year. Data for 2001 were used to construct Figure 8, which shows the ranking of the states for CO_2 from fossil fuel combustion per capita, and Figure 9, which shows the ranking of the states for CO_2 from fossil fuel combustion per million dollars of GSP. Because Figures 5, 6, and 7 all show similar trends, Figures 8 and 9 would look similar regardless of the year chosen to display these relative rankings.

Figure 6 -- CO_2 Emissions from Fossil Fuel Combustion per Capita



Source: California Energy Commission

Figure 7 -- CO_2 Emissions from Fossil Fuel Combustion per GSP Unit



Source: California Energy Commission

Figure 8 shows the relative ranking of states for emissions of CO_2 from fossil fuels per capita for the year 2001. California has the fourth lowest emissions per capita, following Washington (District of Columbia), Vermont, and New York.

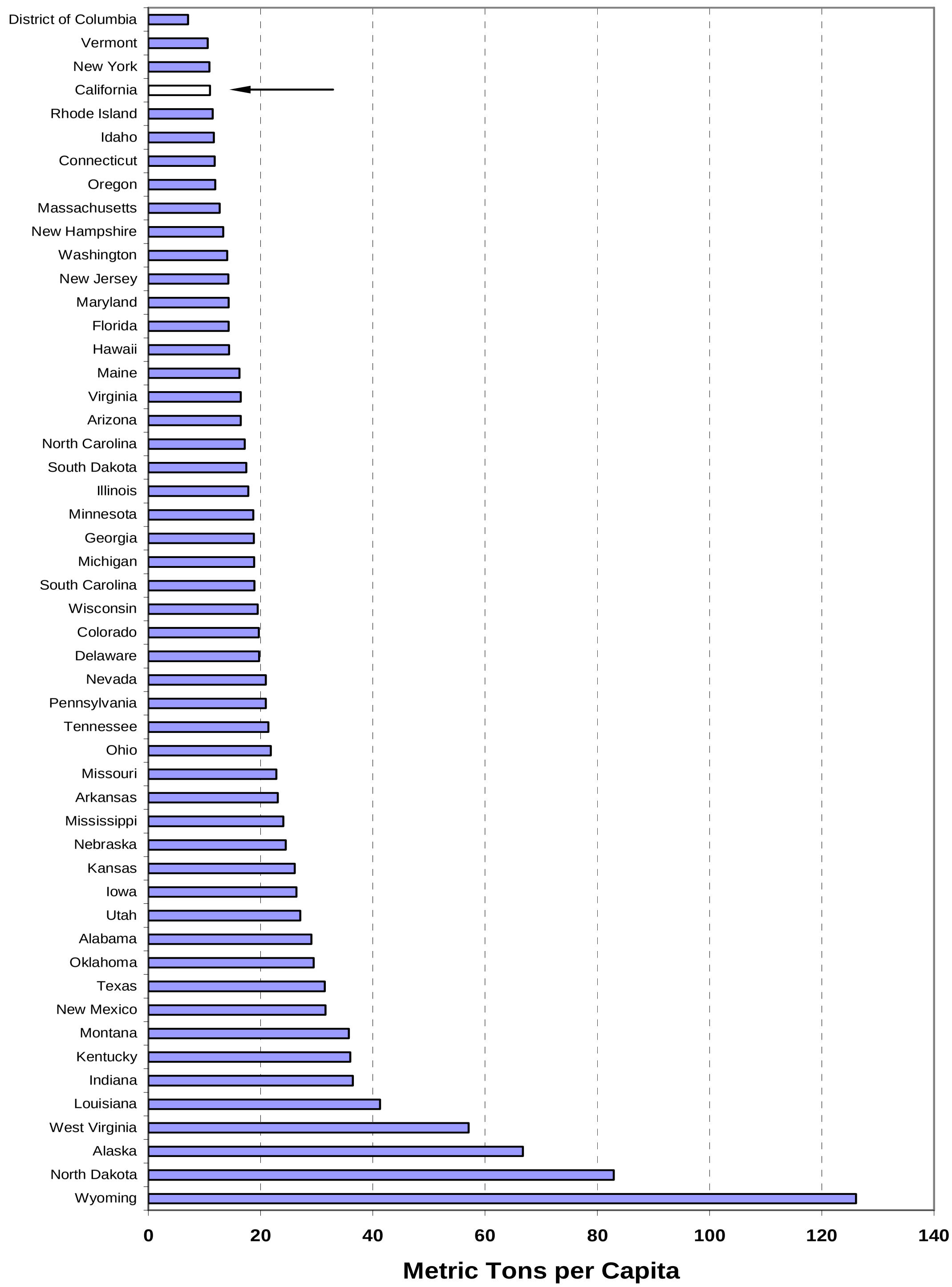
Figure 9 shows relative ranking of states in terms of CO_2 emissions from fossil fuels per unit of GSP for the year 2001. California has the fifth lowest emissions per million dollars of GSP, following Washington (District of Columbia), Connecticut, New York, and Massachusetts.

California's GHG Emissions In a World-Scale Context

Figure 10 shows how California and Texas each would rank if considered separate countries. The figure includes Texas since their emissions are larger than California's. As shown on the figure, Texas would rank as the ninth largest "country," and California would rank as the sixteenth largest. Note that the Texas data are for year 2001 while the other entries on the figure are for 2002. Other attempts to place California GHG emissions into a world-scale context have California placed as high as tenth or so. The data in Figure 10, from the World Resources Institute, do not have California ranked that high, although there is not much difference in emissions from about the eleventh largest (Italy) to the nineteenth largest (Australia).

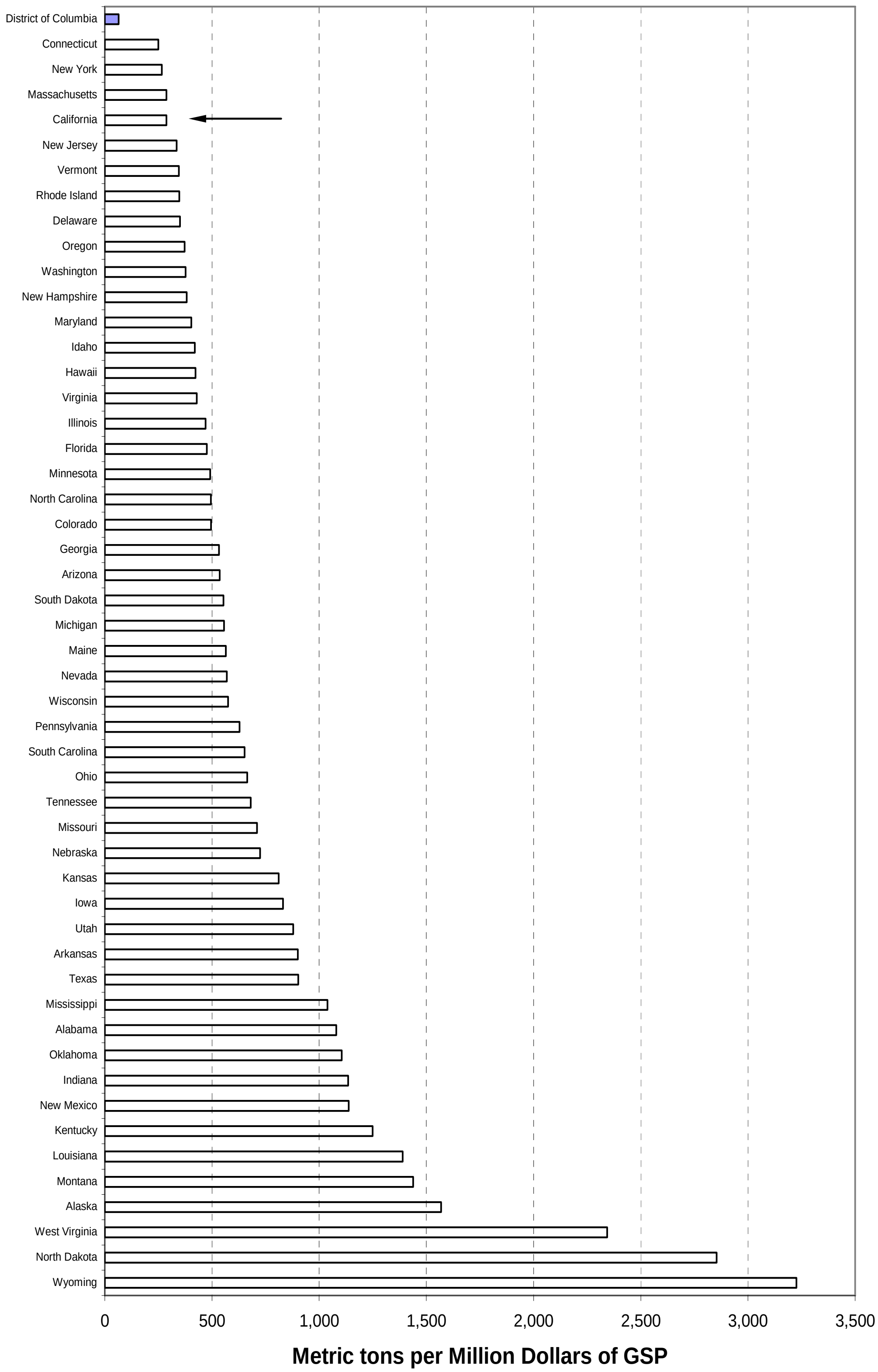
Figure 11 shows how California and Texas each would compare to the top 30 GHG emitting countries on an emissions intensity basis. California's GHG emissions intensity is higher than most of these countries when measured on a per capita basis but lower than most of them when measured per unit of GSP. Texas's emissions are high on a per capita basis because of the scale of its industrial and electric power emissions relative to the size of its population. State GHG emissions data are from the U.S. EPA[42] and state GSP data are from the U.S. Department of Commerce, Bureau of Economic Analysis.[43] Country GHG emissions data are from the World Resources Institute[44] and country GDP data are from the United Nations.[45]

Figure 8 -- CO_2 Emissions from Fossil Fuels per Capita (2001)



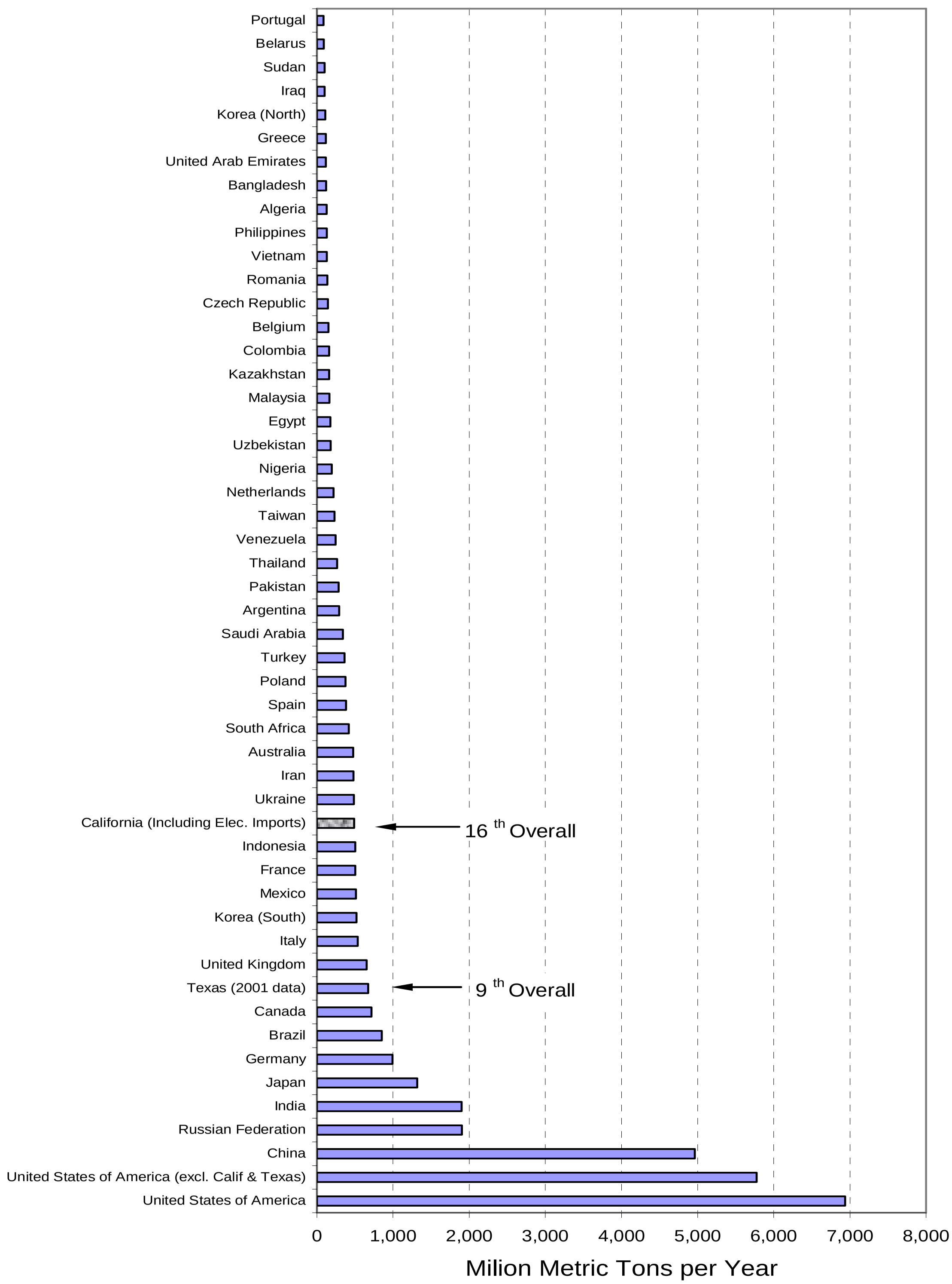
Source: California Energy Commission

Figure 9 -- CO_2 Emissions from Fossil Fuels per Unit of GSP (2001)



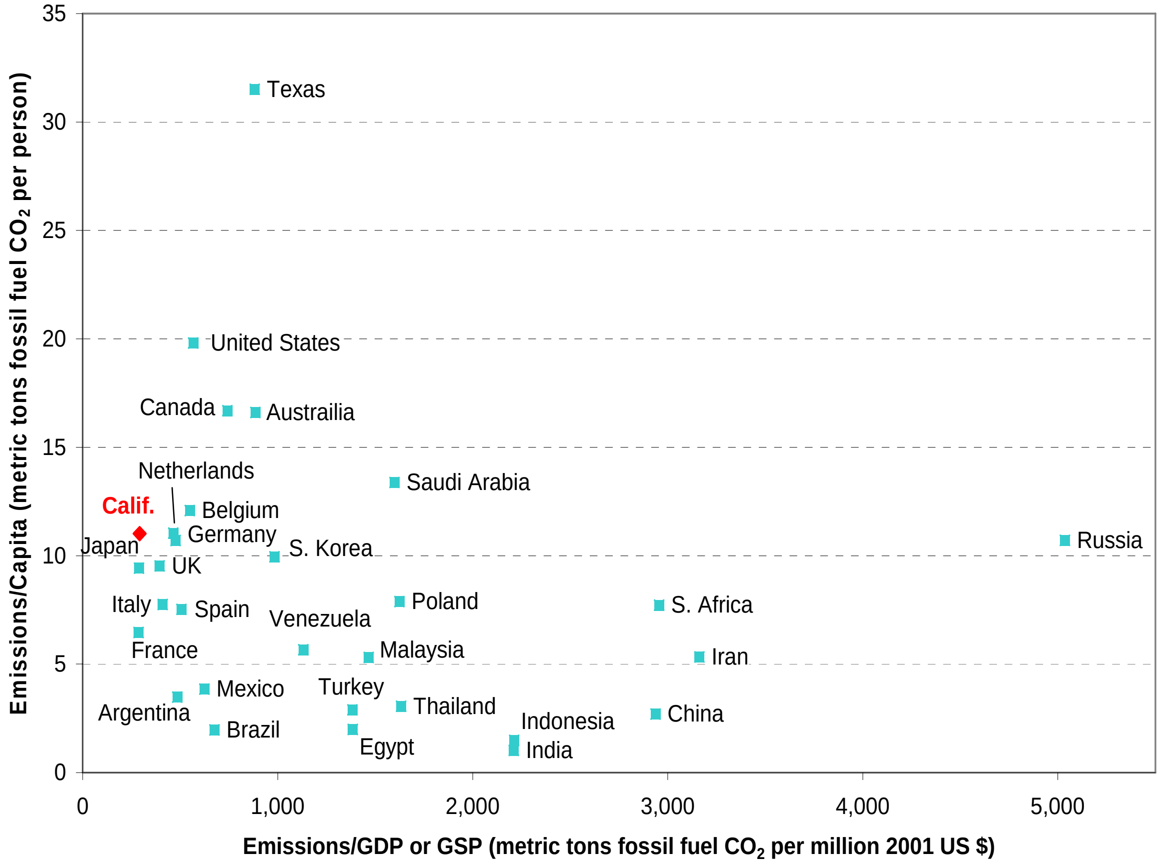
Source: California Energy Commission

Figure 10 -- California GHG Emissions in a World-Scale Context (2002 data)



Source: California Energy Commission (data from World Resource Institute, Climate Analysis Indicator Tool)

Figure 11 – 2001 Emissions Intensities for California, Texas and Top 30 GHG Emitting Countries



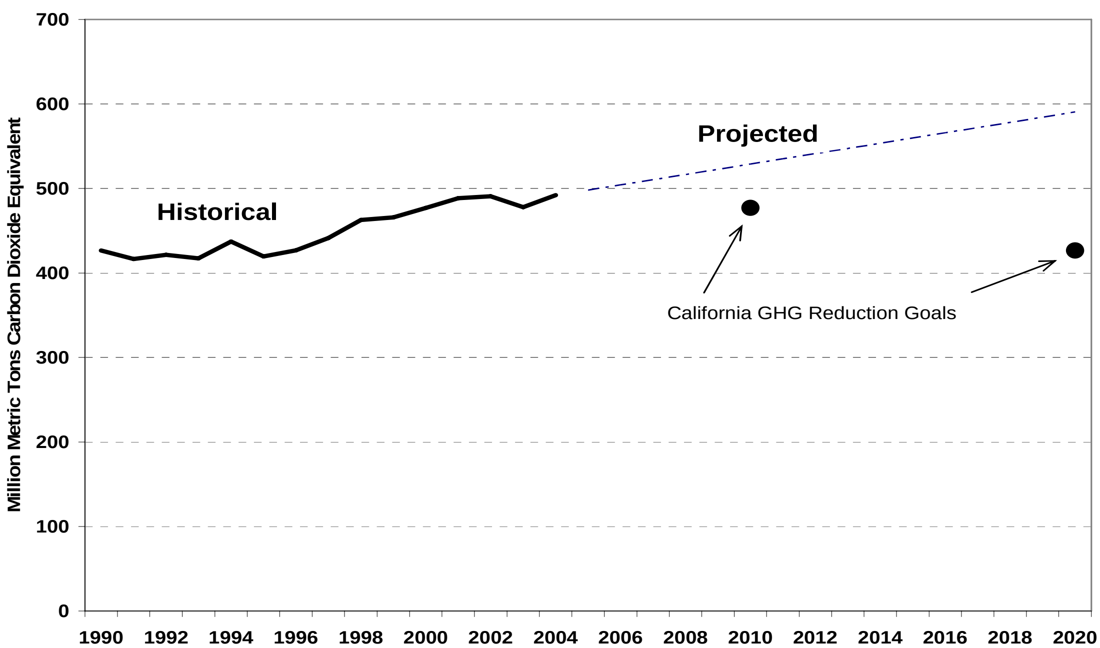
Source: California Energy Commission (country data from World Resources Institute and United Nations; state data from U.S. EPA and U.S. Department of Commerce)

Future GHG Emissions Trends

GHG emissions are expected to grow in the future as California continues its population and economic expansion. Figure 12 shows historical GHG emissions from this GHG inventory and projected future GHG emissions under a "business-as-usual" trend.

Staff projected GHG emissions using forecasts of gasoline demand from the *2005 Integrated Energy Policy Report (IEPR)*, but excluding California Air Resources Board's (ARB's) regulations for GHG emissions from light-duty vehicles that were implemented to comply with AB 1493 (Pavley, Statutes of 2002, Chapter 200). Except as discussed further below, staff assumed that GHG emissions for other categories remained constant at 2002 to 2004 average values. This was necessary because Energy Commission forecasts were not available for the activities associated with them that lead to GHG emissions. These categories generally constitute only a small fraction of California's GHG emissions. Finally, natural gas rather than another coal-fired power plant would replace Mohave, which shut down at the end of 2005.

Figure 12 -- Historical and Projected California GHG Emissions (Includes electricity imports and excludes international bunker fuels)



Source: California Energy Commission

Refinery still gas and petroleum coke emissions at refineries declined steadily from 2001 to 2004. These emissions were assumed to continue this downward trend. Future CO_2 emissions from calcinations in cement kilns were projected from the *2005 IEPR* using natural gas demand projections for that sector. Petroleum and natural gas supply system methane emissions were projected to decrease since these emissions declined overall from 1990 to 2004. CO_2, methane, and nitrous oxide emissions from waste combustion (excluding landfill emissions) were projected to increase slightly at the rate of population growth.

Methane emissions from landfills were projected to increase somewhat, based upon Table 14 from the Energy Commission report titled *Emission Reduction Opportunities for Non-CO_2 Greenhouse Gases in California.*[46] Methane emissions from enteric fermentation and manure management were assumed to continue at the same rate as 1990 to 2004, with manure management emissions increasing somewhat and enteric fermentation decreasing slightly. Nitrous oxide from agricultural soil management was projected to increase at the average of the 1990 to 2004 growth rate.

Methane and nitrous oxide emissions from mobile sources were projected to grow at the same rate as gasoline and diesel demand consumption projections. Methane and nitrous oxide emissions from stationary source combustion were projected to grow at the same rate as population growth.

These projected GHG emissions should be considered rough estimates. They assume no new emissions reduction strategies beyond those currently in place. The State of California, through its Climate Action Team, is developing more than 40 strategies to reduce these "business-as-usual" emissions to meet GHG emissions reduction targets established by Governor Schwarzenegger in Executive Order S-3-05.[47]

Figure 12 shows the historical California GHG emissions, projected "business-as-usual" emissions and the emissions reduction targets for years 2010 and 2020. The Executive Order calls for reducing California GHG emissions to year 2000 levels by 2010, and year 1990 levels by 2020**.** The corresponding target for year 2050 of reducing emissions to 80 percent below 1990 levels is not shown because it is beyond the ending point of the figure.

Current GHG Emissions Inventory Compared to California Climate Action Team Report Values

In response to the Governor's Executive Order S-3-05, in March 2006 the California Environmental Protection Agency (CalEPA) published a Climate Action Team (CAT) report[48] detailing how state agencies could implement a series of policies to meet the 2010 and 2020 goals. The Governor's Executive Order called for reducing 2010 "business-as-usual" emissions to year 2000 emissions and reducing 2020 "business-as-usual" emissions to 1990 emissions. Using the earlier 1990 to 1999 GHG emissions inventory prepared by ICF[49] and fuel demand projections from the Energy Commission's *2003 Integrated Energy Policy Report*,[50] the CAT report indicated that emissions would have to be reduced from business-as-usual trends by 59 million metric tons CO_2-equivalent by 2010 and 174 million metric tons CO_2 -equivalent by 2020 (derived from Table 5-5 on page 64 of CAT report). See Table F-1 in Appendix F for details.

The current 1990 to 2004 GHG inventory is updated from the 1990 to 1999 inventory. In addition, the Energy Commission published its *2005 Integrated Energy Policy Report* in November 2005. Both of these updates cause changes in the number of metric tons of emissions reductions needed to meet the Executive Order goals. The newer numbers indicate that 2010 business-as-usual emissions would need to be reduced by 68 million metric tons to meet the 2010 goal and 177 million metric tons to meet the 2020 goal. See Appendix F for more details.

GHG INVENTORY UPDATE

Table 6 on the next page summarizes the updated GHG emissions inventory, covering the 1990 to 2004 period. This table displays GHG emissions for CO_2, methane, nitrous oxide, and high GWP gases. More detail for each of these gases can be found in Appendix A. The line numbers in the following descriptions provide the reader a reference to the data in Table 6.

Total gross CO_2 emissions from anthropogenic activities are shown in Line 1. These values are obtained by adding Line 2 and Lines 9 through 15. Line 2 is a summary of Lines 3 to 8. These show gross CO_2 emissions for fossil fuel combustion in residential, commercial, industrial, transportation, electricity generation, and other end-use sectors. Lines 9 through 15 show CO_2 emissions from non-fossil fuel sources, and line 16 shows changes in anthropogenic activities that consume CO_2 (also called sinks).

Land use and forestry changes cause CO_2 atmospheric concentrations to increase when carbon-consuming plants are removed or stop growing. These changes cause CO_2 concentrations to decrease when carbon-consuming plants are added to the landscape. When these activities lead to a net reduction they are called carbon sinks.

Land use and forestry changes from anthropogenic activities have caused CO_2 concentrations to increase in some years and to decrease in others. The carbon released in the form of CO_2 from burning wood waste from land uses and forestry practices are included as emissions in the GHG inventory, Line 15. The carbon taken out of the atmosphere in the form of increased acreage of growing trees is

Table 6 -- California Greenhouse Gas Emissions and Sink Summary: 1990 to 2004 ($MMTCO_2Eq.$)

	Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	Carbon Dioxide (Gross)	317.4	310.8	316.3	311.4	329.8	313.7	318.6	328.8	346.4	348.7	368.3	372.5	365.3	347.1	355.9
2	**Fossil Fuel Combustion**	306.4	300.2	305.0	301.8	318.3	302.1	306.7	316.7	332.5	337.5	356.6	359.0	354.1	334.0	342.4
3	Residential	29.0	29.5	27.9	28.4	29.3	26.7	26.6	26.3	30.6	31.9	30.2	27.2	27.3	26.4	27.9
4	Commercial	12.6	12.0	9.7	9.6	10.3	9.8	9.6	9.6	13.5	14.8	15.6	12.0	17.8	15.1	12.2
5	Industrial	66.1	64.8	61.3	64.3	66.0	62.6	68.8	73.0	75.4	71.0	76.2	80.5	71.5	65.5	67.1
6	Transportation	161.1	156.7	161.9	158.9	163.9	166.2	167.4	170.8	173.3	176.3	181.7	182.5	190.2	180.6	188.0
7	Electricity Generation (In State)	36.5	36.6	43.7	40.1	48.3	36.4	33.9	36.5	39.8	43.0	51.9	56.1	41.9	44.1	47.1
8	No End Use Specified	1.1	0.6	0.5	0.6	0.6	0.5	0.5	0.4	-0.1	0.6	0.9	0.7	5.4	2.4	0.2
9	**Cement Production**	4.6	4.3	3.8	4.4	5.1	5.0	5.3	5.5	5.4	5.6	5.9	5.6	6.1	6.3	6.5
10	**Lime Production**	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
11	**Limestone & Dolomite Consumption**	0.2	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
12	**Soda Ash Consumption**	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
13	**Carbon Dioxide Consumption**	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
14	**Waste Combustion**	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
15	**Land Use Change & Forestry Emissions**	5.5	5.6	6.8	4.4	5.6	5.8	5.8	5.9	7.7	4.8	5.1	7.3	4.3	6.0	6.1
16	***Land Use Change & Forestry Sinks***	*(22.7)*	*(22.3)*	*(21.9)*	*(21.5)*	*(21.1)*	*(20.7)*	*(20.3)*	*(19.9)*	*(19.5)*	*(19.1)*	*(19.6)*	*(19.9)*	*(20.3)*	*(20.5)*	*(21.0)*
17	**Carbon Dioxide (Net)**	294.7	288.5	294.4	289.9	308.7	293.0	298.3	308.9	326.9	329.6	348.7	352.6	345.1	326.6	334.9
18	Methane (CH_4)	26.0	24.9	23.8	25.4	25.4	26.2	25.5	24.2	25.3	26.3	26.4	26.7	27.1	27.5	27.9
19	**Petroleum & Natural Gas Supply System**	1.0	0.9	0.4	0.8	0.7	0.7	0.7	0.6	0.6	0.7	0.6	0.6	0.5	0.5	0.5
20	**Natural Gas Supply System**	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.4
21	**Landfills**	8.1	8.0	7.7	8.4	8.2	7.9	8.3	6.1	7.6	7.8	8.0	7.9	8.2	8.3	8.4
22	**Enteric Fermentation**	7.5	7.3	7.4	6.6	7.1	7.3	6.8	6.9	6.8	7.1	6.7	7.0	7.1	7.2	7.2
23	**Manure Management**	3.3	3.9	3.9	4.0	4.3	4.6	4.6	4.9	4.8	5.2	5.4	5.6	5.8	5.9	6.0
24	**Flooded Rice Fields**	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.6
25	**Burning Ag & Other Residues**	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
26	**Wastewater Treatment**	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7
27	**Mobile Source Combustion**	1.2	0.1	0.1	0.7	0.2	1.0	0.2	0.8	0.6	0.5	0.8	0.5	0.7	0.7	0.6
28	**Stationary Source Combustion**	1.3	1.3	0.8	1.2	1.2	1.2	1.4	1.4	1.4	1.4	1.4	1.4	1.2	1.2	1.3
29	Nitrous Oxide (N_2O)	32.7	30.4	30.5	31.5	30.0	31.9	30.8	28.8	29.2	29.4	31.4	30.8	34.5	33.9	33.3
30	**Nitric Acid Production**	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2
31	**Waste Combustion**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	**Agricultural Soil Management**	14.7	13.1	13.4	14.4	13.8	15.5	15.1	13.6	14.0	14.3	15.9	15.3	19.4	19.2	19.2
33	**Manure Management**	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.9	0.9	0.9	0.9	0.9
34	**Burning Ag Residues**	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
35	**Wastewater**	0.9	0.9	0.8	0.9	0.8	0.8	0.9	1.0	1.0	1.0	0.7	1.0	1.0	0.9	1.1
36	**Mobile Source Combustion**	15.6	14.9	14.8	14.8	14.1	14.1	13.6	13.0	13.0	12.8	13.3	13.0	12.8	12.4	11.8
37	**Stationary Source Combustion**	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
38	High GWP Gases (HFCs, PFCs & SF_6)	7.1	7.4	7.9	8.4	8.9	9.3	11.4	12.6	8.9	9.9	10.5	11.2	12.0	12.9	14.2
39	**Substitution of Ozone-Depleting Substances**	4.5	4.9	5.3	5.7	6.1	6.5	8.4	9.8	6.7	7.8	8.6	9.5	10.5	11.4	12.6
40	**Semiconductor Manufacture**	0.4	0.4	0.4	0.5	0.5	0.7	0.7	0.8	0.9	0.9	0.8	0.5	0.5	0.5	0.6
41	**Electricity Transmission & Distribution (SF_6)**	2.3	2.2	2.2	2.2	2.2	2.1	2.3	2.1	1.3	1.2	1.1	1.1	1.0	1.0	1.0
42	**Gross California Emissions (w/o Electric Imports)**	383.3	373.5	378.5	376.5	394.0	381.1	386.2	394.5	409.8	414.3	436.6	441.1	439.0	421.4	431.3
43	***Land Use Change & Forestry Sinks***	*(22.7)*	*(22.3)*	*(21.9)*	*(21.5)*	*(21.1)*	*(20.7)*	*(20.3)*	*(19.9)*	*(19.5)*	*(19.1)*	*(19.6)*	*(19.9)*	*(20.3)*	*(20.5)*	*(21.0)*
44	**Net Emissions (w/o Electric Imports)**	360.6	351.2	356.6	355.1	373.0	360.4	366.0	374.6	390.3	395.1	417.0	421.2	418.7	400.9	410.3
45	**Electricity Imports**	43.3	43.1	43.0	40.8	43.2	38.5	40.6	47.0	52.9	51.7	40.5	47.4	51.7	56.4	60.8
46	**Gross California Emissions with Electricity Imports**	426.6	416.6	421.5	417.4	437.2	419.6	426.8	441.5	462.7	465.9	477.1	488.5	490.7	477.9	492.1
47	**Net California Emissions with Electricity Imports**	403.9	394.3	399.7	395.9	416.2	398.9	406.5	421.6	443.1	446.8	457.5	468.6	470.4	457.3	471.1
48	**International Bunker Carbon Dioxide Emissions**	39.9	34.6	28.0	27.9	32.4	35.8	35.4	27.0	26.8	30.3	33.8	31.8	31.8	24.5	26.5

also included as sinks of CO_2 from anthropogenic activities, Line 16 (repeated for clarity on Line 43).

Net CO_2 emissions are gross emissions from Line 1 minus the sinks from Line 16. These net emissions are shown in Line 17.

The next portion of Table 6 (Lines 18 through 28) includes anthropogenic activities that generate methane emissions. These are reported in CO_2-equivalent units to reflect the GWP of methane compared to CO_2. Agricultural activities and landfills compose the major sources of these emissions. Methane emissions compose 5.7 percent of overall GHG emissions in 2004.

The next portion of Table 6 (Lines 29 through 37) includes anthropogenic activities that generate nitrous oxide emissions. This gas should not be confused with a class of conventional air pollutants called "oxides of nitrogen." The major sources of nitrous oxide emissions are agricultural activities and mobile source fuel combustion. Emissions of nitrous oxide produced 6.8 percent of overall GHG emissions in 2004.

A class of gases called high GWP gases makes up the final set of gases (Lines 38 through 41) that contribute to global warming. Major categories within this set include various gases used in industrial applications to replace gases associated with ozone depletion over the Polar Regions of the Earth, and SF_6, which is used as insulating materials in electricity transmission and distribution.

These high GWP gases composed a small percentage of overall GHG emissions over this time period, although the estimated emissions are difficult to quantify and are thus less certain than other emissions categories. High GWP gases, although small in magnitude, constituted the greatest rate of growth in GHG emissions.

Line 42 is labeled "Gross California Emissions (w/o Electric Imports)." It is the sum of Lines 1, 18, 29, and 38. Gross CO_2 emissions from fossil fuel combustion comprised 81 percent of total GHG emissions in 2004, the largest component of the inventory. Non-fossil fuel CO_2 emissions contributed another 2.8 percent. Total sinks are repeated on Line 43 for clarity. Net CO_2 emissions are shown in Line 44. These are obtained by subtracting Line 43 from Line 42.

A significant portion of the GHG emissions that occur to meet the needs of California's economy comes from fuel combusted in out-of-state power plants that provide electrical energy to California, including two coal-fired power plants owned by California utilities. These emissions are shown on a separate line to avoid double counting. The carbon emissions associated with importing electricity to California are shown on Line 45 and are not part of the California GHG inventory according to IPCC protocol, but are shown for information purposes.

Line 46 is the sum of gross GHG emissions from Line 42 plus CO_2 from imported electricity from Line 45. Line 47 is Line 46 minus CO_2 sinks from Line 43. Line 48 shows international bunker fuels, made up of international use of jet fuel and marine vessel use of residual oil and distillate. These are not part of the California GHG inventory and are shown for information purposes, similar to imported electricity.

Figures 1 and 4 show this information by sector. Appendix A contains documentation of the methods used to prepare the California GHG inventory and a more detailed breakdown of the values in Table 6.

FUTURE GHG INVENTORY IMPROVEMENTS

One major category of GHG inventory improvement that staff recommends is to use a more current estimate of GWP weighting factors for non-CO_2 GHG emissions when they become approved for use by the IPCC. Values used in this inventory are a bit outdated, as they are based upon values approved for use by the IPCC in 1996. Newer GWP factors were developed in 2001, but they have not yet been approved for use. The other major category of GHG inventory improvements that staff recommends is using more recent energy flow data and more local activity and emissions factor data.

GWP Weighting Factors for Non-CO_2 Gases

The current IPCC guidance is to use GWP factors from the Second Assessment Report[51] (SAR, 1996 vintage), since the Third Assessment Report (TAR, 2001 vintage) values have yet to be approved. For methane, the SAR value is 21, and the TAR value is 23 (+0.1 percent). For nitrous oxide, the SAR value is 310, and the TAR value is 296 (-4.5 percent). The most recent *Inventory of U.S. GHG Emissions and Sinks: 1990—2004*[52] uses the SAR values for the nationwide GHG inventory.

Given the relative magnitude of CO_2 and other GHG emissions attributable to California using either the SAR or TAR values, the choice of SAR or TAR has little impact on California's GHG emissions. If TAR GWPs are used, methane emissions reported in 2004 would be unchanged at 27.9 million metric tons CO_2-equivalent ($MMTCO_2E$). Correspondingly, if TAR GWPs are used, nitrous oxide emissions reported in 2004 would be 32.8 $MMTCO_2E$, rather than the SAR value of 33.3 $MMTCO_2E$. These differences are small in a total inventory of more than 480 $MMTCO_2E$.

Data Improvements or Refinements

During the process of developing this GHG update, Energy Commission staff identified the following areas where improvement should be considered for the next inventory update.

- Use more current activity data.

  The most current complete data set for fossil fuel use in California is for 2004. Since more than 80 percent of the California GHG emissions inventory is generated from fossil fuel combustion, it is not possible to report complete GHG data for more current years at this time. These data should be updated as soon as more current data become available.

- Perform a more detailed review of industrial uses of fossil fuels to classify when they are used as fuel versus their use as a process input (and therefore not released into the atmosphere at that step in their usage chain).

  As discussed in Appendix A, petroleum and natural gas are sometimes used in an industrial process rather than combusted as a fuel in an industrial facility. In some cases, feedstock use leads to carbon emissions, but in most cases the carbon in the fuel is transformed at the industrial site into the product of the industrial operation. In this case, no carbon emissions occur at this point in the product's production and use cycle, and there are no CO_2 emissions to document. CO_2 emissions may occur when the object being produced is used in an end use application. This is the point in the usage chain where CO_2 emissions should be counted in the GHG emissions inventory.

  The 1990-1999 California GHG emissions inventory used national data to estimate the amounts of petroleum and natural gas that were used as industrial process feedstocks rather than burned as fuels. This assumes that California's industrial sector exactly matches the national average of industrial activities.

  In the previous and current inventory, staff examined each subcategory of industrial use and judged whether the petroleum or natural gas was used as a feedstock or as a fuel. If they were judged to be used as a feedstock, then the national average values were used. If they were judged to be used as a fuel, staff used the normal calculation process and assumed that the emissions would occur on the site of the industrial process. In addition, methane generation at refineries was assumed to release CO_2 at the refinery. Differences between approaches are minor.

- Industrial wastewater emissions occur from processing fruits and vegetables, red meat and poultry, and pulp and paper. Methane and nitrous oxide emissions from these activities are not yet included in the California inventory and should be added in future updates.

  California produces much of this country's fruits, vegetables, red meat, poultry, and pulp and paper. These products all involve industrial waste water, which should be estimated and added to the California GHG inventory. The EPA guidance document[53] recommends that emissions be estimated for these industrial sources (see page 14.4-5). However, since we do not yet have data on the quantity of waste water generated by these activities, staff was unable to estimate methane or nitrous oxide emissions from waste water used to produce these products.

- Landfill methane emissions should continue to be studied to improve their accuracy. Values are low (40 to 52 percent lower) compared to1990-1999 inventory; these discrepancies need to be resolved. The 1990-1999 inventory was prepared by ICF Consulting under funding by the Energy Commission's PIER Program. In some cases, ICF applied national average values to calculate landfill emissions, and their results may not represent California conditions because California has been aggressive in implementing state level policies to recover energy from landfills and to reduce emissions. Reliance on EPA data does not seem to represent California conditions. GHG emissions from California landfills may be considerably lower, especially at large, well operated landfills with a comprehensive gas collection system and appropriate cover and cap material placement.

  The EPA guidance document[54] recommends obtaining state-level data on the volume of wastes stored in large landfills (that is, those greater than 1.1 million tons of waste in place), and small landfills (less than 1.1 million tons of waste in place), over the previous 30 years to calculate methane emissions from municipal waste landfills (see page 13.4-2). Lacking that, the document recommends using state-level volumes disposed at landfills. If neither of these types of local data is available, the document recommends using state-level population data and national average per-capita landfill rates to calculate emissions.

  The 1990 to 1999 California GHG emissions inventory used state-level data on volumes of waste disposed at California landfills from 1990 to 1999, national data to estimate volumes of waste from 1960 to 1989, and the amount going to small versus large landfills for 1990 to 1999. Estimates were made for methane recovery in landfill gas-to-energy facilities, flares, and oxidation. Emissions were about 17 $MMTCO_2E$ in 1990 and decreased to about 13 $MMTCO_2E$ in 1999 because methane recovery grew faster than waste disposal rates and associated emissions.

  The current California GHG inventory was developed from emissions data obtained from local air pollution control agencies via the ARB. It is more of a "bottoms up" approach based upon a facility-by-facility assessment conducted by the local air districts. Emissions were estimated at about 8 $MMTCO_2E$ in 1990 and remain essentially flat over the entire 1990 to 2004 time period. These data represent emissions only from those facilities that have permits.

GHG inventory guidance documents indicate that some methane is oxidized in the landfill surface cap and not emitted into the atmosphere. The percentage is uncertain, and EPA recommends using local data where available and 10 percent removal where local data are not available. Work is underway to develop a California-specific estimate of this effect.

Local air quality district personnel are updating their landfill data but the results of this work were not available as of September 2006 and are not expected to become available in the near future. In addition, the Energy Commission has active research in progress to better quantify emissions from California, but the results of this work are not expected to become available until 2008.

- Develop California-specific data for SF_6 emissions from electric utilities.

  SF_6 emissions were estimated using national emissions data, and pro-rating state electric energy production to national values. However, California utilities have been actively involved in identifying and implementing methods to reduce these emissions and reducing associated maintenance costs. Individual electric utility companies in California should be contacted to obtain actual state-level data, if available. Since utilities have apparently not tracked their SF_6 as an individual maintenance cost, it may not be possible to use utility-specific data for the entire 1990 to 2004 period.

- Develop California-specific emissions factors for emissions of methane and nitrous oxide from manure management.

  Emissions calculations are based upon national data for animal characteristics, including percentage of dairy versus meat cattle, nitrogen production per head of animal, animal mass, and so forth. These data should be updated with state-specific values and methods of animal management.

- Develop California-specific emissions factors for enteric fermentation.

  Studies indicate that the currently accepted emissions factors may not properly quantify emissions of methane emissions from cattle processing their feed. The ARB is developing new emissions factors for regulatory purposes, and these should be considered for future updates.

- Update data used to calculate emissions for land use and forestry changes.

  The current inventory and the previous one for 1990 to 2002 used forecasted values for changes in acreage of forests provided by the federal Secretary of Agriculture. As satellite data for these changes becomes available, they should be used in place of these forecasted values. California has also recently experienced significant acreage converted to viticulture and pasture, and associated changes in soil carbon need to be reviewed and possibly updated.

- Obtain California-specific data for nitrous oxide emissions of several crops.

  The current inventory and the previous one for 1990 to 2002 used national estimates of nitrous oxide emissions resulting from cultivation of sorghum, oats, rye, soybeans, peanuts, and beans. State-specific data should be obtained if possible. This should be a low-priority activity as estimated emissions are very small.

APPENDIX A

DETAILED DOCUMENTATION OF CALIFORNIA GREENHOUSE GAS EMISSIONS

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CALCULATION METHODOLOGY

This appendix includes detailed documentation of methods used to construct the updated California GHG emissions inventory. First, a discussion of the methodology is provided. Next, a detailed table of California GHG emissions is provided. This detailed table is summarized in Table 6 (page 23 of the main body of this report). Line numbers included in the text below refer to rows in Table 6, unless otherwise stated. Where possible, values in Appendix A that are used to obtain subtotals are shown right justified to facilitate identification by the reader. This is not possible for all levels of subtotaling.

CO_2 Emissions

CO_2 emissions occur largely from combustion of fossil fuels. In 2004, fossil fuel combustion accounted for 96.2 percent of gross CO_2 emissions. Other CO_2 emissions sources included cement and lime production, limestone and dolomite consumption, soda ash, CO_2 consumption, waste combustion, and finally, changes in land use and forestry operations.

CO_2 Emissions from Fossil Fuel Combustion

Fossil fuels used in California include natural gas, petroleum (including liquefied petroleum gas [LPG]), motor gasoline, kerosene, distillate oil, residual oil, petroleum coke, lubricants, asphalt, and small amounts of coal. Biomass is also used as a fuel in some applications, but these emissions are excluded because the net amount of CO_2 released is zero when averaged over the life of the biomass itself. For example, a tree takes as much CO_2 out of the air as it releases into the air when it is burned. Any fuel used to plant, cultivate, and harvest the tree is included in the appropriate fuel use category.

Under contract with the Energy Commission's PIER Program, Lawrence Berkeley National Laboratory evaluated fossil fuel supplies and uses in California and developed a balance between them. Their work led to a document titled *California Energy Balances Report*,[55] (*Energy Balance)* and included a database of energy consumption that can be expressed in volumetric units or trillion British Thermal Units (trillion BTUs, or TBtus). GHG emissions are calculated from TBtus, using appropriate emissions factors provided by the EPA that are consistent with guidance documents from the IPCC.

The *Energy Balance* was developed using data from the EIA, supplemented with data from the Energy Commission. Much of the data used in the *Energy Balance* was obtained from the same EIA data sources used in the 1990-1999 GHG emissions inventory and is thus consistent with it. In some cases, EIA revised and updated its data, and these changes are reflected in the *Energy Balance* and in the updated GHG emissions inventory.

In the current update, these data were supplemented with data from the Energy Commission to enable calculation of emissions for 2004. At the time the current inventory was prepared, the newer Energy Balance data have yet to be published in a report, although the data were made available by the contractor.[56] These data revisions extend the fuel use data to 2004 and make some revisions to data for previous years. The reader is referred to the previous *Development of Energy Balances for the State of California (Energy Balance)* [57] for documentation of most data used in this report. Appendix D contains further discussion of the newer data used for 2004 and describes major differences between the current inventory and the previous one that covers the 1990 to 2002 period.

Energy Commission data were used to provide more detailed resolution of fuel use by end-use sector. One example of major improvements implemented in the two most recent inventories, when compared to the 1990-1999 GHG inventory, is the treatment of electricity generation fuel use. The earlier GHG inventory reported electricity fuel used in the industrial sector unless the electric facility was owned by an electric utility company. The last two GHG inventories identify all fuel used to generate electricity as “Electricity Generation” regardless of the facility’s ownership.

Fossil fuel CO_2 emissions are estimated by multiplying standardized emissions factors (EF) recommended by the EPA in their Emissions Inventory Improvement Program documentation[58] by the TBtu data from the *Energy Balance,* converting from carbon emissions to CO_2 emissions, and then using conversion factors to obtain results in million metric tons of CO_2.

The equation typically used for CO_2 is:

CO_2 = Billion BTUs * Percent Oxidized * EF (lbs C per million BTU) * 0.9072 (converts short tons to metric tons) * 44/12 (converts lbs C to lbs CO_2) * 0.0005 (converts lbs to short tons) / 1,000,000 (expresses results in millions)

This result is expressed in million metric tons of carbon dioxide ($MMTCO_2$). Some manuscripts use the term teragrams rather than metric tons. One million metric tons equals one teragram (Tg).

The trillion BTUs (10^{12} BTUs, also expressed “TBTUs”) of fuel used in various end-use applications in California are shown in Appendix B. These data are largely obtained from the *Energy Balance.* Energy use data are listed in the same series order as the California GHG emissions inventory. For some fuels, data are provided by generally focused categories of end use. Fuels with insufficient data to report detailed end-uses are reported as “Non-specified.”

Emissions are calculated for each fuel using fuel-specific values for percentage oxidized and carbon content as shown in Table A-1 (for fuels which have values that do not change from year-to-year) and Table A-2 (for fuels which values that change from year-to-year). These values were obtained from the EPA[59] and are consistent with IPCC protocol.

CO_2 emissions are calculated individually for each fuel and end-use sector and are then totaled to get sums for CO_2 and for each end-use sector, such as residential, commercial, and so forth.

This method is the same as used in the 1990-1999 GHG emissions inventory with new data as available (except imported electricity, as explained below). See Appendix B for energy use rates used to estimate CO_2 emissions for each end use category and sub-category.

Line 1— CO_2 (Gross)
This line represents the sum of all CO_2 emissions, including fossil fuels, non-fossil fuel CO_2 emissions, and land use and forestry activities that increase CO_2 emissions.

Line 2—Fossil Fuel Combustion Totals
This line is the sum of fossil fuel combustion, Lines 3 through 8.

Line 3—Residential CO_2 Emissions
In California, residential CO_2 emissions are produced from the combustion of natural gas, LPG, kerosene, and distillate fuel.

Line 4—Commercial CO_2 Emissions
Commercial CO_2 emissions are produced from the combustion of coal, petroleum, and natural gas. Only small quantities of coal and petroleum fuels are used in California, so natural gas composes the majority of the fuel used. Most commercial petroleum fuel use is gasoline or distillate, with small amounts of residual oil and LPG. Natural gas is used in applications that range from education through non-specified services.

Line 5—Industrial CO_2 Emissions
Industrial CO_2 emissions are produced from the combustion and feedstock uses of coal, petroleum, and natural gas. This end-use sector uses only a small amount of coal, moderate amounts of petroleum, and relatively large amounts of natural gas.

Even though this sector uses almost twice as much natural gas petroleum on a BTU basis, resulting CO_2 emissions for natural gas and petroleum are similar in magnitude. This results because petroleum has greater carbon intensity per unit of energy and because much of the industrial petroleum use is in feedstock applications (such as asphalt manufacturing) rather than fuel applications (such as making steam for an onsite industrial process). Feedstock applications may or may not cause direct emissions because the carbon may be stored rather than emitted to the atmosphere. For some feedstock applications, the carbon is used in a product that is burned at another step in the product cycle, and that is where the carbon emissions are accounted for in the normal inventory protocol to avoid double counting.

Industrial uses of coal, petroleum, and natural gas must be adjusted to account for these feedstock uses and associated carbon storage. These feedstocks can either be stored on a long-term basis (such as in asphalt pavement) or a short-term basis but later emitted (such as natural gas used as a feedstock to make hydrogen in a petroleum refinery).

In the first case, the carbon associated with the feedstock is locked into the pavement and assumed to never be emitted, and the computed emissions are zero. In the second case, the carbon is released during operation of a steam reformer located at or near a refinery and emitted after separating the hydrogen from the carbon.

In summary, it is necessary to subtract the amount of feedstock used and stored from the amount used as a fuel at the industrial facility.

The approach requires: (1) identification of the percentage of each industrial fuel that is used as a feedstock, not a fuel, and (2) the percentage of the feedstock that is stored rather than emitted in the associated industrial process.

The EPA guidance document indicates that state-level data should be used if available. However, if state-level data are not available, national data can be used. The 1990-1999 California GHG inventory used national data.[60] However, since the *Energy Balance* now provides much more state-level detail for industrial uses of coal, petroleum, and natural gas, it is no longer necessary to assume that these national factors apply in California for every industrial use.

In the new GHG inventory, each industrial subcategory of end-use was examined individually, and the most likely use of the fossil fuel was estimated by the category name. If it was most likely that the fuel was burned onsite for process heat or steam, then all of the fossil fuel was assumed to be burned on site. If it was most likely that the fossil fuel was used as a process input, the national average storage factor was assumed to apply to that subcategory.

The percent feedstock use and storage factor were both assumed to be zero if the subcategory appeared to be a fuel use. Otherwise, the inventory assessment uses the same national numbers as the 1990-1999 inventory. There is room for improvement with either method of assessing the industrial category of fossil fuel emissions.

To determine the degree to which this change impacts the estimated industrial sector CO_2 emissions, they were calculated each way. The results are similar using either approach. For example, for natural gas industrial emissions in 1999, the 1990-1999 method yielded a value of 33.4 $MMTCO_2E$, and the current method yields a value of 34.3 $MMTCO_2E$. The new approach was chosen because state-level energy data were available and the national values did not seem appropriate for some of the industrial subcategories. Using national average data for feedstock use of fossil fuels is equivalent to assuming California has exactly the same industries as all 49 other states.

Industrial fossil fuel use data were available for all fuels each year except liquefied petroleum gas. For this fuel, the average of 1990 to 2001 fuel usage rates was assumed for 2002 through 2004.

While reviewing the Energy Balance data file, it was determined that the 1990 to 2002 GHG inventory inadvertently double counted emissions from burning natural gas while manufacturing stone, clay, glass, and cement. Removing this double counting reduces emissions by 1.5 to 4 $MMTCO_2E$, depending on year. This change is reflected in the 1990 to 2004 inventory for all years.

Line 6—Transportation

CO_2 emissions from the transportation sector constitute the single largest category of California's GHG emissions: 188 $MMTCO_2E$ in 2004. Motor gasoline is the single largest subcategory of transportation emissions at 131 $MMTCO_2E$ in 2004. On-road distillate fuel and jet fuel are the next two largest subcategories, with jet fuel higher in early years and distillate fuel use higher in the later years. In 2004, distillate fuel emissions were 32.2 $MMTCO_2E$ and domestic jet fuel emissions were 22.2 $MMTCO_2E$.

Motor gasoline is used in light-duty vehicles in a wide variety of applications, although most is used in privately owned vehicles. Jet fuel is used in domestic aviation and military aviation. Emissions values do not include international aviation (or international marine) uses.

GHG emissions inventory guidance[61] is to identify international jet and marine fuel uses and report their emissions separately from corresponding domestic uses, if sufficient data are available. These are called "international bunker fuels." This is a bit of a misnomer because the traditional use of the term "bunker fuels" is for marine fuel use, not jet aircraft fuel use. Bunker fuels are heavy, often require heating to flow, and are not used in jet aircraft. However, the term "international bunker fuels" is used in GHG emissions inventories to describe distillate and residual fuels used for international business.

The California GHG inventory includes jet fuel and residual and distillate oils used as domestic fuels. It excludes international jet fuel and marine residual and distillate fuel uses, but values are reported on separate lines for comparison purposes. Prior to the last two California GHG inventories, it was not possible to separate out all international and domestic aviation and marine fuel uses. Thus, for the two most recent inventories, reported transportation GHG emissions values are lower for the entire reporting period than earlier inventories.

In 2004, international aviation accounted for approximately 38 percent of California's total reported jet fuel use and international marine fuel use accounted for 94.5 percent of California's residual oil use and 1 percent of its distillate fuel use.

California Air Resources Board regulations required removal of methyl-tertiary butyl-ether (MTBE) from gasoline by 2004. The petroleum industry responded beginning in 2002, replacing MTBE with ethanol. Approximately 12 percent of the gasoline pool was converted in 2002, 65 percent in 2003 and 98 percent in 2004 and beyond.[62] A small percentage is exempt from this regulation. According to most estimates, ethanol requires about 0.74 gallon of fossil fuel to produce one gallon of ethanol.[63] The net effect of switching from MTBE to ethanol is to reduce CO_2 emissions from gasoline consumption by 0.2 $MMTCO_2E$ in 2002, 1.3 $MMTCO_2E$ in 2003 and 2.0 $MMTCO_2E$ in 2004.

Transportation fossil fuel use data were available for each year for all fuels except liquefied petroleum gas. For this fuel, the average of 1990 to 2001 fuel usage rates was assumed for 2002 through 2004.

Line 7—Electricity Generation (In-State)

CO_2 emissions from electricity generation are produced from the combustion of fossil fuels. Due to environmental and other restrictions, most fossil fuel used to produce electricity in California is natural gas (approximately 43 percent of the total electrical energy produced for use in California in 2001 and 36 percent in 2004).

The 1990-1999 GHG emissions inventory identified utility-owned electricity production, but electricity produced by other entities was reported as a part of industrial emissions. The *Energy Balance* identifies industrial, commercial, and electrical combined heat and power fuel uses, as well as independent power producers, utility-owned electricity generation and non-specified electricity generation. Each is identified as a separate fuel used to generate electricity, as shown in Appendix B. This is a major improvement in the tracking of electricity generation and industrial CO_2 emissions for the California GHG emissions inventory, compared to earlier GHG inventories.

Line 45—Imported Electricity

During the 1990 to 2004 period, California imported 22 to 32 percent of its electric energy from nearby states. The method of generating this imported electric energy ranges from coal-fired power plants to nuclear and hydroelectric power plants. Electricity generated from burning coal releases relatively large amounts of GHG emissions while electricity generated from nuclear and hydroelectric power plants do not emit GHGs.

Electricity imported from the Pacific Northwest has a large hydroelectric component compared to the Southwest, which is largely coal based. Thus, energy imported from the Southwest is much higher in carbon content than is energy imported from the Pacific Northwest.

Due to the nature of imported electrical energy transactions, it is oftentimes not possible to determine the type of facility and associated carbon-based fuel used to generate the imported electricity. However, to estimate carbon emissions from imported electricity, it is necessary to estimate the source(s) of electricity and associated rates of carbon emissions per gigawatt-hour of imported electricity. Thus, an estimate must be made of the fuel used to generate this portion of the imported electricity.

The EPA GHG emissions inventory guidance document[64] recommends that states estimate emissions from net imports of electricity. California occasionally exports a small amount of electricity, but nearly all of the transactions are imports. The GHG inventory of in-state emissions could be reduced to account for the electricity exported from California, but the amount is small enough to ignore this factor. However, 2000 experienced greater than average electricity exports due to the turbulent market conditions that existed at that time.

To estimate the CO_2 emissions from Pacific Northwest electricity imports, we assume 20 percent was generated by coal and 80 percent from hydroelectricity. Correspondingly, for electricity from the Southwest we assume 74 percent coal and 26 percent hydroelectricity. These values were adopted for use in the *1994 Electricity Report* for the 1994 to 1999 period.

This report assumes that these percentages apply for the entire 1990 to 2000 time period. Additional electrical energy is also generated from two out-of-state coal-fired power plants[65] owned by California electric utilities. The fuel used to generate this energy is known to be coal, and there is no need to estimate its fuel source. These emissions are calculated separately and the results added to the values estimated for the Pacific Northwest and Southwest to obtain overall carbon emissions from imported electricity.

To estimate CO_2 emissions from out-of-state electricity generation for 2001 and later years, data from the Energy Commission's Electricity Office was used. This data is based upon reported electrical energy transactions to estimate the percentage of energy from coal, natural gas, oil, nuclear, and other sources. These percentages were used for 2001 through 2004, after removing the two known coal-fired electricity generating facilities.

The State of California's Department of Finance publishes a table (J11) of electrical energy generation from utility-owned and non-utility owned power plants with gigawatt-hours (GWh) of electrical energy production intended for use in California shown by fuel type.[66] The table also shows overall gigawatt imports from the Pacific Northwest and Southwest.

This table is used, along with the percentage data above, to derive annual values for total GWhs of imported electrical energy by fuel type. To convert electrical energy into its British Thermal Unit (BTU) equivalent, staff assumed a thermal conversion rate of 10,000 BTUs per kilowatt-hour (BTU/kWh). This is an approximate value which could be refined, but this step is deemed not necessary due to the uncertainty of other assumptions needed to estimate imported energy levels by type of fuel.

After obtaining annual BTU estimates for each fuel type using the method described above, CO_2 emissions are calculated in the same manner as other sources of fossil fuel emissions for Lines 2 through 8. Appendix C discusses two other approaches for estimating CO_2 emissions from electricity imported to California.

The Energy Commission is developing a more refined way to estimate fuel used to import electricity into California. When these values become available, they will be applied to out-of-state electricity imported to California to provide an improved estimate of these emissions. As of August 2006, this newer approach was not yet available.

Line 8—No End-Use Specified

The *Energy Balance* identified a small amount of natural gas and liquefied petroleum gas use that could not be associated with a specific end-use. The associated CO_2 emissions are listed on Line 8.

CO_2 Emissions from Non-Fossil Fuel Emissions Sources

Some human activities release CO_2 gases without burning fuel. These sources contribute a modest portion of gross CO_2 emissions (2.8 percent in 2004).

Line 9—Cement Production

Cement production involves a chemical conversion process that releases CO_2 gas as limestone is heated in a kiln to produce lime. The resulting clinker is further processed to produce cement. Additional emissions associated with kiln heating are included under fossil fuel combustion and are not repeated here to avoid double counting of these emissions.

Quantities of masonry cement and Portland cement produced in California were obtained from U.S. Geological Survey (USGS) Minerals Yearbook (various years): Table 1, Masonry & Portland Cement Production. Masonry cement and Portland cements were added to determine total cement manufactured, with the bulk of production being Portland cement. See Table A-3 for Masonry and Portland cement production in California.

Clinker production was multiplied by 0.65 to obtain the lime content of the clinker and this value was multiplied by 44/56[67] to convert to CO_2. This value was multiplied by 1.02 to account for clinker dust.

This method is the same as used in the 1990-1999 GHG emissions inventory but with updated or revised data from the USGS Minerals Yearbook (various years) where available.

<u>Line 10—Lime Production</u>
Lime is used in a wide variety of applications, including construction, pulp and paper manufacturing, and sewage treatment. The analysis assumes that California's lime production matches its lime use. Lime production leads to CO_2 emissions in a process similar to cement production. Limestone is heated in a kiln to produce lime, releasing CO_2.

Lime production data for California are obtained from the USGS website [http://minerals.usgs.gov/minerals]. California values are available from USGS for 1990 to 1998 but are withheld for later years to avoid disclosing company proprietary data. Production decreased from 1990 to 1993 but increased thereafter. Values for the 1999 to 2004 time period were extrapolated from 1993 to 1998 values.

California lime production data are shown in Table A-3. There is a decreasing number of lime producing facilities in California. This explains why the lime production data are withheld after 1998. Future inventory methods may not be able to rely upon USGS for California lime production data.

CO_2 emissions are calculated by multiplying lime production by 44/56, the ratio of the molecular weight of CO_2 to lime (CaO).

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data as available.

<u>Line 11—Limestone & Dolomite Consumption</u>
Some uses of limestone and dolomite (both are called "limestone" in mineral industry terms) produce CO_2 emissions,[68] but others do not. No data are available to differentiate limestone and dolomite uses in California that emit CO_2 from those that do not. It is necessary to assume that the national percentage of uses applies equally to California and obtain California's portion by ratio.

Nationwide and California limestone and dolomite consumption are both available from the USGS. Nationwide CO_2 emissions were obtained from the United States GHG inventory. California emissions were obtained by adding limestone and dolomite production and obtaining emissions by ratio. This assumes that the same mix of CO_2-producing uses and non CO_2-producing uses is the same (including flue gas desulfurization), which is not likely. However, no better method is available to estimate these emissions. The small magnitude of these emissions means that further refinement of this data does not appear to be warranted at this time.

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data as available.

Line 12—Soda Ash Consumption

CO_2 emissions occur when soda ash (Na_2CO_3) is used to make glass and soap. Payroll data for California and nationwide were used to estimate the magnitude of CO_2 released from these activities, using the ratio of California to national payrolls to determine California emissions. California's glass-making payroll was 8.5 percent of the national glass-making payroll in 1996, and California's soap-making payroll was 7.6 percent of the national soap-making payroll in 1996. An average of 8.0 percent was used to estimate the California CO_2 emissions from glass- and soap-making activities.

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data as available. The payroll data were not updated.

Line 13— CO_2 Consumption

Nationally, CO_2 is emitted from natural gas wells, as a by-product of chemical production, and when separating crude oil and natural gas. It is also used for a wide variety of activities, including chemical production, food processing, and consumption of carbonated beverages.

California's CO_2 emissions from CO_2 consumption was scaled from national emissions by using the ratio of California's CO_2 production capacity to the national production capacity from year to year.

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data used (as available) for the national CO_2 emissions from CO_2 use.

Line 14—Waste Combustion

CO_2 and nitrous oxide emissions to the atmosphere occur when municipal solid waste (MSW) is combusted to make electricity. A portion of the waste stream is biogenic, and these CO_2 emissions are not counted because the carbon is recycled during the growth period of the biogenic materials. Another portion of the waste stream is made from plastic, synthetic rubber, and synthetic fibers, and this portion is counted because they are derived from fossil fuels. The nitrous oxide emissions calculations (Line 31) are documented below.

There are three MSW facilities in California: Commerce Refuse-to-Energy, Southeast Resource Recovery, and Ogden Martin Systems of Stanislaus, Inc. Representatives of each were contacted to obtain annual tons of municipal wastes processed for 1990 through 2004. These values were multiplied by 0.1104 tons of carbon per ton of MSW for plastics, 0.0174 tons of carbon per ton of MSW for synthetic rubber, and 0.0343 tons of carbon per ton of MSW. These emissions factors are national average values derived by the EPA. Results are summed and converted to million metric tons of CO_2 to get total CO_2 emissions from MSW.

This method is updated from the 1990-1999 GHG emissions inventory, with new emissions factors for waste stream constituents.[69]

Land Use Change & Forestry Overview

The 1990-1999 GHG emissions inventory estimated net CO_2 flux caused by changes in forest carbon stocks, changes in agricultural soil carbon stocks, and changes in yard trimming carbon stocks in landfills. Forested land in California was estimated based on California Department of Forestry's (CDF) five-year inventories, with the last inventory conducted in 1994. Therefore, all values for 1995 through 1999 were extrapolated from 1994 data. The forested land was categorized by ownership, use, and type of vegetation. Net changes in carbon stocks were tracked by modeling carbon flows related to tree growth, forest removals, and decomposition.

The current inventory uses a different approach to reflect methodology and quantification changes developed by Winrock International.[70] Changes in canopy cover were tracked through the California Land Cover Mapping and Monitoring Program (LCMMP) conducted by the CDF's Fire and Resource Assessment Program (FRAP).

LCMMP uses Landsat Thematic Mapper satellite imagery to map vegetation and changes over five-year periods. Carbon flux estimates are derived principally from Forest Inventory and Analysis (FIA) data. This approach allows for use of newer, California-specific information developed by the Energy Commission's Public Interest Energy Research Program.

Winrock provided emissions and removals of GHG by land-use sector for five-year intervals, that is, between 1994 to 2000 for 84 percent of the forests and 42 percent of the rangelands. This was extrapolated to 100 percent of the area. A portion of the carbon associated with harvested forest wood is sequestered in long-term wood products. For softwoods, 75 percent is extracted from the forest and 44 percent of the extracted volume is stored in these long-term products. For hardwoods, 73 percent is extracted and 23 percent of the extracted hardwood volume is stored in long-term products.

Emissions and reductions for 1990 to 1994 were calculated using a FRAP analysis of a 7 percent reduction in forest land between 1953 and 1994. Emissions and reductions for 2002 and later years are based on forecasted reductions in land by the federal Secretary of Agriculture. These values should be updated with future satellite imagery.

Agricultural acreages were based primarily on the National Resource Inventory (NRI) database and provided in discrete values for 1987, 1992, and 1997. Linear regression analysis was used to provide the values for 1990 to 1991, and 1993 to 1996. For 1998 to 2004, acreage data from the California Agricultural Statistics Services were used.

Carbon estimates for woody crops were made by Winrock based on above- and below-ground biomass, crop type (for example, fruit, nut, and vineyard) and planting densities. Changes in agricultural soil carbon were not tracked because it was assumed agricultural land in California has been under cultivation long enough that changes in soil carbon stocks based on soil types are minimal. This may not be true for soils converted to viticulture and pasture, and this factor should be evaluated in future inventory updates.

Inventory categories were changed to reflect the new methodologies and baseline. However, because carbon changes cannot be detected from satellite and there is a lack of data on carbon densities of cropland, this inventory uses the 1990-1999 inventory method for land filling of lumber and urban wood waste and liming of soils as explained below.

Line 15—Land Use Change & Forestry Emissions

Winrock International tracked measurable decreases in canopy cover and the resulting decreases in carbon stocks (carbon emissions) separately from measurable increases in canopy cover (carbon storage). Decreases in carbon stocks (gross and net changes) varied by the cause of the change. Fire and harvest were the dominant causes of emissions on forestlands, and fire was the cause of emissions on rangelands.

Field measurements by Winrock and literature sources indicated no changes in soil carbon with land use or management except in the conversion to some forms of agriculture. Therefore, emission categories attributed to forest and agricultural soils were removed from this inventory.

Agricultural land was categorized by the types of crop grown – woody or non-woody. Total carbon stock was estimated based on area and crop type within the broad categories (fruit, nut, vineyard, berry, row crops, close crops, hay crops, and other).

Although there was an overall decrease in both woody and non-woody crops between 1987 and 1997, the inventory fluctuated between emissions and reductions for agricultural lands based on periods when woody crops increased and annual fluctuations in non-woody crop acreages. The apparent sudden, relatively large increase in reductions between 1997 and 1998 is an anomaly caused by a change in 1998 from NRI data to CASS data. 1990-1999 NRI data points were correlated to CASS acreages to determine they were within the uncertainty range.

Liming of Soils

Limestone and dolomite applied to agricultural soils degrades and releases CO_2. The amount of CO_2 generated from using these soil treatments is estimated using the same method as used in the 1990-1999 inventory[71] with new data as needed.

Tonnage data of limestone and dolomite applied to California soils was obtained from the USGS's *Minerals Yearbook* for various years. These values were multiplied by the appropriate emissions factor (0.12 metric ton of carbon per metric ton of limestone, and 0.13 metric ton of carbon per metric ton of dolomite) and then converted to CO_2 by multiplying by the molecular weight ratio of CO_2 to carbon (44/12).

Line 16—Land Use Change & Forestry Sinks

Since satellite imagery only identifies measurable changes in canopy coverage during the time interval, carbon estimates are derived from FIA for forests and rangeland types with corresponding canopy closures. Tracking carbon stocks through satellite imagery measured changes in canopy overcomes problems with apparent changes in stocks due to land reclassification (for example, moving acreage from private ownership to public ownership).

Agricultural sinks are estimated in the manner described above for Land Use Change and Forestry Emissions (Line 15).

Landfilling Lumber and Urban Wood Waste

Lumber and urban wood wastes disposed at landfills contain significant amounts of lignins, which contain carbon, which is sequestered in anaerobic landfills.

The methods used for Lumber Disposal and Yard Trimming Disposal are the same as the 1990-1999 inventory with new data as needed.

Tonnage of lumber and urban yard trimmings disposed at landfills was obtained for 1990, 1999, and 2003 from the California Integrated Waste Management Board (CIWMB) surveys.[72] Tonnage values for 2004 were estimated by extrapolation from the 1999 and 2003 tonnage values. These surveys inventoried disposal in place (in situ). Therefore, the tonnage reported represented lumber and wood trimmings entering the landfill and not the municipal waste stream, as was assumed in the 1990-1999 inventory.[73]

Emissions factors of -0.30 metric tons of carbon per short ton of lumber, and -0.2082 tons of carbon per short ton of yard trimmings (grass, leaves, and branches) were applied to obtain annual estimates of carbon emissions from theses sources, and then converted to CO_2 by multiplying by the molecular weight ratio of CO_2 to carbon (44/12). Emissions factors are negative because this carbon is sequestered within the landfill.

Line 17— CO_2 (Net)
This line is Line 1 minus Line 16.

Methane Emissions

Methane (CH_4) emissions occur from operation of petroleum and natural gas supply systems, waste operations (landfills and wastewater treatment), agricultural operations (enteric fermentation, manure management, rice fields and agricultural burning), and from mobile and stationary fuel combustion. Methane emissions are converted into CO_{2}- equivalent emissions by multiplying the methane emissions in millions of metric tons by their 100-year GWP. For this inventory, we used a GWP from the Second Assessment Report to be consistent with IPPC guidance and the U.S. EPA methodology. The 100-year GWP for methane emissions is 21 times CO_2 emissions. In the previous report covering the 1990 to 2002 period, some subcategories were inadvertently evaluated using 23 times rather than 21 times. Once the newer GWPs become accepted for use (from the Third Assessment Report or later), all will be evaluated using the newer number. In the meantime, for this report, all of the data have been made consistent using the older GWP, 21.

Line 18—Methane Total Emissions
This line is the sum of Lines 19 to 28.

Line 19—Petroleum & Natural Gas Supply System
The ARB provided the Energy Commission a data file of estimated methane emissions from area sources, including emissions from the petroleum and natural gas supply system. Data were provided annually for 1990 to 2004. ARB documents their methodology for estimating emissions and provides criteria pollutant emissions data on their website.[74]

Essentially, local air districts provide detailed field data to ARB, who summarizes it into statewide emissions. Methane emissions were estimated by ARB from total organic gas (TOG) emissions using a speciation profile[75] to determine the fraction of TOG comprised of methane. The ARB's most recent speciation profile is included in Appendix E. ARB provided data in tons/day. These were multiplied by 365 to convert to tons per year, and then by 0.9072 to convert from short tons to metric tons.

The current method uses data derived from local and regional analyses while the 1990-1999 GHG inventory method used national data. The current method combines emissions from both petroleum and natural gas extraction because they usually occur simultaneously in California due to the fact that natural gas is co-located and co-produced with crude oil. The current method is considered more representative of California's GHG emissions.

Petroleum and natural gas field operations release fugitive methane from oil/water separators, well operations, pumps and compressors, fittings and valves. Emissions also occur from operation of field reciprocating engines and from petroleum seeps.

Petroleum refining also releases small amounts of methane. Petroleum marketing emissions also occur from barge loading, lightering and ballasting and tanker loading.

Line 20—Natural Gas Supply System
Additional natural gas supply system methane emissions were obtained in the same manner explained above for the petroleum and natural gas supply system.

Some natural gas methane emissions are embedded in line 19, which includes emissions associated with producing both petroleum and natural gas. Additional natural gas methane emissions occur from wet gas stripping and field separation and especially from natural gas transmission losses. These are included in Line 20.

Line 21—Landfill Emissions
Landfill methane emissions occur from organic decomposition of wastes placed in them. Most methane production typically occurs one to two years after waste placement and significant emissions can occur for up to 60 years. The quantity of methane generated at a landfill depends upon the amount of waste placed, age of wastes placed, composition of wastes placed, and climate at the waste disposal site. In California, most landfills have methods of controlling these emissions, including methane recovery for electricity production, methane flaring. In addition, methane oxidation in the landfill cover material (or surface layer) also reduces the net emissions. The amount of this oxidation is uncertain and varies by latitude of the landfill, soil characteristics, and other factors. US EPA guidance is to use local oxidation rates if available; if not, 10 percent reduction due to oxidation is recommended. California has an aggressive waste diversion program, aimed at reducing the quantities of wastes placed annually.

Methane emissions from California landfills were obtained in the same manner explained above for the petroleum supply system. These data are collected by local air regulatory agencies and are considered a better representation of California GHG emissions than the method used for the 1990-1999 GHG inventory. Local air pollution district personnel provided these data to the Air Resources Board and are in the process of reviewing and updating this information, but the results are not yet available.

Line 22—Enteric Fermentation
The amount of methane emissions from a domesticated animal depends on whether the animal is a ruminant,[76] the age and weight of the animal, and characteristics of feeding. Quantities of methane generated by ruminant animals are much greater than from non-ruminant animals, therefore, the focus of the quantification is on California's largest population of ruminant animals–cattle.

Although beef cattle populations have declined over the last 12 years, the dairy cattle population has increased significantly. California is the leading dairy state in the nation, and dairy products are the state's number one agricultural commodity.

The 1990-1999 GHG emissions inventory[77] modeled each stage of the cattle population monthly from birth to slaughter. These monthly values are estimates and the method implies an accuracy that is not justified. Current studies indicate emission factors used in the inventory for California cattle may be much higher than what is actually produced with the industry's feeding regimes and may overstate emissions. The ARB is developing new emissions factors for regulatory purposes, and these should be used in future updates to the inventory.

For this inventory, annual data for cattle and other agricultural livestock population (head) were taken from the California Agricultural Statistics Services (CASS). California specific emission factors from the 1990-1999 inventory were applied to these animal populations. This method increases the GHG emissions by approximately 10 percent within the category. The reader is referred to the 1990-1999 California GHG inventory,[78] pages 109 to 115, for an explanation of the method used to estimate these emissions.

Line 23—Manure Management

Methane emissions from livestock are generated through manure management systems. Emission factors for each type of livestock varies considerably since domestic livestock types vary from cattle to poultry.

The annual average animal populations were tabulated for:

1. Cattle (by type such as dairy or beef, and by size)
2. Swine (by type and by size)
3. Poultry (by type)
4. Sheep (by type)
5. Goats
6. Horses

Non-equine animal populations were obtained from California Livestock and Dairy Reports, and County Agricultural Commissioners' Data. Equine populations were estimated from 1999 data for horse populations but are probably low because data is not collected for groups of fewer than 50 horses.

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data as available.

Livestock manure produces methane by anaerobic decomposition of the manure for that fraction that is managed in a liquid storage system such as lagoons, ponds, tanks, or pits. Little or no methane is produced from methane managed as a solid or deposited on rangeland, etc. As ambient temperatures and moisture levels increase, methane emissions increase. Diets higher in energy content produce more methane.

Methane emissions are based on the quantity of volatile solids produced by livestock. This is determined from typical animal mass (TAM) and livestock populations. Methane emissions are estimated using emissions rates typical of each type of animal. These are adjusted by multiplying by a management factor to represent the percentage of emissions based upon type of management practice with zero representing practices that eliminate emissions and 1.0 representing practices that tend to maximize methane production.

Emission factors are based on national animal characteristics and should be updated to reflect California-specific values in future updates to the inventory. These factors range from 18 percent for cattle and goats to 48 percent for swine, with all values depending on type of animal and typical management practice.

Line 24—Flooded Rice Fields

Anaerobic decomposition of organic material by methanogenic bacteria in flooded rice fields produces methane. Some of the methane is oxidized, some is leached to ground water, and the remaining methane is diffused to the atmosphere, primarily through the rice plants.

Methane emissions from rice cultivation is small – representing less than 2 percent of the total methane emissions tracked for California. Although methane emissions increase significantly with ratoon or secondary crops grown from stubble, California does not grow ratoon rice.

The methane emission factor used was based on California studies and is lower than the average factor used by the EPA,[79] which represents rice soil temperatures and management practices throughout the eight rice-growing states. Acreage data for rice was obtained from the CASS.

This method is the same as used in the 1990-1999 GHG emissions inventory[80] with new or revised data as available. Essentially, annual acreage in hectares is multiplied by an emissions factor of 122 kilogram methane per hectare. This is multiplied by the GWP of 21 times CO_2 from the Second Assessment Report, and then divided to obtain million metric tons of CO_2 equivalent.

Line 25—Burning Agricultural Residues and Other Wastes

Field burning is often used to dispose of pruned branches from crops and to dispose of unwanted crop components such as rice straw and field stubble. Agricultural burning is divided into two categories – crop residue burning and other agricultural waste burning. Crop residues are identified as non-woody or field residues, and woody or orchard/vineyard residues. The methodology for estimating GHG emissions from field burning of agricultural residues was based on the type and amount of residues produced, and the crop specific emission factors for methane (and nitrous oxide, see Line 34) released during combustion.

The inventory used California-specific factors for residue tonnages per crop acreage to determine total amounts of non-woody and woody residues. The percentage of the residues burned in the field was applied to these total amounts. Burning permits for other agricultural wastes were used to determine other non-crop agricultural burning.

California's crop residue profile differs from the national profile. Almonds, walnuts, wheat, barley, corn, and rice produce almost 98 percent of the field and woody crop residue burned in California. Adding cherry, apricot, and grape residue captures almost 100 percent of the agricultural residues burned in California, especially since grape acreages have increased substantially in recent years.

Changes in rice residue burning practices have decreased the amount of rice straw burned. California's cultivated rice acreage increased from 425,000 acres in 1990, to 595,000 acres in 2004,[81] and rice residue tonnage has increased proportionally. However, the percent of rice residue burned has decreased from 99 percent before 2001, to 25 percent for 2001 and later years. This change is reflected in the inventory data.

Agricultural Crop Residues

Acreage data for all crops are taken from the annual Crop Reports compiled by the California County Agricultural Commissioners and from the California Agricultural Statistics Service. Emissions for this subcategory are estimated as described above.

Other Waste Burning

Some other agricultural wastes produced and burned in California cannot be calculated based on crop acreages. These emissions are tracked through agricultural burning permits administered by individual air districts. The ARB maintains a database of agricultural emissions based on these permits and supplements these data with estimates where permit information is not available. The estimated Agricultural Crop Residues emissions based on acreages were subtracted from the emissions inventory provided by ARB to get a category we call "Other Agricultural Waste Burning." These emissions include non-agricultural open burning, wild fires, and other miscellaneous waste burning.

Line 26—Wastewater Treatment

Anaerobic degradation of waste water produces methane emissions. These are calculated using California population data and appropriate generation rates and emissions factors from EPA. First, biochemical oxygen demand estimated by the "five-day test" (BOD_5) is estimated at 0.065 kilogram per capita per day. The anaerobic treatment fraction of BOD_5 is estimated at 16.25 percent, and the methane generation rate is assumed to be 0.6 kilograms of methane per kilogram of BOD_5. These factors are multiplied together to get the daily methane production rate and then multiplied by 365 to get a yearly value.

The methodology is the same as the 1990-1999 inventory, but the emission factors have been updated as of June 2003.

Line 27—Mobile Source Combustion

Methane emissions from mobile sources were obtained in the same manner explained above for the petroleum supply system, except the data was generated by ARB staff, not local air quality districts. This updated data source is similar to the overall approach used in the 1990-1999 inventory, except it uses ARB computer representation of the California fleet and is likely to be more detailed than the 1990-1999 approach.

The ARB provided data for gasoline vehicles (passenger cars, light-, medium-, and heavy-duty vehicles, boats, off-road vehicles, motorcycles, and others), for diesel vehicles (passenger cars, light-, medium-, and heavy-duty trucks), and for aviation.

<u>Line 28—Stationary Source Combustion</u>
Methane emissions from electricity combustion were developed in the following manner:

1. Obtain coal, oil, natural gas, and wood higher heating value (HHV) energy consumption data from the EIA for 1990 to 2004.

2. Multiply by 0.95 (for coal and oil) or by 0.90 (for natural gas and wood) to convert HHV to lower heating value (LHV).

3. Multiply by 1055 to convert from LHV BTUs to Joules.

4. Multiply by the appropriate emission factor (1.0 for natural gas and coal, 3.0 for petroleum, and 30.0 for wood) to convert from gigajoule to grams of methane.

5. Adjust to million metric tons.

6. Multiply by the GWP (21 for methane, second assessment report) to convert to CO_2-equivalents.

Methane emissions from other stationary source combustion were developed in the same manner explained above for the petroleum supply system, using data from the ARB. The ARB data were not used for electricity production because the data indicated that these values were only for cogeneration. The ARB values were lower, which is consistent with the fact that they did not include all electricity production.

Industrial stationary source methane emissions include gasoline and diesel used in a variety of equipment, including manufacturing and industrial sectors, food and agricultural processing, off-road equipment of all types, ships and commercial boats, and trains. Industrial methane emissions also include natural gas used in airport ground equipment, mineral processing, surface treatment, industrial equipment, and other industrial processes.

Commercial stationary source methane emissions include diesel and liquefied petroleum gas used in trains, asphalt paving and roofing, commercial lawn and garden equipment, boats, and others. Commercial methane emissions also include natural gas emissions from commercial water and space heating, cooking, and commercial off-road equipment. Another commercial activity is commercial cooking. Additional commercial methane emissions are associated with wood and paper processing.

Residential stationary source methane emissions include LPG and distillate oil combustion; natural gas used in water heating, space heating, and cooking. Residential methane emissions are also associated with wood combustion in wood stoves and fireplaces.

Other stationary source methane emissions include timber and brush fires, structure fires, and other processes not specified.

Nitrous Oxide Emissions

Nitrous oxide (N_2O) emissions occur from nitric acid production, waste combustion, agricultural activities (agricultural soil management, manure management, and burning of agricultural residues), human sewage treatment, and from mobile and stationary fuel combustion. Nitrous oxide emissions are converted into CO_2-equivalent emissions by multiplying the N_2O emissions in millions of metric tons by their 100-year GWP. For this inventory, we choose a GWP from the Second Assessment Report to be consistent with IPPC guidance and the U.S. EPA methodology. The GWP for nitrous oxide emissions is 310 times CO_2 emissions. In the previous report covering the 1990 to 2002 period, some subcategories were inadvertently evaluated using 296 times rather than 310 times. Once the newer GWPs become accepted for use (from the Third Assessment Report or later), all will be evaluated using the newer number. In the meantime, the data have been made consistent using the older GWP, 310.

Line 29—Nitrous Oxide Total Emissions
This line is the sum of Lines 30 to 37.

Line 30—Nitric Acid Production
Nitric acid is used for producing synthetic fertilizer; making adipic acid, rocket propellant, and explosives; for treating stainless steel; for metal etching; and processing nuclear fuel. Nitrous oxide is a by-product of making nitric acid.

California's nitrous oxide emissions were estimated using the same method as the 1990-1999 GHG inventory.[82] The first step was to develop a ratio of California's nitric acid production capacity to the federal production capacity and then multiplying this ratio times the national estimates of CO_2-equivalent nitrous oxide emissions from nitric acid production.

California's nitric acid production capacity data were available for 1990, 1992, 1993, 1995, 1996, and 1998. Values for intervening years were estimated by interpolation, and values after 1998 were held constant at 1998 capacity. California's percentage of the national production capacity decreased steadily from 3.0 percent in 1990, to 1.4 percent in 1998. Thus, holding this percentage constant for 1999 through 2004 may slightly overstate California's nitrous oxide emissions from nitric acid production.

Line 31—Waste Combustion

CO_2 and nitrous oxide emissions to the atmosphere occur when MSW is combusted to make electricity. See Line 14 (above) for a brief description of waste combustion and resulting CO_2 emissions. Nitrous oxide emissions are estimated in the same manner but using an emission factor of 0.0001 ton of nitrous oxide emitted per ton of municipal solid waste combusted.

Line 32—Agricultural Soil Management

Nitrous oxide emissions from agricultural soils are affected by fertilizer use, amounts and types of residues incorporated into the soil, the type of soil, animal manures, and the amount of leaching and runoff. This method is the same as used in the 1990-1999 GHG emissions inventory with the following exception.

In the 1990-1999 inventory, the residue tonnages produced and incorporated into the soil were based on a residue-to-crop mass ratio. When these tonnages were compared to the total tonnages produced based on California factors (see Burning Ag Residues), they were up to five times greater than were calculated for agricultural burning. Therefore, the residue-to-crop mass ratio and the fraction of residue applied was adjusted down for barley, corn, rice, and wheat to reflect California factors for the amount of residue produced per acre and the fractions not burned. California specific factors for sorghum, oats, rye, soybeans, peanuts, and beans were not determined for this inventory.

Line 33—Manure Management

Nitrous oxide emissions from manure (and urine) occur from a nitrification process when ammonia in the waste first decomposes to nitrites in the presence of oxygen (aerobic conditions), followed by further decomposition to nitrous oxide under anaerobic conditions. Dry lot systems are generally aerobic. However, these may evolve to anaerobic conditions after rainfall.

A portion of the nitrous oxide generated from these wastes is included under Agricultural Soil Management (Line 32), including manure and urine in pastures and rangeland, and in paddocks, as well as manure used as a soil amendment. The remaining sources of nitrous oxide from manure management are estimated in this category of emissions.

Nitrous oxide emissions from this sector depend heavily on amount of un-volatilized organic nitrogen and ammonia in manure. This is called "total Kjeldahl nitrogen" and is estimated by multiplying animal population times TAM and the ratio of TAM to Kjeldahl nitrogen, times 0.80 (80 percent is assumed to not volatialize) and remain behind to decompose. All values are specific to type of animal and the feeding regimen. TAM and Kjeldahl nitrogen values are based on national animal characteristics and should be updated to reflect California-specific values in future updates to the inventory.

Line 34—Burning Agricultural Residues
Crop-specific nitrous oxide emissions are calculated in the same manner as methane emissions from burning agricultural residues (Line 25), except nitrous oxide emissions factors are substituted for methane emissions factors.

Line 35—Wastewater (formerly, Human Sewage)
Nitrous oxide emissions occur as a natural by-product of organic-laden domestic (human sewage) and industrial waste water, converting nitrate to nitrous oxide under anaerobic conditions.

Municipal wastewater emits nitrous oxide as a consequence of nitrogen in protein digested in the human diet. These emissions are estimated in the following steps:

- Obtain U.S. per capita protein consumption from the EPA Emissions Inventory Improvement Program guidance document[83] (this data shows the same value for 1998 to 2000, analysis assumes the value also applies through 2004).
- Multiply by the state population for each year,
- Multiply by 0.01 kilogram N_2O-N per kilogram N,
- Multiply by 44/28 (ratio of molecular weight of nitrous oxide to atomic weight of nitrogen),
- Multiply by GWP of nitrous oxide to obtain metric tons of CO_2- equivalent,
- Divide by 1,000,000 to get million metric tons CO_2-equivalent.

This is the same approach used in the 1990-1999 GHG emissions inventory.

Industrial wastewater emissions occur from processing fruits and vegetables, red meat and poultry, and pulp and paper. These are not yet included in the California inventory but should be added.

Line 36—Mobile Source Combustion
Combustion of gasoline and diesel in internal combustion engines releases small quantities of nitrous oxide in the exhaust. The rate of emissions depends on engine type and type of pollution control applied to the engine.

ARB staff provided annual nitrous oxide emissions from gasoline and diesel fueled vehicles from their EMFAC model. These were adjusted to tons per year by multiplying by 365, then from short tons to metric tons by multiplying by 0.9072, and by the nitrous oxide GWP to convert to CO_2-equivalents.

<u>Line 37—Stationary Source Combustion</u>
Nitrous oxide data were not available from the ARB. Instead, emissions were calculated using fuel consumption data from the EIA's *State Energy Data Report* for 1990 to 2001. Because data were no more current than 2001 and magnitude of emissions is small, values for 2002 through 2004 were assumed to equal 2001 values. Values were derived for electricity generation, industrial, commercial/ institutional, and residential fuel uses. The process is the same as Line 28, Stationary Source Combustion (methane) for electricity production, except the emission factor in Step 4 is replaced with the appropriate value for nitrous oxide, in units of grams nitrous oxide per gigajoule of fuel use: coal = 1.4, petroleum = 0.6, natural gas = 0.1, and wood = 4.0

High GWP Gas Emissions

High GWP gas emissions include atmospheric release of gases used in place of ozone-depleting gases, semiconductor manufacturing, and electricity transmission and distribution. Substitution of ozone-depleting gases involves a number of hydrofluorocarbons (HFCs).

High GWP gas emissions are converted into CO_2-equivalent emissions by multiplying the methane emissions in millions of metric tons by their 100-year GWP. For this inventory, we choose GWPs for each gas from the Second Assessment Report to be consistent with IPPC guidance and the U.S. EPA methodology. The GWP for high GWP gases is different for each gas. Most of the values used in this inventory are shown in Table 5 of the 1990-1999 California GHG inventory.[84]

<u>Line 38—High GWP Gas Total Emissions</u>
This line is the sum of Lines 39 to 41.

<u>Line 39—Substitution of Ozone-Depleting Substances</u>
Several anthropogenic substances have been linked to ozone depletion over the Earth's Polar Regions and are being phased out due to international agreements. These ozone-depleting substances (ODS) were historically used in industrial refrigeration and space conditioning equipment, solvents, foams, etc. A wide range of replacement substances are being used in increasing amounts in the United States, and these are associated with global warming.

California ODS GHG emissions were estimated by scaling U. S. ODS emissions by the ratio of California-to-United States population, about 12 percent. This is the same method used in the 1990-1999 GHG inventory.[85]

Line 40—Semiconductor Manufacture

Semiconductor manufacturing releases several compounds that have strong global warming impacts, including trifluoromethane, perfluoromehtane, perfluoroethane, and SF_6. The exact combination of compounds is difficult to estimate.

California GHG emissions from semiconductor manufacturing operations were estimated by scaling U.S. semiconductor manufacturing emissions by the ratio of California-to-United States population, about 12 percent. This is the same method as the 1990-1999 GHG emissions inventory.[86] This approach may underestimate California emissions due to the significance of this industry to California.

Line 41—Electricity Transmission & Distribution (Sulfur Hexafluoride)

Electricity transmission and distribution requires the use of circuit breakers, gas-insulated substations, and switch gear. Sulfur hexafluoride (SF_6) is used to insulate this equipment and can leak out, especially in older equipment. Emissions also occur during installation and servicing.

The Second Assessment Report GWP for SF_6 is 23,900 times that of CO_2, so a small amount of SF_6 can significantly impact global warming. Fortunately, California utilities are finding that they can reduce maintenance costs by better management of SF_6. However, since California-specific data are not currently available, SF_6 emissions are estimated from national values, prorated by ratio of California to national energy consumption, expressed in GWh. This method is the same method as the 1990-1999 GHG inventory.[87] This approach probably overstates California's sulfur hexafluoride emissions because California utilities are implementing procedures to control their SF_6 emissions and reduce their maintenance costs.[88]

Table A-1. Fossil Fuel Emissions Factors and Percentage Oxidized (Fuels Where Values Do Not Vary from Year to Year)

Fuel	Percent Oxidized	Emission Factor (lb C/mm BTU)
Natural Gas	99.5	31.9
Petroleum Products		
- Asphalt	99	45.5
- Aviation Gasoline	99	41.6
- Distillate	99	44.0
- Jet Fuel	99	43.5
- Kerosene	99	43.5
- Liquefied Petroleum Gas	99.5	37.8
- Motor Gasoline	99	42.8
- Misc. Petroleum Products	99	44.7
- Petroleum Coke	99	61.4
- Refinery Still Gas	99	38.6

Table A-2. Fossil Fuel Emissions Factors and Percentage Oxidized (Fuels Where Values Vary from Year to Year)

	Percent Oxidized	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000 to 2004
Coal												
- Commercial	99	55.66	55.69	55.66	55.66	55.66	55.66	55.66	55.66	55.67	55.66	55.66
- Industrial	99	55.80	55.80	55.69	55.66	55.66	55.66	55.66	55.71	55.79	55.80	55.80
- Utility	99	56.62	56.65	56.65	56.67	56.70	56.75	56.75	56.78	56.78	56.78	56.78

(Assume 2000 to 2004 values are constant at 1999 values)

Table A-3. Minerals Production in California
(Thousand Metric Tons)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002-04
Cement													
- Portland	8,874	8,178	7,289	8,510	9,640	9,360	9,910	10,300	10,000	10,300	10,900	10,100	11,200
- Masonry					99	154	198	169	410	466	484	564	637
Total Cement	8,874	8,178	7,289	8,510	9,739	9,514	10,108	10,469	10,410	10,766	11,384	10,664	11,837
1990													
Lime Production	313.2	278.7	254.2	193.0	203.2	228.2	207.9	199.7	185.2	181.6	185.7	182.2	178.6
								(Shaded areas extrapolated from 1993-98)					
Limestone & Dolomite		17.8		18.2	23.5	23.4	25.3	23.2	25.0	26.9	28.3	27.9	35.7
	(1990 assumed equal to 1991; 1992 assumed equal to 1993)												
Soda Ash Consumption	522	502	506	502	501	520	511	518	514	514	511	510	514

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Carbon Dioxide	**317.43**	**310.78**	**316.28**	**311.35**	**329.76**	**313.68**	**318.60**	**328.82**	**346.40**	**348.69**	**368.30**	**372.52**	**365.35**	**347.08**	**355.88**
Residential	**28.97**	**29.54**	**27.86**	**28.42**	**29.26**	**26.65**	**26.61**	**26.34**	**30.60**	**31.91**	**30.25**	**27.21**	**27.32**	**26.40**	**27.86**
Natural Gas	27.52	27.84	26.62	27.15	28.00	25.46	25.59	25.41	29.12	30.50	28.53	25.92	25.98	25.06	26.49
Petroleum	1.44	1.70	1.24	1.27	1.26	1.20	1.02	0.93	1.49	1.41	1.71	1.29	1.34	1.33	1.37
LPG	1.30	1.57	1.09	1.14	1.13	1.11	0.92	0.83	1.38	1.29	1.55	1.07	1.20	1.20	1.20
Kerosene	0.05	0.04	0.05	0.04	0.04	0.01	0.03	0.03	0.04	0.05	0.06	0.10	0.08	0.08	0.11
Distillate	0.09	0.08	0.10	0.10	0.10	0.08	0.06	0.07	0.07	0.08	0.11	0.13	0.06	0.05	0.06
Commercial	**12.65**	**11.99**	**9.70**	**9.61**	**10.25**	**9.80**	**9.58**	**9.61**	**13.49**	**14.77**	**15.63**	**12.04**	**17.84**	**15.06**	**12.19**
Coal	0.05	0.09	0.00	0.27	0.34	0.27	0.38	0.22	0.23	0.06	0.05	0.00	0.00	0.00	0.00
Natural Gas	9.40	8.71	7.94	8.00	8.59	7.83	7.82	8.07	11.70	13.15	13.88	10.46	16.56	13.93	11.13
Education	1.41	1.27	1.08	1.12	1.27	0.98	0.94	1.04	1.26	1.38	1.39	0.95	1.14	1.10	1.15
College	0.69	0.60	0.53	0.54	0.69	0.51	0.47	0.56	0.68	0.74	0.84	0.54	0.62	0.63	0.66
School	0.71	0.67	0.55	0.57	0.58	0.47	0.47	0.48	0.58	0.64	0.55	0.41	0.53	0.47	0.49
Food Services	1.88	1.87	1.85	1.87	1.90	1.89	1.94	2.02	2.15	2.26	2.33	2.10	2.23	2.33	2.49
Restaurant	1.62	1.63	1.61	1.62	1.64	1.64	1.68	1.74	1.84	1.93	1.99	1.80	1.93	2.02	2.11
Food & Liquor	0.25	0.25	0.24	0.25	0.26	0.25	0.26	0.28	0.31	0.33	0.33	0.31	0.30	0.30	0.38
Retail & Wholesale	0.60	0.55	0.54	0.61	0.65	0.59	0.49	0.55	0.56	0.62	0.60	0.22	0.58	0.58	0.57
Retail	0.29	0.26	0.22	0.23	0.24	0.19	0.19	0.19	0.23	0.25	0.22	0.20	0.26	0.27	0.25
Warehouse	0.31	0.29	0.32	0.24	0.26	0.37	0.27	0.32	0.30	0.33	0.33	0.00	0.29	0.27	0.26
Warehouse, refrigerated	0.00	0.00	0.00	0.15	0.15	0.03	0.03	0.03	0.04	0.04	0.04	0.02	0.03	0.04	0.06
Health Care	1.31	1.32	1.12	1.05	1.22	1.13	1.14	1.15	1.24	1.35	1.31	1.15	1.18	1.21	1.27
Hotel	0.67	0.65	0.62	0.60	0.62	0.60	0.60	0.61	0.64	0.67	0.67	0.61	0.62	0.61	0.63
Office	1.45	1.39	1.27	1.31	1.40	1.31	1.36	1.35	1.54	1.75	1.60	1.35	1.82	1.78	1.87
Transportation Services	0.03	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.05	0.06	0.06	0.04	0.00	0.00	0.00
Transportation	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Water Transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Airports	0.02	0.03	0.02	0.03	0.03	0.02	0.04	0.02	0.04	0.05	0.04	0.03	0.00	0.00	0.00
Communication	0.07	0.07	0.06	0.04	0.06	0.06	0.06	0.08	0.06	0.07	0.06	0.05	0.10	0.08	0.08
U.S. Postal Service	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
Telephone & Cell Phone Service	0.05	0.05	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.01	0.01
Other Message Communication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.04
Radio Broadcasting Stations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Non-Specified (Communication)	0.00	0.00	0.00	0.00	0.02	0.01	0.02	0.03	0.01	0.01	0.01	0.01	0.00	0.01	0.01
Utilities	0.34	0.33	0.36	0.27	0.29	0.32	0.41	0.39	3.98	4.10	4.85	3.16	3.51	3.86	2.89
Electric, Nat'l Gas, Steam	0.14	0.16	0.16	0.10	0.11	0.12	0.17	0.15	3.71	3.79	4.53	2.94	3.34	3.47	2.43
Sewerage Systems	0.07	0.07	0.08	0.07	0.08	0.09	0.13	0.13	0.18	0.17	0.16	0.14	0.08	0.13	0.26
Water Supply	0.12	0.10	0.11	0.10	0.10	0.10	0.11	0.11	0.10	0.13	0.16	0.09	0.09	0.25	0.20
Street Lights	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
National Security	0.56	0.64	0.54	0.54	0.50	0.40	0.36	0.46	0.34	0.29	0.24	0.30	0.17	0.17	0.18
Non-specified (Services)	1.09	0.57	0.48	0.56	0.65	0.53	0.47	0.40	-0.12	0.60	0.78	0.52	5.21	2.21	0.00
Petroleum	3.20	3.18	1.77	1.35	1.32	1.70	1.38	1.32	1.55	1.56	1.70	1.58	1.28	1.12	1.05
LPG	0.23	0.28	0.19	0.20	0.20	0.20	0.16	0.15	0.24	0.23	0.23	0.23	0.23	0.23	0.23
Motor Gasoline	0.71	0.61	0.55	0.10	0.08	0.09	0.08	0.08	0.09	0.08	0.09	0.09	0.09	0.09	0.10
Kerosene	0.07	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.03	0.01	0.02	0.03
Distillate	1.78	1.89	0.99	1.03	1.03	1.40	1.12	1.09	1.17	1.22	1.37	1.21	0.95	0.78	0.70
Residual Oil	0.41	0.37	0.02	0.01	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.02	0.00	0.00	0.00
Industrial	**66.12**	**64.77**	**61.32**	**64.30**	**66.00**	**62.58**	**68.81**	**73.00**	**75.37**	**70.96**	**76.17**	**80.48**	**71.53**	**65.47**	**67.13**
Natural Gas	27.81	27.56	24.25	24.70	25.15	28.31	31.89	35.24	38.72	35.09	36.70	36.66	31.34	27.30	30.41
Agriculture	0.54	0.50	0.48	0.41	0.62	0.53	0.59	0.66	0.72	0.86	0.95	0.63	0.65	0.64	0.67
Crop Production	0.44	0.42	0.41	0.34	0.45	0.40	0.49	0.57	0.63	0.70	0.75	0.54	0.57	0.57	0.61
Livestock Production	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.08	0.09	0.07	0.07	0.06	0.07
Irrigation	0.04	0.02	0.02	0.02	0.12	0.08	0.05	0.04	0.03	0.08	0.11	0.03	0.01	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.03	0.03	0.04	0.04	0.04	0.31	0.34	0.32	0.39	0.32	0.33	0.30	0.39	0.41	0.13
Metal	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minerals	0.03	0.03	0.04	0.04	0.04	0.30	0.34	0.32	0.39	0.32	0.33	0.29	0.39	0.41	0.13
Manufacturing	12.32	11.68	10.51	10.43	11.04	11.10	11.47	11.14	12.57	12.04	12.37	13.07	10.72	8.28	7.73
Food	3.05	3.25	3.21	3.26	3.25	3.16	3.11	3.14	3.56	3.74	3.72	3.17	3.15	2.83	3.02
Food Processing	1.19	1.32	1.36	1.33	1.24	1.35	1.39	1.37	1.60	1.66	1.51	1.19	1.43	1.24	1.30
Sugar & Confections	0.46	0.47	0.37	0.41	0.47	0.42	0.27	0.23	0.30	0.36	0.40	0.34	0.00	0.00	0.00
Non-specified (Food Processing)	1.40	1.46	1.49	1.53	1.53	1.39	1.44	1.54	1.66	1.73	1.81	1.64	1.73	1.59	1.72
Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Textiles	0.38	0.35	0.35	0.39	0.43	0.43	0.45	0.48	0.51	0.56	0.57	0.46	0.10	0.08	0.09
Textile Mills	0.32	0.30	0.31	0.34	0.38	0.39	0.40	0.43	0.46	0.52	0.53	0.42	0.07	0.06	0.07
Leather	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apparel	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.03	0.03	0.02	0.02
Wood & Furniture	0.23	0.22	0.23	0.25	0.26	0.40	0.35	0.30	0.31	0.30	0.30	0.32	0.16	0.13	0.11
Lumber & Wood Products	0.18	0.18	0.19	0.22	0.22	0.36	0.31	0.27	0.26	0.26	0.26	0.28	0.12	0.09	0.07
Furnature & Fixtures	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.04
Pulp & Paper	1.79	1.52	1.04	1.15	1.55	1.57	1.84	1.48	1.78	1.39	1.61	1.43	0.93	0.94	0.56
Pulp Mills	0.06	0.08	0.13	0.05	0.03	0.00	0.00	0.00	0.20	0.00	0.20	0.00	0.00	0.00	0.00
Paper Mills	0.39	0.33	0.25	0.40	0.67	0.65	0.71	0.48	0.57	0.56	0.54	0.50	0.74	0.66	0.37
Paperboard Mills	0.90	0.73	0.35	0.40	0.54	0.65	0.82	0.72	0.69	0.53	0.58	0.63	0.00	0.09	0.00
Non-specified (Pulp & Paper)	0.44	0.38	0.32	0.30	0.30	0.27	0.31	0.28	0.32	0.30	0.29	0.30	0.19	0.18	0.18
Printing & Publishing	0.11	0.12	0.11	0.12	0.13	0.15	0.14	0.14	0.15	0.15	0.12	0.11	0.08	0.08	0.08
Chemicals & Allied Products	1.75	1.57	1.21	0.97	1.12	1.11	1.16	0.98	1.31	1.05	1.28	1.06	1.04	0.61	0.63
Plastics & Rubber	0.23	0.22	0.19	0.19	0.19	0.20	0.20	0.23	0.25	0.27	0.27	0.20	0.00	0.00	0.00
Plastics	0.18	0.17	0.15	0.15	0.15	0.16	0.16	0.18	0.21	0.22	0.23	0.16	0.00	0.00	0.00
Non-specified (Plastics & Rubber)	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.00	0.00	0.00
Stone, Clay, Glass, Cement & Other	1.82	1.64	1.60	1.53	1.47	1.54	1.64	1.70	1.87	1.70	1.67	1.49	1.31	1.22	1.32
Flat Glass	0.09	0.06	0.08	0.09	0.08	0.09	0.16	0.17	0.16	0.17	0.15	0.12	0.00	0.00	0.00
Glass containers	0.68	0.64	0.62	0.61	0.60	0.53	0.53	0.51	0.54	0.51	0.50	0.45	0.57	0.53	0.53
Cement	0.18	0.19	0.17	0.19	0.13	0.19	0.19	0.16	0.23	0.14	0.16	0.11	0.17	0.17	0.18
Non-specified (Stone, Clay, Glass & Cement)	0.87	0.75	0.73	0.65	0.66	0.73	0.77	0.86	0.94	0.88	0.86	0.82	0.56	0.53	0.60
Primary Metals	0.94	0.89	0.75	0.76	0.85	0.79	0.82	0.84	0.86	0.88	0.91	0.75	0.67	0.67	0.46
Metal Durables	0.91	0.82	0.77	0.78	0.76	0.79	0.81	0.83	0.86	0.81	0.81	0.75	0.81	0.68	0.78
Fabricated Metal Products	0.58	0.58	0.55	0.55	0.53	0.56	0.57	0.59	0.60	0.59	0.60	0.57	0.53	0.44	0.48
Computers & Office Machines	0.13	0.12	0.10	0.10	0.09	0.08	0.08	0.08	0.09	0.09	0.09	0.07	0.17	0.15	0.17
Industrial Machinery & Equipment	0.20	0.12	0.12	0.13	0.14	0.15	0.16	0.16	0.17	0.13	0.12	0.10	0.10	0.09	0.13
Electric & Eletronic Equipment	0.35	0.33	0.32	0.29	0.29	0.28	0.29	0.31	0.33	0.37	0.34	0.26	0.21	0.18	0.15
Telephone & Broadcasting Equipment	0.06	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.00	0.00	0.00
Semiconductors & Related Products	0.19	0.20	0.19	0.18	0.18	0.18	0.20	0.21	0.22	0.23	0.22	0.16	0.17	0.15	0.12
Non-specified (Elec. Equipment)	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.08	0.09	0.11	0.09	0.07	0.04	0.03	0.03
Transportation Equipment	0.53	0.53	0.53	0.51	0.51	0.47	0.43	0.44	0.48	0.51	0.50	0.44	0.41	0.28	0.25
Instruments & Related Products	0.07	0.09	0.08	0.10	0.09	0.08	0.09	0.09	0.10	0.11	0.10	0.09	0.00	0.00	0.00
Construction	0.12	0.11	0.08	0.09	0.09	0.09	0.11	0.13	0.15	0.13	0.12	0.10	0.09	0.10	0.17
Non-specified (Industrial)	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.06	0.06	0.06	2.43	1.76	0.47	0.13
Energy Industrial Sector	14.78	15.28	13.14	13.78	13.43	16.34	19.42	23.04	24.94	21.76	22.98	22.55	19.48	17.84	21.79
Transformation at Refinery	0.00	0.00	0.00	1.30	1.89	1.26	2.62	2.01	2.52	1.87	2.07	1.81	0.65	0.65	0.65
Refining	4.38	4.11	3.73	3.68	3.15	4.27	5.61	5.86	5.48	5.00	5.57	4.87	5.45	1.82	6.68
Oil & Gas Extraction	10.39	11.17	9.41	8.81	8.39	10.81	11.18	15.18	16.94	14.90	15.34	15.86	13.38	15.36	14.47
Flaring	0.15	0.07	0.08	0.04	0.03	0.04	0.07	0.07	0.09	0.10	0.07	0.11	0.09	0.14	0.08
Natural Gas Liquids	0.10	0.06	0.08	0.08	0.08	0.07	0.04	0.04	0.04	0.04	0.21	0.19	0.03	0.03	0.03
Petroleum	35.23	34.15	34.41	37.65	38.57	31.85	34.06	34.38	32.77	31.44	34.95	39.44	35.90	33.87	32.51
LPG	1.63	1.47	2.36	1.65	1.80	1.34	1.01	0.84	0.66	0.78	0.76	0.97	0.76	0.99	0.88
Manufacturing	0.83	0.55	0.79	0.59	0.64	0.55	0.45	0.39	0.37	0.52	0.30	0.30	0.51	0.51	0.51
Chemicals & Allied Products	0.19	0.19	0.22	0.21	0.22	0.22	0.24	0.24	0.25	0.26	0.24	0.22	0.22	0.22	0.22
Non-specified (Industry)	0.64	0.36	0.58	0.39	0.42	0.33	0.21	0.14	0.12	0.26	0.06	0.08	0.29	0.29	0.29
Oil Refinery Use	0.80	0.92	1.57	1.05	1.16	0.79	0.56	0.46	0.29	0.25	0.47	0.66	0.25	0.48	0.37
Motor Gasoline	1.17	1.21	1.22	0.99	1.02	1.05	0.99	1.04	1.17	0.69	0.71	1.64	1.74	1.81	2.04
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.51	0.51	0.59
Non-specified (Agriculture)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.39	0.40	0.51
Non-speified (Industrial)	1.17	1.21	1.22	0.99	1.02	1.05	0.99	1.04	1.17	0.69	0.71	0.81	0.85	0.90	0.95
Refinery Still Gas	15.69	15.63	15.11	18.72	18.95	13.26	15.33	15.16	14.93	13.66	13.12	14.80	14.70	15.68	14.84
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.07	0.07	0.03	0.01	0.02
Industrial	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.07	0.06	0.01	0.01	0.01
Agricultural	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Distillate	7.35	6.01	5.45	5.63	6.09	5.12	5.12	6.07	5.61	6.51	8.16	9.18	6.28	4.62	5.92
Agriculture	3.29	2.70	3.17	3.10	3.17	2.55	2.87	3.62	3.33	3.91	3.98	3.99	3.58	2.82	3.35
Industry	3.85	3.20	2.14	2.37	2.77	2.47	2.20	2.39	2.22	2.48	4.09	5.07	2.58	1.70	2.44
Oil and Gas Extraction	0.21	0.11	0.14	0.16	0.14	0.10	0.05	0.05	0.06	0.11	0.10	0.10	0.12	0.10	0.12
Oil Refinery Use	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Residual Oil	0.82	0.81	0.81	0.75	0.74	0.77	0.21	0.10	0.08	0.33	0.05	0.23	0.09	0.02	0.01
Refining	0.21	0.21	0.16	0.18	0.18	0.12	0.09	0.06	0.06	0.03	0.00	0.00	0.00	0.00	0.00
Oil & Gas Extraction	0.01	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.22	0.07	0.01	0.00
Industry	0.59	0.57	0.58	0.57	0.56	0.65	0.12	0.04	0.02	0.28	0.05	0.01	0.02	0.02	0.01

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Petroleum Coke	6.76	7.48	7.76	8.20	8.42	8.87	10.09	9.83	8.71	7.59	10.56	10.97	10.56	9.23	7.48
Oil Refinery Use	6.76	7.42	7.61	7.66	7.52	7.43	9.50	9.09	8.07	6.95	9.77	10.25	9.71	8.38	6.63
Cement	0.00	0.05	0.15	0.55	0.90	1.43	0.60	0.74	0.65	0.64	0.79	0.72	0.85	0.85	0.85
Lubricants	0.87	0.78	0.79	0.81	0.84	0.83	0.81	0.85	0.89	0.90	0.89	1.08	1.07	0.99	1.00
Waxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asphalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Special Naptha	0.93	0.75	0.89	0.89	0.69	0.60	0.48	0.47	0.69	0.94	0.63	0.51	0.66	0.52	0.33
Other Petroleum Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	2.98	3.00	2.58	1.87	2.20	2.35	2.81	3.34	3.85	4.39	4.30	4.18	4.26	4.27	4.18
Transportation	**161.08**	**156.70**	**161.88**	**158.85**	**163.86**	**166.16**	**167.38**	**170.84**	**173.34**	**176.26**	**181.68**	**182.49**	**190.19**	**180.64**	**187.95**
Natural Gas	0.16	0.18	0.17	0.17	0.17	0.17	0.21	1.42	0.71	0.73	0.77	0.78	0.74	0.65	0.87
Rail	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Road	0.06	0.06	0.05	0.06	0.07	0.07	0.10	0.11	0.12	0.14	0.14	0.11	0.09	0.07	0.05
Freight	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02
Passenger	0.02	0.02	0.02	0.02	0.03	0.03	0.05	0.05	0.05	0.06	0.07	0.05	0.03	0.03	0.01
Private Auto	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Taxi & Buses	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.00	0.00	0.00
Non-spedified (Local Transit)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.02	0.03	0.03	0.01
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.04	0.01	0.06	0.06	0.06
Non-specified (Air Transport)	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.04	0.01	0.06	0.06	0.06
Pipeline	0.07	0.09	0.09	0.09	0.07	0.08	0.09	1.29	0.55	0.57	0.57	0.64	0.57	0.50	0.74
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.21	0.48	0.50	0.50	0.56	0.50	0.45	0.67
Other Than Natural Gas Pipeline	0.07	0.09	0.09	0.09	0.07	0.08	0.09	0.08	0.07	0.06	0.07	0.08	0.07	0.05	0.07
Petroleum	160.92	156.52	161.71	158.69	163.69	165.99	167.17	169.42	172.62	175.53	180.92	181.71	189.45	179.98	187.09
LPG	0.21	0.17	0.15	0.15	0.23	0.13	0.11	0.08	0.15	0.09	0.36	0.43	0.19	0.19	0.19
Motor Gasoline	111.33	108.69	115.01	113.14	112.72	114.84	113.85	114.51	116.91	120.21	122.01	125.28	130.97	126.30	130.92
Aviation Gasoline	0.38	0.38	0.37	0.28	0.27	0.28	0.27	0.29	0.20	0.29	0.25	0.23	0.25	0.25	0.21
Jet Fuel	24.00	22.77	21.92	22.56	24.98	24.10	26.24	26.08	26.64	24.95	26.04	24.58	25.87	20.92	22.24
Domestic Jet Fuel Aviation	24.00	22.77	21.92	22.56	24.98	24.10	26.24	26.08	26.64	24.95	26.04	24.58	25.87	20.92	22.24
Distillate	22.66	22.49	22.50	20.79	23.55	24.48	24.65	26.78	27.02	28.08	30.23	29.58	30.61	31.02	32.16
Railroad	2.24	2.37	2.16	1.90	2.06	2.35	2.51	2.48	2.61	2.70	2.97	2.80	2.94	2.69	3.08
Road Transportation	18.28	17.78	18.52	18.33	19.95	21.00	21.26	22.99	23.50	24.70	26.45	26.40	27.17	27.87	28.58
Water Transportation	0.30	0.69	0.41	0.14	0.44	0.02	0.06	1.09	0.68	0.57	0.71	0.00	0.00	0.05	0.00
Non-specified (Transport)	1.82	1.64	1.43	0.41	1.10	1.12	0.82	0.21	0.23	0.11	0.10	0.38	0.50	0.41	0.50
Residual Oil	1.19	0.97	0.70	0.68	0.82	1.07	0.98	0.56	0.51	0.72	0.84	0.79	0.77	0.56	0.61
Water Transportation	1.19	0.97	0.69	0.67	0.81	0.99	0.91	0.52	0.50	0.71	0.84	0.79	0.76	0.55	0.61
Non-specified (Transport)	0.00	0.00	0.01	0.01	0.01	0.08	0.07	0.03	0.02	0.01	0.00	0.00	0.01	0.01	0.00
Lubricants	1.16	1.04	1.06	1.08	1.13	1.11	1.08	1.14	1.19	1.20	1.19	0.81	0.81	0.74	0.75
Electricity Generation (In State)	**36.53**	**36.62**	**43.75**	**40.10**	**48.27**	**36.41**	**33.90**	**36.49**	**39.85**	**43.03**	**51.93**	**56.09**	**41.86**	**44.08**	**47.14**
Natural Gas	36.42	36.51	43.61	39.96	48.13	36.28	33.79	36.39	39.75	42.94	51.84	56.00	41.76	43.99	47.14
Commercial CHP	0.64	0.57	0.64	0.66	0.73	0.75	0.77	0.73	0.74	0.73	0.71	0.65	0.64	0.81	0.82
Electric CHP	6.46	6.70	7.36	7.65	7.87	7.85	7.80	8.23	8.16	8.15	7.98	7.30	9.60	8.21	9.12
Industrial CHP	4.19	4.52	4.38	4.41	4.55	4.58	5.05	4.75	4.78	4.76	4.73	4.80	5.22	4.90	7.49
Utility	24.89	24.37	30.78	25.34	32.66	21.40	17.23	20.33	14.57	7.68	6.85	6.35	4.73	5.20	5.37
Merchant Power	0.24	0.35	0.46	0.62	0.42	0.42	0.34	0.34	9.05	19.78	29.44	35.04	20.91	20.58	23.99
Refinery Self Generation	0.00	0.00	0.00	1.29	1.91	1.28	2.60	2.01	2.44	1.84	2.13	1.86	0.67	4.29	0.36
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	0.11	0.11	0.13	0.14	0.13	0.13	0.11	0.10	0.09	0.10	0.10	0.09	0.10	0.09	0.00
Electric CHP	0.07	0.10	0.10	0.11	0.10	0.09	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.08	0.00
Industrial CHP	0.04	0.01	0.03	0.03	0.04	0.03	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Merchant Power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Not Sector-Specific; Other End Use	**1.09**	**0.57**	**0.48**	**0.56**	**0.65**	**0.53**	**0.47**	**0.40**	**-0.12**	**0.60**	**0.88**	**0.68**	**5.38**	**2.38**	**0.17**
Natural Gas	1.09	0.57	0.48	0.56	0.65	0.53	0.47	0.40	-0.12	0.60	0.78	0.52	5.21	2.21	0.00
Liqueified Petroleum Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.17	0.17	0.17	0.17
Cement Production	**4.62**	**4.26**	**3.80**	**4.43**	**5.07**	**4.96**	**5.27**	**5.45**	**5.42**	**5.61**	**5.93**	**5.56**	**6.11**	**6.32**	**6.49**
Lime Production	**0.25**	**0.22**	**0.20**	**0.15**	**0.16**	**0.18**	**0.16**	**0.16**	**0.15**	**0.14**	**0.15**	**0.14**	**0.14**	**0.14**	**0.13**
Limestone & Dolomite Consumption	**0.16**	**0.15**	**0.13**	**0.13**	**0.17**	**0.23**	**0.26**	**0.20**	**0.21**	**0.25**	**0.18**	**0.17**	**0.23**	**0.19**	**0.27**
Soda Ash Consumption	**0.22**	**0.21**	**0.21**	**0.21**	**0.21**	**0.22**	**0.21**	**0.22**	**0.21**	**0.21**	**0.21**	**0.21**	**0.21**	**0.21**	**0.21**
Carbon Dioxide Consumption	**0.08**	**0.08**	**0.07**	**0.08**	**0.08**	**0.08**	**0.07**	**0.07**	**0.08**	**0.07**	**0.08**	**0.07**	**0.08**	**0.11**	**0.10**
Waste Combustion	**0.12**	**0.12**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.12**	**0.12**	**0.13**	**0.12**	**0.13**	**0.13**	**0.13**	**0.12**
Forests	**4.51**	**4.50**	**4.49**	**4.48**	**4.48**	**4.48**	**4.48**	**4.48**	**4.48**	**4.48**	**4.48**	**4.47**	**4.47**	**4.47**	**4.46**

Table A-4   Full Detail--California Greenhouse Gas Emissions (MMTCO$_2$E)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Rangeland	**0.65**	**0.65**	**0.65**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**
Woody Ag Soils	**0.27**	**0.27**	**1.15**	**(0.93)**	**(0.04)**	**(0.04)**	**(0.04)**	**(0.23)**	**(1.21)**	**(1.20)**	**(0.62)**	**0.96**	**0.21**	**0.41**	**0.44**
Non-Woody Ag Soils	**0.04**	**0.04**	**0.36**	**0.10**	**0.41**	**0.41**	**0.41**	**0.67**	**3.52**	**0.53**	**0.31**	**1.02**	**-1.24**	**0.21**	**0.34**
Ag soil Liming	**0.07**	**0.10**	**0.11**	**0.07**	**0.16**	**0.27**	**0.27**	**0.35**	**0.25**	**0.30**	**0.27**	**0.16**	**0.23**	**0.24**	**0.24**
Methane Emissions	**25.82**	**24.79**	**23.83**	**25.26**	**25.28**	**26.09**	**25.38**	**24.16**	**25.24**	**26.25**	**26.32**	**26.62**	**27.07**	**27.49**	**27.80**
Petroleum & Natural Gas Supply System	0.88	0.78	0.37	0.68	0.64	0.60	0.59	0.59	0.56	0.66	0.51	0.56	0.49	0.49	0.50
Field Production	0.87	0.76	0.37	0.67	0.63	0.59	0.58	0.58	0.55	0.65	0.50	0.56	0.48	0.48	0.50
Marketing	0.01	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Natural Gas Supply System	1.56	1.54	1.51	1.50	1.48	1.45	1.41	1.37	1.32	1.28	1.29	1.32	1.31	1.33	1.36
Processing	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.03	0.03	0.03	0.00	0.00	0.00
Transmission	1.51	1.48	1.46	1.44	1.42	1.40	1.35	1.32	1.28	1.26	1.26	1.29	1.30	1.33	1.36
Landfills	8.13	7.97	7.74	8.45	8.19	7.86	8.31	6.06	7.56	7.79	8.01	7.93	8.17	8.31	8.45
MSW (Class II & III)	8.10	7.95	7.74	8.42	8.18	7.84	7.09	6.05	5.69	7.75	7.96	7.83	8.03	8.16	8.30
Other Class II & III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.11	0.11	0.11	0.12
Others	0.02	0.02	0.00	0.03	0.01	0.02	1.22	0.01	1.87	0.00	0.00	0.00	0.03	0.03	0.03
Enteric Fermentation	7.53	7.25	7.37	6.59	7.14	7.25	6.77	6.88	6.84	7.08	6.70	7.01	7.05	7.19	7.17
Dairy Cattle	3.67	3.74	3.86	3.55	3.82	3.88	3.56	3.75	3.78	4.05	4.09	4.40	4.49	4.69	4.69
Beef Cattle	3.44	3.09	3.09	2.64	2.88	2.95	2.80	2.72	2.67	2.63	2.21	2.22	2.18	2.12	2.11
Horses	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25	0.25
Sheep	0.17	0.17	0.17	0.15	0.18	0.17	0.15	0.15	0.13	0.14	0.14	0.14	0.13	0.12	0.11
Swine	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manure Management	3.29	3.87	3.93	4.03	4.30	4.55	4.55	4.88	4.80	5.21	5.36	5.58	5.79	5.94	6.03
Beef Cattle	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08
Dairy Cattle	2.92	3.49	3.54	3.65	3.92	4.17	4.18	4.51	4.43	4.83	5.00	5.23	5.43	5.60	5.70
Swine	0.06	0.07	0.09	0.09	0.09	0.09	0.07	0.08	0.07	0.07	0.05	0.04	0.06	0.05	0.05
Poultry	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.15	0.14	0.14	0.14	0.13	0.13
Sheep	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horses	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Flooded Rice Fields	0.41	0.36	0.41	0.45	0.50	0.48	0.52	0.54	0.47	0.52	0.57	0.49	0.55	0.53	0.61
Burning Ag Residues	0.11	0.10	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.10	0.10	0.10	0.10
Agricultural Crop Residues	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.03	0.03	0.03	0.03
Non-woody/Field	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.01	0.01	0.01
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.01	0.01	0.01
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Woody/Orchard & Vineyard	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Almonds	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Walnuts	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Agricultural Waste Burning	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Wastewater Treatment	1.45	1.48	1.51	1.52	1.53	1.54	1.55	1.58	1.60	1.62	1.65	1.69	1.68	1.71	1.72
Mobile Source Combustion	1.20	0.14	0.13	0.72	0.17	1.04	0.18	0.82	0.55	0.55	0.76	0.54	0.69	0.66	0.61
Gasoline Highway Vehicles	1.05	0.00	0.00	0.54	0.00	0.85	0.00	0.62	0.36	0.35	0.55	0.32	0.47	0.44	0.39
Passenger Cars	0.49	0.00	0.00	0.23	0.00	0.39	0.00	0.29	0.16	0.16	0.27	0.15	0.23	0.21	0.19
Light-Duty Trucks	0.31	0.00	0.00	0.17	0.00	0.25	0.00	0.18	0.11	0.11	0.17	0.10	0.14	0.13	0.12
Medium & Heavy-Duty Trucks	0.23	0.00	0.00	0.13	0.00	0.19	0.00	0.14	0.08	0.08	0.11	0.07	0.09	0.09	0.08
Motorcycles	0.02	0.00	0.00	0.01	0.00	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Diesel Highway Vehicles	0.03	0.00	0.00	0.02	0.00	0.02	0.00	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.02
Passenger Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medium & Heavy-Duty Trucks	0.03	0.00	0.00	0.01	0.00	0.02	0.00	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.02
Aviation	0.04	0.06	0.04	0.07	0.07	0.07	0.06	0.06	0.05	0.06	0.06	0.07	0.07	0.07	0.07
Other Transportation	0.08	0.09	0.09	0.09	0.10	0.10	0.12	0.12	0.12	0.12	0.12	0.14	0.13	0.13	0.13
Stationary Source Combustion	1.26	1.30	0.76	1.20	1.20	1.19	1.39	1.34	1.41	1.43	1.36	1.41	1.24	1.24	1.24
Electricity Generation	0.21	0.23	0.01	0.21	0.21	0.20	0.24	0.26	0.29	0.31	0.25	0.28	0.25	0.24	0.25
Industrial	0.25	0.28	0.15	0.28	0.29	0.30	0.36	0.34	0.37	0.36	0.36	0.35	0.32	0.32	0.33
Petroleum	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.02	0.02	0.02
Natural Gas	0.07	0.07	0.05	0.09	0.10	0.10	0.14	0.13	0.15	0.14	0.14	0.13	0.14	0.14	0.14
Other	0.15	0.18	0.08	0.16	0.17	0.17	0.19	0.18	0.19	0.19	0.19	0.19	0.16	0.16	0.16

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Commercial	0.25	0.23	0.06	0.17	0.17	0.17	0.25	0.20	0.22	0.22	0.22	0.24	0.14	0.14	0.14
Petroleum	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.02
Natural Gas	0.18	0.15	0.02	0.11	0.11	0.10	0.18	0.14	0.16	0.15	0.13	0.14	0.08	0.08	0.08
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.04	0.05	0.01	0.03	0.03	0.02	0.04	0.04	0.04	0.05	0.07	0.08	0.04	0.04	0.04
Residential	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Wood	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Other	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Nitrous Oxide Emissions	**32.75**	**30.38**	**30.54**	**31.46**	**30.04**	**31.90**	**30.79**	**28.83**	**29.20**	**29.35**	**31.43**	**30.76**	**34.48**	**33.85**	**33.34**
Nitric Acid Production	0.37	0.36	0.39	0.27	0.26	0.33	0.20	0.21	0.19	0.19	0.18	0.15	0.16	0.15	0.15
Waste Combustion	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Agricultural Soil Management	14.68	13.12	13.42	14.42	13.75	15.53	15.12	13.64	13.99	14.26	15.92	15.35	19.37	19.22	19.16
Direct	5.74	5.09	5.14	5.49	5.27	5.83	5.67	5.07	5.19	5.30	5.84	5.57	7.25	7.14	7.10
Fertilizers	2.82	2.27	2.46	2.92	2.54	3.33	3.16	2.54	2.70	2.72	3.32	3.06	4.60	4.55	4.57
Crop Residues	0.12	0.09	0.10	0.10	0.10	0.09	0.10	0.10	0.10	0.10	0.10	0.14	0.15	0.15	0.16
N-Fixing Crops	1.32	1.28	1.15	1.07	1.18	0.99	0.99	1.04	1.02	1.09	1.06	1.04	1.17	1.12	1.07
Histosols	0.18	0.16	0.16	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13
Livestock	1.31	1.29	1.27	1.24	1.30	1.28	1.27	1.25	1.24	1.26	1.22	1.21	1.19	1.19	1.17
Indirect	6.11	5.56	5.70	6.09	5.83	6.57	6.43	5.91	6.05	6.16	6.88	6.71	8.12	8.10	8.09
Fertilizers	2.50	2.02	2.19	2.60	2.26	2.96	2.81	2.25	2.40	2.42	2.96	2.72	4.09	4.05	4.06
Livestock	3.61	3.54	3.52	3.49	3.57	3.61	3.62	3.66	3.65	3.74	3.93	3.99	4.03	4.06	4.02
Leaching/Runoff	2.82	2.47	2.58	2.84	2.64	3.12	3.02	2.66	2.75	2.80	3.20	3.07	4.00	3.98	3.98
Manure Management	0.81	0.76	0.74	0.72	0.70	0.72	0.70	0.70	0.70	0.71	0.90	0.92	0.92	0.92	0.89
Beef Cattle	0.17	0.14	0.13	0.15	0.12	0.14	0.11	0.12	0.13	0.13	0.14	0.14	0.14	0.14	0.14
Dairy Cattle	0.26	0.26	0.28	0.28	0.30	0.30	0.31	0.31	0.32	0.34	0.36	0.37	0.38	0.39	0.37
Swine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.37	0.35	0.32	0.28	0.27	0.27	0.27	0.25	0.24	0.22	0.38	0.39	0.38	0.37	0.37
Sheep	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burning Ag Residues	0.10	0.09	0.09	0.11	0.11	0.11	0.12	0.12	0.11	0.12	0.13	0.06	0.06	0.06	0.07
Non-woody/Field	0.07	0.06	0.07	0.08	0.08	0.08	0.09	0.09	0.08	0.08	0.09	0.03	0.03	0.03	0.03
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.06	0.05	0.06	0.07	0.07	0.07	0.08	0.08	0.07	0.08	0.08	0.02	0.02	0.02	0.02
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Woody/Orchard & Vineyard	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04
Almonds	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Walnuts	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wastewater	0.91	0.86	0.84	0.92	0.84	0.85	0.88	0.98	1.01	1.04	0.75	1.03	0.95	0.92	1.07
Municipal (formerly Human Sewage)	0.91	0.86	0.84	0.92	0.84	0.85	0.88	0.98	1.01	1.04	0.75	1.03	0.95	0.92	1.07
Industrial	(Category not yet included in inventory)														
Mobile Source Combustion	15.62	14.94	14.81	14.80	14.15	14.13	13.56	12.98	13.00	12.82	13.33	13.04	12.80	12.37	11.78
Gasoline Highway Vehicles	7.85	7.58	7.45	7.33	7.17	6.94	6.02	5.75	5.60	5.38	5.17	4.78	4.35	3.96	3.65
Diesel Highway Vehicles	7.50	7.11	7.12	7.23	6.73	6.96	7.29	6.98	7.14	7.19	7.90	8.02	8.21	8.18	8.13
Aviation	0.27	0.25	0.24	0.23	0.24	0.23	0.25	0.25	0.26	0.24	0.25	0.24	0.25	0.23	
Stationary Source Combustion	0.24	0.23	0.23	0.21	0.21	0.20	0.20	0.18	0.17	0.18	0.19	0.19	0.19	0.19	0.19
Electricity Generation	0.02	0.02	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	0.11	0.10	0.10	0.09	0.08	0.08	0.08	0.09	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Natural Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Wood	0.08	0.07	0.07	0.05	0.05	0.05	0.04	0.05	0.04	0.05	0.05	0.06	0.06	0.06	0.06

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Commercial/Institutional	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Wood	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Residential	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Wood	0.07	0.08	0.08	0.07	0.07	0.08	0.08	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
High Global-Warming Potential Gas Emissions	**7.14**	**7.43**	**7.86**	**8.38**	**8.87**	**9.31**	**11.37**	**12.62**	**8.89**	**9.88**	**10.48**	**11.19**	**12.04**	**12.94**	**14.20**
Substitution of Ozone-Depleting Substances	4.46	4.88	5.32	5.74	6.14	6.52	8.40	9.76	6.69	7.76	8.58	9.54	10.47	11.40	12.61
HFC-23	4.43	4.23	4.06	3.86	3.65	3.43	3.95	3.81	0.00	0.01	0.01	0.01	0.01	0.01	0.01
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.05	0.05
HFC-125	0.00	0.11	0.22	0.33	0.43	0.54	0.77	1.05	1.08	1.23	1.35	1.49	1.63	1.79	1.99
HFC-134a	0.00	0.44	0.89	1.33	1.77	2.21	2.99	3.84	4.32	4.96	5.47	6.02	6.50	6.92	7.52
HFC-143a	0.00	0.02	0.04	0.07	0.09	0.11	0.28	0.49	0.64	0.81	0.99	1.22	1.48	1.78	2.11
HFC-236fa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.11	0.17	0.22	0.26	0.28	0.28
CF4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C2F6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others	0.04	0.08	0.12	0.16	0.19	0.23	0.42	0.55	0.56	0.59	0.55	0.54	0.56	0.56	0.65
Semiconductor Manufacture	0.36	0.36	0.36	0.46	0.52	0.67	0.67	0.77	0.87	0.89	0.76	0.54	0.53	0.52	0.57
Electricity Transmission & Distribution (SF6)	2.32	2.20	2.18	2.18	2.21	2.11	2.30	2.09	1.32	1.23	1.14	1.10	1.04	1.01	1.02
GROSS TOTALS:	**383.14**	**373.38**	**378.52**	**376.45**	**393.95**	**380.98**	**386.15**	**394.43**	**409.72**	**414.17**	**436.53**	**441.09**	**438.94**	**421.35**	**431.22**
Gross California Emissions with Electricity Imports	**426.45**	**416.45**	**421.54**	**417.27**	**437.13**	**419.49**	**426.72**	**441.40**	**462.59**	**465.85**	**477.00**	**488.46**	**490.67**	**477.80**	**492.04**
Electricity Imports	**43.31**	**43.07**	**43.02**	**40.82**	**43.18**	**38.51**	**40.57**	**46.97**	**52.86**	**51.68**	**40.48**	**47.37**	**51.73**	**56.44**	**60.81**
Forest Sinks	(13.14)	(13.11)	(13.09)	(13.07)	(13.05)	(13.05)	(13.05)	(13.05)	(13.05)	(13.05)	(13.05)	(13.04)	(13.03)	(13.02)	(13.01)
Rangeland Sinks	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.09)	(1.09)	(1.09)	(1.09)
Landfill Lumber Disposal Sinks	(3.73)	(3.54)	(3.35)	(3.17)	(2.98)	(2.79)	(2.61)	(2.42)	(2.23)	(2.05)	(2.74)	(3.31)	(3.88)	(4.33)	(5.01)
Yard Trimming Landfill Disposal Sinks	(4.74)	(4.54)	(4.34)	(4.14)	(3.94)	(3.74)	(3.54)	(3.34)	(3.14)	(2.94)	(2.72)	(2.51)	(2.30)	(2.09)	(1.87)
NET TOTALS:	**360.43**	**351.08**	**356.63**	**354.97**	**372.88**	**360.30**	**365.86**	**374.52**	**390.20**	**395.03**	**416.92**	**421.14**	**418.65**	**400.83**	**410.24**
Net California Emissions with Electricity Imports	**403.74**	**394.16**	**399.65**	**395.79**	**416.06**	**398.81**	**406.43**	**421.49**	**443.07**	**446.71**	**457.40**	**468.51**	**470.38**	**457.27**	**471.05**
International Bunker Carbon Dioxide Emissions	**39.88**	**34.61**	**28.00**	**27.95**	**32.40**	**35.76**	**35.35**	**27.03**	**26.85**	**30.30**	**33.82**	**31.80**	**31.83**	**24.47**	**26.47**
Jet Fuel (Aviation)	14.72	13.96	13.44	13.84	15.32	14.78	16.09	15.99	16.34	15.30	15.97	15.07	15.86	12.83	13.64
Distillate Oil (Marine)	1.23	1.01	0.71	0.69	0.84	1.03	0.95	0.54	0.52	0.74	0.88	0.80	0.69	0.57	0.46
Residual Oil (Marine)	23.93	19.63	13.85	13.42	16.25	19.95	18.31	10.50	9.99	14.27	16.98	15.93	15.27	11.08	12.37

APPENDIX B

FUEL USED IN CALIFORNIA
(TRILLION BTUS)

Sources:

California Energy Balance[89]

California Energy Commission Data

Energy Flows in Trillion (10^12) BTUs

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Statewide Energy Use (Trillion BTUs)	**5,657**	**5,770**	**5,714**	**5,647**	**5,988**	**5,763**	**5,883**	**6,003**	**6,375**	**6,515**	**6,879**	**6,917**	**6,669**	**6,264**	**6,382**
Residential	**544.16**	**554.21**	**523.76**	**534.33**	**550.22**	**501.16**	**500.77**	**496.04**	**575.10**	**600.06**	**567.58**	**511.15**	**511.22**	**493.73**	**521.21**
Natural Gas	**521.36**	**527.30**	**504.32**	**514.27**	**530.33**	**482.19**	**484.72**	**481.34**	**551.56**	**577.72**	**540.52**	**490.92**	**492.15**	**474.75**	**501.70**
Petroleum	**22.80**	**26.90**	**19.44**	**20.06**	**19.89**	**18.97**	**16.05**	**14.71**	**23.54**	**22.34**	**27.06**	**20.22**	**19.07**	**18.98**	**19.51**
LPG	20.84	25.12	17.40	18.16	18.00	17.69	14.74	13.33	22.02	20.65	24.80	17.11	17.11	17.11	17.11
Kerosene	0.74	0.61	0.67	0.52	0.49	0.20	0.43	0.42	0.49	0.64	0.78	1.38	1.08	1.15	1.57
Distillate	1.21	1.17	1.37	1.39	1.40	1.07	0.89	0.96	1.03	1.05	1.47	1.73	0.88	0.72	0.83
Commercial	**223.12**	**210.44**	**175.35**	**173.44**	**185.16**	**175.16**	**171.71**	**173.83**	**246.14**	**271.80**	**287.51**	**220.42**	**331.99**	**279.99**	**226.01**
Coal	**0.50**	**0.95**	**0.00**	**2.89**	**3.66**	**2.93**	**4.15**	**2.38**	**2.56**	**0.66**	**0.56**	**0.00**	**0.00**	**0.00**	**0.00**
Natural Gas	**178.01**	**165.06**	**150.32**	**151.49**	**162.78**	**148.34**	**148.16**	**152.83**	**221.63**	**249.03**	**262.92**	**198.15**	**313.76**	**263.94**	**210.90**
Education	26.63	24.11	20.51	21.18	24.06	18.60	17.80	19.66	23.92	26.08	26.33	18.04	21.68	20.82	21.87
College	13.12	11.38	10.02	10.30	13.09	9.75	8.94	10.52	12.89	13.97	15.93	10.20	11.73	11.98	12.51
School	13.51	12.73	10.49	10.88	10.97	8.85	8.85	9.14	11.04	12.11	10.40	7.84	9.95	8.84	9.36
Food Services	35.58	35.50	34.97	35.36	35.93	35.78	36.80	38.27	40.66	42.85	44.05	39.82	42.25	44.08	47.22
Restaurant	30.77	30.84	30.51	30.70	31.03	31.01	31.83	32.99	34.88	36.65	37.73	34.04	36.64	38.32	40.05
Food & Liquor	4.81	4.66	4.46	4.66	4.91	4.77	4.97	5.28	5.78	6.20	6.32	5.78	5.61	5.77	7.17
Retail & Wholesale	11.34	10.45	10.20	11.57	12.30	11.21	9.26	10.36	10.62	11.77	11.27	4.17	10.99	10.98	10.76
Retail	5.45	4.92	4.23	4.28	4.46	3.68	3.64	3.66	4.27	4.78	4.24	3.73	4.93	5.13	4.77
Warehouse	5.89	5.53	5.97	4.48	5.00	6.95	5.04	6.11	5.66	6.23	6.29	0.00	5.42	5.08	4.88
Warehouse, refrigerated	0.00	0.00	0.00	2.81	2.85	0.58	0.58	0.58	0.69	0.76	0.74	0.44	0.64	0.77	1.11
Health Care	24.88	25.04	21.25	19.87	23.10	21.47	21.61	21.84	23.42	25.53	24.89	21.83	22.34	22.98	23.98
Hotel	12.61	12.32	11.75	11.34	11.68	11.33	11.32	11.63	12.08	12.74	12.75	11.51	11.68	11.51	11.97
Office	27.37	26.32	23.97	24.80	26.49	24.80	25.82	25.49	29.18	33.22	30.27	25.66	34.41	33.79	35.46
Transportation Services	0.65	0.71	0.51	0.74	0.71	0.60	0.82	0.54	1.02	1.20	1.05	0.78	0.00	0.00	0.00
Transportation	0.13	0.15	0.15	0.15	0.14	0.11	0.08	0.09	0.11	0.13	0.14	0.21	0.00	0.00	0.00
Water Transportation	0.07	0.08	0.07	0.05	0.07	0.07	0.07	0.06	0.07	0.08	0.10	0.07	0.00	0.00	0.00
Airports	0.44	0.48	0.29	0.54	0.50	0.41	0.68	0.39	0.84	0.99	0.81	0.50	0.00	0.00	0.00
Communication	1.31	1.38	1.10	0.82	1.16	1.05	1.17	1.46	1.13	1.24	1.11	0.85	1.83	1.55	1.46
U.S. Postal Service	0.27	0.28	0.23	0.26	0.34	0.36	0.42	0.33	0.39	0.40	0.36	0.30	0.30	0.28	0.25
Telephone & Cell Phone Service	0.90	0.95	0.74	0.39	0.43	0.36	0.36	0.39	0.42	0.49	0.40	0.33	0.43	0.26	0.27
Other Message Communication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.83	0.81
Radio Broadcasting Stations	0.09	0.09	0.08	0.08	0.09	0.08	0.09	0.12	0.11	0.12	0.10	0.12	0.00	0.00	0.00
Non-Specified (Communication)	0.04	0.05	0.05	0.08	0.31	0.25	0.30	0.62	0.20	0.24	0.25	0.11	0.07	0.19	0.14
Utilities	6.36	6.34	6.73	5.09	5.46	5.98	7.75	7.33	75.47	77.67	91.84	59.94	66.58	73.10	54.75
Electric, Nat'l Gas, Steam	2.67	2.98	3.11	1.94	2.13	2.28	3.24	2.75	70.20	71.88	85.74	55.66	63.31	65.75	46.10
Sewerage Systems	1.39	1.38	1.58	1.27	1.45	1.78	2.46	2.50	3.45	3.31	3.03	2.57	1.54	2.52	4.84
Water Supply	2.30	1.99	2.03	1.88	1.88	1.92	2.05	2.08	1.82	2.48	3.08	1.71	1.73	4.81	3.81
Street Lights	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
National Security	10.61	12.04	10.28	10.16	9.57	7.55	6.85	8.68	6.46	5.42	4.60	5.75	3.31	3.21	3.43
Non Specified (Services)	20.67	10.86	9.06	10.56	12.31	9.98	8.96	7.56	-2.32	11.32	14.77	9.79	98.69	41.93	0.00
Petroleum	**44.61**	**44.43**	**25.02**	**19.05**	**18.71**	**23.88**	**19.40**	**18.63**	**21.96**	**22.12**	**24.02**	**22.27**	**18.23**	**16.05**	**15.10**
LPG	3.68	4.43	3.07	3.21	3.18	3.12	2.60	2.35	3.89	3.64	3.64	3.64	3.64	3.64	3.64
Motor Gasoline	10.12	8.65	7.80	1.37	1.19	1.24	1.18	1.18	1.27	1.20	1.21	1.26	1.30	1.35	1.39
Kerosene	0.95	0.50	0.23	0.11	0.13	0.11	0.11	0.07	0.15	0.39	0.23	0.36	0.16	0.27	0.41
Distillate	24.61	26.05	13.67	14.27	14.17	19.38	15.43	15.01	16.19	16.89	18.93	16.77	13.12	10.79	9.66
Residual Oil	5.25	4.80	0.25	0.10	0.04	0.02	0.08	0.01	0.47	0.00	0.00	0.24	0.00	0.00	0.00
Industrial	**1,194.56**	**1,451.34**	**1,346.53**	**1,393.70**	**1,414.70**	**1,422.13**	**1,577.54**	**1,711.41**	**1,827.32**	**1,720.18**	**1,804.52**	**1,908.66**	**1,689.15**	**1,624.74**	**1,609.68**
Natural Gas	**528.18**	**814.49**	**711.15**	**731.08**	**732.99**	**848.20**	**974.65**	**1,106.85**	**1,209.54**	**1,080.87**	**1,134.04**	**1173.74**	**1000.61**	**1001.68**	**981.91**
Agriculture	10.14	9.46	9.14	7.85	11.74	9.97	11.24	12.57	13.70	16.21	18.05	12.01	12.38	12.12	12.77
Crop Production	8.42	8.03	7.84	6.49	8.53	7.63	9.36	10.86	11.92	13.22	14.26	10.14	10.80	10.87	11.51
Livestock Production	1.00	1.06	1.00	0.95	0.95	0.90	0.91	1.01	1.12	1.48	1.62	1.34	1.30	1.22	1.26
Irrigation	0.72	0.37	0.30	0.41	2.26	1.44	0.97	0.70	0.66	1.51	2.17	0.53	0.26	0.02	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Mining	0.52	0.58	0.77	0.68	0.71	5.84	6.48	6.14	7.48	6.09	6.26	5.61	7.48	7.75	2.37
Metal	0.01	0.01	0.01	0.01	0.02	0.14	0.06	0.06	0.02	0.01	0.01	0.01	0.00	0.00	0.00
Coal	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.02	0.02	0.00	0.00	0.00
Minerals	0.52	0.57	0.76	0.67	0.69	5.69	6.42	6.08	7.44	6.06	6.24	5.58	7.48	7.75	2.37
Manufacturing	234.07	513.11	450.24	460.05	464.93	521.35	587.18	649.64	713.24	643.23	671.97	679.22	575.59	565.02	555.64
Food	57.83	61.52	60.89	61.81	61.56	59.78	58.83	59.47	67.49	70.88	70.38	60.06	59.76	53.64	57.28
Food Processing	22.56	24.96	25.79	25.16	23.55	25.52	26.34	25.94	30.26	31.45	28.52	22.52	27.03	23.55	24.71
Sugar & Confections	8.73	8.94	6.96	7.73	8.94	8.02	5.20	4.33	5.72	6.75	7.64	6.38	0.00	0.00	0.00
Non-specified (Food Processing)	26.55	27.63	28.13	28.92	29.07	26.24	27.30	29.20	31.52	32.68	34.22	31.16	32.73	30.09	32.58
Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Energy Flows in Trillion (10^12) BTUs

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Textiles	7.12	6.57	6.68	7.36	8.08	8.18	8.49	9.04	9.60	10.62	10.80	8.73	1.90	1.57	1.67
Textile Mills	6.15	5.63	5.83	6.44	7.17	7.36	7.58	8.07	8.72	9.78	9.98	7.99	1.31	1.21	1.27
Leather	0.15	0.12	0.07	0.10	0.11	0.09	0.09	0.07	0.07	0.07	0.07	0.09	0.00	0.00	0.00
Apparel	0.82	0.82	0.79	0.82	0.80	0.74	0.82	0.90	0.81	0.76	0.74	0.65	0.59	0.37	0.40
Wood & Furniture	4.45	4.13	4.38	4.80	4.94	7.51	6.60	5.77	5.81	5.74	5.72	6.11	2.99	2.49	1.99
Lumber & Wood Products	3.47	3.34	3.68	4.09	4.23	6.84	5.92	5.03	5.00	4.86	4.84	5.38	2.23	1.77	1.24
Furnature & Fixtures	0.97	0.78	0.70	0.71	0.71	0.67	0.68	0.75	0.82	0.88	0.88	0.73	0.76	0.72	0.75
Pulp & Paper	33.92	28.84	19.74	21.86	29.30	29.81	34.83	28.09	33.64	26.40	30.55	27.12	17.64	17.72	10.53
Pulp Mills	1.19	1.47	2.43	1.04	0.61	0.00	0.01	0.00	3.71	0.00	3.87	0.00	0.00	0.00	0.00
Paper Mills	7.36	6.18	4.66	7.56	12.71	12.33	13.40	9.16	10.88	10.58	10.21	9.44	13.99	12.51	7.09
Paperboard Mills	17.12	13.90	6.62	7.52	10.29	12.36	15.52	13.62	12.99	10.12	10.93	11.93	0.00	1.75	0.00
Non-specified (Pulp & Paper)	8.26	7.28	6.03	5.75	5.69	5.11	5.91	5.31	6.07	5.70	5.53	5.75	3.65	3.46	3.43
Printing & Publishing	2.13	2.29	2.09	2.28	2.50	2.82	2.69	2.67	2.90	2.75	2.22	2.04	1.59	1.46	1.56
Chemicals & Allied Products	34.36	30.65	23.59	18.93	21.97	21.63	22.62	19.21	25.58	20.59	25.13	20.76	20.34	12.00	12.40
Plastics & Rubber	4.42	4.25	3.76	3.69	3.82	3.89	3.90	4.42	4.93	5.25	5.28	3.90	0.00	0.00	0.00
Plastics	3.49	3.31	2.98	2.87	2.99	3.08	3.09	3.59	4.10	4.40	4.44	3.22	0.00	0.00	0.00
Non-specified (Plastics & Rubber)	0.93	0.94	0.78	0.82	0.83	0.80	0.81	0.83	0.83	0.85	0.84	0.68	0.00	0.00	0.00
Stone, Clay, Glass, Cement & Other	34.55	31.15	30.29	29.04	27.90	29.10	31.10	32.27	35.36	32.27	31.58	28.23	24.83	23.18	24.92
Flat Glass	1.68	1.17	1.48	1.65	1.55	1.74	2.99	3.17	3.01	3.30	2.82	2.29	0.00	0.00	0.00
Glass containers	12.97	12.20	11.73	11.58	11.28	10.06	9.98	9.70	10.16	9.70	9.42	8.45	10.89	9.98	10.05
Cement	3.48	3.51	3.20	3.55	2.48	3.54	3.59	3.07	4.42	2.67	3.03	2.02	3.30	3.13	3.44
Non-specified (Stone, Clay, Glass & Cement)	16.43	14.26	13.88	12.26	12.59	13.76	14.53	16.32	17.78	16.61	16.31	15.47	10.64	10.07	11.43
Primary Metals	17.77	16.86	14.21	14.32	16.13	14.88	15.48	15.96	16.35	16.73	17.24	14.29	12.64	12.70	8.76
Metal Durables	17.21	15.49	14.50	14.68	14.38	15.05	15.42	15.67	16.30	15.42	15.32	14.12	15.36	12.85	14.74
Fabricated Metal Products	10.94	11.04	10.42	10.46	10.13	10.64	10.88	11.17	11.42	11.24	11.39	10.81	10.13	8.32	9.01
Computers & Office Machines	2.46	2.19	1.90	1.84	1.64	1.59	1.50	1.50	1.68	1.77	1.65	1.38	3.30	2.86	3.27
Industrial Machinery & Equipment	3.81	2.27	2.19	2.37	2.62	2.82	3.04	3.00	3.21	2.41	2.28	1.93	1.93	1.67	2.47
Electric & Eletronic Equipment	6.57	6.31	5.97	5.59	5.49	5.36	5.51	5.91	6.30	6.99	6.41	4.97	3.98	3.38	2.78
Telephone & Broadcasting Equipment	1.21	0.75	0.72	0.55	0.45	0.40	0.43	0.47	0.54	0.62	0.65	0.61	0.00	0.00	0.00
Semiconductors & Related Products	3.54	3.85	3.59	3.38	3.50	3.43	3.72	3.91	4.13	4.31	4.15	3.01	3.24	2.90	2.24
Non-specified (Elec. Equipment)	1.82	1.71	1.65	1.66	1.54	1.52	1.36	1.53	1.62	2.07	1.61	1.34	0.74	0.49	0.54
Transportation Equipment	10.04	10.01	9.96	9.66	9.72	8.98	8.17	8.43	9.06	9.68	9.47	8.30	7.68	5.30	4.74
Instruments & Related Products	1.34	1.62	1.55	1.80	1.74	1.56	1.64	1.71	1.90	2.13	1.85	1.75	0.00	0.00	0.00
Construction	2.35	2.09	1.61	1.73	1.79	1.78	2.16	2.52	2.88	2.44	2.28	1.94	1.74	1.93	3.13
Non-specified (Industrial)	0.71	0.59	0.58	0.60	0.66	0.67	0.68	0.72	1.08	1.08	1.09	47.63	34.53	9.28	2.48
Energy Industrial Sector	279.92	289.47	248.96	261.12	254.36	309.53	367.77	436.49	472.37	412.27	435.33	427.12	368.94	404.88	407.09
Transformation at Refinery	0.00	0.00	0.00	24.59	35.81	23.90	49.65	38.03	47.78	35.33	39.30	34.33	12.34	79.37	6.57
Natural Gas Use at Refinery (Not transformation)	83.03	77.93	70.69	69.72	59.59	80.93	106.26	110.98	103.76	94.63	105.52	92.28	103.18	34.57	126.45
Oil & Gas Extraction	196.89	211.54	178.27	166.82	158.96	204.69	211.86	287.48	320.83	282.31	290.51	300.51	253.43	290.95	274.07
Flaring	2.82	1.28	1.47	0.78	0.59	0.84	1.29	1.29	1.67	1.99	1.34	2.16	1.68	2.63	1.56
Natural Gas Liquids	**4.94**	**3.61**	**3.96**	**4.07**	**4.14**	**4.14**	**2.38**	**2.19**	**1.96**	**2.42**	**11.60**	**10.31**	**1.48**	**1.46**	**1.47**
Petroleum	**497.94**	**477.71**	**483.32**	**525.17**	**543.89**	**436.26**	**462.65**	**464.67**	**441.90**	**428.24**	**460.09**	**523.69**	**481.46**	**458.03**	**464.81**
LPG	53.82	45.44	64.26	46.62	52.88	42.95	33.00	27.89	24.58	32.26	23.43	27.04	31.60	35.18	31.47
Manufacturing	41.03	30.70	39.21	29.75	34.40	30.24	23.99	20.54	19.98	28.20	15.95	16.41	27.53	27.53	27.53
Chemicals & Allied Products	9.21	10.54	10.67	10.29	11.93	12.20	12.65	12.82	13.38	13.94	12.70	11.86	11.85	11.85	11.85
Non-specified (Industry)	31.82	20.16	28.53	19.46	22.47	18.05	11.34	7.73	6.60	14.27	3.25	4.55	15.68	15.68	15.68
Oil Refinery Use	12.79	14.75	25.06	16.86	18.48	12.71	9.02	7.35	4.60	4.06	7.48	10.63	4.06	7.64	5.85
Motor Gasoline	16.60	17.17	17.31	13.99	14.48	14.96	14.05	14.79	16.58	9.77	10.02	23.28	24.73	25.81	29.26
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.66	7.17	7.26	8.31
Non-specified (Agriculture)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.17	5.52	5.68	7.20
Non-speified (Industrial)	16.60	17.17	17.31	13.99	14.48	14.96	14.05	14.79	16.58	9.77	10.02	11.45	12.04	12.88	13.75
Refinery Still Gas	246.92	245.98	237.75	294.61	298.08	208.59	241.13	238.49	234.96	214.91	206.46	232.79	231.34	249.42	237.39
Kerosene	0.13	0.17	0.19	0.20	0.17	0.11	0.21	0.19	0.28	0.64	1.01	0.95	0.39	0.19	0.24
Industrial	0.11	0.15	0.12	0.13	0.08	0.08	0.11	0.11	0.24	0.59	0.98	0.90	0.19	0.14	0.17
Agricultural	0.03	0.02	0.07	0.07	0.09	0.03	0.09	0.08	0.04	0.05	0.03	0.06	0.20	0.05	0.07
Distillate	102.64	83.91	76.12	78.57	85.04	71.45	71.53	84.69	78.26	90.83	113.96	128.21	87.73	64.54	82.63
Agriculture	45.90	37.64	44.21	43.33	44.30	35.55	40.12	50.52	46.49	54.59	55.55	55.74	49.98	39.34	46.82
Industry	53.81	44.71	29.91	33.05	38.67	34.55	30.70	33.44	30.93	34.61	57.05	70.78	36.01	23.74	34.05
Oil and Gas Extraction	2.87	1.50	1.97	2.17	1.98	1.34	0.66	0.72	0.83	1.60	1.36	1.45	1.74	1.44	1.73
Oil Refinery Use	0.05	0.06	0.02	0.02	0.09	0.00	0.04	0.02	0.01	0.03	0.01	0.24	0.01	0.02	0.02
Residual Oil	10.94	11.07	10.92	10.02	9.92	10.50	2.88	1.37	1.03	4.72	0.76	2.90	1.20	0.34	0.08
Refining	2.70	2.67	2.07	2.25	2.25	1.52	1.16	0.83	0.79	0.41	0.02	0.00	0.00	0.00	0.00
Oil & Gas Extraction	0.17	0.33	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	2.76	0.87	0.11	0.00
Industry	8.08	8.07	8.05	7.77	7.67	8.98	1.72	0.54	0.24	4.13	0.74	0.14	0.33	0.23	0.08

Energy Flows in Trillion (10^12) BTUs

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Petroleum Coke	66.88	73.96	76.77	81.16	83.33	87.71	99.85	97.25	86.19	75.10	104.45	108.52	104.48	82.56	83.74
Oil Refinery Use	66.88	73.43	75.31	75.76	74.42	73.53	93.95	89.89	79.80	68.77	96.63	101.36	96.06	74.14	75.33
Cement	0.00	0.53	1.46	5.40	8.91	14.18	5.90	7.36	6.39	6.33	7.82	7.16	8.42	8.42	8.42
Lubricants	**13.06**	**11.68**	**11.91**	**12.13**	**12.68**	**12.46**	**12.09**	**12.77**	**13.37**	**13.51**	**13.31**	**16.26**	**16.07**	**14.85**	**15.05**
Waxes	**3.25**	**4.02**	**4.26**	**4.58**	**4.64**	**4.64**	**5.39**	**4.84**	**4.69**	**4.15**	**3.66**	**4.02**	**3.56**	**3.44**	**3.41**
Asphalt	**98.62**	**94.57**	**89.97**	**82.51**	**81.20**	**81.04**	**82.28**	**76.39**	**103.34**	**129.31**	**125.30**	**127.05**	**129.32**	**90.58**	**92.03**
Special Naptha	**12.88**	**10.37**	**12.32**	**12.32**	**9.55**	**8.35**	**6.67**	**6.47**	**9.60**	**13.02**	**8.72**	**7.03**	**9.17**	**7.21**	**4.57**
Other Petroleum Products	**3.29**	**2.27**	**1.49**	**1.41**	**1.58**	**1.45**	**0.73**	**0.80**	**0.97**	**0.92**	**0.98**	**1.02**	**1.10**	**1.03**	**0.93**
Coal	**32.4**	**32.6**	**28.1**	**20.4**	**24.0**	**25.6**	**30.7**	**36.4**	**41.9**	**47.7**	**46.8**	**45.5**	**46.4**	**46.4**	**45.5**
Cement	0.0	26.6	22.5	20.4	24.0	23.5	28.7	25.4	24.0	32.1	31.1	29.4	30.8	0.0	0.0
Other Industrial Use	32.4	6.0	5.6	0.0	0.0	2.1	2.0	11.0	17.9	15.6	15.8	16.1	15.6	46.4	45.5
Transportation	**2,579.09**	**2,502.60**	**2,563.95**	**2,517.23**	**2,607.48**	**2,632.14**	**2,667.72**	**2,713.65**	**2,777.33**	**2,830.09**	**2,911.74**	**2,913.53**	**3,038.26**	**2,837.38**	**2,963.57**
Natural Gas	**3.05**	**3.46**	**3.23**	**3.15**	**3.16**	**3.18**	**3.94**	**26.83**	**13.50**	**13.92**	**14.49**	**14.80**	**13.94**	**12.37**	**16.46**
Rail	0.36	0.35	0.25	0.18	0.18	0.17	0.18	0.14	0.25	0.25	0.23	0.27	0.18	0.23	0.27
Road	1.06	1.12	1.01	1.11	1.35	1.34	1.95	2.10	2.28	2.69	2.71	2.15	1.73	1.38	1.01
Freight	0.30	0.27	0.25	0.26	0.26	0.22	0.23	0.22	0.25	0.29	0.22	0.22	0.42	0.39	0.45
Passenger	0.38	0.42	0.38	0.43	0.55	0.56	0.86	0.94	1.01	1.20	1.25	0.97	0.66	0.49	0.28
Private Auto	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Taxi & Buses	0.19	0.22	0.16	0.18	0.26	0.27	0.45	0.40	0.45	0.49	0.49	0.50	0.00	0.00	0.00
Non-spedified (Local Transit)	0.20	0.21	0.23	0.25	0.28	0.29	0.41	0.54	0.56	0.71	0.76	0.46	0.66	0.49	0.28
Water	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.05	0.06	0.04
Air	0.35	0.36	0.27	0.24	0.25	0.18	0.18	0.18	0.56	0.24	0.79	0.17	1.18	1.19	1.19
Non-specified (Air Transport)	0.35	0.36	0.27	0.24	0.25	0.18	0.18	0.18	0.56	0.24	0.79	0.17	1.18	1.19	1.19
Pipeline	1.27	1.62	1.69	1.61	1.36	1.48	1.61	24.40	10.39	10.72	10.75	12.20	10.80	9.50	13.95
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.89	9.03	9.51	9.48	10.67	9.40	8.48	12.68
Other than Natural Gas	1.27	1.62	1.69	1.61	1.36	1.48	1.61	1.50	1.36	1.22	1.26	1.53	1.40	1.03	1.27
Non-specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	**2,576.05**	**2,499.13**	**2,560.72**	**2,514.08**	**2,604.32**	**2,628.96**	**2,663.78**	**2,686.81**	**2,763.84**	**2,816.17**	**2,897.25**	**2,898.73**	**3,024.32**	**2,825.01**	**2,947.11**
LPG	3.35	2.75	2.36	2.37	3.66	2.04	1.74	1.26	2.42	1.39	5.73	6.93	3.00	3.00	3.00
Motor Gasoline	1,579.69	1,542.34	1,632.02	1,605.45	1,599.51	1,629.49	1,615.52	1,624.85	1,658.92	1,705.69	1,731.34	1,777.74	1,861.72	1,810.37	1,885.15
Aviation Gasoline	5.58	5.51	5.35	4.13	4.00	4.07	3.88	4.22	2.90	4.16	3.65	3.31	3.67	3.67	3.00
Jet Fuel	538.12	510.66	491.52	506.01	560.16	540.38	588.39	584.83	597.54	559.48	584.02	551.22	580.08	469.10	498.77
International Jet Fuel Aviation	203.12	192.75	185.53	191.00	211.43	203.97	222.09	220.75	225.54	211.18	220.44	208.06	218.96	177.06	188.26
Domestic Jet Fuel Aviation	335.01	317.91	305.99	315.02	348.72	336.41	366.30	364.08	371.99	348.30	363.58	343.16	361.13	292.04	310.51
Distillate	317.13	314.49	314.14	288.18	327.79	340.68	342.39	370.62	373.91	388.35	418.02	409.52	424.06	429.50	445.53
Railroad	31.33	33.12	30.13	26.56	28.75	32.79	35.01	34.69	36.40	37.73	41.40	39.11	41.08	37.57	43.02
Road Transportation	252.38	245.42	255.57	253.02	275.39	289.82	293.43	317.33	324.43	340.95	365.14	364.39	374.97	384.71	394.46
Water Transportation	4.25	9.70	5.66	1.99	6.10	0.22	0.86	15.26	9.44	7.92	9.90	0.00	0.00	0.70	0.00
Non-specified (Transport)	29.17	26.24	22.79	6.61	17.56	17.86	13.10	3.34	3.64	1.75	1.58	6.02	8.01	6.52	8.05
Residual Oil	16.14	13.24	9.48	9.25	11.09	14.64	13.46	7.61	6.99	9.77	11.45	10.77	10.41	7.65	8.34
Water Transportation	16.14	13.24	9.34	9.05	10.96	13.46	12.35	7.08	6.74	9.62	11.45	10.74	10.30	7.47	8.34
Non-specified (Transport)	0.00	0.00	0.14	0.21	0.14	1.18	1.11	0.53	0.25	0.15	0.00	0.03	0.11	0.18	0.00
Lubricants	17.41	15.57	15.88	16.17	16.90	16.61	16.12	17.03	17.83	18.02	17.75	12.19	12.05	11.14	11.29
Marine Bunkers (Report separately in GHG Inventory	323.67	265.48	187.26	181.46	219.72	269.87	247.71	141.98	135.14	192.97	229.62	215.05	205.25	149.79	164.90
Distillate Bunkers	17.05	13.98	9.86	9.56	11.57	14.21	13.05	7.48	7.12	10.16	12.09	10.99	9.56	7.89	6.40
Residual Oil Bunkers	306.62	251.50	177.40	171.91	208.15	255.66	234.66	134.50	128.02	182.81	217.53	204.06	195.69	141.90	158.50
Electricity Generation (Excludes Wood, Landfill & MSW)	**691.02**	**692.71**	**827.56**	**758.53**	**913.22**	**688.62**	**641.22**	**690.36**	**754.02**	**814.39**	**982.96**	**1061.69**	**792.17**	**834.30**	**894.15**
Natural Gas	**689.82**	**691.54**	**826.12**	**757.02**	**911.78**	**687.26**	**640.08**	**689.31**	**753.04**	**813.37**	**981.93**	**1060.72**	**791.09**	**833.34**	**893.01**
Commercial CHP	12.18	10.83	12.13	12.41	13.78	14.29	14.61	13.73	14.10	13.89	13.46	12.40	12.06	15.39	15.51
Electric CHP	122.39	126.91	139.34	144.89	149.04	148.75	147.66	155.85	154.57	154.34	151.16	138.22	181.90	155.47	172.70
Industrial CHP	79.29	85.54	82.88	83.55	86.11	86.72	95.72	90.05	90.59	90.08	89.58	90.89	98.80	92.73	141.91
Utility	471.47	461.59	583.06	480.04	618.73	405.36	326.29	385.13	276.04	145.52	129.71	120.28	89.63	98.49	101.67
Merchant Power	4.50	6.66	8.71	11.73	8.02	7.92	6.49	6.47	171.47	374.63	557.74	663.76	396.04	389.93	454.49
Refinery Self Generation	0.00	0.00	0.00	24.40	36.10	24.23	49.30	38.08	46.26	34.92	40.28	35.18	12.65	81.35	6.74
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	**1.20**	**1.17**	**1.45**	**1.50**	**1.44**	**1.36**	**1.13**	**1.05**	**0.98**	**1.02**	**1.03**	**0.97**	**1.08**	**0.95**	**1.13**
Electric CHP	0.78	1.02	1.09	1.20	1.05	1.00	0.80	0.78	0.84	0.88	0.88	0.82	0.93	0.82	0.92
Industrial CHP	0.41	0.15	0.36	0.30	0.39	0.36	0.33	0.27	0.14	0.15	0.15	0.15	0.16	0.13	0.21
Merchant Power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood & Wood Waste (exclude for carbon dioxide)	**60.33**	**62.20**	**59.75**	**55.29**	**61.93**	**40.72**	**45.66**	**45.88**	**41.31**	**51.58**	**53.12**	**49.41**	**0.00**	**0.00**	**0.00**
Landfill & MSW (exclude for carbon dioxide)	**20.87**	**20.61**	**21.05**	**22.67**	**23.22**	**23.11**	**21.42**	**22.49**	**21.27**	**22.17**	**25.18**	**24.18**	**0.00**	**0.00**	**0.00**
Not Sector-Specific; Other End Use	**20.67**	**10.86**	**9.06**	**10.56**	**12.31**	**9.98**	**8.96**	**7.56**	**-2.32**	**11.32**	**16.38**	**12.45**	**100.83**	**44.06**	**2.14**
Natural Gas	20.67	10.86	9.06	10.56	12.31	9.98	8.96	7.56	-2.32	11.32	14.77	9.79	98.69	41.93	0.00
Liqueified Petroleum Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.61	2.66	2.14	2.14	2.14

APPENDIX C

DISCUSSION OF ALTERNATIVE METHODS OF ESTIMATING CO_2 EMISSIONS FROM ELECTRICITY IMPORTED TO CALIFORNIA

Introduction

At least three approaches have been used to estimate out-of-state CO_2 emissions from electricity imported to California: (1) the current GHG inventory method, (2) a method used by Joseph Loyer, and described below, and (3) the method used in the 1990-1999 inventory. Energy imported to California from the Pacific Northwest and Southwest is not correlated to specific fuel types and the fuel types need to be estimated. Emissions from two out-of-state coal-fired power plants owned by California electric utilities are evaluated in the normal manner and reported as out-of-state emissions.

Current GHG Inventory

The method used to develop the current GHG inventory is described in the main body of this paper.

Joseph Loyer Method

Joseph Loyer of the Energy Commission's Electricity Office estimated percentages of various fuels used to generate electricity for import to California for the 1994 and 1995 calendar years, and presented his results in a report titled *Fuel~Resource Profiles of Electricity Generation and Related CO_2 Emissions for The State of California, 1994 and 1995*. This report is dated April 2, 1998.

To determine CO_2 emissions from the two out-of-state coal facilities, the author used data appropriate for coal-fueled combustion. To determine CO_2 emissions from the Pacific Northwest and Southwest, the author used data from the DOE to determine the amount of energy (measured in GWh) sold by each company to California in 1994 and 1995. He then used each company's annual percentages of GWh by fuel type each year and assumed that these percentages applied to electrical energy sold to California. From this, he estimated the amount of energy in GWh by fuel type for electricity sold for use in California, and corresponding CO_2 emissions.

Using Loyer's data, in 1994 imported coal-based electricity comprised 18.9 percent of the total GWh imported for use in California. Using the approach described above for the current GHG inventory, in 1994 coal comprised 18.0 percent of the total GWh imported for use in California. Correspondingly, for 1995 Loyer's method yields imported coal energy comprising 17.7 percent of California's total GWh consumption while using the current GHG inventory method yields imported coal energy comprising 16.1 percent.

1990-1999 Inventory Method

The 1990-1999 inventory[90] also included estimates of GHG emissions from out-of-state electric power production imported to California. That analysis used the conventional approach to estimate CO_2 emissions from the out-of-state coal facilities owned by California utilities. For the remainder of the electrical energy imported to California from the Pacific Northwest and Southwest, it assumed an emissions factor of 800 metric tons CO_2 per GWh. This emissions factor was said to be uncertain because the underlying mix of fuel used to generate the GWh was unknown. This emissions factor was calculated from 1994 and 1995 data in the Loyer reference. The April 2, 1998 version of the Loyer reference produces an emissions factor of 808 metric tons of CO_2 per GWh for 1994, and 861 metric tons of CO_2 per GWh for 1995. These values were rounded to 800 due to data uncertainty.

This emissions factor was assumed to apply to the imports for the Pacific Northwest and Southwest for the entire 1990 to 1999 period. However, documentation in the 1990-1999 GHG emissions inventory report cautioned that the approach may overstate emissions because the total amount of GWh imported in 1994 and 1995 was relatively low compared to other years during the 1990 to 1999 period.

Summary of Options to Estimate CO_2 Emissions from Electric Imports

All three methods used conventional data and emissions factors for the two out-of-state coal fired electric power plants owned by California utilities. To estimate CO_2 emissions from electrical energy imported from the Pacific Northwest and Southwest, each method was different and had one or more limitations:

(1) The approach used for this inventory is based upon an Energy Commission adopted estimate of the fuel profile used to generate electricity imported from the Pacific Northwest and Southwest. This estimate was somewhat arbitrary, and was not officially adopted for the entire 1990 to 2000 period.

(2) The method used by Loyer was only done for 1994 and 1995, and it assumed each import providing company's annual average fuel profile applied to the electricity that California imported.

(3) The method used in the 1990-1999 inventory assumed that the fuel mix used to import electricity from the Southwest and Pacific Northwest in 1994 and 1995 matched the fuel mix for the entire 1990 to 1999 period.

Table C-1 compares these three different approaches for estimating CO_2 emissions from imported electricity. The Loyer approach was only done for 1994 and 1995. The current approach shows the lowest estimates for each year and the 1990-1999 inventory method shows the highest. The Loyer approach is mid range.

Table C-1. Comparing Three Methods to Estimate CO_2 Emissions from Imported Electricity (Million Metric Tons of CO_2)

Inventory Approach	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
-Current	43.3	43.1	43.0	40.8	43.2	38.5	40.6	47.0	52.9	51.7	40.5	47.4	51.7	56.4
-Loyer					48.3	45.6								
-Previous	67.5	65.4	59.6	55.0	57.5	55.1	62.7	67.5	70.5	73.0				

APPENDIX D

DIFFERENCES BETWEEN CURRENT INVENTORY AND JUNE 2005 INVENTORY

Introduction

This appendix describes the emissions categories and sub-categories with more significant changes from the 1990 to 2002 inventory published July 2005. The text is followed by a table showing the differences. Reductions are shown in parentheses.

Natural Gas Combustion CO_2 Emissions

This section summarizes differences for CO2 emissions from natural gas combustion in residential, commercial, industrial, electricity generation, and non-sector specific categories.

Residential

Residential natural gas use In the current (1990 to 2004) GHG inventory is based on Energy Commission data from utilities. There is a modest increase in 2000 (0.6 $MMTCO_2E$), followed by a decrease of 1 $MMTCO_2E$ in 2001 and then a medium increase in 2002 (2.5 $MMTCO_2E$).

Commercial

See above for changed data source. There are small decreases in the early 1990s followed by fairly large decreases in 1998 to 2000 (2.8 to 6.7 $MMTCO_2E$), followed by increases in 2001 (0.8 $MMTCO_2E$) and 2002 (2.3 $MMTCO_2E$). For Electricity Producers' own fuel use (not generation) the previous inventory was based on very high fuel uses for 1998 to 2000. There is a large decrease (6.7 $MMTCO_2E$ in 1999) in emissions from this sector. The new energy balance shows much lower numbers for these years, more consistent with other years. These changes are due to how natural gas used for thermal purposes in combined heat and power facilities are allocated.

Industrial

The 1990 to 2002 inventory inadvertently double counted "Stone, Clay, Glass, Cement & Other" emissions. This factor reduces inventory 0.8 to 1.6 $MMTCO_2E$. Refinery natural gas use now based on Energy Commission data; older inventory used EIA data. This factor increases "Transformation" emissions slightly in 2000 (0.5 $MMTCO_2E$) and decreases them somewhat in 2001 and 2002 (0.8 and 2.3 $MMTCO_2E$).

Electricity Generation

In the current 1990 to 2004 GHG inventory, natural gas used for electricity generation is from EIA's Electric Power Annual Report. Emissions increase and decrease each year by up to about 3 $MMTCO_2E$.

Non-Sector Specific

Fuel not ascribed to a specific end use is greater in 2002 due to changed data sources. Specifically, data collection changed from SIC categories to NAICS categories, with some difficulty in linking them together. This caused increases in the "non sector specific" category, but this does not represent a change in fuel use or GHG emissions. Non-sector emissions decrease by 4.7 $MMTCO_2E$ in 2002.

Coal Combustion CO_2 Emissions

This section summarizes differences for CO_2 emissions from coal combustion in the electricity generation sector.

Electricity Generation

Revised EIA data used in the current 1990 to 2004 GHG inventory indicates a much lower number for electricity generation in California using coal. Emissions decrease about up to about 3 $MMTCO_2E$.

Non-Fossil Fuel CO_2 Emissions

This section includes CO_2 emissions from agricultural soils and woody crops.

Agricultural Soils; Woody Crops

Previous inventory used different data sets for this category and for wood waste combustion. These are now consistent, causing minor changes in this category. The biggest change is in 1998, caused by moving from one data set to another for agricultural soil CO_2 emissions, in the previous inventory. In 1998 emissions increase 3.5 $MMTCO_2E$.

Methane Emissions

This section includes methane emissions from the petroleum and natural gas supply system, landfills, enteric fermentation, and manure management.

Petroleum & Natural Gas Supply System

Emissions decrease 0.2 to 0.8 MMTCO2E due to updated data from ARB.

Natural Gas Supply System (Gas Transmission Subcategory)

Emissions decreases 0.6 to 1.8 $MMTCO_2E$ due to updated data from ARB.

Landfills

Emissions decrease about 2 $MMTCO_2E$.

Enteric Fermentation

Previous inventory used TAR GWPs, not SAR values. This change reduces methane emissions in carbon-dioxide equivalents by 0.7 $MMTCO_2E$.

Manure Management

Previous inventory used TAR GWPs, not SAR values. This change reduces methane emissions in carbon-dioxide equivalents by 0.3 to 0.6 $MMTCO_2E$.

N_2O Emissions

This section includes methane emissions from fertilizer uses in agricultural applications.

Agricultural Soil Management (Direct Fertilizers and Indirect Fertilizers & Crop Residues)

Minor changes (increases of about 0.5 $MMTCO_2E$ are caused by changing data sources to California Agricultural resources Directory for consistency with other sub-categories.

High GWP Emissions

California High GWP gases are scaled from the nationwide GHG inventory proportioned by population. Nationwide GHG inventory values change each year the GHG inventory is updated. Values affected are smaller for 1990 to 1997 (about 2 $MMTCO_2E$) and somewhat larger after that (2.5 to 5 $MMTCO_2E$).

Appendix D--Differences between current, 2006 values and values published in 2005

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Carbon Dioxide (Gross)	(5.41)	(5.45)	(5.82)	(4.01)	(3.19)	(3.99)	(2.52)	(3.10)	(0.76)	(7.93)	(2.06)	1.25	5.11
Fossil Fuel Combustion	**(5.41)**	**(5.45)**	**(5.82)**	**(4.01)**	**(3.19)**	**(3.99)**	**(2.52)**	**(3.10)**	**(4.31)**	**(8.04)**	**(1.92)**	**1.23**	**5.16**
Residential	**(0.01)**	**0.01**	**0.03**	**(0.01)**	**0.04**	**0.05**	**(0.02)**	**0.01**	**(0.13)**	**0.09**	**0.62**	**(1.00)**	**2.55**
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	(0.01)	0.01	0.03	(0.01)	0.04	0.05	(0.02)	0.01	(0.13)	0.09	0.62	(1.00)	2.55
Commercial	**(1.14)**	**(1.38)**	**(1.36)**	**(1.37)**	**(1.34)**	**(1.29)**	**(1.45)**	**(1.58)**	**(2.84)**	**(6.68)**	**(1.90)**	**0.54**	**2.35**
Coal	(0.01)	(0.01)	0.00	(0.04)	(0.02)	(0.01)	0.00	(0.01)	(0.01)	0.00	(0.00)	0.00	0.00
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02
Natural Gas	(1.14)	(1.38)	(1.36)	(1.34)	(1.33)	(1.28)	(1.45)	(1.57)	(2.83)	(6.68)	(1.92)	0.52	2.33
Industrial	**(2.04)**	**(1.68)**	**(1.59)**	**(1.05)**	**(0.82)**	**(1.42)**	**(1.33)**	**(1.53)**	**(1.86)**	**(1.16)**	**(0.64)**	**0.97**	**(3.09)**
Coal	(0.38)	(0.17)	(0.17)	0.32	0.45	(0.13)	0.02	(0.18)	(0.13)	0.09	(0.05)	(0.05)	(0.05)
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.01)	0.00	(0.00)
Natural Gas	(1.65)	(1.51)	(1.42)	(1.37)	(1.27)	(1.29)	(1.36)	(1.35)	(1.73)	(1.25)	(0.58)	1.02	(3.04)
Natural Gas Liquids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation	**(0.00)**	**0.00**	**0.00**	**(0.00)**	**0.00**	**0.00**	**(0.00)**	**0.00**	**(0.00)**	**0.00**	**0.01**	**0.93**	**0.30**
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.33
Natural Gas	(0.00)	0.00	0.00	(0.00)	0.00	0.00	(0.00)	0.00	(0.00)	0.00	0.01	(0.01)	(0.02)
Electricity Generation (In State)	**(2.22)**	**(2.40)**	**(2.90)**	**(1.57)**	**(1.06)**	**(1.33)**	**0.29**	**0.00**	**0.53**	**(0.29)**	**(0.03)**	**(0.19)**	**(1.61)**
Coal	(2.22)	(2.40)	(2.90)	(2.86)	(2.97)	(2.60)	(2.32)	(2.01)	(1.92)	(2.14)	(2.16)	(2.05)	(2.27)
Natural Gas	0.00	0.00	0.00	1.29	1.91	1.28	2.60	2.01	2.44	1.84	2.13	1.86	0.67
Not Sector-Specific	**(0.00)**	**0.00**	**0.00**	**(0.00)**	**0.00**	**0.00**	**(0.00)**	**0.00**	**0.00**	**0.00**	**0.02**	**(0.02)**	**4.66**
Cement Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.06)
Lime Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Limestone & Dolomite Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.00)	(0.00)	0.00	0.00
Soda Ash Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide Consumption	(0.00)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)
Waste Combustion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Land Use Change & Forestry	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3.55**	**0.11**	**(0.13)**	**0.02**	**0.02**
Forests	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Carbon Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Reductions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rangelands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Reductions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Soils	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3.55**	**0.11**	**(0.13)**	**0.02**	**0.02**
Woody Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.46	0.11	(0.13)	0.02	0.06
Non-Woody Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	(0.00)	(0.01)	(0.04)
Liming of Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landfills	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Lumber Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yard Trimming Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide Emissions (Net)	**(5.41)**	**(5.45)**	**(5.82)**	**(4.01)**	**(3.19)**	**(3.99)**	**(2.52)**	**(3.10)**	**(0.76)**	**(7.93)**	**(2.06)**	**1.25**	**5.11**
Methane (CH_4)	**(5.11)**	**(6.22)**	**(7.26)**	**(4.76)**	**(5.41)**	**(4.68)**	**(4.70)**	**(6.27)**	**(4.81)**	**(4.37)**	**(3.94)**	**(4.21)**	**(4.13)**
Petroleum & Natural Gas Supply System	**(0.24)**	**(0.34)**	**(0.79)**	**(0.34)**	**(0.32)**	**(0.31)**	**(0.31)**	**(0.31)**	**(0.32)**	**(0.20)**	**(0.33)**	**(0.30)**	**(0.37)**
Field Production	(0.40)	(0.45)	(0.79)	(0.43)	(0.42)	(0.40)	(0.39)	(0.38)	(0.39)	(0.28)	(0.40)	(0.35)	(0.42)
Refining	0.16	0.09	0.00	0.08	0.08	0.09	0.08	0.05	0.06	0.07	0.07	0.05	0.05
Marketing	0.01	0.01	(0.00)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Natural Gas Supply System	**(1.75)**	**(1.64)**	**(1.54)**	**(1.43)**	**(1.32)**	**(1.21)**	**(1.10)**	**(0.99)**	**(0.88)**	**(0.76)**	**(0.60)**	**(0.59)**	**(0.62)**
Processing	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.03	0.03	0.03	0.00
Transmission	(1.81)	(1.70)	(1.60)	(1.48)	(1.37)	(1.27)	(1.15)	(1.03)	(0.91)	(0.79)	(0.62)	(0.62)	(0.63)
Landfills	**(1.87)**	**(2.00)**	**(2.18)**	**(1.44)**	**(1.65)**	**(1.95)**	**(1.52)**	**(3.79)**	**(2.31)**	**(2.11)**	**(1.91)**	**(2.06)**	**(1.90)**
MSW (Class II & III)	(Previous Inventory did not include this sub-category)												
Other Class II & III	(Previous Inventory did not include this sub-category)												
Others	(Previous Inventory did not include this sub-category)												
Enteric Fermentation	**(0.72)**	**(0.69)**	**(0.70)**	**(0.63)**	**(0.68)**	**(0.69)**	**(0.64)**	**(0.66)**	**(0.65)**	**(0.67)**	**(0.64)**	**(0.67)**	**(0.67)**
Dairy Cattle	(0.35)	(0.36)	(0.37)	(0.34)	(0.36)	(0.37)	(0.34)	(0.36)	(0.36)	(0.39)	(0.39)	(0.42)	(0.43)
Beef Cattle	(0.33)	(0.29)	(0.29)	(0.25)	(0.27)	(0.28)	(0.27)	(0.26)	(0.25)	(0.25)	(0.21)	(0.21)	(0.21)
Horses	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Sheep	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Swine	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Goats	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Manure Management	**(0.31)**	**(0.37)**	**(0.37)**	**(0.38)**	**(0.41)**	**(0.43)**	**(0.43)**	**(0.46)**	**(0.46)**	**(0.50)**	**(0.51)**	**(0.53)**	**(0.55)**
Beef Cattle	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Dairy Cattle	(0.28)	(0.33)	(0.34)	(0.35)	(0.37)	(0.40)	(0.40)	(0.43)	(0.42)	(0.46)	(0.48)	(0.50)	(0.52)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Swine	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Poultry	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Sheep	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Goats	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Horses	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Flooded Rice Fields	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Burning Ag Residues	**(0.06)**	**(0.06)**	**(0.06)**	**(0.06)**	**(0.06)**	**(0.06)**	**(0.05)**	**(0.05)**	**(0.05)**	**(0.05)**	**(0.05)**	**(0.04)**	**(0.03)**
Non-woody/Field	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.01
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Woody/Orchard & Vineyard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Almonds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Walnuts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Waste Burning	**0.01**	**0.01**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.04**
Wastewater Treatment	**(0.14)**	**(0.14)**	**(0.14)**	**(0.14)**	**(0.15)**	**(0.15)**	**(0.15)**	**(0.15)**	**(0.15)**	**(0.15)**	**(0.17)**	**(0.16)**	**(0.16)**
Mobile Source Combustion	**(0.13)**	**(1.14)**	**(1.11)**	**(0.47)**	**(0.98)**	**(0.06)**	**(0.86)**	**(0.16)**	**(0.36)**	**(0.31)**	**(0.04)**	**(0.21)**	**(0.02)**
Gasoline Highway Vehicles	(0.22)	(1.23)	(1.18)	(0.60)	(1.10)	(0.21)	(0.99)	(0.32)	(0.51)	(0.46)	(0.20)	(0.39)	(0.19)
Passenger Cars (subcategories revised)	(0.06)	(0.52)	(0.50)	(0.25)	(0.46)	(0.04)	(0.41)	(0.09)	(0.19)	(0.17)	(0.03)	(0.13)	(0.03)
Light-Duty Trucks (subcategories revised)	(0.02)	(0.31)	(0.30)	(0.12)	(0.28)	(0.02)	(0.25)	(0.05)	(0.10)	(0.09)	(0.01)	(0.07)	(0.02)
Medium & Heavy-Duty Trucks (subcategories revised)	(0.02)	(0.24)	(0.24)	(0.09)	(0.22)	(0.02)	(0.19)	(0.03)	(0.07)	(0.06)	(0.01)	(0.05)	(0.01)
Motorcycles (subcategories revised)	(0.01)	(0.03)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Diesel Highway Vehicles	0.01	(0.02)	(0.01)	0.00	(0.01)	0.01	(0.01)	0.01	0.00	0.00	0.01	0.00	0.01
Passenger Cars	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Light-Duty Trucks	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Medium & Heavy-Duty Trucks	0.01	(0.01)	(0.01)	0.00	(0.01)	0.01	(0.01)	0.01	0.00	0.00	0.01	0.00	0.01
Aviation	0.00	0.02	0.00	0.04	0.04	0.04	0.02	0.02	0.02	0.03	0.03	0.04	0.04
Other Transportation (subcategories revised)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.00)	(0.01)	(0.01)	(0.02)	(0.03)	(0.00)	0.00
Stationary Source Combustion	**0.03**	**0.10**	**(0.43)**	**0.05**	**0.08**	**0.10**	**0.29**	**0.23**	**0.30**	**0.31**	**0.24**	**0.28**	**0.12**
Electricity Generation	0.20	0.22	(0.01)	0.20	0.19	0.19	0.23	0.25	0.27	0.30	0.23	0.26	0.24
Petroleum	(Previous Inventory did not include this sub-category)												
Natural Gas	(Previous Inventory did not include this sub-category)												
Wood	(Previous Inventory did not include this sub-category)												
Other	(Previous Inventory did not include this sub-category)												
Industrial	(0.19)	(0.15)	(0.29)	(0.13)	(0.11)	(0.10)	(0.04)	(0.06)	(0.04)	(0.06)	(0.07)	(0.07)	(0.10)
Petroleum	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Natural Gas	(0.28)	(0.27)	(0.28)	(0.23)	(0.22)	(0.21)	(0.17)	(0.18)	(0.17)	(0.18)	(0.18)	(0.20)	(0.19)
Wood (Previous inventory did not include this sub-categor	0.02	0.02	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other	0.08	0.11	0.01	0.10	0.11	0.11	0.13	0.12	0.12	0.12	0.12	0.12	0.09
Commercial	0.03	0.03	(0.13)	(0.01)	(0.00)	0.01	0.10	0.05	0.07	0.07	0.07	0.09	(0.01)
Petroleum	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.01
Natural Gas	0.02	0.01	(0.12)	(0.02)	(0.01)	(0.00)	0.07	0.03	0.05	0.04	0.03	0.03	(0.03)
Wood	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Other	(0.01)	0.01	(0.03)	(0.01)	(0.02)	(0.02)	(0.00)	(0.00)	0.00	0.01	0.03	0.05	0.00
Residential	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other (was listed separately from residential in previous ir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrous Oxide (N_2O)	**0.60**	**0.54**	**0.59**	**0.61**	**0.57**	**0.54**	**0.58**	**0.46**	**0.48**	**0.47**	**0.61**	**0.50**	**0.97**
Nitric Acid Production	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Waste Combustion	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Agricultural Soil Management	**0.66**	**0.59**	**0.61**	**0.65**	**0.62**	**0.59**	**0.59**	**0.50**	**0.51**	**0.50**	**0.60**	**0.53**	**0.76**
Direct	0.26	0.23	0.23	0.25	0.24	0.15	0.16	0.11	0.11	0.09	0.15	0.09	0.21
Fertilizers	0.13	0.10	0.11	0.13	0.11	0.15	0.14	0.11	0.12	0.12	0.15	0.14	0.21
Crop Residues	0.01	0.00	0.00	0.00	0.00	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
N-Fixing Crops	0.06	0.06	0.05	0.05	0.05	(0.05)	(0.04)	(0.05)	(0.07)	(0.09)	(0.06)	(0.10)	(0.05)
Histosols	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Livestock	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05
Indirect	0.28	0.25	0.26	0.27	0.26	0.30	0.29	0.27	0.27	0.28	0.31	0.30	0.37
Fertilizers	0.11	0.09	0.10	0.12	0.10	0.13	0.13	0.10	0.11	0.11	0.13	0.12	0.18
Livestock	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.16	0.17	0.18	0.18	0.18
Leaching/Runoff	0.13	0.11	0.12	0.13	0.12	0.14	0.14	0.12	0.12	0.13	0.14	0.14	0.18
Manure Management	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.04**	**0.04**	**0.04**
Beef Cattle	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Dairy Cattle	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Swine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Sheep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burning Ag Residues	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Non-woody/Field	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Woody/Orchard & Vineyard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Almonds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Walnuts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wastewater	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.05**	**0.05**	**0.03**	**0.05**	**0.04**
Municipal (formerly Human Sewage)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.03	0.05	0.04
Industrial	(Category not yet included in inventory)												
Mobile Source Combustion	**0.01**	**0.01**	**0.05**	**0.01**	**0.01**	**0.01**	**0.05**	**0.01**	**0.01**	**0.01**	**0.05**	**0.01**	**0.25**
Gasoline Highway Vehicles	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00
Diesel Highway Vehicles	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00
Aviation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.25
Stationary Source Combustion	**(0.16)**	**(0.14)**	**(0.14)**	**(0.13)**	**(0.13)**	**(0.13)**	**(0.13)**	**(0.13)**	**(0.12)**	**(0.12)**	**(0.11)**	**(0.13)**	**(0.13)**
Electricity Generation	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Coal	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Petroleum	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	(0.13)	(0.11)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.10)	(0.11)	(0.10)	(0.12)	(0.12)
Coal	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Petroleum	(0.10)	(0.08)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.09)	(0.09)
Natural Gas	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial/Institutional	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	0.00	0.00	0.00	0.00
Coal	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	0.00	0.00
Petroleum	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Natural Gas	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	0.00	0.00	(0.00)	(0.00)
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Residential	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Coal	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	0.00	0.00
Petroleum	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Natural Gas	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	0.00	(0.00)	(0.00)
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Global-Warming Potential Gases	**(2.74)**	**(2.56)**	**(2.39)**	**(2.08)**	**(1.92)**	**(1.73)**	**(1.81)**	**(1.70)**	**(7.77)**	**(6.78)**	**(6.56)**	**(4.90)**	**(5.22)**
Substitution of Ozone-Depleting Substances	(2.39)	(2.28)	(2.19)	(2.08)	(1.97)	(1.85)	(1.93)	(1.81)	(7.38)	(6.37)	(6.34)	(4.76)	(5.05)
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(5.12)	(3.90)	(3.71)	(2.48)	(2.49)
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.04
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.23)	(0.26)	(0.29)	(0.32)	(0.34)
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.18)	(0.25)	(0.31)	(0.36)	(0.41)
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.09)	(0.11)	(0.13)	(0.16)	(0.19)
HFC-236fa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.02)	(0.05)	(0.07)	(0.10)	(0.13)
CF_4	(1.80)	(1.70)	(1.60)	(1.49)	(1.38)	(1.26)	(1.34)	(1.22)	(1.07)	(1.07)	(1.04)	(0.52)	(0.62)
C_2F_6	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.11)	(0.17)	(0.23)	(0.27)	(0.30)
Semiconductor Manufacture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.00)	(0.00)
Electricity Transmission & Distribution (SF_6)	(0.35)	(0.27)	(0.21)	0.00	0.05	0.12	0.13	0.11	(0.39)	(0.42)	(0.22)	(0.14)	(0.17)
Electricity Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net California Emissions w/o Electric Imports)	(12.66)	(13.69)	(14.89)	(10.25)	(9.95)	(9.86)	(8.44)	(10.60)	(12.85)	(18.62)	(11.95)	(7.36)	(3.27)
Gross California Emissions with Electric Imports	(12.66)	(13.69)	(14.89)	(10.25)	(9.95)	(9.86)	(8.44)	(10.60)	(12.85)	(18.62)	(11.95)	(7.36)	(3.27)
Net California Emissions with Electric Imports	(12.66)	(13.69)	(14.89)	(10.25)	(9.95)	(9.86)	(8.44)	(10.60)	(12.85)	(18.62)	(11.95)	(7.36)	(3.27)
International Bunker Carbon Dioxide Emissions	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Jet Fuel (Aviation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distillate Oil (Marine)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residual Oil (Marine)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Fossil Fuel Carbon Dioxide =	**(5.41)**	**(5.45)**	**(5.82)**	**(4.01)**	**(3.19)**	**(3.99)**	**(2.52)**	**(3.10)**	**(4.31)**	**(8.04)**	**(1.92)**	**1.23**	**5.16**
Gross FF CO2 & Imports & International Fuels =	**(5.41)**	**(5.45)**	**(5.82)**	**(4.01)**	**(3.19)**	**(3.99)**	**(2.52)**	**(3.10)**	**(4.31)**	**(8.04)**	**(1.92)**	**1.23**	**5.16**
Non-Fossil Fuel CO2 Portion of GHG Inventory =	**(7.26)**	**(8.23)**	**(9.06)**	**(6.23)**	**(6.76)**	**(5.87)**	**(5.92)**	**(7.50)**	**(8.55)**	**(10.58)**	**(10.02)**	**(8.59)**	**(8.43)**

APPENDIX E

METHANE SPECIATION PROFILE PROVIDED BY CALIFORNIA AIR RESOURCES BOARD

Type of Source	Percent Methane
ALCOHOLS PRODUCTION - AVERAGE (EPA 9007)	43.3%
Animal waste decomposition	70.0%
Asphalt roofing - tar kettle	21.3%
Bar screen waste incinerator- solid waste	80.4%
Carbon black manufacturing	22.4%
Cat stabilzed exhaust 2004 SSD etoh 2% O (MTBE phaseout)	17.9%
Cat stabilzed exhaust 2005 SSD etoh 2% O (MTBE phaseout)	18.7%
Cat stabilzed exhaust 2006 SSD etoh 2% O (MTBE phaseout)	19.5%
Cat stabilzed exhaust 2007 SSD etoh 2% O (MTBE phaseout)	20.3%
Cat stabilzed exhaust 2008 SSD etoh 2% O (MTBE phaseout)	21.2%
Cat stabilzed exhaust 2009 SSD etoh 2% O (MTBE phaseout)	22.0%
Cat stabilzed exhaust 2010 SSD etoh 2% O (MTBE phaseout)	22.8%
Cat stabilzed exhaust 2011 SSD etoh 2% O (MTBE phaseout)	23.7%
Cat stabilzed exhaust 2012 SSD etoh 2% O (MTBE phaseout)	24.5%
Cat stabilzed exhaust 2013 SSD etoh 2% O (MTBE phaseout)	25.3%
Cat stabilzed exhaust 2014 SSD etoh 2% O (MTBE phaseout)	26.2%
Cat stabilzed exhaust 2015 SSD etoh 2% O (MTBE phaseout)	27.0%
Cat stabilzed exhaust 2016 SSD etoh 2% O (MTBE phaseout)	27.8%
Cat stabilzed exhaust 2017 SSD etoh 2% O (MTBE phaseout)	28.6%
Cat stabilzed exhaust 2018 SSD etoh 2% O (MTBE phaseout)	29.5%
Cat stabilzed exhaust 2019 SSD etoh 2% O (MTBE phaseout)	30.3%
Cat stabilzed exhaust 2020 SSD etoh 2% O (MTBE phaseout)	31.1%
Cat start exhaust 1996 SSD etoh 2.0% o (MTBE phaseout)	5.4%
CHEMICAL MANUFACTURING - AVERAGE (EPA 9004)	5.1%
Coal combustion - bituminous - fluidized bed	83.6%
Coke oven blast furnace- process gas	40.9%
Coke oven stack gas - primary metals	45.3%
Composite jet exhaust JP-5 (EPA 1097-1099)	11.4%
Composite natural gas	93.7%
Crude oil - storage tanks - Kern county	30.0%
Crude oil evaporation- vapor composite from fixed roof tanks	8.8%
Daytime biogenic profile- Kern county crops	25.0%
Evaporative emissions-distillate fuel	4.2%
External combustion boiler - natural gas	56.0%
External combustion boiler - process gas	7.6%
External combustion boiler- coke oven gas	82.8%
External combustion boilers- distillate or residual	5.0%
Farm equipment - diesel - light & heavy - (ems=actual weight)	4.1%
Forest fires	17.7%
Gasoline - catalyst - FTP Bag 1-3 STARTS - ARB IUS summer 1994	6.2%
Gasoline - catalyst - FTP Bag 1-3 STARTS - ARB IUS summer 1996	5.3%
Gasoline - catalyst - stabilized exhaust - ARB IUS summer 1987	11.0%
Gasoline - catalyst - stabilized exhaust - ARB IUS summer 1990	12.6%
Gasoline - catalyst - stabilized exhaust - ARB IUS summer 1996	15.8%
Gasoline - catalyst - stabilized exhaust - ARB summer 1988	11.0%
Gasoline - catalyst - stabilized exhaust - ARB summer 1989	12.1%
Gasoline - catalyst - stabilized exhaust - ARB summer 1991	13.1%
Gasoline - catalyst - stabilized exhaust - ARB summer 1992	13.6%
Gasoline - catalyst - stabilized exhaust - ARB summer 1993	14.1%
Gasoline - catalyst - stabilized exhaust - ARB summer 1995	15.6%

Type of Source	Percent Methane
Gasoline - catalyst - stabilized exhaust - ARB summer 1997	16.3%
Gasoline - catalyst - stabilized exhaust - ARB summer 1998	16.8%
Gasoline - catalyst - stabilized exhaust - ARB summer 1999	17.3%
Gasoline - catalyst - stabilized exhaust - ARB summer 2001	18.1%
Gasoline - catalyst - stabilized exhaust - ARB summer 2002	18.4%
Gasoline - catalyst - stabilized exhaust - ARB summer 2003	18.7%
Gasoline - catalyst -stabilized exhaust-from 96IUS summer 2000	17.8%
Gasoline - non-cat - FTP Bag 1-3 STARTS - ARB IUS summer 1994	9.3%
Gasoline - non-cat - FTP bag1-3 STARTS - ARB IUS summer 1996	6.5%
Gasoline - non-cat - FTP Composite - ARB IUS summer 1994	8.4%
Gasoline - non-cat - stabilized exhaust - ARB IUS summer 1994	9.0%
Gasoline - non-cat - stabilized exhaust - ARB IUS summer 1996	5.6%
Geysers power plant main steam	85.9%
ICE-reciprocating-natural gas	76.6%
Industrial ice- distillate oil	11.6%
INDUSTRIAL PROCESSES - AVERAGE (EPA 9003)	9.0%
Iron production - blast furnace - ore charging	15.8%
Iron sintering - primary metals	73.3%
LANDFILLS, USEPA LANDFILL EMISSION MODEL	98.6%
MINERAL PRODUCTS - AVERAGE (EPA 9011)	18.6%
Nighttime biogenic profile - Kern county crops	60.0%
Non-cat stabilized exhaust 1996 SSD 2.0% o etoh (MTBE phaseout)	5.7%
Non-cat start exhaust 1996 SSD 2.0% o etoh (MTBE phaseout)	6.7%
OCS - gas seeps	75.0%
Oil & gas extraction - compressor seals	73.0%
Oil & gas extraction - pipeline valves & fittings	59.7%
Oil & gas extraction - pump seals	49.3%
Oil & gas extraction - well heads & cellars/oil&water separator	37.5%
Oil & gas production fugitives-gas service	61.3%
Oil & gas production fugitives-liquid service	37.6%
Oil & gas production fugitives-valves-unspecified	45.8%
Open burning dump- landscape/pruning (modified KVB 121)	56.0%
PETROLEUM INDUSTRY - AVERAGE (EPA 9012)	13.0%
Petroleum industry - refinery catalytic reformer - fugitive emissions	0.9%
PRIMARY METAL PRODUCTION - AVERAGE (EPA 9009)	29.1%
Primary metals - steel production - basic oxygen furnace	11.1%
PRINTING/PUBLISHING - AVERAGE (EPA 9026)	10.0%
Red oak combustion - wood stove (w/o catalyst)	51.1%
Refinery co boiler - fcc	36.0%
Refinery flares- natural gas	20.0%
Refinery- fugitive emissions from covered drainage/separation pits	2.9%
Refinery- pipes, valves & flanges- composite	28.6%
Refinery- pump seals- composite	3.3%
Species unknown- all category composite	25.0%
Utility equipment - gasoline - 2 cycle - CalPoly 1991	2.1%
Utility equipment - gasoline - 4 cycle - CalPoly 1991	6.3%

Derived as a subset from:
[http://www.arb.ca.gov/ei/speciate/speciate.htm (ORGPROF]

APPENDIX F

COMPARING THE CURRENT 1990 TO 2004 GHG EMISSIONS INVENTORY AND 2005 INTEGRATED ENERGY POLICY REPORT TO CORRESPOINDING VALUES USED BY THE CALIFORNIA CLIMATE ACTION TEAM

Introduction

GHG emissions inventories are by necessity approximations derived from numerous calculations and assumptions. As data and methodologies to perform this function improve, revisions are needed. In this GHG inventory, emissions estimates changed from previously published values for a variety of reasons, including revised estimates of fuel used in California and to correct problems in the previous inventory, including double counting one sub-category and instances of not using consistent GWPs to determine CO_2 equivalents for methane and nitrous oxide emissions. These are detailed in various places elsewhere in this report.

In addition, the Energy Commission updates its Integrated Energy Policy Report every two years. The Climate Action Team (CAT) used the *2003 Integrated Energy Policy Report (IEPR)* to project fuel demand, not the *2005 IEPR*. These two categories of factors cause changes in both the historical GHG emissions and in the emissions projections.

This appendix compares the current GHG inventory and projections based upon the *2005 IEPR* to the 1990 to 1999 GHG inventory and projections based upon the *2003 IEPR* as used by the CAT. The CAT emissions reduction needed to meet the Governor's 2010 goal was 59 $MMTCO_2E$ (from Table 5-5 of the CAT report) while the current GHG inventory and projections would require 68 $MMTCO_2E$ reductions in 2010. Likewise, the CAT report indicates that 174 $MMTCO_2E$ reductions would be needed in 2020 while the current GHG inventory and projections indicates that 177 $MMTCO_2E$ reductions are needed in 2020.

Projections based upon *2003 IEPR*

The California Climate Action Team used work products prepared earlier by the Tellus Institute. This work was initially conducted as part of a tri-state effort to address global warming issues and included California, Oregon, and Washington. The Tellus work was refocused to include only California and was initially produced as a draft in December 2004[91] and then in revised form in July 2005.[92]

Tellus Institute summarized emissions from in-state electricity production, out-of-state electricity produced for use in California, direct fuel use, transportation fuel use, and non-carbon GHG emissions. They first projected the 1990 to 1999 GHG inventory to 2002, then extended it to 2010 and 2020. They made adjustments to reflect the impact of recent policies that were adopted by the California Public Utilities Commission, the Energy Commission, and the Air Resources Board. Also, the CAT removed international bunker fuels from the Tellus values. California GHG emissions estimates as used by the CAT are shown in Table F-1.

Out-of-state electricity emissions were projected by first assuming California's Renewables Program goal of having 20 percent of our electrical energy supplied by renewables by 2017 and assuming 32 percent of California's electricity is supplied by out-of-state resources. The non-renewable portion of the growth in our-of-state gigawatt hours was assumed to be 50 percent coal and 50 percent natural gas.

Although the major emissions categories were projected to 2010 and 2020, several of the sub-categories were either held constant at their 2002 values or projected using draft data from a report from the Energy Commission's Public Interest Energy Research (PIER) Program.[93] Specifically:

(1) GHG emissions from cement manufacturing and other industrial processes were held constant, except the PIER report was used to project nitric acid emissions;

(2) Soils and forest sinks were held constant at 1999 values;

(3) CO_2 and nitrous oxide emissions from waste combustion were both held constant at 1999 values. Methane emissions from wastewater and nitrous oxide emissions from human sewage were projected using the PIER report;

(4) Methane and nitrous oxide emissions from manure management were projected using the PIER report while methane emissions from enteric fermentation and other agricultural activities were held constant at 1999 values;

(5) Methane and nitrous oxide emissions from mobile and stationary sources were held constant at 1999 values; and

(6) High GWP gas emissions from substitution of ozone depleting substances, semiconductor manufacturing and sulfur hexafluoride use were all projected using the PIER report.

Projections based upon *2005 IEPR*

The current inventory and publication of the *2005 Integrated Energy Policy Report* provide opportunities to update the Climate Action Team (CAT) data. These updates may prove useful to the CAT when they update their work in January 2007. While it would be prudent to use the forthcoming *2007 IEPR* work, it is not expected to be available by January 2007. As an alternative, this appendix presents the results of projecting emissions using the 1990 to 2004 GHG inventory and the *2005 IEPR*. Table F-2 summarizes the results.

An approach similar to that used by the CAT was used to project the 1990 to 2004 inventory to 2010 and 2020. Updated values from the *2005 IEPR* were used to project electricity demand. This projected demand included California Public Utilities Commission decisions and Energy Commission adopted standards for both appliances and buildings. Also, the renewable program goals were assumed to be met.

The remaining growth in electricity demand was assumed to be met by 100 percent natural gas for both in-state and out-of-state electricity supply resources. The recently-adopted SB 1368 (Perata, Chapter 598, Statutes of 2006) will ensure all electrical load growth will be served by facilities that emit no more than a modern, combined-cycle natural gas power plant. The California Public Utilities Commission (CPUC) has a current regulatory proceeding[94] to develop an appropriate emissions rate in term of pounds carbon dioxide per megawatt-hour. CPUC staff has proposed a rate of 1,100 pounds of carbon dioxide emissions per megawatt-hour. This value was used to project 2010 and 2020 emissions from the non-renewable portion of electricity demand growth.

Non-carbon emissions were either held constant at 2004 values, were projected using either underlying data, or data from a technical report prepared for the Energy Commission's PIER Program by ICF Consulting and titled *Emissions Reduction Opportunities for Non-*CO_2 *Greenhouse Gases in California*[95] or projected using fuel demand data from the *2005 IEPR*:

(1) GHG emissions from industrial processes were held constant at 2004 values. These emissions tend to be small in magnitude and do not tend to change over the 1990 to 2004 time period. Emissions from cement manufacturing were assumed to grow in proportion to the projected demand for natural gas use in the cement manufacturing sector. Although other fuels are likely used, including petroleum coke and waste tires, the amount of CO_2 emissions from cement clinker production was assumed to correlate better to expected future natural gas demand values than holding them constant, as was done in the earlier CAT report projections. This assumes that the fuel mix remains constant.

(2) Soils and forestry sink emissions were estimated at the average of their 1990 to 2004 values. Since historical values fluctuate over time, this seems to be a better representation than holding them constant at near-year values.

(3) Methane emissions from oil and natural gas production decline steadily over the 1990 to 2004 period. These were projected to continue to decline by about 15 percent to 2020 as stated in the ICF Consulting report. This treatment matches the earlier CAT report projections.

(4) GHG emissions from waste combustion and wastewater treatment were projected to increase with population. Methane emissions from landfills were assumed to increase as stated in the ICF Consulting report. The CAT report held the waste combustion and wastewater treatment emissions constant and used a

draft of the ICF report for landfill projections (no change in data in the final report).

(5) Agricultural emissions of methane and nitrous oxide were projected using either an extrapolation of historical trends or assumed constant. Methane emissions from enteric fermentation and manure management and nitrous oxide emissions from agricultural soil management were projected using extrapolation. Methane emissions from flooded rice fields and agricultural burning as well as nitrous oxide emissions from manure management and agricultural burning were each held constant at 2002 to 2004 average values. The earlier CAT projections for manure management were projected from the ICF report. However, these gases are combined in that report but need to be separated out for the projections.

(6) Methane and nitrous oxide emissions from mobile source combustion were projected using gasoline and diesel demand forecasts from the *2005 IEPR*. The CAT projections held these constant.

(7) Methane and nitrous oxide emissions from stationary source combustion were projected using population data from the *2005 IEPR*. The CAT projections held these constant.

(8) GHG emissions from high GWP gases, with the exception of non-refrigeration gases, were projected using data from the ICF Consulting report. The ICF Consulting report treats refrigeration gases separately, and this was incorporated in the current projections. In the most recent projections, the non-refrigeration gases are held constant at the average of their 2002 to 2004 values.

Table F-1 -- California Greenhouse Gas Emissions (from Tellus Institute, final numbers used by CAT)

Buildings, Industry, Electricity	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2010	2020
Electricity Generation Totals with Impact of Recent Policies	**86.8**	**89.8**	**100.2**	**92.7**	**99.8**	**80.7**	**77.3**	**90.9**	**100.5**	**102.7**	**103.7**	**113.6**	**108.8**	**113.6**	**125.0**
In state generating resources	**42.5**	**45.4**	**54.9**	**50.9**	**55.5**	**41.5**	**35.0**	**42.4**	**45.7**	**48.6**	**60.2**	**61.1**	**51.0**	**54.5**	**61.4**
Existing Coal Plants	4.4	3.6	4.3	3.0	3.1	1.3	3.4	2.7	3.2	4.3	3.8	4.7	5.0	5.0	5.0
Existing Gas Plants	34.6	41.4	50.3	46.2	50.9	39.8	31.1	39.6	42.3	44.3	56.5	56.4	46.1	46.1	46.1
Existing Oil Plants	3.6	0.5	0.3	1.6	1.5	0.4	0.5	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0
New (non-renewable) Electricity Generation Sources														3.5	10.4
Out of state generating resources	**44.3**	**44.4**	**45.3**	**41.8**	**44.3**	**39.2**	**42.3**	**48.5**	**54.8**	**54.1**	**43.5**	**52.5**	**57.8**	**60.5**	**65.9**
Utility owned out of state (Coal)	18.1	20.8	29.4	20.8	22.9	17.2	23.1	25.4	32.5	33.4	34.4	37.5	37.4	37.4	37.4
Imports from NW	6.6	6.0	4.1	3.2	3.2	4.1	6.2	5.3	4.1	5.4	3.9	1.4	5.7	5.7	5.7
Imports from SW	19.6	17.5	11.7	17.8	18.2	17.9	13.1	17.8	18.2	15.2	5.2	13.6	14.7	14.7	14.7
New (non-renewable) Electricity Generation Sources														2.7	8.1
Impact of Recent Policies														**(1.4)**	**(2.3)**
CPUC Energy Savings Goals (IOUs; 2004/2005 Only)														(0.9)	(1.0)
2005 Building Standards														(0.6)	(1.3)
Direct Fuel Use	**109.1**	**104.6**	**95.3**	**94.3**	**96.6**	**97.0**	**100.7**	**104.7**	**110.2**	**106.6**	**103.4**	**101.5**	**102.3**	**107.0**	**110.4**
Natural Gas	67.0	65.5	60.0	61.9	63.8	63.4	67.4	70.8	77.0	76.9	73.7	71.9	72.6	77.4	80.8
Coal	1.6	2.3	1.6	2.2	2.2	4.3	1.5	1.8	2.7	1.6	1.6	1.6	1.6	1.6	1.6
Oil (largely in refineries)	40.4	36.8	33.7	30.2	30.6	29.3	31.8	32.1	30.5	28.0	28.0	28.0	28.0	28.0	28.0
Impact of Recent Policies														**(0.1)**	**(0.3)**
CPUC Energy Savings Goals (IOUs; 2004/2005 Only)														0.0	0.0
2005 Building Standards														(0.1)	(0.3)
Direct Fuel Use With Impact of Recent Policies	**109.1**	**104.6**	**95.3**	**94.3**	**96.6**	**97.0**	**100.7**	**104.7**	**110.2**	**106.6**	**103.4**	**101.5**	**102.3**	**106.9**	**110.1**
Transportation	**1990**	1991	1992	1993	1994	1995	1996	1997	1998	1999	**2000**	2001	2002	**2010**	**2020**
On-Road Gasoline Demand	110.0	108.8	106.9	108.9	110.0	110.1	112.7	114.1	116.2	119.5	122.1	124.0	129.0	148.9	165.4
Impact of Recent Policies (switch to 5.7% ethanol in CaRFG3)														**(1.5)**	**(1.7)**
On-Road Diesel Outlook	18.9	17.1	19.7	18.2	20.1	21.1	21.2	22.9	23.4	24.1	26.0	27.5	26.0	32.1	37.3
International Bunker Fuels (mostly residual oil)	20.4	21.7	11.8	9.7	8.5	10.1	10.0	10.2	9.2	10.2	10.2	10.2	10.2	10.2	10.2
Other Petroleum (Off-Road Diesel/Gasoline, Military jetfuel, etc.)	20.1	12.5	15.1	16.6	20.4	23.2	20.2	12.9	11.4	15.3	15.3	15.3	15.3	15.3	15.3
Natural Gas	1.1	1.0	0.8	0.7	0.7	1.1	1.1	1.3	0.6	0.7	0.7	0.7	0.7	0.7	0.7
Jet Fuel - Commercial (non-military)	38.3	36.4	35.1	36.2	40.1	38.7	42.2	41.9	42.8	40.1	41.8	36.9	30.3	41.8	60.3
Transportation Totals with Impact of Recent Policies	**208.8**	**197.5**	**189.4**	**190.2**	**199.9**	**204.3**	**207.4**	**203.3**	**203.6**	**209.9**	**216.1**	**214.5**	**211.5**	**247.4**	**287.5**
Fossil Fuel CO2 Subtotals	**1990**	1991	1992	1993	1994	1995	1996	1997	1998	1999	**2000**	2001	2002	**2010**	**2020**
With Electric Imports, Bunker Fuel, and International Fuels Included:															
Base Case Projections (Carbon Dioxide Only)	**404.7**	**391.9**	**384.9**	**377.2**	**396.2**	**382.0**	**385.5**	**398.9**	**414.3**	**419.1**	**423.2**	**429.6**	**422.6**	**467.8**	**522.6**
Non-Carbon GHG Emissions (in CO2 Equivalents)															
Agriculture (CH4 and N2O)	27.1	25.7	26.3	26.6	26.8	29.1	28.2	27.3	27.4	28.4	28.7	28.8	28.8	29.0	28.6
Soils and Forests Carbon Sinks	(25.6)	(25.2)	(21.0)	(20.7)	(20.3)	(19.9)	(19.6)	(19.3)	(19.1)	(18.8)	(18.8)	(18.8)	(18.8)	(18.8)	(18.8)
ODS substitutes	0.1	0.1	0.2	0.7	1.2	2.9	4.2	5.2	6.1	7.0	8.0	9.1	10.2	19.2	31.0
Semi-conductor manufacture (PFCs)	0.4	0.4	0.4	0.5	0.5	0.7	0.9	0.9	0.8	0.8	2.3	2.3	2.3	2.3	2.3
Electric Utilities (SF6)	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.9	1.8	1.9	0.4	0.4	0.4	0.4	0.4
Cement, Other Industrial Processes	5.8	5.4	5.2	5.1	5.7	6.0	5.9	6.1	6.2	6.5	6.5	6.5	6.5	6.5	6.5
Solid Waste Management, Landfill Gas, and Wastewater	19.5	19.5	19.7	19.9	19.6	19.2	17.7	16.9	15.0	15.9	23.3	23.6	23.8	26.0	27.7
Methane from oil and gas systems	3.9	3.8	3.9	3.4	3.3	3.4	3.3	3.3	3.3	3.3	2.2	2.2	2.2	2.2	2.2
Methane and N20 from Fossil Fuel Combustion	8.5	8.7	8.8	8.7	8.6	8.4	8.2	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Total Non-Carbon GHG Emissions	**41.3**	**40.0**	**45.3**	**46.0**	**47.3**	**51.5**	**50.5**	**49.9**	**49.1**	**52.7**	**60.3**	**61.7**	**63.1**	**74.3**	**87.5**
TOTAL BASELINE GREENHOUSE GAS EMISSIONS	**1990**	1991	1992	1993	1994	1995	1996	1997	1998	1999	**2000**	2001	2002	**2010**	**2020**
	446	432	430	423	444	434	436	449	463	472	483	491	486	542	610
Totals Excluding International Bunker Fuels	**426**	**410**	**418**	**413**	**435**	**423**	**426**	**439**	**454**	**462**	**473**	**481**	**475**	**532**	**600**
Reductions Needed to Meet Governor's GHG Reduction Goals:														**59**	**174**

Table F-2 -- California Greenhouse Gas Emissions
(Energy Commission's 1990 to 2004 GHG Inventory & 2005 IEPR for Projections)

(Projections are 3-yr average centered on 2002)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2010	2020
Buildings, Industry, Electricity																	
Electricity Generation Totals with Impact of Recent Policies	**80**	**80**	**87**	**81**	**91**	**75**	**74**	**83**	**93**	**95**	**92**	**103**	**94**	**101**	**108**	**119**	**129**
In state generating resources	**37**	**37**	**44**	**40**	**48**	**36**	**34**	**36**	**40**	**43**	**52**	**56**	**42**	**44**	**47**	**63**	**69**
Existing Coal Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Gas Plants	36	37	44	40	48	36	34	36	40	43	52	56	42	44	47	63	69
Existing Oil Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Out of state generating resources	**43**	**43**	**43**	**41**	**43**	**39**	**41**	**47**	**53**	**52**	**40**	**47**	**52**	**56**	**61**	**56**	**61**
Utility owned out of state (Coal)	17	19	27	19	21	16	21	23	30	31	31	22	22	22	23	22	22
Imports from PNW	6	5	4	3	3	4	6	5	4	5	4	4	6	8	7	N/A	N/A
Imports from PSW	21	19	12	19	19	19	14	19	19	16	6	22	24	27	31	N/A	N/A
GWH Growth																34	38
Impact of Recent Policies																	
CPUC Energy Savings Goals (IOUs; 2004/2005 Only)																	
2005 Building Standards																	
Direct Fuel Use	**109**	**107**	**99**	**103**	**106**	**100**	**105**	**109**	**119**	**118**	**123**	**120**	**122**	**109**	**107**	**113**	**116**
Natural Gas	65	64	59	60	62	62	65	69	80	79	79	73	74	66	68	74	79
Coal	3	3	3	2	3	3	3	4	4	4	4	4	4	4	4	4	4
Oil (largely still gas & pet. Coke used in refineries)	40	39	37	40	41	35	36	37	36	34	38	42	39	36	35	35	32
Non-specified Fuel Use (balancing entry)	1	1	0	1	1	1	0	0	0	1	1	1	5	2	0	0	0
Natural Gas Liquids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Impact of Recent Policies																	
CPUC Energy Savings Goals (IOUs; 2004/2005 Only)																	
2005 Building Standards																	
Direct Fuel Use With Impact of Recent Policies	**109**	**107**	**99**	**103**	**106**	**100**	**105**	**109**	**119**	**118**	**123**	**120**	**122**	**109**	**107**	**113**	**116**
Transportation																	
On-Road Gasoline Demand (before switch from MTBE to Ethanol)	111	109	115	113	113	115	114	115	117	120	122	125	131	126	131	144	145
Impact of Recent Policies (switch to ~6% ethanol in CaRFG; only needed for 2010 & 2020)																(2.0)	(2.1)
On-Road Diesel Outlook	23	22	23	21	24	24	25	27	27	28	30	30	31	31	32	38	50
International Bunker Fuels (mostly residual oil)	40	35	28	28	32	36	35	27	27	30	34	32	32	24	26	26	26
Other Petroleum (Off-Road Diesel/Gasoline, Military jetfuel, etc.)	3	3	2	2	2	3	2	2	2	2	3	2	2	2	2	2	2
Natural Gas	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0
Jet Fuel - Commercial (non-military)	24	23	22	23	25	24	26	26	27	25	26	25	26	21	22	29	38
Transportation Totals with Impact of Recent Policies	**161**	**157**	**162**	**159**	**164**	**166**	**167**	**171**	**173**	**176**	**182**	**182**	**190**	**181**	**188**	**211**	**233**

Table F-2 -- California Greenhouse Gas Emissions
(Energy Commission's 1990 to 2004 GHG Inventory & 2005 IEPR for Projections)

(Projections are 3-yr average centered on 2002)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2010	2020
Fossil Fuel CO2 Subtotals																	
With Electric Imports and International Fuels Included:																	
Base Case Projections (Carbon Dioxide Only)	**350**	**343**	**348**	**343**	**361**	**341**	**347**	**364**	**385**	**389**	**397**	**406**	**406**	**390**	**403**	**444**	**478**
Non-Carbon GHG Emissions (in CO2 Equivalents)																	
Agriculture (CH4 and N2O)	26.8	25.5	26.0	26.4	26.6	28.7	27.8	26.8	27.0	27.9	29.6	29.4	33.8	33.9	34.0	35.7	40.6
Soils and Forests Carbon Sinks	(17.2)	(16.7)	(15.1)	(17.1)	(15.4)	(14.9)	(14.5)	(14.0)	(11.8)	(14.4)	(14.5)	(12.7)	(16.0)	(14.6)	(14.9)	(15.1)	(15.1)
ODS substitutes	4.5	4.9	5.3	5.7	6.1	6.5	8.4	9.8	6.7	7.8	8.6	9.5	10.5	11.4	12.6	19.9	30.7
Semi-conductor manufacture (PFCs)	0.4	0.4	0.4	0.5	0.5	0.7	0.7	0.8	0.9	0.9	0.8	0.5	0.5	0.5	0.6	2.5	5.7
Electric Utilities (SF6)	2.3	2.2	2.2	2.2	2.2	2.1	2.3	2.1	1.3	1.2	1.1	1.1	1.0	1.0	1.0	1.5	1.9
Cement, Other Industrial Processes	5.7	5.3	4.8	5.3	6.0	6.0	6.2	6.3	6.3	6.5	6.7	6.3	6.9	7.1	7.3	7.4	7.3
Solid Waste Management, Landfill Gas, and Wastewater	10.7	10.5	10.3	11.1	10.8	10.5	11.0	8.8	10.4	10.7	10.6	10.9	11.0	11.2	11.5	11.8	12.8
Methane from oil and gas systems	2.6	2.4	1.9	2.3	2.2	2.1	2.1	2.0	1.9	2.0	1.9	1.9	1.8	1.9	1.9	1.9	2.1
Methane and N20 from Fossil Fuel Combustion	18.3	16.6	15.9	16.9	15.7	16.6	15.3	15.3	15.1	15.0	15.7	15.2	14.9	14.5	13.8	16.5	16.9
Total Non-Carbon GHG Emissions	**54.2**	**51.0**	**51.7**	**53.2**	**54.7**	**58.3**	**59.2**	**57.9**	**57.7**	**57.6**	**60.4**	**62.2**	**64.6**	**66.9**	**67.9**	**82.1**	**102.8**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2010	2020
TOTAL BASELINE GREENHOUSE GAS EMISSIONS	**404**	**394**	**400**	**396**	**416**	**399**	**407**	**422**	**443**	**447**	**457**	**469**	**470**	**457**	**471**	**526**	**581**
Reductions Needed to Meet Governor's GHG Reduction Goals:																**68**	**177**
CAT Reductions:																59	174

APPENDIX G

CHANGES AFTER THE NOVEMBER 30, 2006 WORKSHOP

Submitted Comments and Replies

The Energy Commission opened a docket to receive comments on a draft of this report. The docket number is 06-IEP-1G. The following information summarized docketed comments. More detail can be found in the docketed submissions.

Steven Brink, California Forestry Association

Mr. Brink asked for more details on the method used to estimate forest sinks. These additional details are provided on page 45 of the final report as follows:

> A portion of the carbon associated with harvested forest wood is sequestered in long-term wood products. For softwoods, 75 percent is extracted from the forest and 44 percent of the extracted volume is stored in these long-term products. For hardwoods, 73 percent is extracted and 23 percent of the extracted hardwood volume is stored in long-term products.

Mr. Brink also referred to what he described as an "inappropriate forestry protocol for the carbon equation." The GHG inventory used research work performed by Winrock International, not a forestry protocol.

Mr. Brink stated that changes in forestry management could be an important tool for climate change mitigation. The Energy Commission agrees, although mitigation options are outside the scope of the GHG emissions inventory.

Bud Hoekstra, BerryBlest Organic Farm

Mr. Hoekstra commented that organic farming needs to be studied and that increased organic farming could be an important global warming mitigation option. Although mitigation options are outside the scope of the GHG emissions inventory, the Energy Commission agrees that changes in agricultural practices (including increased use of organic farming) could become an important mitigation option and the Energy Commission's Public Interest Research and Development (PIER) Program is studying them.

David Coale, Palo Alto/Stanford Green Ribbon Task Force

Mr. Coale stated that it was difficult to find baseline and future "business-as-usual" values for transportation. He recommended implementing a new law requiring odometer readings to be taken at the time of vehicle registration to allow computation of fuel consumption by vehicle class by combining miles traveled with typical fuel economy of that class. This comment is outside the scope of the GHG emissions inventory, although having such information would enable transportation fuel consumption to be subdivided by vehicle class and this would enrich the GHG inventory data.

Randy S. Howard, Los Angeles Department of Water and Power

Mr. Howard submitted data that his company had reported to the California Climate Action Registry. The table below summarizes that data.

Year	LADWP Emissions (Million Metric Tons of Carbon Dioxide)
2000	18.4
2001	17.8
2002	16.4
2003	16.9
2004	17.4

The GHG inventory in this report includes data for total electricity generation within the State of California and GHG emissions associated with electricity imported into the state. It does not break down this data by load-serving entity (LSE) and the data submitted by LADWP cannot be reconciled against this GHG inventory data.

Errata

In the draft report, some of the data in Table 2, page 3 were incorrect because a portion of the data represented net emissions, when gross emissions were needed for consistency with other tables in this section. The correct values were shown in Table 5.

Endnotes number 10 & 55 were updated from a draft report on the California Energy Balance to the final report. The bibliography was also updated.

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ENDNOTES

[1] Derived from U. S. Department of Commerce, Bureau of Economic Analysis, June 6, 2006, [http://www.bea.gov/bea/regional/gsp/], (accessed October 3, 2006). California's GSP grew from $788.3 trillion dollars in 1990 to $1,410.5 trillion dollars in 2003, for an increase of 83 percent. Correspondingly, Texas' GSP grew from $384.1 trillion dollars in 1990 to $828.5 trillion dollars in 2003, for an increase of 115 percent.

[2] Data are for total greenhouse gas emissions and include emissions from electricity imported into California, from World Resources Institute's Climate Analysis Indicators Tool. Strictly speaking, California was the sixteenth largest emitter of CO_2 in 2002. Other estimates place the California ranking higher, and rankings as high as tenth are possible. Since the magnitude of the differences among the ranked governmental bodies (all are countries except for California and Texas) are small, the exact ranking is rather arbitrary and not worth debating. California and Texas are both major contributors to world-scale greenhouse gas emissions.

[3] NRDC comments to the Energy Commission, April 5, 2005.

[4] Gross emissions represent emissions without taking into account emissions reductions, or sinks. The term "CO_2-equivalent" (also expressed as "CO_2-equivalent") is used to describe the ensemble of GHG gases that contribute to global warming, including CO_2, methane, nitrous oxide, and a class of gases called high GWP gases (see end note 20 for this definition). These non-CO_2 gases cause the atmosphere to heat (called "radiative forcing") at a faster rate than CO_2. To determine CO_2-equivalence of these non- CO_2 gases, CO_2 is given a weighting factor of 1.0, and the other gases are given a weighting factor that represents their rate of warming compared to CO_2. These weighting factors are called "GWPs" and are usually based upon the impact of the subject gas estimated over a 100-year period of time. These GWPs are studied and reported through an international review process.

[5] The term "anthropogenic" is used to describe something that is human-derived rather than naturally occurring.

[6] Intergovernmental Panel on Climate Change (2001), *Climate Change 2001: Synthesis Report, Summary for Policy Makers,* page 2, [http://www.grida.no/climate/ipcc_tar/vol4/english/076.htm].

[7] Energy Commission, June 2005, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update*, Sacramento, California, CEC-600-2005-025, [http://www.energy.ca.gov/2005publications/CEC-600-2005-025/index.html].

[8] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[9] EPA, June 2003 and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

[10] California Energy Commission, June 2005, *Development of Energy Balances for the State of California*, Sacramento, California, CEC-500-2005-068, prepared by Lawrence Berkeley National Laboratory.

[11] EPA, June 2003 and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

[12] Because it was not possible to obtain full GHG inventory data for the other states, staff used estimates of CO_2 emissions from fossil fuel combustion to compare California emissions to other states and to evaluate how they compare in relative GHG emissions intensity.

[13] California Energy Commission, October 1990, 1988 *Inventory of California Greenhouse Gas Emissions*, Sacramento, California, Final Staff Report.

[14] California Energy Commission, March 1997, *California's Greenhouse Gas Emissions Inventory 1990*, Sacramento, California, P500-97-004.

[15] See Footnote 4 for definition.

[16] The term "international bunker fuels" applies to fuels used in international aviation or marine transportation. In accordance with international GHG emissions reporting procedures, in the current inventory these emissions are calculated and reported separately but are not considered a part of the California GHG emissions inventory.

[17] California Energy Commission, January 1998, *Appendix A. Historical and Forecasted Greenhouse Gas Emissions Inventories for California*, Sacramento, California, P500-98-001V3.

[18] Environmental Science and Technology, Volume 4, 2001,*Uncertainties in Greenhouse Gas Emissions Inventories—Evaluation, Comparability and Implications*, pages 107 to 116.

[19] Ibid, page 108.

[20] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[21] California Energy Commission, June 2005*, Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002*, Sacramento, CA, Publication CEC-600-2005-025, [http://www.energy.ca.gov/2005publications/CEC-600-2005-025/CEC-600-2005-025.PDF].

[22] The term "high GWP gases" is applied to a series of gases used in industrial processes, including perfluorocarbons, hydrofluorocarbons, and SF_6. These are used mainly as replacements for ozone-depleting industrial gases (see separate end note for definition), as byproducts of manufacturing processes, for semiconductor manufacturing, and for electric power transmission and distribution switchyard gear.

[23] The term "transportation" includes CO_2, methane, and nitrous oxide emissions from on-road and off-road uses of petroleum and natural gas fuels. Petroleum transportation fuel use includes liquefied petroleum gas, motor gasoline, aviation gasoline, jet fuel, distillate, residual oil, lubricants, and pipeline transport of fuels. Natural gas transportation fuel use includes rail, road, water, and air (most likely ground support equipment at airports).

[24] The term "industrial" includes CO_2 emissions from coal use and petroleum use (including LPG, motor gasoline, refinery still gas, kerosene, distillate, residual oil, petroleum coke, lubricants, and special naphtha). It also includes industrial activities that produce CO_2 directly from their production or use, including cement production, lime production, limestone and dolomite consumption, soda ash consumption, and waste combustion. Industrial GHGs also include methane emissions from petroleum and natural gas extraction, transmission, storage and marketing; landfill emissions; waste water treatment; and industrial fuel combustion. Industrial GHGs also include nitrous oxide emissions from waste combustion; municipal waste (formerly

called “human waste”); and industrial fuel use, including wood. Finally, industrial GHGs also include high GWP gases used as substitutes for ozone-depleting gases (see definition in separate note) and in semiconductor manufacture. Because the trend analysis is based upon gross emissions to the degree possible, it excludes emissions reductions from yard trimmings and lumber disposal and associated increased CO_2 emissions atmosphere.

[25] The term “agriculture” includes CO_2 emissions from natural gas used in crop production, livestock production and irrigation; rangeland, woody crop, and non-woody crop management and soil liming. Agricultural GHG gases also include methane emissions from enteric fermentation, manure management, rice field flooding, and agricultural burning. Agricultural GHG gases also include nitrous oxide emissions from manure management and agricultural residue burning. Because the trend analysis is based upon gross emissions to the degree possible, emissions reductions from expanding rangelands and associated increased CO_2 removal from the atmosphere are excluded.

[26] The term “forestry” includes CO_2 emissions from forestry management. Because the trend analysis is based upon gross emissions to the degree possible, emissions reductions from expanding forestry management and associated increased CO_2 removal from the atmosphere are excluded.

[27] The term “commercial” includes CO_2 emissions from coal, petroleum (includes LNG, motor gasoline, kerosene, distillate, and residual oil), and natural gas (includes education, food services, retail, and wholesale, healthcare, hotel, office, transportation services, communication, utilities excluding electricity production, national security, and non-specified services), and non-specified fuel uses. Commercial GHG gas also include methane emissions from petroleum, natural gas, wood and non-specified fuel use; and nitrous oxide emissions from coal, petroleum, natural gas, and wood use.

[28] The term “residential” includes CO_2 emissions from liquefied natural gas, kerosene, and distillate; methane emissions from petroleum, natural gas, and wood; and nitrous oxide emissions from coal, petroleum, natural gas, and wood.

[29] The term “residual oil” is applied to one of the distilled products from refining crude oil. Residual oil is the heavy residue that remains in liquid form after more valuable products such as gasoline and distillate are recovered. It is often used in other states as an industrial fuel but ARB regulations often preclude its use in California.

[30] The trend analysis includes out-of-state GHG emissions because energy policy decisions made by the State of California, including the Energy Commission, will affect emissions both within and outside the state. GHG inventory guidelines established by the International Panel on Climate Change (IPCC) and by the EPA do not require reporting emissions from within one political boundary that that supply energy to another political entity. Thus, out-of-state GHG emissions do not need to be considered when developing GHG inventories. Out-of-state GHG emissions from electricity production are reported separately from in-state emissions in the GHG inventory. As noted elsewhere in this document, in-state GHG emissions for electricity exported are small and included as in-state GHG emissions. Policy decisions in other end-use sectors such as petroleum fuel use should consider out-of-state emissions affected by the policy decision to the extent possible.

[31] The category “Other Transportation Fuels” includes CO_2 from aviation gasoline, liquefied petroleum gas, residual oil, and lubricating oil; nitrous oxide from diesel fuel and aviation gasoline; and other minor sources.

[32] These "other" emissions are CO_2 emissions from fuel end-uses not specified in the *California Energy Balances Report*.

[33] These industrial gases are being used in increasing amounts due to the Montreal Protocol to mitigate loss of high-altitude ozone. The Montreal Protocol on Substances That Deplete the Ozone Layer is a landmark international agreement designed to protect the stratospheric ozone layer. The treaty was originally signed in 1987 and substantially amended in 1990 and 1992. The Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere--chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform--are to be phased out by 2000 (2005 for methyl chloroform). Scientific theory and evidence suggest that, once emitted to the atmosphere, these compounds could significantly deplete the stratospheric ozone layer that shields the planet from damaging UV-B radiation.

[34] Data from Form 1.2, California Energy Commission, September 2005, California Energy Demand 2006-2016; Staff Energy Demand Forecast, Revised September 2005, CEC-400-2005-034-SF-ED2.

[35] The *California Energy Balances Report* indicates a small amount of coal is combusted in utility and industrial combined heat and power facilities.

[36] These emissions per gigawatt-hour (GWH) are based upon all sources of electricity used, including those that are carbon free.

[37] The term "emissions intensity trends" as used in this section represents the efficiency of using carbon-based fuels and other activities that emit GHGs. The intensity is measured with respect to the economic activity as measured by Gross State Product and as measured by the magnitude of the population. This term is not to be confused with the term "carbon intensity," which often refers to the carbon content of a fuel relative to other fuels; natural gas is considered to be a fuel with low carbon intensity while coal is considered to be a fuel with relatively high carbon intensity.

[38] California's CO_2 emissions from fossil fuel combustion comprise about 83 percent of total GHG emissions when imported electricity is excluded or about 84 percent when imported electricity is included. The percentage changes very little over the 1990 to 2001 period. These percentages are consistent with the percent gas composition for Washington (81 percent in 1990; 85 percent in 2000), Connecticut (90.5 percent in 2000), Pennsylvania (90.3 percent in 1999) and Michigan (86.2 percent in 1990; 86.5 percent in 2002) but somewhat greater than Iowa (79.5 percent in 1990; 67.1 percent in 2000) and Oklahoma (58.9 percent in 1990; 58.2 percent in 1999). Percentages for the United States overall were 77 percent in 1990; 80 percent in 2004).

[39] U. S. Department of Commerce, Bureau of Economic Analysis, December 15, 2004, [http://www.bea.gov/bea/regional/gsp/], (April 2005).

[40] Although Texas is at the top of Figure 5, it is in the middle of Figure 6. California's gross emissions are second from the top in Figure 5 but near the bottom of Figure 6. On the other hand, Wyoming is near the bottom of Figure 5, but at the top of Figure 6.

[41] The term GSP means the total value of the goods and services produced by the residents of the state during a specific period, such as a year.

[42] U.S. Environmental Protection Agency web site, [http://epa.gov/climatechange/emissions/state.html], October 26, 2006.

[43] U. S. Department of Commerce, Bureau of Economic Analysis web site, [http://bea.gov/bea/regional/gsp.htm], October 26, 2006.

[44] World Resources Institute, Climate Analysis Indicator Tool, Version 3, [http://cait.wri.org]. October 26, 2006.

[45] United Nations, [http://unstats.un.org/unsd/snaama/dnllist.asp], October 26, 2006.

[46] Energy Commission, July 2005, *Emission Reduction Opportunities for Non-CO2 Greenhouse Gases in California*, Sacramento, California, CEC-500-2005-121.

[47] Executive Order S-3-05, June 1, 2005, [http://www.governor.ca.gov/state/govsite/gov_htmldisplay.jsp?BV_SessionID=@@@@1044157704.1119371305@@@@&BV_EngineID=cccdaddemgghlmicfngcfkmdffidfng.0&iOID=69591&sTitle=Executive+Order+S-3-05&sFilePath=/govsite/executive_orders/20050601_S-3-05.html&sCatTitle=Exec+Order], June 21, 2005, [http://www.climatechange.ca.gov/climate_action_team/index.html].

[48] California Environmental Protection Agency, March 2006, Climate Action Team Report to Governor Schwarzenegger and the Legislature, July 31, 2006.

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[50] California Energy Commission, December 2003, *2003 Integrated Energy Policy Report*, Publication Number 100-03-019, [http://www.energy.ca.gov/2003_energypolicy/index.html].

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ATTACHMENT E

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Draft Guidance Document – Interim CEQA Greenhouse Gas (GHG) Significance Threshold

October 2008

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This Draft *Guidance Document – Interim CEQA Greenhouse Gas (GHG) Significance Threshold* document contains the proposed interim GHG significance threshold, rationale for developing the threshold, and details of the working group meetings and represents a work-in-progress of staff's efforts to date. This document will be updated as more information becomes available. For the staff recommendation to the Governing Board at the December 5, 2008 public hearing, please refer to Attachment A of Agenda Item Number 31.

Finally, to facilitate identifying changes to this Guidance Document since its release in October 2008, added text is underlined and deleted text is denoted with ~~strikethrough~~ text.

LIST OF ACRONYMS AND ABBREVIATIONS

List of Acronyms and Abbreviations

Acronym/ Abbreviation	Definition
AB 32	Assembly Bill 32 Global Warming Solutions Act of 2006
AER	Annual Emission Reporting
AG	Attorney General
ARB	Air Resources Board
BACT	Best Available Control Technology
BARCT	Best Available Retrofit Control Technology
BAU	Business as Usual
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resource Board
CAT	Climate Action Team
CCAR	California Climate Action Registry
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CPUC	California Public Utilities Commission
EIR	Environmental Impact Report
EPA	U.S. Environmental Protection Agency
FY	Fiscal Year
GHG	Greenhouse Gas
GGRP	Greenhouse Gas Reduction Plan
GP	General Plan
GWP	Global Warming Potential
IGR	Intergovernmental Review
IPCC	International Panel on Climate Change
ITE	Institute of Transportation Engineers
km	Kilometer
LNG	Liquefied Natural Gas
MMBTU	Million British Thermal Units
MND	Mitigated Negative Declaration
MMT CO_2e	Million Metric Tons Carbon Dioxide Equivalent
MW	Megawatts
N_2O	Nitrous Oxide
ND	Negative Declaration
NO_X	Oxides of Nitrogen
OPR	State Office of Planning and Research
PFC	Perfluorocarbon

List of Acronyms and Abbreviations (Concluded)

Acronym/ Abbreviation	Definition
PM	Particulate Mater
ROG	Reactive Organic Gas
RPS	Renewable Portfolio Standards
S-3-05	Executive Order S-3-05
SB	Senate Bill
SCAQMD	South Coast Air Quality Management District
SIP	State Implementation Plan
SO_X	Sulfur Oxides
TAC	Toxic Air Contaminants
URBEMIS	Urban Emissions Model
VMT	Vehicle Miles Traveled

CHAPTER 1

INTRODUCTION AND EXECUTIVE SUMMARY

Introduction

Purpose of This Guidance Document

California Environmental Quality Act and GHGs

Legal Authority

Contents of This Guidance Document

INTRODUCTION

The California Environmental Quality Act (CEQA) requires public agencies in California to analyze potential adverse impacts for proposed projects undertaken by a public agency, funded by a public agency, and requiring discretionary approval by a public agency. The fundamental purposes of CEQA are to inform governmental decision-makers and the public about the significant environmental effects of proposed activities, identify ways to avoid or significantly reduce environmental damage, use feasible alternatives or mitigation measures to avoid significant damage, and disclose to the public why a governmental agency approved a project if significant effects are involved (CEQA Guidelines §15002[a]). To disclose potential adverse impacts from a proposed project, pursuant to CEQA lead agencies typically prepare multidisciplinary environmental impact analysis and make decisions based on the analysis regarding the environmental effects of the proposed project (CEQA Guidelines §15002[a]).

In the past, air quality analyses tended to focus on potential adverse impacts from criteria pollutants and toxic air contaminants. Subsequent to the adoption of Assembly Bill (AB) 32 – The California Global Warming Solutions Act of 2006, lead agencies have increasingly faced legal challenges to their CEQA documents for failure to analyze greenhouse gases (GHGs) or making a determination of significance regarding GHG emission impacts.

Greenhouse gases are those gases that have the ability to trap heat in the atmosphere, a process that is analogous to the way a greenhouse traps heat. GHGs may be emitted as a result of human activities as well as through natural processes. As a result of human activities, such as electricity production, vehicle use, etc., GHGs have been accumulating in the earth's atmosphere at a faster rate than has occurred historically, i.e., prior to the Industrial Age starting approximately 150 years ago. Increasing GHG concentrations in the atmosphere are leading to global climate change.

The Intergovernmental Panel on Climate Change (IPCC) provided the first unequivocal evidence that global climate temperatures are increasing (2007a). Further, the primary driver of global climate change is increased emissions of GHGs due to human activities. According to the IPCC, there is very high confidence, based on more evidence from a wider range of species, that recent warming is strongly affecting terrestrial, marine, freshwater biological systems.

Carbon dioxide (CO2) is the most important anthropogenic GHG because it comprises the majority of total GHG emissions emitted per year and it is very long-lived in the atmosphere. Annual emissions of CO2 have increased approximately 80 percent between 1970 and 2004. In addition to CO2, other GHG pollutants emitted directly as a result of human activities include methane (CH4), nitrous oxide (N2O) and halocarbons (a group of gases containing fluorine, chlorine or bromine). Without changes in current climate change mitigation policies and related sustainable development practices, GHG emissions and global climate temperatures will continue to increase.

To prevent or minimize further increases in global temperatures resulting from increases in GHG emissions due to human activities, it is necessary to stabilize the concentration of GHGs in the atmosphere. Stabilizing GHGs in the atmosphere can only occur through reducing GHG emissions. Without further reductions in GHGs, increased global temperatures will surpass humans' and ecosystems' ability to adapt to these changing conditions (IPCC, 2007b).

In response to the increasing body of evidence that GHGs will continue to affect global climate, Governor Schwarzenegger issued executive order (EO S-3-05), which established the following greenhouse gas emission reduction targets for California: by 2010, reduce GHG emissions to 2000 levels; by 2020, reduce GHG emissions to 1990 levels; by 2050, reduce GHG emissions to 80 percent below 1990 levels.

Subsequent to the Governor's issuance of EO S-3-05, the California State Legislature adopted Assembly Bill (AB) 32 – The California Global Warming Solutions Act of 2006. With the adoption of AB 32, the California State Legislature recognized the growing concern regarding changes to global climate resulting from increasing emissions of greenhouse gases (GHGs). AB 32 establishes a cap on statewide greenhouse gas emissions and sets forth the regulatory framework to achieve the corresponding reduction in statewide emissions levels. Specifically, (AB 32) recognizes the serious threat to the "economic wellbeing, public health, natural resources, and the environment of California" that results from global warming. Consequently, AB 32 mandates a significant reduction in GHGs in order to contribute to efforts to stabilize atmospheric concentrations of GHGs. Under AB 32, greenhouse gases are defined as: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

In general, there is currently an absence of regulatory guidance with regard to analyzing GHG emission impacts in CEQA documents. Similarly, no public agency in California has formally adopted GHG significance thresholds. Recognizing the absence of guidance regarding analyzing and determining the significance of GHGs, the California Air Pollution Control Officers Association (CAPCOA) prepared a White Paper reviewing policy choices, analytical tools, and mitigation strategies for GHGs. In particular, the White Paper identifies a number of options for establishing GHG significance thresholds, but makes no formal recommendation of one approach over another.

Air districts typically act in an advisory capacity to local governments in establishing the framework for environmental review of air pollution impacts under CEQA. This may include recommendations regarding significance thresholds, analytical tools to estimate emissions and assess impacts, and mitigations for potentially significant impacts. Although districts will also address some of these issues on a project-specific basis as responsible agencies, they may provide general guidance to local governments on these issues.

Because of its expertise in establishing air quality analysis methodologies and comprehensive efforts to establish regional and localized significance thresholds for criteria pollutants, local public agencies have asked South Coast Air Quality Management District (SCAQMD) for guidance in quantifying GHG impacts and recommending GHG significance thresholds to assist them with determining whether or not GHG impacts in their CEQA documents are significant. As a result, SCAQMD staff has received requests from a number of public agencies and other stakeholders to provide guidance on analyzing GHG impacts and establishing a GHG significance threshold. In response to these requests from the various stakeholders, SCAQMD established a stakeholder working group to receive input on establishing a GHG significance threshold. In the meantime, SCAQMD staff has joined many other stakeholders urging CARB to establish a statewide threshold for GHGs. In the absence of a statewide threshold, SCAQMD staff will recommend its interim approach to the Governing Board for consideration and it will also become the SCAQMD's input to the statewide process.

PURPOSE OF THIS GUIDANCE DOCUMENT

The purpose of this Guidance Document, therefore, is to provide information on GHG legislation relative to CEQA, a brief summary of the Working Group process, development of the resulting staff-recommended interim GHG significance threshold proposal, and how to use it. This Guidance Document also provides information on the SCAQMD's authority to establish a GHG significance threshold pursuant to CEQA and some background information on GHGs and global climate change. This Guidance Document also discusses future efforts to further refine the interim GHG significance threshold as necessary, includes recommendations for analyzing GHG impacts using current modeling tools, and describes measures to mitigate GHG emission impacts.

CALIFORNIA ENVIRONMENTAL QUALITY ACT AND GHGS

- California Attorney General's Office

Subsequent to adopting AB 32, the California Attorney General's Office determined that GHG emissions contributing to global climate change also contribute to potential adverse environmental impacts that should be evaluated pursuant to the California Environmental Quality Act (CEQA). The Attorney General's Office has submitted numerous comment letters to lead agencies on their CEQA documents for failure to analyze GHG emissions, failure to make a significance determination, and failure to implement feasible mitigation measures to reduce GHG emissions to the maximum extent feasible.

For example, the California Attorney General, on behalf of the people of California, filed a legal challenge against the County of San Bernardino for failure to analyze "reasonably foreseeable" GHG emissions in the CEQA document prepared for its

General Plan update. The County reached a settlement with the Attorney General by committing to developing a GHG inventory and a plan for reducing GHGs.

Similarly, the California Attorney General submitted comments on the CEQA document for a refinery in northern California. Although GHG emissions were quantified, the Attorney General cited the failure of the lead agency to make a determination of significance relative to GHG emissions stating, "[E]ven if there is no established threshold in law or regulation, lead agencies are obligated by CEQA to determine significance. Neither CEQA, nor the regulations, authorize reliance on the lack of an agency-adopted standard as the basis for determining that a project's potential cumulative impact is not significant." In other words, the absence of a threshold does not in any way relieve lead agencies of their obligations to address GHG emissions from projects under CEQA. By not concluding whether or not a project is significant, the lead agency may be avoiding its responsibility to implement GHG mitigation measures.

- Senate Bill (SB) 97 – CEQA: Greenhouse Gas Emissions

In August 2007, Governor Schwarzenegger signed into law Senate Bill (SB) 97 – CEQA: Greenhouse Gas Emissions stating, "This bill advances a coordinated policy for reducing greenhouse gas emissions by directing the Office of Planning and Research (OPR) and the Resources Agency to develop CEQA guidelines on how state and local agencies should analyze, and when necessary, mitigate greenhouse gas emissions." Specifically, SB 97 requires OPR, by July 1, 2009, to prepare, develop, and transmit to the Resources Agency guidelines for the feasible mitigation of greenhouse gas emissions or the effects of greenhouse gas emissions, as required by CEQA, including, but not limited to, effects associated with transportation or energy consumption. The Resources Agency would be required to certify and adopt those guidelines by January 1, 2010. OPR would be required to periodically update the guidelines to incorporate new information or criteria established by the State Air Resources Board pursuant to the California Global Warming Solutions Act of 2006. SB 97 also identifies a limited number of types of projects that would be exempt under CEQA from analyzing GHG emissions. Finally, the legislation will be repealed on January 1, 2010.

- Office of Planning and Research Technical Advisory

Consistent with SB 97, on June 19, 2008, OPR released its *Technical Advisory on CEQA and Climate Change*, which was developed in cooperation with the Resources Agency, the California Environmental Protection Agency (Cal/EPA), and the California Air Resources Board (CARB). According to OPR, the *Technical Advisory* offers the informal interim guidance regarding the steps lead agencies should take to address climate change in their CEQA documents, until CEQA guidelines are developed pursuant to SB 97 on how state and local agencies should analyze, and when necessary, mitigate greenhouse gas emissions.

According to OPR, lead agencies should determine whether greenhouse gases may be generated by a proposed project, and if so, quantify or estimate the GHG emissions by type and source. Second, the lead agency must assess whether those emissions are individually or cumulatively significant. When assessing whether a project's effects on climate change are "cumulatively considerable" even though its GHG contribution may be individually limited, the lead agency must consider the impact of the project when viewed in connection with the effects of past, current, and probable future projects. Finally, if the lead agency determines that the GHG emissions from the project as proposed are potentially significant, it must investigate and implement ways to avoid, reduce, or otherwise mitigate the impacts of those emissions.

- SB 375 (Steinberg) Transportation, Land Use, and the California Environmental Quality Act (CEQA)

On September 30, 2008, Governor Schwarzenegger signed into law SB 375 (Steinberg). SB 375 focuses on housing and transportation planning decisions to reduce fossil fuel consumption and conserve farmlands and habitat. This legislation is important to achieving AB 32 goals because greenhouse gas emissions associated with land use, which includes transportation, are the single largest sector of emissions in California. Further, SB 375 provides a path for better planning by providing incentives to locate housing developments closer to where people work and go to school, allowing them to reduce vehicle miles traveled (VMT) every year. The following bullet points summarize some of the main provisions of the bill.

- Require the regional governing bodies in each of the state's major metropolitan areas to adopt, as part of their regional transportation plan, a "sustainable community strategy" that will meet the region's target for reducing GHG emissions. These strategies would get people out of their cars by promoting smart growth principles such as: development near public transit; projects that include a mix of residential and commercial use; and projects that include affordable housing to help reduce new housing developments in outlying areas with cheaper land and reduce vehicle miles traveled (VMT).

- Create incentives for implementing the sustainable community strategies by allocating federal transportation funds only to projects that are consistent with the emissions reductions.

- Provide various forms of CEQA relief by allowing projects that are shown to conform to the preferred sustainable community strategy through the local general plans (and therefore contribute to GHG reduction) to have a more streamlined environmental review process. Specifically, SB 375 will change CEQA in two ways:

    - If a development is consistent with the sustainable community's strategy and incorporates any mitigation measures required by a prior EIR, then the environmental review does not have to consider: a) growth-inducing impacts, or b) project-specific or cumulative impacts from cars on global warming or the regional transportation network.

- A narrowly-defined group of "transit priority projects" will be exempt from CEQA review.

LEGAL AUTHORITY

CEQA Guidelines §15022(a) states that a public agency shall adopt objectives, criteria, and specific procedures consistent with CEQA and these [State] Guidelines for administering its responsibilities under CEQA. CEQA Guidelines §15022(d) states further, "In adopting procedures to implement CEQA, a public agency may adopt the State CEQA Guidelines through incorporation by reference. The agency may then adopt only those specific procedures or provisions described in subsection [15022] (a) which are necessary to tailor the general provisions of the guidelines to the specific operations of the agency." At the December 11, 1998 Public Hearing the SCAQMD's Governing Board formally incorporated by reference the State CEQA Guidelines as the implementing guidelines for the SCAQMD's CEQA program. Adopting GHG significance thresholds would be consistent with CEQA Guidelines §15022 provision to tailor a public agency's implementing guidelines by adopting criteria relative to the specific operations of the SCAQMD.

Specifically with regard to thresholds of significance, CEQA Guidelines §15064.7(a) states, "Each public agency is encouraged to develop and publish thresholds of significance that the agency uses in the determination of the significance of environmental effects." Subsection (b) of the same section states further, "Thresholds of significance to be adopted for general use as part of the lead agency's environmental review process must be adopted by ordinance, resolution, rule or regulation, and developed through a public review process and be supported by substantial evidence." Staff's recommended GHG significance threshold has undergone a public review process as part of stakeholder working group meetings that are open to the public. This Guidance Document provides the substantial evidence relative to the methodology for developing the interim GHG significance threshold. After completion of the public process, the proposed interim GHG significance threshold will be brought to the SCAQMD's Governing Board at a public meeting, where it will be considered for adoption by resolution, consistent with CEQA Guidelines §15064.7(b). Staff's proposed interim GHG significance threshold is a recommendation only for lead agencies and not a mandatory requirement. The GHG significance threshold may be used at the discretion of the local lead agency. However, if adopted the SCAQMD will use the interim GHG significance threshold for projects where it is the lead agency.

- Considerations When Establishing Significance Thresholds

No significance thresholds for GHG emissions have been developed, adopted, or endorsed statewide or at the local level[1]. Air districts have primary authority under

[1] In response to comments submitted by the Attorney General's Office on a dairy project, the San Joaquin Valley Air Pollution Control District (SJVAPCD) identified a significance threshold of 38,477 metric tons of

state law for "control of air pollution from all sources, other than emissions from motor vehicles" (H&SC §40000). The term air contaminant or "air pollutant" is defined extremely broadly, to mean "any discharge, release, or other propagation into the atmosphere" and includes, but is not limited to, soot, carbon, fumes, gases, particulate matter, etc. Greenhouse gases and other global warming pollutants such as black carbon would certainly be included in this definition. The U.S. Supreme Court held in Massachusetts v. EPA 549 U.S. 497 (2009) that greenhouse gases were clearly within the Federal Clean Air Act's broad definition of air pollutants. Therefore, air districts have the authority to regulate global warming pollutants primarily from non-vehicular sources, while pursuant to AB 32 CARB has authority over a wide range of sources, including vehicular sources.

Appendix G of the CEQA Guidelines provides a checklist of suggested environmental topics that should be addressed in a CEQA document. Questions under each environmental topic area are designed to elicit information on whether a project has the potential to generate significant adverse environmental impacts to that environmental topic area. However, neither the CEQA statutes nor the implementing Guidelines discuss or identify thresholds of significance or particular methodologies for performing an impact analysis. These tasks are left to a lead agency's judgment and discretion, based upon factual data and guidance from regulatory agencies and other sources where available and applicable.

The determination of whether a project may have a significant effect on the environment calls for careful judgment on the part of the public agency involved, based to the extent possible on scientific and factual data. An ironclad definition of significant effect is not always possible because the significance of an activity may vary with the setting. For example, an activity which may not be significant in an urban area may be significant in a rural area (CEQA Guidelines §15064(b)). Further, in evaluating the significance of the environmental effect of a project, the Lead Agency shall consider direct physical changes in the environment which may be caused by the project and reasonably foreseeable indirect physical changes in the environment which may be caused by the project (§15064(d)). Significance conclusions must be based on substantial evidence, which includes facts, reasonable assumptions predicated upon facts, and expert opinion supported by facts (CEQA Guidelines §15064(f)(5)).

Each public agency is encouraged to develop and publish thresholds of significance that the agency uses in the determination of the significance of environmental effects. A threshold of significance is essentially a regulatory standard or set of criteria that represent the level at which a lead agency finds a particular environmental effect of a project to be significant. Specifically, a threshold of significance is an identifiable quantitative, qualitative or performance level of a particular environmental effect, non-compliance with which means the effect will normally be determined to be significant

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carbon dioxide equivalent per year (MT CO2eq./yr). According to SJVAPCD staff, the agency currently has no plans to formally adopt this significance threshold through a public process.

by the agency and compliance with which means the effect normally will be determined to be less than significant (§15064.7(a)).

Even in the absence of clearly defined significance thresholds for GHG emissions, the California Attorney General has advised that such emissions from CEQA projects must be disclosed and mitigated to the extent feasible whenever the lead agency determines that the project contributes to a significant, cumulative climate change impact.

CONTENTS OF THIS GUIDANCE DOCUMENT

The following subsections provide brief summaries of the chapters contained in this guidance document.

- Summaries of Chapter 1

Chapter 1 is the introductory chapter of this document that contains general background information on GHGs and the determination that GHGs must be analyzed in CEQA documents. There is also information on CEQA legislation related to GHGs and global climate change. Finally, the chapter contains information on the legal authority that allows the SCAQMD to adopt significance thresholds for the purpose of determining the severity of impacts analyzed in CEQA documents

- Summaries of Chapter 2

Chapter 2 contains more detailed background information on GHG emissions relative to global climate change, both internationally and nationally. This chapter also provides more detailed information on legislation to reduce GHG house gas emissions, e.g., Assembly Bill 32 – the Global Warming Solutions Act of 2006, etc. Finally, Chapter 2 contains information on early guidance on evaluating GHG emissions in CEQA documents.

- Summaries of Chapter 3

Chapter 3 contains information on the working group established by the SCAQMD to provide feedback to staff on the development of an interim GHG significance threshold. The chapter also includes discussions on considerations in establishing an interim GHG significance threshold and describes the current staff proposal for an interim GHG significance threshold.

- Summaries of Chapter 4

Chapter 4 contains general recommendations for analyzing GHG emissions in CEQA documents.

- Summaries of Chapter 5

In Chapter 5 it is assumed that the SCAQMD Governing Board will adopt staff's proposed interim GHG significance threshold. Therefore, this chapter discusses future action items, including outreach to interested stakeholders, compiling lists of applicable GHG design features and mitigation measures, and periodic review and update, as necessary of the interim GHG significance threshold.

CHAPTER 2

BACKGROUND INFORMATION ON GHGS

General Background Information
Legislative Background – California
Initial Guidance on Evaluating GHGs Pursuant to CEQA

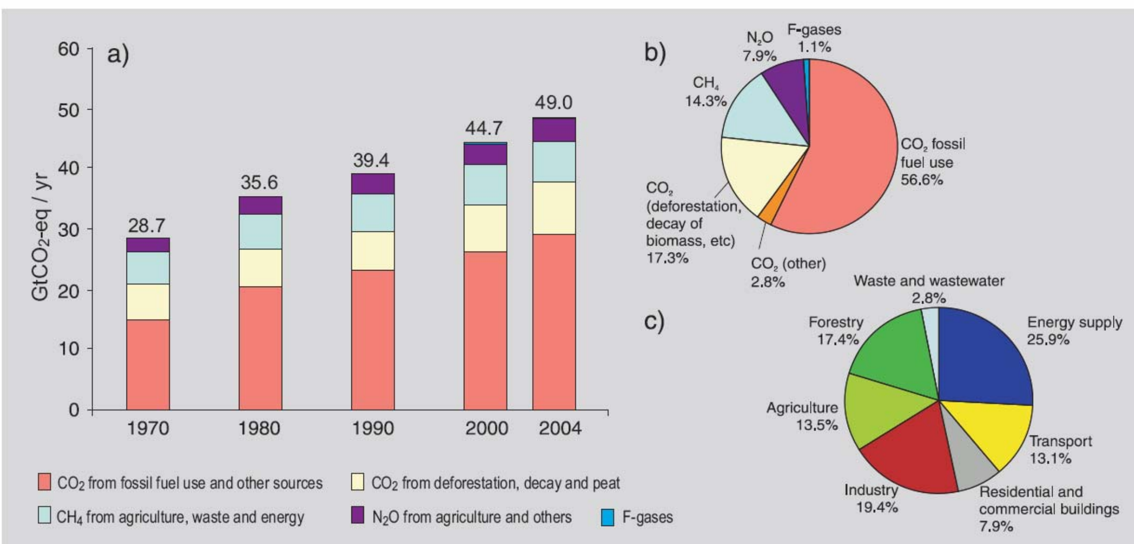
GENERAL BACKGROUND INFORMATION ON GHGS

- Intergovernmental Panel on Climate Change

In the last few years information and data have been compiled that demonstrate unequivocally that increases in average global air and ocean temperatures are occurring (IPCC, 2007a). For example, 11 of the last 12 years (1995-2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850). The temperature increase is widespread over the globe and is greater at higher northern latitudes. Further, increases in sea level are consistent with global warming. For example, global average sea level rose at an average rate of 1.8 [1.3 to 2.3]mm per year over 1961 to 2003 and at an average rate of about 3.1 [2.4 to 3.8]mm per year from 1993 to 2003. According to the IPCC (2007b), there is very high confidence, based on more evidence from a wider range of species, that recent warming is strongly affecting terrestrial, marine, and freshwater biological systems.

One of the major drivers in global climate change has been directly linked to the increase in greenhouse gas (GHG) emissions due to human activities worldwide (Figure 2-1). Carbon dioxide (CO2) is the most important anthropogenic GHG. Annual CO2 emissions have increased approximately 80 percent between 1970 and 2004 (IPCC, 2007b)

Figure 2-1
Global Anthropogenic GHG Emissions



Source – IPCC, 2007b: (a) Global annual emissions of anthropogenic GHGs from 1970 to 2004.5 (b) Share of different anthropogenic GHGs in total emissions in 2004 in terms of CO2-eq. (c) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO2-eq. (Forestry includes deforestation.) {WGIII Figures TS.1a, TS.1b, TS.2b}

Human activities have been responsible for substantial increases in four long-lived GHGs, including: CO2, methane (CH4), nitrous oxide (N2O) and halocarbons (a group of gases containing fluorine, chlorine or bromine). Global increases in CO2 concentrations are due primarily to fossil fuel use, with land-use change providing another significant but smaller contribution. It is very likely that the observed increase in CH4 concentration is predominantly due to agriculture and fossil fuel use. The increase in N2O concentration is primarily due to agriculture (IPCC, 2007).

According to the IPCC (2007), for the next couple of decades global temperatures are expected to rise approximately 0.2^{o} C per decade under a variety of scenarios. Further, global temperatures are expected to continue for centuries as a result of human activities due to the time scales associated with climate processes and feedbacks, even if GHG concentrations are stabilized. As a result, based on the current understanding of climate-carbon feedback, model studies show that substantial GHG emission reductions are necessary to avoid substantial increases in global air and ocean temperatures.

LEGISLATIVE BACKGROUND – CALIFORNIA

California has taken a leadership role in not only recognizing the future impacts to global climate change from anthropogenic sources of GHG emissions, but in establishing policies and adopting laws to substantially reduce GHG emissions by 2050. In addition to the GHG legislation related to CEQA described in Chapter 1, California has adopted the following policies and laws that specifically address reducing GHG emissions.

- Governor Schwarzenegger's Executive Order (June 2005)

In June 2005, Governor Arnold Schwarzenegger signed Executive Order (EO) S-3-05, which establishes greenhouse gas emission reduction targets in response to projected increases in global air and ocean temperatures. Specifically, EO S-3-05 establishes the following three GHG emission reduction targets:

- Reduce GHG emissions to 2000 emission levels by 2010;
- Reduce GHG emissions to 1990 emission levels by 2020; and
- Reduce GHG emissions to 80 percent below 1990 levels by 2050.

Further, EO S-3-05 charges the California Environmental Protection Agency (CalEPA) secretary to coordinate with the Secretary of the Business, Transportation and Housing Agency, Secretary of the Department of Food and Agriculture, Secretary of the Resources Agency, Chairperson of the CARB, Chairperson of the Energy Commission and President of the Public Utilities Commission to develop a Climate Action Plan. EO S-3-05 also charges the Secretary of CalEPA with the oversight of efforts to meet the above GHG emission reduction targets and the responsibility to prepare biannual reports on progress in meeting the GHG emission reduction targets.

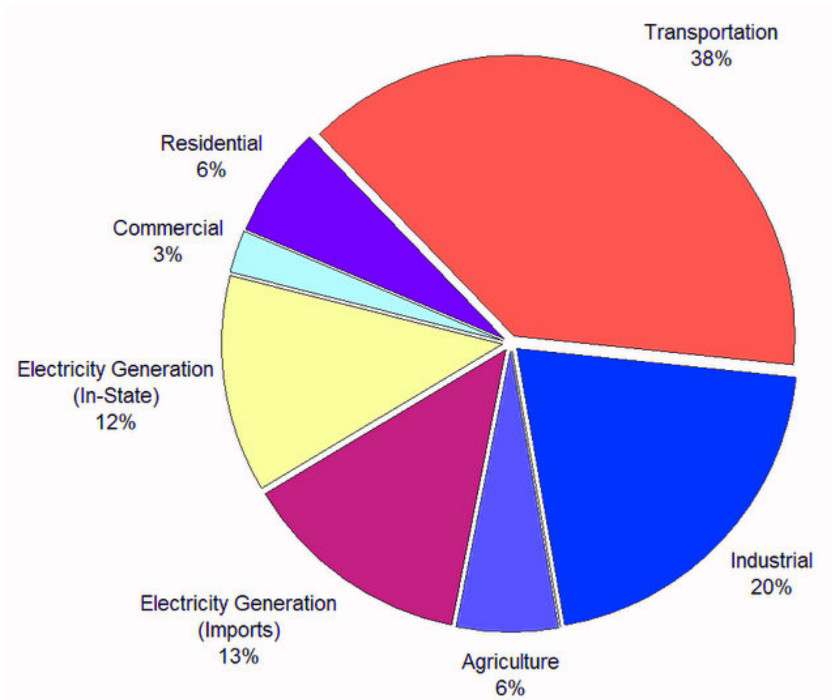
- Global Warming Solutions Act of 2006 (Assembly Bill (AB) 32)

The Global Warming Solutions Act of 2006 (AB 32) was adopted by the California State Legislature in 2006. AB 32 assigns CARB the responsibilities of monitoring and reducing GHG emissions. Specifically, AB 32 requires CARB to:

- Establish a statewide greenhouse gas emissions cap for 2020, based on 1990 emissions, by January 1, 2008;
- Adopt mandatory reporting rules for significant sources of greenhouse gases by January 1, 2009;
- Adopt a plan by January 1, 2009, indicating how emission reductions will be achieved from significant greenhouse gas sources via regulations, market mechanisms and other actions;
- Adopt regulations by January 1, 2011, to achieve the maximum technologically feasible and cost-effective reductions in greenhouse gas, including provisions for using both market mechanisms and alternative compliance mechanisms;
- Convene an Environmental Justice Advisory Committee and an Economic and Technology Advancement Advisory Committee to advise CARB;
- Ensure public notice and opportunity for comment for all CARB actions;
- To adopt rules for “sources” including non-vehicular; and
- Prior to imposing any mandates or authorizing market mechanisms, CARB must evaluate several factors, including but not limited to impacts on California's economy, the environment and public health; equity between regulated entities; electricity reliability; conformance with other environmental laws, and must ensure that the rules do not disproportionately impact low-income communities.

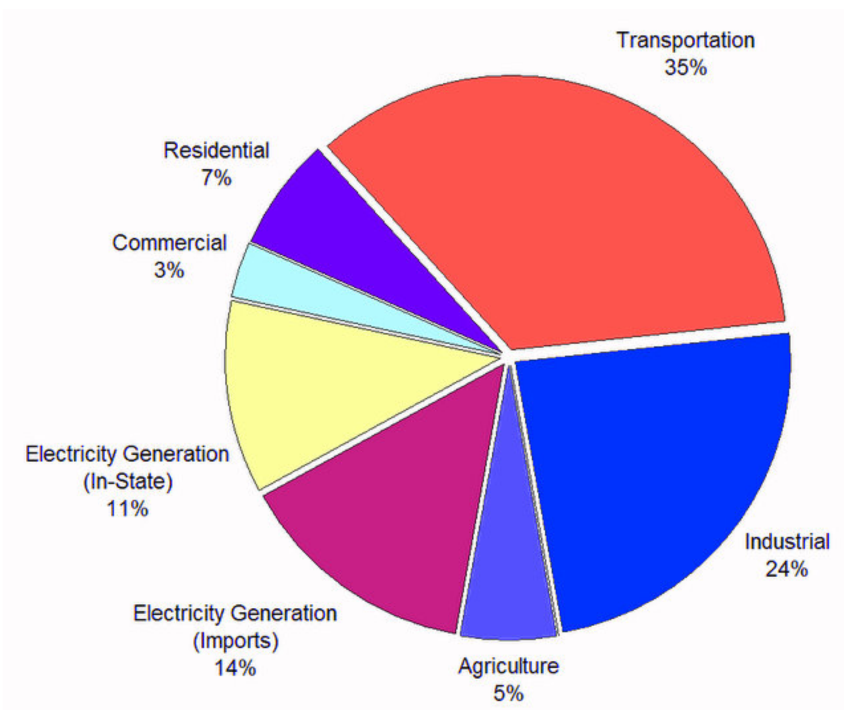
According to the schedule of milestones laid out in AB 32, CARB has made progress in the following areas. Consistent with AB 32’s requirement to establish a GHG emission inventory, in December 2007 CARB adopted the California Greenhouse Gas Emission Inventory. The Inventory accounts for all GHG emissions within the state of California and supports the AB 32 Climate Change Program. Figure 2-2 shows CARB’s inventory for the year 2004. The Inventory also serves as the basis for developing future year GHG emission forecasts necessary to support measure development and Scoping Plan recommendations. ARB staff has developed a year 2020 “business-as-usual” (BAU) forecast of GHG emissions for use in developing the Draft Scoping Plan. Figure 2-3 shows CARB’s inventory for the year 2020, which is AB 32’s target inventory.

Figure 2-2
2004 GHG Emissions by Sector (Gross Emissions: 484.4 MMT CO2eq.)



Source: CARB, 2007

Figure 2-3
1990 GHG Emissions by Sector (Gross Emissions: 433.3 MMT CO2eq.)



Source: CARB, 2007

On December 6, 2007, the Air Resources Board (ARB) approved a regulation for the mandatory reporting of greenhouse gas emissions from major sources, pursuant to AB 32. The mandatory reporting regulation specifies the types of facilities that must report their GHG emissions, requirements for reporting and estimating the GHG emissions, and requirements for emissions verification. Upon adoption, the CARB Board directed staff to make other conforming modifications, as may be appropriate, based on comments received. Subsequent to adoption, the mandatory reporting regulation has undergone two sets of modifications.

Consistent with the requirement to develop a scoping plan indicating how GHG emission reductions will be achieved through regulations, market mechanisms, and other actions, the Draft Scoping Plan was released for public review and comment on June 26, 2008, followed by workshops in July and August, 2008.

The Draft Scoping Plan calls for achievable GHG emission reduction in California's carbon footprint to 1990 levels. Reducing greenhouse gas emissions to 1990 levels means cutting approximately 30 percent from BAU emission levels projected for 2020, or about 10 percent from today's levels. Key elements of CARB's preliminary recommendation for reducing California's greenhouse gas emissions to 1990 levels by 2020 contained in the Draft Scoping Plan include the following:

- Expansion and strengthening of existing energy efficiency programs and building and appliance standards;
- Expansion of the Renewables Portfolio Standard for electricity generation to 33 percent;
- Development of a California cap-and-trade program that links with other WCI Partner programs to create a regional market system;
- Implementation of existing State laws and policies, including California's clean car standards, goods movement measures, and the Low Carbon Fuel Standard; and
- Targeted fees to fund the State's long-term commitment to AB 32 administration.

The Scoping Plan is expected go to the CARB Board for adoption in November, 2008.

INITIAL GUIDANCE ON EVALUATING GHGS PURSUANT TO CEQA

As noted in Chapter 1, both the California Attorney General's Office and the OPR determined that GHG emissions contributing to global climate change have the potential to generate adverse environmental impacts that should be evaluated pursuant to CEQA. Until recently, however, there has been little or no guidance relative to analyzing GHG emissions in CEQA documents or determining significance. The first explicit guidance was provided by the Association of Environmental Professionals (AEP) in its White Paper on Global Climate Change (AEP, 2007) and the White Paper on CEQA and Climate Change prepared by the California Air Pollution Control Officers Association (CAPCOA, 2008). The content of each of these White Papers is summarized in the following subsections.

- **Association of Environmental Professionals – White Paper on Global Climate Change**

AEP's White Paper (AEP) was one of the first attempts to discuss GHGs in the context of CEQA. The intent of the White Paper was to provide practical, interim information to CEQA practitioners and to help Lead Agencies determine how to address GHGs and global climate change in CEQA documents prior to the development and adoption of guidance by appropriate government agencies. Further, AEP's White Paper provided a summary of the current regulatory environment surrounding GHG emissions, and the various approaches that a Lead Agency may select in a CEQA document to address the potential impacts of global climate change and a project's cumulative contribution to GHG. The White Paper described several approaches for addressing GHGs and global Climate Change in CEQA documents, but did not recommend a single approach or methodology, leaving that decision to local Lead Agencies. The AEP White Paper identified eight approaches for analyzing GHGs and global climate change, which are summarized in the following bullet points.

- **Approach 1 – No Analysis:** under this approach the Lead Agency would not mention or discuss GHGs or global climate change.
- **Approach 2 – Screening Analysis:** under this approach the Lead Agency would establish a process to screen projects and determine that they would not make significant contributions to GHG emissions or GCC and, therefore, would not need to mitigate accordingly.
- **Approach 3 – Qualitative Analysis without Significance Determination:** this approach involves a qualitative discussion of GHGs and global climate change and potential ways the project will contribute to the generation of GHG emissions, but does not provide any significance conclusions.
- **Approach 4 – Qualitative Analysis with Significance Determination:** under this approach the Lead Agency would qualitatively discuss GHGs and climate change impacts and conclude that the project impacts are significant.
- **Approach 5 – Quantitative Analysis without Significance Determination:** under this approach the Lead Agency would quantify GHG emissions from the proposed project, but the results are not compared to a quantitative significance threshold.
- **Approach 6 – Quantitative Analysis with Net Zero Threshold:** this approach involves quantifying GHG emissions and using zero net carbon dioxide equivalent increase as the threshold.
- **Approach 7 – Quantitative Analysis Relative to California GHG Emission Reduction Strategies:** this approach employs both quantitative and qualitative components. The quantitative analysis contains an inventory of project GHG emissions. The qualitative component involves project compliance with the emission reduction strategies contained in the California Climate Action Team's (CAT) Report to the Governor, which contains recommendations and strategies to help ensure the targets in Executive Order S-3-05 are met.
- **Approach 8 – Use of Partial Exemption, "Within the Scope" of a Program EIR, or Tiering:** this option relies on the preparation of a broad EIR on a plan, program, or zoning action that is certified and contains a cumulative GHG and global climate change

impact analysis and mitigation. A later project that is consistent with the actions, goals, and/or policies in that plan, program, or zoning action need not again evaluate the cumulative impact regarding the project's GHG contribution to global climate change. In this situation, the later project may use the "partial exemption" provision of Public Resources Code §21083.3 and CEQA Guidelines §15183.

Since the date that the AEP White Paper was finalized (June, 2007), it has become clear that any of the above eight options that do not include quantification of GHG emissions and a determination of significance would be vulnerable to legal challenge. In addition, with the exception of the net zero approach in option 6, none of the options evaluated identify potential GHG significance thresholds. Approaches to developing GHG significance thresholds were specifically addressed in CAPCOA's White Paper (CAPCOA, 2008).

- California Air Pollution Control Officers Association – White Paper: CEQA and Climate Change

The intent of CAPCOA's White Paper is to serve as a resource for public agencies as they establish procedures for reviewing GHG emissions from projects under CEQA. It considers the application of thresholds and offers three alternative programmatic approaches toward determining whether GHG emissions are significant. Although the White Paper considers an option of not establishing a GHG significance threshold, as already noted this option is not considered to be a viable approach and will not be considered further. Ultimately, the White Paper is intended to provide consistent approaches for public agencies to ensure that GHG emissions are appropriately considered and addressed under CEQA.

The CAPCOA White Paper identifies three programmatic approaches to establishing GHG significance thresholds and also discusses the benefits and problems associated with each approach. Each approach has inherent advantages and disadvantages. The three basic approaches are:

- No significance threshold for GHG emissions (not discussed further);
- GHG emissions threshold set at zero; or
- GHG threshold set at a non-zero level, two approaches.

The following subsections briefly summarize two of the three major programmatic approaches developed by CAPCOA.

- *Zero Threshold*

An air district or lead agency may determine that any degree of project-related increase in GHG emissions would contribute considerably to climate change which, therefore, would be considered a significant impact. As a result, the air district or lead agency could adopt a zero-emission GHG threshold. If the zero threshold option is chosen, the lead agency would be required to quantify and mitigate GHG emissions for all projects subject to CEQA, regardless of the size of the project or the availability of GHG reduction measures available to reduce the project's emissions. Projects that could not meet the zero-emission threshold would be required to undergo an environmental impact report (EIR) CEQA process to disclose the unmitigable significant impact, and develop the justification for a statement of overriding consideration to be adopted by the lead agency.

CAPCOA notes in the White Paper that if an air district or lead agency elects to adopt a zero threshold approach, it should consider the administrative costs and the environmental review system capacity. Some projects that previously would have qualified for an exemption could require further substantial analysis, including preparation of a Negative Declaration (ND), a Mitigated Negative Declaration (MND) or an EIR. Moreover, the trade-offs between the volume of projects requiring review and the quality of consideration given to reviews should be considered. It may also be useful to consider whether meaningful mitigation can be achieved from smaller projects.

- *Approach 1: Non-Zero Threshold – Statute and Executive Order Approach*

According to CAPCOA, a non-zero GHG significance threshold could minimize the resources spent reviewing environmental analyses that do not result in real GHG reductions or to prevent the environmental review system from being overwhelmed. The practical advantages of considering non-zero thresholds for GHG significance determinations can fit into the concept regarding whether the project's GHG emissions represent a "considerable contribution to the cumulative impact" and therefore warrant analysis.

The first non-zero GHG significance threshold approach is based on achieving the objectives of AB 32 or executive order EO S-3-05 and explores four possible options under this scenario. A project would be required to meet the target objectives, or reduce GHG emissions to the target objectives, to be considered less than significant. The options under this approach are variations of ways to achieve the 2020 goals of AB 32 from new development, which is estimated to be about a 30 percent reduction from business-as-usual. Table 2-1 summarizes the four statute and executive order approaches identified by CAPCOA. SCAQMD staff has identified and included in Table 2-1 potential pros and cons identified for each option.

- *Approach 2: Non-Zero Threshold – Tiered Threshold Options*

The second non-zero GHG significance threshold approach is comprised of a number of tiered GHG significance threshold options. Within this option, the CAPCOA White Paper discusses seven variations. The tiered threshold options offer both quantitative and qualitative approaches to setting a threshold, as well as different metrics for establishing the various tiers. Variations range from setting the first tier at zero to second tiers set at defined emission levels or based on the size of a project. This approach would then prescribe a set of GHG mitigation strategies that would have to be incorporated into the project in order for the project to be considered less than significant. CAPCOA notes that some applications of the tiered threshold approach may require inclusion in a General Plan or adoption of enabling regulations or ordinances to render them fully effective and enforceable. The various tiered threshold options are summarized in Table 2-2. SCAQMD staff has identified and included in Table 2-2 potential pros and cons identified for each option.

Table 2 – 1
Statute and Executive Order Approach

Threshold Number	Description of Threshold	Pros*	Cons*
1.1	Project must reduce emissions compared to business as usual to be less than significant, two approaches: a. Project must reduce GHG emissions 33 percent compared to business-as-usual (BAU) (2020 target), or b. Project must reduce GHG emissions 80 percent compared to business-as-usual (2050 target).	• Could reduce resource impacts compared to zero threshold, as not every project would require an EIR • Would achieve GHG reductions consistent with AB 32 • A single threshold is easier to apply and understand	• Could be viewed as setting a de minimis level • Fewer projects would trigger significance, thus, less mitigation • BAU should be defined by CARB • BAU may be difficult to define for all projects
1.2	All new projects must reduce GHG emissions compared to BAU by a uniform percentage to be considered less than significant, e.g., 50 percent.	• Same as 1.1 • May produce greater percent reduction of GHGs • Single threshold easier to apply & understand	• Could produce substantially greater GHG reductions than 1.1, but may be difficult to achieve • BAU should be defined by CARB • BAU may be difficult to define for all projects

* Pros and cons reflect only SCAQMD staff's evaluation of the approaches.

Table 2 – 1 (Concluded)
Statute and Executive Order Approach

Threshold Number	Description of Threshold	Pros*	Cons*
1.3	Projects must reduce GHG emissions compared to business-as-usual by a uniform percentage based on economic sector to be less than significant, i.e., different reductions required for different market sectors.	• Sector-specific approach may be more appropriate approach • Would take into account costs & available control technologies • Avoids over- or under-regulation of GHGs per sector	• Requires extensive information on emission inventories • Requires extensive information on control technologies • Difficult to determine percent reduction by sector • Because of information requirements, may be more viable in the long term
1.4	Uniform GHG emission reduction by region. Regional GHG reduction plan developed consistent with AB32 emission reductions, e.g., reduce GHG emissions 33% or 80% compared to BAU. A project is not significant if its GHG emissions are consistent with plan.	• Could tailor GHG reductions to specific regional needs • GHG reduction strategies could be integrated into regional plans	• Would need to establish GHG regions • Requires extensive information on regional emission inventories • Because of the need to develop a regional plan, may be a more viable interim approach

* Pros and cons reflect only SCAQMD staff's evaluation of the approaches.

Table 2 – 2
Tiered Threshold Options

Threshold Number	Description of Threshold	Pros*	Cons*
2.1	This threshold employs a decision tree approach. Tier 1, no increase in GHG emissions, not significant (zero threshold). If GHG emissions greater than zero, tier two, use one of the following threshold options.	• Tiered approach allows flexibility by establishing multiple thresholds to cover a wide range of projects • Tier 2 may minimize administrative burden & costs • Tiers could be set at different levels depending on GHGs, size & other project characteristics • Projects exceeding tier 2 must implement mitigation	• Tier 1 may increase administrative burdens & costs • There may not be meaningful mitigation for small projects • Available mitigation may consist of purchasing offsets • EJ concerns of purchasing offsets because of associated criteria pollutant emissions • Offset markets not well established
2.2	Establish a quantitative threshold based on capturing a percentage, e.g., 90%, of future discretionary projects, CAPCOA's threshold is 900 metric tons CO2eq per year (equivalent to 50 houses or 30,000 square feet of commercial space, i.e., CAPCOA assumes 90% of all projects are this size or greater). Projects less than this would not be significant.	• Would capture a larger percentage of projects in the district than is currently the case • Would exclude small projects from further GHG analysis • Single threshold easier to apply & understand	• Would increase administrative & cost burden, especially in developing & moderate growth areas • May not be amenable to industrial projects because of the diversity of these projects • There may not be meaningful mitigation for small projects

* Pros and cons reflect only SCAQMD staff's evaluation of the approaches.

Table 2 – 2 (Continued)
Tiered Threshold Options

Threshold Number	Description of Threshold	Pros*	Cons*
2.3	This threshold is based on CARB's proposed mandatory reporting threshold of 25,000 metric tons of CO2eq per year. Alternatively, use the Market Advisory Committee of 10,000 metric tons of CO2eq per year. Projects less than either would not be significant.	• CARB estimates this threshold would capture 90 % of all industrial projects • Single threshold easier to apply & understand	• May not be amenable to industrial projects because of the diversity of these projects • There may not be meaningful mitigation for small projects
2.4	This approach establishes a GHG threshold based on and analogous to a NOx/VOC criteria pollutant CEQA significance threshold and is established using the following four steps: a. Define NOx/VOC CEQA thresholds in tons per year (e.g., 10 t/yr) b. Define the regional NOx/VOC inventory in tons per year (e.g., annual NOx inventory for 2005 from 2007AQMP ~ 375,585 t/yr) c. Calculate percentage of NOx/VOC inventory the significance threshold represents (10 / 375,585 = 0.00003) to obtain "minimum percentage of regulated inventory" for NOx/VOC.	• Single threshold easier to apply & understand	• Threshold cumbersome to derive • Threshold would change periodically as inventory goes up or down • Could have widely divergent thresholds by air basin because of varying inventories

* Pros and cons reflect only SCAQMD staff's evaluation of the approaches.

Table 2 – 2 (Continued)
Tiered Threshold Options

Threshold Number	Description of Threshold	Pros*	Cons*
2.4 (Cont.)	d. Define California GHG emission inventory for 2004 in tons CO2eq per year (499 MMT CO2eq). Apply minimum percentage of regulated inventory to California GHG inventory for 2004 to develop a GHG threshold analogous to the CEQA Threshold (e.g., 0.00003 x 499 MMT = 14,970 metric tons CO2eq per year = significance threshold).	•	•
2.5	Establish quantitative unit-based thresholds based on capturing a percentage, e.g., 90%, of future discretionary projects in specific market sectors (similar to 2.2 above). CAPCOA examples include: • 30,000 square-foot (SF) office =800 metric tons CO2eq per year; • 30,000 SF retail = 2,500 metric tons CO2eq per year; • 30,000 SF supermarket = 43,000 metric tons CO2eq per year.	• Would capture a larger percentage of projects in the district than is currently the case • Would exclude small projects from further GHG analysis • Single threshold easier to apply & understand	• Would increase administrative & cost burden, especially in developing & moderate growth areas • May not be amenable to industrial projects because of the diversity of these projects • There may not be meaningful mitigation for small projects

* Pros and cons reflect only SCAQMD staff's evaluation of the approaches.

Table 2 – 2 (Concluded)
Tiered Threshold Options

Threshold Number	Description of Threshold	Pros*	Cons*
2.6	This threshold would include tiered CEQA thresholds based on CEQA's definition of "projects with statewide, regional or areawide significance (§15206(b)), which include: • Residential development > 500 dwellings • Shopping center or business establishment employing > 1,000 persons or > 500,000 SF • Commercial office building employing >1,000 persons or > 250,000 SF • Hotel/motel > 500 rooms • Industrial, manufacturing or processing plant or industrial park employing > 1,000 persons or > 600,000 SF	• Could capture up to 50% of all future commercial development	• May capture substantially less than 50% if future development, resulting less GHG mitigation • Percentage capture of industrial/manufacturing projects currently unknown
2.7	Efficiency-based thresholds would be based on measurements of efficiency compared to intensity. Must be based on reasonable GHG emissions compared to business-as-usual.	• Would benchmark GHG intensity against target levels of efficiency • Thresholds established to provide future foreseeable GHG reductions compared to BAU • Would support AB 32 target objectives	• Would require substantial data & possibly modeling • May be more appropriate as a threshold in the long term

* Pros and cons reflect only SCAQMD staff's evaluation of the approaches.

CHAPTER 3

INTERIM GHG SIGNIFICANCE THRESHOLD STAFF PROPOSAL

INTRODUCTION

Because GHG emissions affect global climate, some have argued that it may be more appropriate for national or state agencies to establish significance thresholds or GHG emission reduction target objectives. However, no agency has established GHG significance thresholds that could assist Lead Agencies with determining the significance of GHG emissions in CEQA documents. In the absence of statewide guidance on this issue and in response to requests from a variety of stakeholders, the SCAQMD established a GHG Significance Threshold Stakeholder Working Group (Working Group) to establish an interim GHG significance threshold until such time as the state establishes a GHG significance threshold or provides recommended guidance on establishing a GHG significance threshold. Staff's goal is to reach consensus regarding an interim GHG significance threshold to the extent possible and take the staff proposal to the SCAQMD Governing for consideration and approval.

The Working Group was formed to assist staff's efforts to develop an interim GHG significance threshold an is comprised of a wide variety of stakeholders including: state agencies, OPR, CARB, and the Attorney General's Office; local agencies, city and county planning departments, utilities such as sanitation and power, etc.; regulated stakeholders, industry and industry groups; and organizations, both environmental and professional. Stakeholders were chosen based on their participation in other related stakeholder working groups and their expressed interest in participating in the developing a GHG significance threshold. Working group meetings are open to the public and have been well attended. The members of the Working Group and other interested parties who have requested to be notified of the meetings are listed in Appendix A. Information on the progress of the Working Group, including agendas, overhead presentations, and letters received from the various stakeholders can be found at the following website: https://www.aqmd.gov/ceqa/handbook/GHG/GHG.html.

Part of the purpose of the Working Group is to provide a forum to solicit comments and suggestions from the various stakeholders to assist SCAQMD staff with developing an interim GHG significance threshold that is consistent with CEQA requirements for developing significance thresholds, is supported by substantial evidence, and provides guidance to CEQA practitioners with regard to determining whether GHG emissions from a proposed project are significant.

SCAQMD staff held the first Working Group meeting in April 2008. Except for September, Working Group meetings have been held on a monthly basis since April. Brief summaries of each Working Group meeting and the topics and staff GHG significance threshold proposals discussed to date are provided in Appendix B. Staff's initial proposed has been modified over time based on comments and concerns raised at Working Group meetings or in written comments. The following sections summarize staff's latest recommended interim GHG significance threshold proposal and some of the concepts necessary to understanding the various components of staff's proposal. The latest staff proposal is considered to be a work-in-progress as staff is continuing to solicit further public input and suggestions.

The following subsections briefly summarize the GHG significance threshold design criteria concepts included as part of staff's proposed interim GHG significance threshold proposal. Following the discussion of design concepts, SCAQMD staff's current interim proposal is described.

GHG ANALYSIS CONSIDERATIONS

Before discussing quantification methodologies, it is necessary to consider design criteria that establish the parameters upon which the actual GHG analysis is based. The following subsections include discussions from the Working Group of some of the most important design criteria to be considered when quantifying GHG emissions. The following topics include some of the most important parameters that should be considered when quantifying GHG emissions and, therefore, should not be considered an exhaustive list of considerations as individual projects may include characteristics that may require additional considerations.

Policy Objective

The overarching policy objective with regard to establishing a GHG significance threshold for the purposes of analyzing GHG impacts pursuant to CEQA is to establish a performance standard or target GHG reduction objective that will ultimate contribute to reducing GHG emissions to stabilize climate change. Full implementation of the Governor's Executive Order S-3-05 would reduce GHG emissions 80 percent below 1990 levels or 90 percent below current levels by 2050. It is anticipated that achieving the Executive Order's objective would contribute to worldwide efforts to cap GHG concentrations at 450 ppm, thus, stabilizing global climate.

As described below, staff's recommended interim GHG significance threshold proposal uses a tiered approach to determining significance. Tier 3, which is expected to be the primary tier by which the AQMD will determine significance for projects where it is the lead agency, uses the Executive Order S-3-05 goal as the basis for deriving the screening level. Specifically, the Tier 3 screening level for stationary sources is base on an emission capture rate of 90 percent for all new or modified projects. A 90 percent emission capture rate means that 90 percent of total emissions from all new or modified stationary source projects would be subject to some type of CEQA analysis, including a negative declaration, a mitigated negative declaration, or an environmental impact.

Therefore, the policy objective of staff's recommended interim GHG significance threshold proposal is to achieve an emission capture rate of 90 percent of all new or modified stationary source projects. A GHG significance threshold based on a 90 percent emission capture rate may be more appropriate to address the long-term adverse impacts associated with global climate change. Further, a 90 percent emission capture rate sets the emission threshold low enough to capture a substantial fraction of future stationary source projects that will be constructed to accommodate future statewide population and economic growth, while setting the emission threshold high enough to exclude small projects that will in aggregate contribute a relatively small fraction of the cumulative statewide GHG emissions. This assertion is based on the fact that staff estimates that these GHG emissions would account for less than one percent of future 2050 statewide GHG emissions target (85 MMTCO2eq/yr). In addition, these small projects would be subject to future applicable GHG control regulations that would further reduce their overall future contribution to the statewide GHG inventory

- **GHG Pollutants**

Gases that trap heat in the atmosphere are often called greenhouse gases. The Kyoto Protocol, adopted in December 1997, is an agreement under which industrialized countries will reduce their collective emissions of greenhouse gases by specified percentages, depending on the country, compared to 1990 levels. The goal is to lower overall emissions of six greenhouse gases - carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons, averaged over the period of 2008-2012.

Similarly, AB 32 defines GHGs as including the following: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (Health and Safety Code, section 38505(g)). The most common GHG that results from human activity is carbon dioxide, followed by methane and nitrous oxide.

Some greenhouse gases such as carbon dioxide occur naturally and are emitted to the atmosphere through natural processes and human activities. Other greenhouse gases (e.g., fluorinated gases) are created and emitted solely through human activities. The principal greenhouse gases that enter the atmosphere because of human activities are:

- **Carbon Dioxide (CO_2):** Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Carbon dioxide is also removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

- **Methane (CH_4):** Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

- **Nitrous Oxide (N_2O):** Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

- **Fluorinated Gases:** Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (i.e., CFCs, HCFCs, and halons). Fluorinated gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as high global warming potential gases (high GWP gases).
  - Hydrofluorocarbons are manmade chemicals that have historically replaced Chlorofluorocarbons used in refrigeration and semiconductor manufacturing.
  - Perfluorocarbons are manmade chemicals that are by-products of aluminum smelting and uranium enrichment.
  - Sulfur hexafluoride is a manmade chemical that is largely used in heavy industry to insulate high voltage equipment and to assist in the manufacturing of cable cooling systems.

GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale that compares the gas in question to the same mass of carbon dioxide (whose GWP is by definition 1). A GWP is calculated over a specific time interval and the value of this must be stated whenever a GWP is quoted or else the value is meaningless. A substance's GWP depends on the time span over which the potential is calculated. A gas which is quickly removed from the atmosphere may initially have a large effect but for longer time periods as it has been removed becomes less important. For the purposes of a CEQA analysis, especially an analysis of operation emissions, the maximum GWP is typically used, regardless of the actual atmospheric lifetime. This approach simplifies the analysis and provides a very conservative analysis, especially for the fluorinated gases. The GWP of the six Kyoto GHGs is shown in Table 3-1.

The SCAQMD staff recommends that a GHG analysis include the six Kyoto GHGs, to the extent emission factors are available primarily because there is more information on these GHGs than other potential GHGs. Other GHGs would be added to the list as scientific information becomes available and agreed to by national or international protocols and agreements.

Table 3-1

Global Warming Potential of Kyoto GHGs

Gas	Atmospheric Lifetime	GWP
Carbon dioxide (CO2)	50 – 200	1
Methane (CH4)	12 ± 3	21
Nitrous oxide (N2O)	120	310
HFC-23 (Hydrofluorocarbons)	264	11,700
HFC-32	5.6	650

Table 3-1 (Concluded)
Global Warming Potential of Kyoto GHGs

Gas	Atmospheric Lifetime	GWP
HFC-125	32.6	2,800
HFC-134a	14.6	1,300
HFC-143a	48.3	3,800
HFC-152a	1.5	140
HFC-227ea	36.5	2,900
HFC-236fa	209	6,300
HFC-4310mee	17.1	1,300
CF4 (Perfluorocarbons)	50,000	6,500
C2F6	10,000	9,200
C4F10	2,600	7,000
C6F14	3,200	7,400
Sulfer hexafluoride (SF6)	3,200	23,900

Source: U.S. EPA (http://www.epa.gov/)

Carbon black, a form of particulate air pollution most often produced from biomass burning, cooking with solid fuels and diesel exhaust, may also have a warming effect in the atmosphere. It is estimated that carbon black's contribution to climate change is second only to carbon dioxide. Carbon black contributes to global warming by absorbing heat while airborne in the atmosphere. Carbon black is of particular concern in the arctic because it settles on ice and snow, reducing its reflectivity and increasing the rate of melting.

Based on a survey of available information, there are little data available for calculating carbon black effects on global warming. As a result, SCAQMD staff is not recommending analyzing carbon black effects on global warming. As information becomes available, staff will reconsider adding carbon black to the list of GHGs to be analyzed in CEQA documents.

Business-As-Usual (BAU)

In CARB's Scoping Plan (CARB, 2008) CARB states that the BAU case is a representation of what the state of the California economy will be in the year 2020 assuming that none of the measures recommended in the Scoping Plan are implemented. CARB's projected BAU GHG emissions in 2020 are shown in Table 3-2.

Table 3-2
2002-2004 Average Emissions and 2020 Projected Emissions (Business-as-Usual) (MMTCO2E)

Sector	2002-2004 Average Emissions	Projected 2020 Emissions [BAU]
Transportation	179.3	225.4
Electricity	109.0	139.2
Commercial and Residential	41.0	46.7
Industry	95.9	100.5
Recycling and Waste	5.6	7.7
High GWP	14.8	46.9
Agriculture	27.7	29.8
Forest Net Emissions -	4.7	0.0
Emissions Total	**469**	**596**

Source: CARB, 2008 – Scoping Plan, Table 1

CARB's Scoping Plan states further that continuing increases in global greenhouse gas emissions at BAU rates would result, by late in the century, in California losing 90 percent of the Sierra snow pack, sea level rising by more than 20 inches, and a three to four times increase in heat wave days, flood damage, etc. To avoid future foreseeable environmental impacts to California, the Scoping plan calls for an ambitious but achievable reduction in California's carbon footprint. Reducing greenhouse gas emissions to 1990 levels means reducing approximately 30 percent from BAU emission levels projected for 2020, or about 15 percent from today's levels. On a per-capita basis, that means reducing our annual emissions of 14 tons of carbon dioxide equivalent for every man, woman and child in California down to about 10 tons per person by 2020.

Although CARB's Scoping Plan calls for reducing GHG emissions 30 percent from BAU levels, it does not explicitly define BAU. There is, however, a brief definition of BAU in CARB's GHG inventory document (CARB, 2007). In that document CARB describes BAU as:

- BAU is based on GHG emissions estimates in the absence of policies and reduction measures, and
- BAU is based on forecasted demographic and economic growth.

In its White Paper, CAPCOA provides a more detailed definition of BAU compared to the above definition in CARB's inventory document. In the White Paper BAU is defined as follows:

- The projection of GHGs into the future based on current technologies and regulations;

- The adoption of new GHG reduction regulations, e.g., CARB's Scoping Plan measures, in the future establishes new BAU, i.e., the definition of BAU evolves over time; and
- BAU will normally define the CEQA no project alternative, but does not necessarily form the project baseline.

Based on the above definitions and discussions from the Working Group, SCAQMD staff defines BAU as the following

- Is used to project project's future emissions (consistent with CAPCOA and CARB definitions), i.e., level from which GHG reductions must occur;
- Is based first and foremost on current regulatory requirements (consistent with CAPCOA and CARB definitions);
- Regulatory requirements may determine current technology, e.g., advanced technology may be available, but not required, such as combined cycle gas turbine;
- Will normally define the no project alternative (consistent with CAPCOA and CARB definitions); and
- May be used to establish a project's CEQA baseline, only if consistent with CEQA Guidelines §15125.

The importance of BAU lies not only in the fact that it is a methodology for calculating a project's future emissions, is also forms the emission level from which GHG emission reductions must occur. SCAQMD staff's current GHG significance threshold proposal includes the Tier 4 compliance option 1 that establishes a performance standard of reducing GHG emissions 30 percent below the project's projected BAU emissions through design features and/or mitigation measures. A 30 percent reduction from BAU is consistent with the target objectives of AB 32 and CARB's Scoping Plan. The intent of the Tier 4 compliance option 1 is to provide a feasible target objective, that will not only contribute to achieving the AB 32 target objective, but will also contribute to achieving the 2050 target of the Governor's Executive Order S-3-05, which establishes of target objective of reducing GHG emissions 80 percent below 1990 levels or a 90 percent reduction from current BAU estimates.

As recognized by CAPCOA and SCAQMD, BAU will evolve over time as the current regulatory framework changes to implement GHG reduction strategies, either statewide strategies, e.g., CARB's Scoping Plan, or any future federal strategies. Evolving BAU creates two issues for the CEQA practitioner. First, staff's proposed Tier 4 compliance option 1 target objective is unchanged from 30 percent, then over time as BAU changes to incorporate GHG reduction strategies, achieving the target objective will become more difficult. Second, any GHG significance thresholds that rely on BAU will have higher uncertainties because they rely on a constantly changing BAU, which may be difficult to define.

To resolve some of these issues of an evolving definition of BAU, SCAQMD staff recommends that a statewide definition be developed by CARB that is updated periodically. Until such time as a statewide definition of BAU is developed, the SCAQMD staff will rely on the above definition. Because the SCAQMD's staff's GHG significance proposal is considered to be an interim proposal, future updates or revisions to staff's proposal would also include updates to BAU or the target objective as BAU levels decline over time. It may be that a target objective percent reduction from BAU levels is a short-term GHG threshold proposal and may become less important in the future as other concepts are evaluated and more fully developed.

- GHG Source Categories to Analyze

Life Cycle Analysis

CEQA requires that the lead agency analyze direct and indirect impacts from a proposed project, giving due consideration to short-term and long-term effects (CEQA Guidelines 15126.2(a)). In the case of GHG pollutants a systems approach to evaluating the consequences of a particular product, process or activity may be more appropriate because of the long atmospheric lifetimes of the various GHGs (see Table 3-1). One of the most effective ways of evaluating GHGs using a systems approach is through the preparation of a life cycle analysis (LCA).

The goal of a life cycle analysis is to compare the full range of environmental damages assignable to products and services, to be able to choose the least burdensome one. The term 'life cycle' refers to the concept that a fair, holistic assessment requires the assessment of raw material production, manufacture, distribution, use and disposal including all intervening transportation steps necessary or caused by the product's existence. The sum of all those steps - or phases - is the life cycle of the product.

Performing a life cycle analysis may be difficult for a number of projects or processes because life cycle emission factors may not be well established for many activities or projects and the life cycle process itself may not be known or well-defined. SCAQMD staff, however, recommends that life cycle analyses be prepared for all projects undergoing a CEQA analysis, as this will produce a more defensible approach. If, however, any component of the life cycle analysis is unavailable, unknown, or not supported by scientific evidence, the lead agency should note such an analysis would be speculative pursuant to CEQA Guidelines §15145 and terminate discussion of that impact.

Direct/Indirect Impacts

Consistent with CEQA, indirect and direct impacts of the project, typically within California, are required to be analyzed in the CEQA document for a proposed project. The analysis of direct GHG impacts is relatively straightforward as onsite GHG sources or directly related offsite GHG sources, such as worker commute trips, are generally readily identifiable. Indirect GHG emission sources are less obvious, but may include some of the sources identified in the following paragraphs. In general, for most projects information on direct and indirect emissions may be available, rather than a full life-cycle analysis of emissions. The lead agency has typically been expected to address emissions that are closely related and within the capacity of the project proponent to control and/or influence.

Direct Impacts - are primary effects that are caused by a project and occur at the same time and place, such as emissions from boilers, heaters, or other onsite emissions sources. Direct impacts generated by a project may include offsite sources directly related to the project such as emissions from worker commute trips, haul truck trips to import raw materials and/or export finished products or other goods.

Direct GHG emission impacts will include both construction and operation activities. Because impacts from construction activities occur over a relatively short-term period of time, they contribute a relatively small portion of the overall lifetime project GHG emissions. In addition, GHG emission reduction measures for construction equipment are relatively limited. Therefore, SCAQMD staff is recommending that construction emissions be amortized over a 30-year project lifetime, so that GHG reduction measures will address construction GHG emissions as part of the operational GHG reduction strategies.

Indirect Impacts - The CEQA Guidelines define indirect impacts as the following: an indirect physical change in the environment…which is not immediately related to the project, but which is caused indirectly by the project. If a direct physical change in the environment in turn causes another change in the environment, then the other change is an indirect change in the environment (CEQA Guidelines §15064 (d)(2)). Indirect or secondary effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystems (CEQA Guidelines §15358)(a)(2)).

DRAFT STAFF INTERIM GHG SIGNIFICANCE THRESHOLD PROPOSAL

As indicated by the evolution of the staff proposal over time, SCAQMD has generally recommended a tiered decision tree approach to establishing a GHG significance threshold. In CAPCOA's White Paper, eight of the 12 significance threshold options are based on a tiered threshold approach (see also Table 2-2 in Chapter 2). A tiered GHG significance threshold approach is an appealing approach because it provides flexibility in determining whether or not GHG emissions from a project are significant typically using a single methodology to establish various tiers that can be based on the physical size of the project, land use type, or other characteristics. The tiered approach envisioned by SCAQMD staff would require quantification of GHG emissions for all projects that are subject to CEQA and quantification of the GHG reduction effectiveness of design parameters incorporated into the project and any mitigation measures imposed by the lead agency. It may even be necessary to quantify GHG emissions, if any, for projects that would otherwise qualify for a categorical exemption to document that no "cumulative impact of successive projects of the same type in the same place, over time is significant" (CEQA Guidelines §15300.2(b), or that there is no "reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances." (CEQA Guidelines §15300.2(c)).

The CAPCOA White Paper also includes a discussion of a decision tree approach to tiering. Instead of using a single methodology to establish tiers, a decision tree approach would use multiple methodologies to demonstrate significance for a broad range of projects/plans that may be difficult to address using a single GHG significance threshold methodology. Using a decision tree approach promotes even greater flexibility in determining significance for a variety of project types.

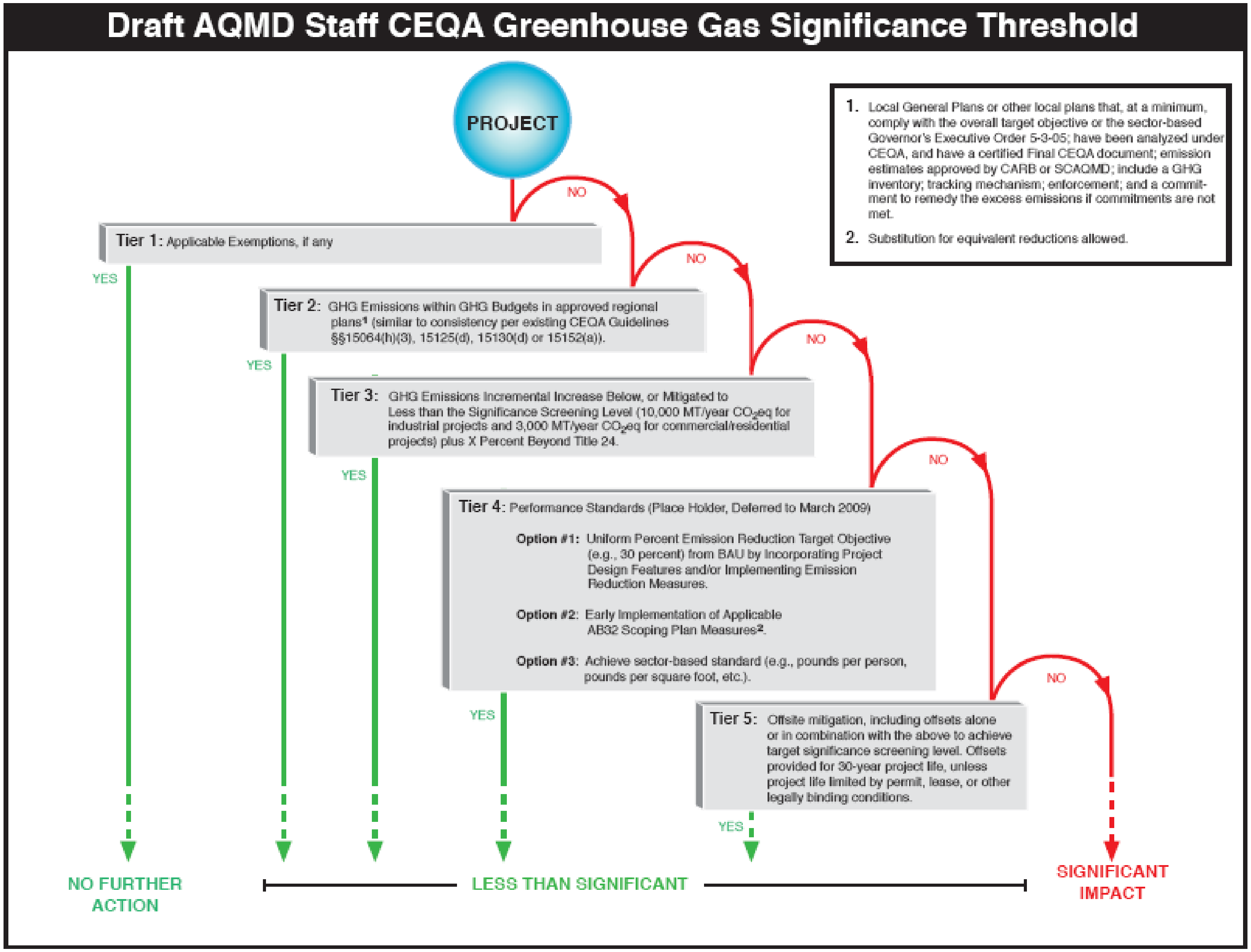
At the August 27, 2008 Working Group meeting #5, staff presented the revised interim GHG significance proposal #3, which included a tiered decision tree approach. Unlike the decision tree approach discussed in CAPCOA's White Paper, some tiers include multiple approaches for determining whether a project's GHG emissions are significant, rather than using a single different methodology for each tier.

For the purposes of determining whether or not GHG emissions from affected projects are significant, project emissions will include direct, indirect, and, to the extent information is available, life cycle emissions during construction and operation. Construction emissions will be amortized over the life of the project, defined as 30 years, added to the operational emissions, and compared to the applicable interim GHG significance threshold tier. The following bullet points describe the basic structure of staff's tiered GHG significance threshold proposal for stationary sources. The components of revised staff proposal #3 are described in the following paragraphs and shown graphically in Figure 3-1.

- **Tier 1 –** consists of evaluating whether or not the project qualifies for any applicable exemption under CEQA. For example, SB 97 specifically exempts a limited number of projects until it expires in 2010. If the project qualifies for an exemption, no further action is required. If the project does not qualify for an exemption, then it would move to the next tier.

- **Tier 2 –** consists of determining whether or not the project is consistent with a GHG reduction plan that may be part of a local general plan, for example. The concept embodied in this tier is equivalent to the existing concept of consistency in CEQA Guidelines §§15064(h)(3), 15125(d), or 15152(a). The GHG reduction plan must, at a minimum, comply with AB 32 GHG reduction goals; include emissions estimates agreed upon by either CARB or the SCAQMD, have been analyzed under CEQA, and have a certified Final CEQA document. Further, the GHG reduction plan must include a GHG emissions inventory tracking mechanism; process to monitor progress in achieving GHG emission reduction targets, and a commitment to remedy the excess emissions if AB 32 goals are not met (enforcement).

Figure 3-1
Revised Staff Proposal #3 Tiered Decision Tree Approach – August 27, 2008



If the proposed project is consistent with the local GHG reduction plan, it is not significant for GHG emissions. If the project is not consistent with a local GHG reduction plan or there is no approved plan, the GHG reduction does not include all of the components described above, or there is no adopted GHG reduction plan, the project would move to tier 3.

- **Tier 3 –** attempts to identify small projects that would not likely contribute to significant cumulative GHG impacts. However, because of the magnitude of increasing global temperatures from current and future GHG emissions, staff is recommending that all projects must implement some measure or measures to contribute to reducing GHG emissions. Therefore, Tier 3 includes a requirement that ~~all~~ residential/commercial projects with GHG emissions less than the screening level must include efficiency components that ~~reduce a certain~~go X percent~~age~~ beyond the requirements of Title 24 (Part 6, California Code of Regulations), California's energy efficiency standards for residential and nonresidential buildings. Project proponents would also have to reduce by a specified percentage electricity demand from water use, primarily electricity used for water conveyance.

  ~~The most recently~~A past recommended screening level proposed by staff was 6,500 MTCO2eq./year. This screening level was derived using the SCAQMD's existing NOx operational threshold as a basis. The daily NOx operational significance threshold, 55 pounds per day was annualized, which results in 10 tons of NOx per year.

  Staff initially considered and then rejected a bifurcated screening level, that is one screening level for residential and commercial projects and a different screening level for industrial projects based on the URBEMIS modeling runs used to derive the 6,500 MTCO3eq/yr screening level because GHG emissions from industrial were of the same magnitude as the GHG emissions from residential and commercial projects. Staff has reconsidered the bifurcated screening level approach as there is a more scientific basis for deriving the different screening levels.

  SCAQMD staff is now recommending a bifurcated screening level approach to address two greatly differing project types: industrial projects as opposed to residential and commercial projects (which are largely indirect sources). The former category typically contains stationary source equipment whose emissions are largely permitted or regulated by the SCAQMD; whereas the latter category is mostly residential, commercial (may also include industrial) building structures that attract or generate mobile source emissions. In light of the GHG reductions needed to stabilize the climate while considering implementation resource requirements, the policy objective used to establish the screening thresholds is to capture projects that represent approximately 90 percent of GHG emissions from new sources. The following paragraphs describe the steps taken to derive the screening threshold values.

Industrial Projects: Since the majority of GHG emissions in the district are comprised of CO2 emissions from burning natural gas rather than other types of fossil fuel, staff compiled reported annual natural gas consumption for 1,297~~115~~ permitted facilities for 2006-2007 and rank-ordered the facilities to estimate the 90^{th} percentile of the cumulative natural gas usage for all permitted facilities. Operators of these facilities are required to report their emissions and associated throughput under the SCAQMD's Annual Emission Reporting (AER) Program if any of their criteria pollutant emissions exceed four tons per year (100 tons per year for CO) or if the facility has any reportable air toxics emission. Figure 3-2 shows that approximately 10 percent of facilities evaluated comprise more than 90 percent of the total natural gas consumption, which corresponds to 10,000 metric tons per year (tpy) of CO2 emissions. This value represents a boiler with a rating of approximately 27 million British thermal units per hour (mmbtu/hour) of heat input, operating at ~~a~~n ~~25~~ 80 percent capacity factor. If the screening threshold of 10,000 MTCO2eq./yr is implemented, based on the permitting activities for 2006-2007 it will result in at least 31 additional MNDs or EIRs being prepared by the SCAQMD as the lead agency unless another tier option is selected to demonstrate no significant impacts for GHG emissions. It should be noted that this analysis did not include other possible GHG pollutants such as methane, N2O; a life-cycle analysis; mobile sources; or indirect electricity consumption. Therefore, under a 10,000 MTCO2eq./yr screening level more projects would be required to go through an MND or EIR environmental analysis than is currently the case. Furthermore, when the SCAQMD acts as a lead agency, the stationary source equipment employed as part of the proposed project typically must comply with BACT or other SCAQMD rules, regulations, programs that require reducing criteria pollutants or air toxics. Therefore, staff is proposing to replace the 6,500 MTCO2/yr screening level with the 10,000 MTCO2eq/yr as the screening level in tier III for industrial projects when the SCAQMD is the lead agency for the project.

Residential and Commercial Projects: To achieve the same 90 percent GHG emission capture rate for this segment of projects GHG emissions from residential and commercial sectors were compared to the GHG emissions from the industrial sector including the in-state power plants. The draft AB32 scoping plan indicates that based on statewide 2002-2004 average GHG emissions, the residential and commercial sectors account for approximately nine percent of the total statewide GHG inventory, while the industrial sector (including instate power plants) accounts for approximately 30 percent of the statewide GHG emission inventory. The inventory methodology for both sectors includes only on-site energy use, consistent with the staff approach taken in deriving the 10,000 tpy threshold. Assuming similar emission characteristics also exist for the residential and commercial sector (i.e., large residential or commercial projects, although fewer in numbers, contribute substantially more to the total emissions), it is estimated that at a threshold of approximately 3,000 MTCO2eq/yr emissions (10,000 x (9 percent / 30 percent)) would capture 90 percent of the GHG emissions from new residential or commercial projects. A series of sensitivity analyses was performed by the staff using URBEMIS to assess the likely project size for 3,000 MTCO2eq/yr emissions. Table 3-3 illustrates various projects by size and shape.

Figure 3-2

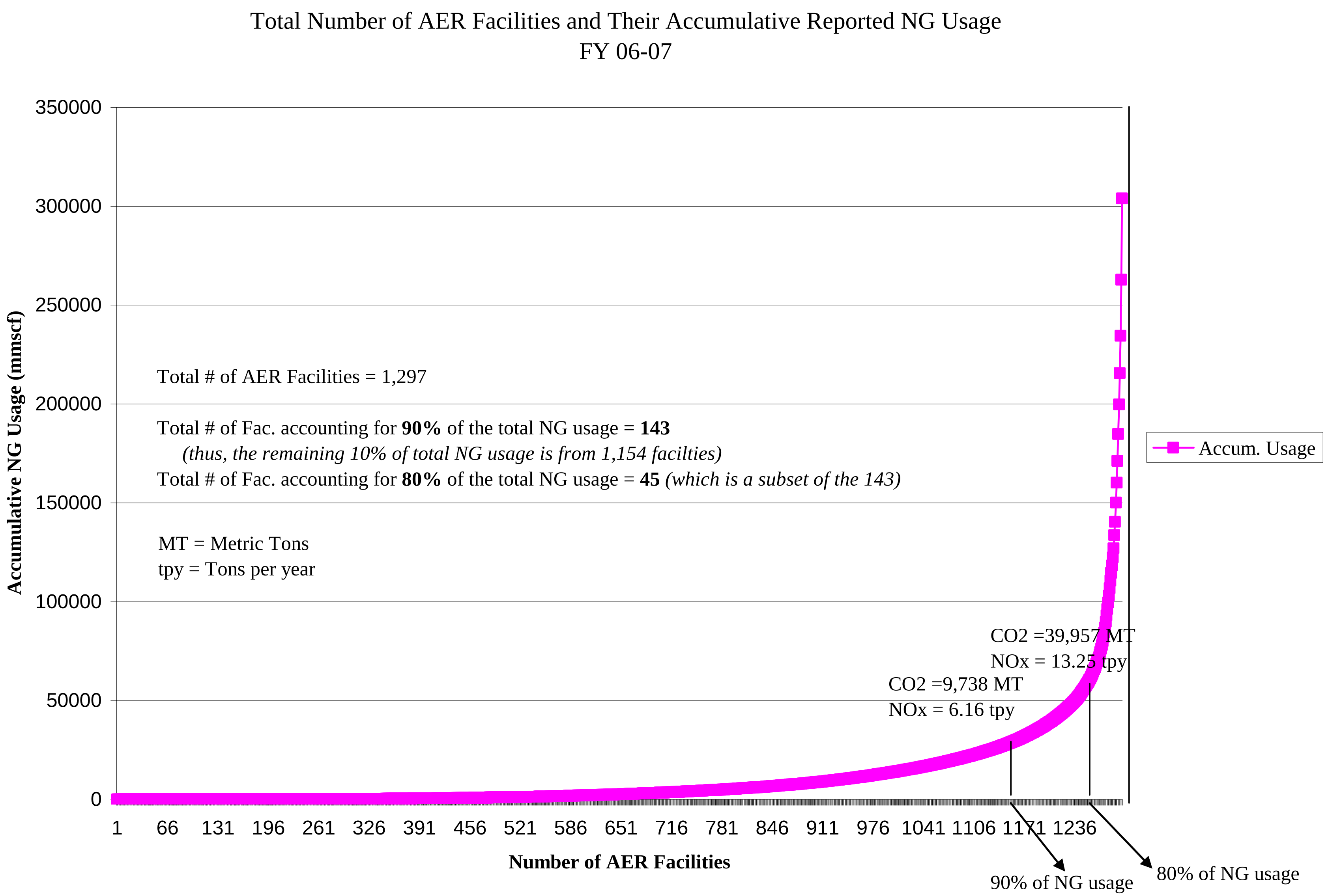

Total Number of AER Facilities and Their Accumulative Reported NG Usage
FY 06-07
Accumulative NG Usage (mmscf)
350000
300000
250000
200000
150000
100000
50000
0
Total # of AER Facilities = 1,297
Total # of Fac. accounting for **90%** of the total NG usage = **143**
(thus, the remaining 10% of total NG usage is from 1,154 facilties)
Total # of Fac. accounting for **80%** of the total NG usage = **45** *(which is a subset of the 143)*
MT = Metric Tons
tpy = Tons per year
CO2 =39,957 MT
NOx = 13.25 tpy
CO2 =9,738 MT
NOx = 6.16 tpy
Accum. Usage
1 66 131 196 261 326 391 456 521 586 651 716 781 846 911 976 1041 1106 1171 1236
Number of AER Facilities
90% of NG usage
80% of NG usage

Table 3-3

URBEMIS Run Results for Residential/Commercial Projects Emitting Approximately 3,000 MTCO2 per Year*

			Area Source Emissions		*Operational Emissions*		**TOTAL**
	Weighted Avg Trip Rate	**Size**	**CO2 (tons/year)**	**CO2 (MT/year)**	**CO2 (tons/year)**	**CO2 (MT/year)**	**CO2 (MT/year)**
Res - Single Unit	19.54	80 units	326.86	297.15	3003.56	2730.51	3027.65
Res - Apt	9.17	175 units	422.70	384.27	2971.95	2701.77	3086.05
Comm - Office	6.02	265,000 ft^2	387.41	352.19	2961.75	2692.50	3044.69
Comm - Bank	206.22	9,500 ft^2	14.38	13.07	3192.90	2902.64	2915.71
Single/Apt	19.54	35 units	379.59	345.08	2964.82	2695.29	3040.37
	9.17	100 units					
Office/Bank	6.02	170,000 ft^2	254.19	231.08	3042.71	2766.10	2997.18
	206.22	3,400 ft^2					
Office/Single	6.02	135,000 ft^2	355.13	322.85	2956.32	2687.56	3010.41
	19.54	40 units					
Office/Apt	6.02	135,000 ft^2	403.19	366.54	2952.34	2683.95	3050.48
	9.17	85 units					
Bank/Single	206.22	3,700 ft^2	202.81	184.37	3052.93	2775.39	2959.76
	19.54	50 units					
Bank/Apt	206.22	4,000 ft^2	248.12	225.56	3042.64	2766.04	2991.60
	9.17	100 units					
Single/Apt/Office	19.54	20 units	382.60	347.82	2945.26	2677.51	3025.33
	9.17	65 units					
	6.02	100,000 ft^2					
Single/Apt/Bank	19.54	20 units	241.78	219.80	3020.76	2746.15	2965.95
	9.17	65 units					
	206.22	3,550 ft^2					
						Avg CO2 (MT/year):	**3009.60**

*Offsite electricity use, water use, or other potential life cycle emissions not included.

As shown in Table 3-3, this threshold would represent a residential development of about 70 single-family dwelling units. It should be noted that the sensitivity analysis did not include GHG emissions from electricity use and water use. As a result, similar to the earlier discussion of industrial projects, this screening level of 3,000 MTCO2eq/yr could capture development projects less than 70 single-family dwelling units.

In CAPCOA's White Paper, it is suggested that a thresholds of 900 MTCO2eq/yr would capture 90 percent of all development projects, which should translate into at least 90 percent of GHG emissions from the residential and commercial sectors[2]. According to CAPCOA 900 MTCO2eq/yr equates to approximately 50 single-family dwelling units. This information appears to corroborate the SCAQMD staff's finding that the policy objective of capturing 90 percent of all GHG emissions for this region can be achieved with a screening level of 3000 MTCO2eq/yr. Therefore, staff is recommending that this value be used by lead agencies for residential and commercial developments, including industrial parks, warehouses, etc.

- **Tier 4 – Decision Tree Options:** consists of three decision tree options to demonstrate that a project is not significant for GHG emissions. The three compliance options are as follows.

  Compliance Option 1 – the lead agency would calculate GHG emissions for a project using a BAU methodology. Once GHG emissions are calculated, the project proponent would need to incorporate design features into the project and/or implement GHG mitigation measures to demonstrate a 30 percent reduction from BAU. Although a 30 percent reduction below BAU is consistent with the target objectives of AB 32, it will continue to reduce GHG emissions beyond 2020, thus, contributing to GHG reductions pursuant to the Governor's Executive Order S-3-05 (a 90 percent reduction compared to current GHG emissions). A 30 percent reduction is also considered to be an achievable GHG reduction target based on current technologies.

  Compliance Option 2 – this option consists of early compliance with AB 32 through early implementation of CARB's Scoping Plan Measures. The intent of this compliance option is to accelerate GHG emission reductions from the various

[2] Although the CAPCOA White Paper implies that 900 metric tons per year equates to a 90 percent capture rate, there is no explicit information provided in the White Paper that demonstrates this correlation. Indeed, the CAPCOA authors state that 900 metric tons, which represents approximately 50 residential units, corresponds to widely divergent capture rate percentile rankings depending on the project location (see discussion on page 43 of the White Paper). Percentile rankings were based on a survey of four cities in California. A project of 900 metric tons per year representing a 90 percent capture rate appears to be a working assumption for which there appears to be no factual basis. Further, although not explicitly stated, it is assumed that the 900 metric tons were derived using the URBEMIS2007 model. It should be noted that that the URBEMIS2007 model only quantifies CO2 emissions and direct emissions primarily from on-road mobile sources. It does not capture other GHG pollutants or indirect GHG emissions such as emissions from energy generation, water conveyance, etc. Therefore, it is likely that a 50-unit residential project would actually generate higher GHG emissions than 900 metric tons per year.

sectors subject to CARB's Scoping Plan to eliminate GHG emission, especially for those GHGs that have a long atmospheric lifetime such as CO2, sulfur hexafluoride, etc., to minimize future projected impacts to California from global climate change.

Compliance Option 3 – this compliance option consists of establishing sector-based performance standards. For example, it may be possible to use the 1990 inventory required under AB 32 to establish an efficiency standard such as pounds per person, pounds per worker, pounds per square feet, pounds per item manufactured, etc. When calculating GHG emissions from a project, if they are less than the established efficiency standard the project would not be significant relative to GHG emissions, while projects exceeding the efficiency standard would be significant.

If the lead agency or project proponent cannot achieve the performance standards on any of the compliance options in Tier 4, GHG emissions would be considered significant.

- **Tier 5** – under this tier, the lead agency would quantify GHG emissions from the project and the project proponent would implement offsite mitigation (GHG reduction projects) or purchase offsets to reduce GHG emission impacts to less than the proposed screening level. In addition, the project proponent would be required to provide offsets for the life of the project, which is defined as 30 years. If the project proponent is unable to obtain sufficient offsets, incorporate design features, or implement GHG reduction mitigation measures to reduce GHG emission impacts to less than the screening level, then GHG emissions from the project would be considered significant. Since it is currently uncertain how offsite mitigation measures, including purchased offsets, interact with future AB 32 Scoping Plan measures, the AQMD would allow substitution of mitigation measures that include an enforceable commitment to provide mitigation prior to occurrence of emissions and to prevent mitigating the same emissions twice.

  Mitigation Preference – If a project generates significant adverse impacts, CEQA Guidelines §15126.4 requires identification of mitigation measures to minimize potentially significant impacts. Because GHG emissions contribute to global change, mitigation measures could be implemented locally, nationally, or internationally and still provide global climate change benefits. Because reducing GHG emissions may provide co-benefits through concurrent reductions in criteria pollutants, when considering mitigation measures when the AQMD is the lead agency under CEQA, staff will implement mitigation measures that are real, quantifiable, verifiable, and surplus in the following order of preference.

  - Incorporate GHG reduction features into the project design, e.g., increase a building's energy efficiency, use materials with a lower global warming potential than conventional materials, purchase building materials locally, etc.

  - Implement onsite measures that provide direct GHG emission reductions onsite, e.g., replace onsite combustion equipment (boilers, heaters, steam generators, etc.) with more efficient combustion equipment, replace existing high global warming potential refrigerants with low global warming refrigerants, eliminate or minimize fugitive emissions, etc.

- Implement neighborhood mitigation measure projects that could include incentives for installing solar power, increasing energy efficiency by exceeding Title 24 building standards through replacing low efficiency water heaters with high efficiency water heaters, increasing building insulation, using fluorescent bulbs, replacing old inefficient refrigerators with efficient refrigerators using low global warming potential refrigerants, etc.

- Implement in-district mitigation measures such as any of the above identified GHG reduction measures; reducing vehicle miles traveled (VMT) through greater rideshare incentives, transit improvements, etc.

- Implement in-state mitigation measures, which could include any of the above measures.

- Implement out of state mitigation measure projects, which may include purchasing offsets if no other options are available.

CARB's Interim GHG Significance Threshold Proposal

In October 2008 CARB released its interim GHG significance threshold proposal and held a public workshop on October 27, 2008. CARB's threshold is considered to be an interim threshold because CARB staff intends to periodically review and change its threshold proposal as necessary. CARB's Preliminary Draft Staff Proposal (Proposal) states that non-zero GHG significance thresholds can be supported by substantial evidence. Futher, different GHG significance thresholds may be established for different sectors. Therefore, as part of its initial interim GHG significance threshold proposal CARB is proposing two separate GHG significance thresholds, one for new industrial projects and another for residential/commercial projects subject to CEQA. CARB's proposal uses a tiered approach (see Table 3-4).

Table 3-4
Comparison of CARB's and AQMD's Interim GHG Significance Thresholds Approaches

	Stationary/Industrial Sector Projects		Residential/Commercial Sector Projects	
	CARB	AQMD	CARB	AQMD (Not Recommended at this Time)
Policy Objective	Capture 90% of statewide stationary project emissions	Capture 90% of district wide GHG emissions (industrial)	Capture X% of statewide residential/commercial project emissions	Capture 90% of district wide residential/commercial project GHG emissions
Exemption	Apply applicable exemption	Apply applicable exemption	Apply Applicable Exemption	Apply Applicable Exemption
Regional GHG Reduction Plan	N.A.	Project Consistent with Applicable GHG Reduction Plan with GHG inventorying, monitoring, enforcement, etc.	Project Consistent with Applicable GHG Reduction Plan with GHG inventorying, monitoring, enforcement, etc.	Project Consistent with Applicable GHG Reduction Plan with GHG inventorying, monitoring, enforcement, etc.
Thresholds	Project < 7,000 MTCO2eq/yr & meets construction & transportation performance standards	GHG emissions from industrial project is < 10,000 MTCO2eq/yr, includes construction emissions amortized over 30 years & added to operational GHG emissions	Project meets construction & operation performance tandards, e.g., energy, water use, waste & ransportation & < X MTCO2eq/yr	Project is < 3,000 MTCO2eq/yr & exceeds Title 24 Energy Efficiency Standards by X%, if applicable – construction emissions amortized over 30 years & added to operational GHG emissions
Performance Standards	See above	NA	See above	3 Compliance Options: 1) Reduce GHG emissions 30% below BAU; 2) Early Implement AB 32 Measure; 3) Comply with Performance Standard
Offsets	Offsite substitution allowed	Implement offsite mitigation for life of project, i.e., 30 years, with mitigation preference	Offsite substitution allowed	Implement offsite mitigation for life of project, i.e., 30 years with mitigation preference
Determination	GHG emissions significant, EIR is prepared, if meeting none of the above	GHG emissions significant, EIR is prepared, if meeting none of the above	GHG emissions significant, EIR is prepared, if meeting none of the above	GHG emissions significant, EIR is prepared, if meeting none of the above

CARB's interim GHG significance threshold for industrial sources was developed to capture "the vast majority (~90% statewide) of the GHG emissions from new industrial projects being subject to CEQA's requirement to impose feasible mitigation." According to CARB's Proposal, CARB staff used data from a survey of industrial boilers performed by the Oak Ridge National Laboratory in which it was concluded that small boilers with an input capacity of 10 MMBtu/hr corresponded to 93 percent of total industrial boiler input capacity, or 4,660 MTCO2e/yr. Using this result and accounting for process losses, purchased electricity, and water usage and wastewater discharge, CARB staff is recommending 7,000 MTCO2eq/yr as a GHG significance threshold for industrial projects. The following bullet points summarize CARB's proposed interim GHG significance threshold for industrial sources.

- Box 1 – Apply any applicable categorical or statutory exemptions. If the project does not qualify for an exemption, move to Box 2.

- Box 2 – The industrial project must meet both of the following performance standards or equivalent mitigation measures to be deemed insignificant for GHGs:

  - Construction – Project must meet an interim performance standard for construction- related emissions (performance standard not yet defined).

  - Transportation – Project must meet an interim performance standard for transportation (performance standard not yet defined).

AND

  - Project with mitigation will emit no more than 7,000 MTCO2eq/yr. If the project does not qualify for either of the performance standards or exceeds 7,000 MTCO2eq/yr, move to Box 3.

- Box 3 – Project is deemed significant and an EIR must be prepared.

- CARB's Preliminary Draft Proposal for Residential and Commercial projects is summarized in the following bullet points.

- Box 1 – Apply any applicable categorical or statutory exemptions. If the project does not qualify for an exemption, move to Box 2.

- Box 2 – Project complies with a previously approved plan that addresses GHG emissions and must: include a GHG reduction target consistent with AB 32; be consistent with transportation-related target adopted by CARB pursuant to SB 375; include a GHG inventory and mechanism for monitoring GHG emissions; include enforceable GHG requirements; include a mechanism for periodic updates to plan; and have a certified CEQA document. If the project is consistent with a GHG plan that includes all of these elements, it is presumed to be insignificant for GHGs. If the project is not consistent with a GHG plan or there is no adopted GHG plan that includes all of the above elements, move to Box 3.

- Box 3 – The residential/commercial project must meet all of the following performance standards or equivalent mitigation measures to be deemed insignificant for GHGs:

    - Construction – Project must meet an interim performance standard for construction- related emissions (performance standard not yet defined).

    - Operations – Project must meet the following performance standards: energy use performance standard defined in CEC's Tier II Energy Efficiency goal; an interim performance standard for water use (performance standard not yet defined); an interim performance standard for waste (performance standard not yet defined); and an interim performance standard for transportation (performance standard not yet defined).

AND

The project with performance standards or equivalent mitigation will emit no more than X MTCO2eq/yr (criterion to be developed). If the project does not qualify for any one of the performance standards or exceeds X MTCO2eq/yr, move to Box 4.

- Box 4 – Project is deemed significant and an EIR must be prepared.

For a detailed description of CARB's interim GHG significance threshold proposal, refer to the following URL: http://www.arb.ca.gov/cc/localgov/ceqa/meetings/102708/prelimdraftproposal102408.pdf.

CARB is currently accepting comments on its Draft Proposal and has scheduled a second public workshop on December 9, 2008. CARB staff currently anticipates taking their proposal to their Board in February 2009.

CHAPTER 4

CONSIDERATIONS WHEN ANALYZING GHG EMISSIONS

INTRODUCTION

As noted in Chapter 1, on June 19, 2008, OPR, in collaboration with the California Resources Agency, the California Environmental Protection Agency and the California Air Resources Board, released a *Technical Advisory* containing informal guidance for public agencies as they address the issue of climate change in their CEQA documents. With regard to analyzing GHG emission impacts OPR states,

"Each public agency that is a lead agency for complying with CEQA needs to develop its own approach to performing a climate change analysis for projects that generate GHG emissions. A consistent approach should be applied for the analysis of all such projects, and the analysis must be based on best available information… Lead agencies should determine whether greenhouse gases may be generated by a proposed project, and if so, quantify or estimate the GHG emissions by type and source."

Other than this general advice, the *Technical Advisory* does not provide explicit details for quantifying GHG emissions.

CAPCOA's White Paper provides a comprehensive discussion of modeling tools that are currently available for analyzing GHG emissions[3]. As indicated in the White Paper, no one model is currently available that is capable of estimating all of a project's direct and indirect GHG emissions. It is likely, however, that the Urban Emissions (URBEMIS) Model will be the most commonly used model for calculating GHG emissions because it currently calculates CO2 emissions (in addition to criteria pollutant emissions) during both construction and operation of proposed projects, it is publicly available, and already widely used in California. Statewide use of the URBEMIS model would provide consistency throughout California with regard to quantifying GHG emissions. For a list of currently available models that calculate GHG emissions and summaries of the capabilities, advantages, and disadvantages of each model refer to Table 10 on pages 75 through 78 in the CAPCOA White Paper.

The purpose of this chapter is to provide more explicit guidance to CEQA practitioners with regard to quantifying GHG emissions than OPR's *Technical Advisory*, while building on the information provided CAPCOA's White Paper.

GHG ANALYSIS RECOMMENDATIONS

Direct/Indirect Impacts

As noted in Chapter 3 of this Guidance Document, consistent with CEQA, indirect and direct impacts of the project, typically within California, are required to be analyzed in the CEQA document for a proposed project. The analysis of direct GHG impacts is

[3] For maximum transparency with regard to quantifying GHG emissions and disclosure to the public, SCAQMD staff recommends using only publicly available models.

relatively straightforward as onsite GHG sources or directly related offsite GHG sources, such as worker commute trips, are generally readily identifiable. Indirect GHG emission sources are less obvious, but may include some of the sources identified in the following paragraphs. In general, for most projects information on direct and indirect emissions may be available, rather than a full life-cycle analysis of emissions. The lead agency has typically been expected to address emissions that are closely related and within the capacity of the project proponent to control and/or influence.

Direct Impacts - are primary effects that are caused by a project and occur at the same time and place, such as emissions from boilers, heaters, or other onsite emissions sources. Direct impacts generated by a project may include offsite sources directly related to the project such as emissions from worker commute trips, haul truck trips to import raw materials and/or export finished products or other goods. The following paragraphs provide general guidance on quantifying direct GHG emissions.

CAPCOA's White Paper provides a comprehensive discussion of modeling tools that are currently available for analyzing GHG emissions. Further, no one model is currently available that is capable of estimating all of a project's direct and indirect GHG emissions. Although there are a number of modeling tools available to calculate GHG emissions the following discussion focuses on a combination of approaches using the URBEMIS model as the basis for analyzing GHG emission impacts. Other approaches for calculating GHG emissions can be used, as long as they are supported by scientific evidence and include publicly available information.

The URBEMIS model is a publicly available model that is currently used statewide to calculate criteria pollutant emissions from construction and operation activities for a wide variety of land use projects. The model is regularly updated through a collaboration of air pollution control agencies, including the SCAQMD, to reflect the most current data, methodologies, and emission factors for quantifying criteria pollutant emissions. The most current update to the model is URBEMIS2007 version 9.2.4, which quantifies CO2 emissions in addition to criteria pollutant emissions.

Currently, there are several disadvantages to using the URBEMIS model to calculate GHG emissions from a proposed project and, as a result, it should not be the only tool used to calculate GHG emissions. For example, currently the URBEMIS model only quantifies CO2 emissions and not other GHG pollutants, with the exception of methane from mobile sources, which is converted to CO2eq. emissions. Since CO2 emissions comprise the bulk of GHG emissions from most projects, URBEMIS GHG results are fairly representative of GHG emissions from a project.

To quantify mobile source emissions from on-road mobile sources, the URBEMIS model uses trip rate information from the Institute of Transportation Engineers Trip Generation Handbook (ITE, 2001) as the trip rate default factor for all land uses. ITE trip rate information is widely used and is considered legally defensible as they rely on substantial reports and surveys of trip rates in cities with little or no transit. As a result, the ITE trip rates are also considered to provide a conservative estimate of trip rates and associated emissions. The model, however, treats each trip as a separate trip and doesn't consider that a single trip may be used for more than one purpose, referred to as "internalization." The model also does not fully account for interaction between land uses in its estimation of mobile source operational emissions. URBEMIS does allow the user to overwrite the default trip rates and characteristics with more project-specific data from a traffic study prepared for a project.

In spite of the disadvantages of the URBEMIS model described above, it can be used as the first step in quantifying GHG emissions for typical land use projects because it establishes default parameters for the most common emission sources from a project including construction equipment types and activity profiles, area of site disturbed during construction, building size, number vehicle trips, etc., if the level of information about the project is low. If more information about the project is available such as a precise profile of construction equipment and activity levels, number of vehicle trips based on a traffic study prepared for the project, etc., this information can be incorporated into the model. The model can then quantify CO2 emissions from both construction and operation.

The URBEMIS construction analysis quantifies criteria pollutant and CO2 emissions from both off-road sources (primarily construction equipment) and on-road sources (worker commute trips, haul truck trips, etc.). To further flesh out the construction analysis, the lead agency would have to identify emission factors for other GHG pollutants likely to be emitted during construction, i.e., methane and nitrous oxide[4], for both off-road and on-road emissions sources and then quantify the GHG emission results using spreadsheets or other available tools.

The off-road CO2 emission factors in the URBEMIS model are generated from CARB's off- road model (http://www.arb.ca.gov/msei/offroad/offroad.htm). Methane emission factors for off-road equipment can also be obtained from CARB's OFFROAD2007 model. CO2 and methane emission factors for off-road equipment that are based on CARB's OFFROAD2007 model can also be found on the SCAQMD's CEQA webpages at the following URL: http://www.aqmd.gov/ceqa/handbook/offroad/offroad.html. Other sources of off-road GHG emissions factors for equipment used in California may be used, as long as they are supported by scientific evidence and are publicly available.

The URBEMIS model is able to quantify mobile source CO2 emissions during construction from on-road mobile sources such as construction worker commute trips, heavy-duty truck trips to haul away demolition debris, soil hauling to and from the site etc., and during operation, primarily vehicle trips using ITE's Trip Generation Manual (ITE, 2001). The on-road CO2 emission factors in the URBEMIS model for both construction and operation are generated from CARB's on- road mobile source emissions model, EMFAC2007 (http://www.arb.ca.gov/msei/onroad/onroad.htm). Methane emission factors for on-road mobile sources can also be obtained from

[4] Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are not combustion emissions, so would not normally be emitted during construction.

CARB's EMFAC2007 model. CO2 and methane emission factors for on-road mobile sources that are based on CARB's EMFAC2007 model can also be found on the SCAQMD's CEQA webpages at the following URL: http://www.aqmd.gov/ceqa/handbook/onroad/onroad.html.

The analysis of operation emissions from all types of land uses in the URBEMIS model focuses primarily on mobile source emissions and some area sources. The model does not quantify emissions from stationary sources. For stationary sources that require a permit from the SCAQMD, emission calculation procedures and methodologies are available in the SCAQMD's Best Available Control Technology Guidelines (http://www.aqmd.gov/bact/partd7-9-2004update.pdf). Examples of facilities that use stationary sources requiring a permit from the SCAQMD include: fossil fuel power plants[5], cement plants, landfills, wastewater treatment plants, gas stations, dry cleaners and industrial boilers. The SCAQMD has procedures and methodologies for projects subject to SCAQMD permits to calculate criteria pollutants and air toxics. It is anticipated that these same procedures and methodologies could be extended to estimate a permitted facility's GHG calculations. For are any stationary and area sources that do not require SCAQMD permits, the same methodologies used for permitted sources could be used. It will be necessary to contact the SCAQMD to obtain information on GHG emission calculation methodologies applicable to stationary source equipment.

Indirect Impacts - Indirect or secondary effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystems (CEQA Guidelines §15358)(a)(2)). The examples of facilities that use stationary sources requiring a permit from the SCAQMD that may contribute to direct environmental impact (fossil fuel power plants, cement plants, landfills, wastewater treatment plants, gas stations, dry cleaners and industrial boilers) may also contribute to indirect impacts and, therefore, should be included, as necessary in the CEQA analysis of GHGs.

Quantification Methodologies and GHG Emission Factors

Methodologies for calculating GHG emissions and GHG emission factors are currently not readily available. Until such time as GHG calculation methodologies and emission factors become well established and more readily available, lead agencies may want to consult the following references to identify acceptable methodologies and emission factors.

1. The first useful reference for GHG emission factors for stationary sources is EPA's Air Pollutant (AP)-42, which is a compilation of air pollutant emission

[5] According to CEQA Guidelines §15227, CEQA does not apply to projects outside of California. The California Attorney General's Office has rendered an opinion stating that the definition of the environment in CEQA does not stop at the borders of California. Further, California public agencies that take an action outside of California is still bound by the requirements of CEQA to prepare an EIR if the action may cause a significant effect on the environment.

factors for stationary point and area sources. Each of the first 13 chapters of AP-42 is dedicated to a specific source activity such as solid waste disposal, petroleum industry, and metallurgical industry. Since the publication of the fifth edition (and supplementals) in 2001, there have been a number of updates to the various specific stationary sources such as hot asphalt plants, organic liquid storage tanks, and coke production. In addition to the criteria pollutant emissions, some of the updated AP-42 chapters provide GHG emission factors for a variety of sources. For example, Chapter 15 of AP-42 focuses on GHG emissions from biogenic sources such as soils, termites, lightning, and enteric fermentation (animal digestive fermentation).

2. Second, the California Climate Action Registry (C-CAR) has prepared a General Reporting Protocol (GRP), which is a relatively easy-to-follow user's manual that outlines the principles, concepts, calculation methodologies and procedures required for effective participation in the California Registry. The appendices of the GRP provide GHG emissions factors, specifically CO2, CH4 and N2O, for electricity use, mobile combustion and stationary combustion based on fuel usage type.

3. Third, a thorough internet search should be conducted to find reliable sources of emissions factors that would assist in accurately determining GHG emissions from a specific source being evaluated. Again, all potential GHGs, such as CO2, CH4 and N2O, should be evaluated to the best of one's ability to locate dependable information.

4. Finally, a material balance approach also may provide reliable average emission estimates for specific sources. A material balance is when one accounts for (or "balances") all the materials going into and coming out of the process in order to make a credible emissions estimation. For some sources, a material balance may provide a better estimate of emissions especially in situations where a high percentage of material is lost to the atmosphere (e. g., sulfur in fuel, or solvent loss in an uncontrolled coating process.) In other cases, material balances may be inappropriate where material is consumed or chemically combined in the process, or where losses to the atmosphere are a small portion of the total process throughput.

Reporting GHG Emissions – Daily vs. Annual Emissions

The analysis of GHGs is a much different analysis than the analysis of criteria pollutants for the following reasons. For criteria pollutants, significance thresholds are based on daily emissions because attainment or non-attainment is based on daily exceedances of applicable ambient air quality standards. Further, several ambient air quality standards are based on relatively short term exposure effects on human health, e.g., one-hour and eight-hour. Since the half-life of CO2 is approximately 100 years, the effects of GHGs are longer-term, affecting global climate over a relatively long time frame (see also Table 3-1).

Typical GHG emission inventories (EPA5, ARB6, etc.) represent directly emitted GHGs during a given year. As a result, the current convention is to present GHG emissions as annual emissions. The URBEMIS model can be set to calculate annual emissions for a project. When using the URBEMIS model to calculate annual GHG emissions, it may be useful to modify the trip rate for each land use using a weighted trip rate average to more accurately reflect annualized trip rates. A weighted trip rate average reflects the trip rates during the week, as well as trip rates during Saturdays and Sundays. Trip rate information for weekdays and weekend days can be found in the ITE Trip Rate Handbook.

CHAPTER 5

CONCLUSION

INTRODUCTION

CEQA Guidelines §15064.7(a) encourages lead agencies to establish thresholds of significance to determine the significance of an environmental impact. Further, thresholds of significance to be adopted for general use as part of the lead agency's environmental review process must be adopted by ordinance, resolution, rule, or regulation, and developed through a public review process and be supported by substantial evidence (CEQA Guidelines §15064.7(b)). Staff's proposed interim GHG significance threshold proposal has been developed through a public process consisting of a series of Stakeholder Working Group meetings. Staff proposals have been modified over time based on written and oral feedback from the Working Group. Staff's intent was to reach consensus to the extent feasible, but for some items staff could not find common ground with some of the stakeholders.

The next immediate step for SCAQMD staff is to present a final interim GHG significance threshold proposal to the SCAQMD Governing Board for consideration. If the Governing Board approves staff's final interim GHG significance threshold proposal, then staff will embark on a number of short-term and intermediate term activities to provide outreach to public agencies that might use staff's interim GHG significance threshold to determine whether or not their projects' GHG emissions are significant, periodically revisit and revise as necessary the interim proposal, and accommodate stakeholders' requests for more information on GHG calculation methodologies and mitigation measures. The following sections provide discussions on future anticipated action items

FUTURE ACTION ITEMS

Interim GHG Significance Threshold Outreach Program

It is currently anticipated that staff's interim GHG significance threshold proposal will be presented to, and considered by the Board at the November 7, 2008 public hearing. Consistent with other significance threshold proposals adopted by the Governing Board, if the draft GHG significance threshold proposal is adopted, staff will meet with local cities, councils of governments, and leagues of cities to discuss the staff proposal and address any questions or concerns.

Once the interim GHG significance threshold is adopted, this Guidance Document will be posted on the SCAQMD's CEQA web pages. Staff will also send notice of the adoption of the staff proposal to all agencies, organizations, and individuals on the SCAQMD's CEQA "Interested Parties" mailing list. In addition, it is expected that staff will prepare and make available an informational brochure that summarizes information about the interim GHG significance proposal in addition to this Guidance Document.

Starting in January 2009, as part of its intergovernmental review (IGR) responsibilities under CEQA, where the SCAQMD reviews and CEQA documents prepared by other public agencies, SCAQMD will begin more thorough evaluations of CEQA documents with regard to their GHG analyses and the basis by which they make a determination of significance. Staff will begin recommending use of the staff's interim GHG significance threshold proposal or other available GHG significance thresholds based on substantial evidence in comment letters on notices of preparation of an EIR. As of March 1, 2009, staff will formally recommend use of staff's interim GHG significance threshold proposal or other available GHG significance thresholds based on substantial evidence in comment letters on NDs and MNDs. As of July 1, 2009, staff will formally recommend use of staff's interim GHG significance threshold proposal or other available GHG significance thresholds based on substantial evidence in comment letters on EIRs.

Compile Lists of GHG Design Features and Mitigation Measures

CEQA Guidelines §15126.4 requires an EIR to "describe feasible measures which could minimize significant adverse impacts, including where relevant, inefficient and unnecessary consumption of energy." Ideally, it is desirable to avoid impacts altogether through incorporating design features into the proposed project. Because staff's recommended interim GHG significance threshold includes performance standards (see tier 4 compliance options 1 and 3) or a project proponent may try to reduce GHG emissions to less than the applicable screening levels, mitigation measures or design features are important components of the overall GHG significance threshold strategy. As a result, a number of GHG Working Group stakeholders has requested that SCAQMD compile lists of design features or mitigation measures to assist with reducing GHG emissions for all land use types.

In response to the request from GHG Working Group stakeholders to develop GHG design features and mitigation measures, over the next year SCAQMD staff will compile lists of GHG reduction strategies, including control efficiencies, by sector and make the lists available online with other recommended mitigation measures. There is already a robust body of mitigation measures available (see in particular the CAPCOA bullet point discussion below), but in most cases, they do not include control efficiencies. SCAQMD staff will use the following mitigation sources as a basis from which to compile mitigation strategies.

- **CEQA Guidelines, Appendix F –** this appendix includes a list of general energy conservation measures that may be used as a basis to identify GHG reduction strategies. The measures do not contain GHG control efficiencies, so they would need further review to determine if control efficiencies are available.

- **CAPCOA White Paper –** this document provides a comprehensive discussion of GHG reduction strategies and specific mitigation measures are listed in Table 16 in Appendix B. The mitigation measures are grouped by emissions source type, such as transportation measures, parking measures, commercial and residential design features, etc. Table 16 also provides other useful information about each mitigation measure including source of each measure, comments and descriptions about each control measure, etc. Most importantly, for many of the mitigation measures CAPCOA has included an emission reduction score. In most cases, the emission reduction score is given as a range. As a result, further evaluation would be necessary to provide a single more precise emission reduction score or a defensible average. Otherwise, it is likely that the high end of the emission reduction score would be used.

- **CARB -** is actively working to develop and adopt GHG protocols to support the Climate Change Program. CARB is working in collaboration with other agencies and organizations, including the California Climate Action Registry, to adopt consistent and standardized methods to accurately report GHG emissions. There are two kinds of GHG protocols, a reporting protocol and a project protocol. The project protocol may be useful as it sets standards and provides specific guidance to define GHG reduction projects and quantify and report GHG reductions from project activities. Some example protocols include manure management and urban forestry. It is expected that additional protocols will be developed and adopted by CARB. It is also expected that CARB's Scoping Plan may provide guidance on regulatory guidance that could be used to develop GHG emission reduction measures. GHG reduction strategies that may also serve as GHG mitigation measures to be developed by CARB over the next two years are shown in Table 5-1.

Table 5-1

California Air Resources Board GHG Emission Reduction Strategies

Strategy	Description of Strategy
Other Light Duty Vehicle Technology	New standards would be adopted to phase in beginning in the 2017 model year
Hydrofluorocarbon Reduction	1) Ban retail sale of HFC in small cans; 2) Require that only low global warming potential (GWP) refrigerants be used in new vehicular systems; 3) Adopt specifications for new commercial refrigeration; 4) Add refrigerant leak-tightness to the pass criteria for vehicular Inspection and Maintenance programs; 5) Enforce federal ban on releasing HFCs.
Transportation Refrigeration Units, Off-Road Electrification, Port Electrification	Strategies to reduce emissions from TRUs, increase off-road electrification, and increase use of shore-side/port electrification.
Manure Management	San Joaquin Valley Rule 4570 (adopted 6/15/06) reduces volatile organic compounds from confined animal facilities through implementation of control options.
Alternative Fuels: Biodiesel Blends	CARB would develop regulations to require the use of 1 to 4 percent biodiesel displacement of California diesel fuel.

Table 5-1 (Concluded)

California Air Resources Board GHG Emission Reduction Strategies

Strategy	Description of Strategy
Alternative Fuels: Ethanol	Increased use of ethanol fuel.
Heavy-Duty Vehicle Emission Reduction Measures	Increased efficiency in the design of heavy duty vehicles and an education program for the heavy duty vehicle sector.
Reduced Venting and Leaks in Oil and Gas Systems	Rule considered for adoption by the Air Pollution Control Districts for improved management practices.
Hydrogen Highway	The California Hydrogen Highway Network (CA H2 Net) is a State initiative to promote the use of hydrogen as a means of diversifying the sources of transportation energy.
Achieve 50% Statewide Recycling Goal	Achieving the State's 50 percent waste diversion mandate as established by the Integrated Waste Management Act of 1989, (AB 939, Sher, Chapter 1095, Statutes of 1989), will reduce climate change emissions associated with energy intensive material extraction and production as well as methane emission from landfills. According to the California Integrated Waste Management Board, in 2005 the statewide waste diversion rate was 52 percent.[6]
Landfill Methane Capture	Install direct gas use or electricity projects at landfills to capture and use emitted methane.
Zero Waste - High Recycling	Additional recycling beyond the State's 50% recycling goal.

- CEC and CPUC – These agencies are actively developing GHG emission reduction strategies that may also be used to develop GHG mitigation measures for specific energy production sources. Examples of CEC and CPUC GHG emission reduction strategies are shown in Table 5-2.

Other sources of potential GHG emission reduction measures will be evaluated and incorporated, as applicable into any GHG mitigation measure lists developed by the SCAQMD.

[6] CIWMB, 2007; http://www.ciwmb.ca.gov/LGCentral/Rates/Diversion/2005/Default.htm

Table 5-2
GHG Emission Reduction Strategies Implemented by CEC and CPUC

Strategy	Description of Strategy
ENERGY COMMISSION (CEC)	
Building Energy Efficiency Standards in Place and in Progress	Public Resources Code 25402 authorizes the CEC to adopt and periodically update its building energy efficiency standards (that apply to newly constructed buildings and additions to and alterations to existing buildings).
Appliance Energy Efficiency Standards in Place and in Progress	Public Resources Code 25402 authorizes the Energy Commission to adopt and periodically update its appliance energy efficiency standards (that apply to devices and equipment using energy that are sold or offered for sale in California).
Cement Manufacturing	Cost-effective reductions to reduce energy consumption and to lower carbon dioxide emissions in the cement industry.
Municipal Utility Strategies	Includes energy efficiency programs, renewable portfolio standard, combined heat and power, and transitioning away from carbon intensive generation.
Alternative Fuels: non-Petroleum Fuels	Increasing the use of non-petroleum fuels in California's transportation sector, as recommended in the CEC's 2003 and 2005 Integrated Energy Policy Reports.
PUBLIC UTILITIES COMMISSION (PUC)	
Accelerated Renewable Portfolio Standard (33 percent by 2020)	The Governor has set a goal of achieving 33 percent renewables in the State's resource mix by 2020. The joint PUC/Energy Commission September 2005 Energy Action Plan II (EAP II) adopts the 33 percent goal.
California Solar Initiative	The solar initiative includes installation of 1 million solar roofs or an equivalent 3,000 MW by 2017 on homes and businesses, increased use of solar thermal systems to offset the increasing demand for natural gas, use of advanced metering in solar applications, and creation of a funding source that can provide rebates over 10 years through a declining incentive schedule.
Investor-Owned Utility	This strategy includes energy efficiency programs, combined heat and power initiative, and electricity sector carbon policy for investor owned utility.

Periodically Review the Interim GHG Significance Threshold

SCAQMD staff will periodically review and revise staff's GHG proposal to incorporate applicable updated information on GHGs and GHG reduction strategies resulting from regulatory requirements or advances in technology. Some areas of the current proposal that may be reevaluated include the tier 3 screening levels, and the tier 4 compliance option 1 GHG reduction target objective. Further, staff will evaluate whether or not sector based performance standards can be developed for tier 4 compliance option 3.

If a statewide GHG significance threshold is developed by CARB, staff will review that threshold and report to the Governing Board by March 2009 considering such a threshold for adoption.~~regarding any implementation issues and ways to transition into the recommended GHG significance threshold within six months of formal approval by the CARB Board~~.

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APPENDIX A

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APPENDIX B

SUMMARIES OF WORKING GROUP MEETINGS

WORKING GROUP MEETING #1 (APRIL 30, 2008)

At the first Working Group meeting SCAQMD staff presented the Working Group with a number of policy objectives and design criteria for consideration to establish the framework for developing a GHG significance threshold. Policy objectives include the following concepts. First, the GHG significance threshold should minimize environmental degradation, that is, it should not make impacts worse. To this end, it may be useful to develop a GHG significance threshold that achieves GHG emissions reductions that are consistent with the goals of AB 32 estimated to be approximately 30 percent reduction of GHG emissions from business-as-usual. Although CEQA or a GHG significance threshold established pursuant to CEQA may be useful tools in reducing GHG emissions, they would act in parallel with regulatory requirements, e.g., AB 32, but they do not replace them. As a result, there is no requirement that a GHG significance threshold must reduce GHG emissions consistent with AB 32 or EO S-3-05.

In addition to policy considerations, a number of GHG significance threshold design criteria were also considered. An important consideration in developing a GHG significance threshold is the potential administrative burden it may create on lead agencies through increased resource impacts such as increased costs and staff if the significance threshold is established too low. For example, a zero threshold might result in eliminating or substantially reducing the number of projects that qualify for a categorical exemption, a negative declaration, or a mitigated negative declaration. Other design considerations discussed included establishing a single GHG threshold, such as a “bright line” numerical threshold or multiple thresholds, such as the tiered approaches identified by CAPCOA, etc.

WORKING GROUP MEETING #2 (MAY 28, 2008)

At the second Working Group meeting, staff presented design criteria recommendations based on the discussion at the first Working Group meeting and correspondence received subsequent to the first Working Group meeting. With regard to analyzing life cycle GHG emissions, staff’s initial recommendation was to exclude an analysis of life cycle emissions because life cycle process are not well established. Instead, the GHG emissions analysis should focus on direct and indirect impacts, consistent with current CEQA requirements (CEQA Guidelines §15064(d)). Feedback from the Working Group suggested that a CEQA analysis may be considered deficient without making an effort to conduct a life cycle analysis. Further, if life cycle emissions data are not available, the lead agency should note this consider further analysis speculative and terminate the discussion (CEQA Guidelines §15145).

Another design criteria recommendation made by staff was to take into consideration the administrative burden and resources impacts when establishing a GHG significance threshold. Staff recommended that the GHG significance threshold should not be set too low, which could result in all projects going through the EIR process. It was pointed out that requiring an EIR for all projects does not necessarily result in more mitigation, no meaningful mitigation may be available for small projects, and it may provide a disincentive for implementing mitigation if the measures are unable to reduce GHG impacts to less than significant.

Other design criteria recommended by staff included analyzing the six Kyoto GHGs, any GHG significance threshold established would be considered interim and would be periodically evaluated and updated as necessary, etc. Staff also introduced the concept of preferred GHG mitigation strategies using a hierarchy from the most to least preferred strategies as shown below.

1. Incorporate GHG reduction strategies into project design
2. Mitigate GHGs from other onsite sources for modification projects
3. Mitigate offsite GHG emission reduction projects
4. Mitigate both construction & operational GHG impacts
5. Consider feasible mitigation based on economic factors (cost) pursuant to CEQA Guidelines §15364
6. Purchase acceptable GHG offsets with preference toward GHG reduction projects occurring in-basin or in-state (offset cost a consideration). The following points should be considered:
    a. Offset market still developing, so it is necessary to ensure offsets are obtained from a credible source
    b. Offsets should be provided for at least 10 years of project operation (see SJVAPCD indirect source Rule 9510 §6.2 mitigation requirements)

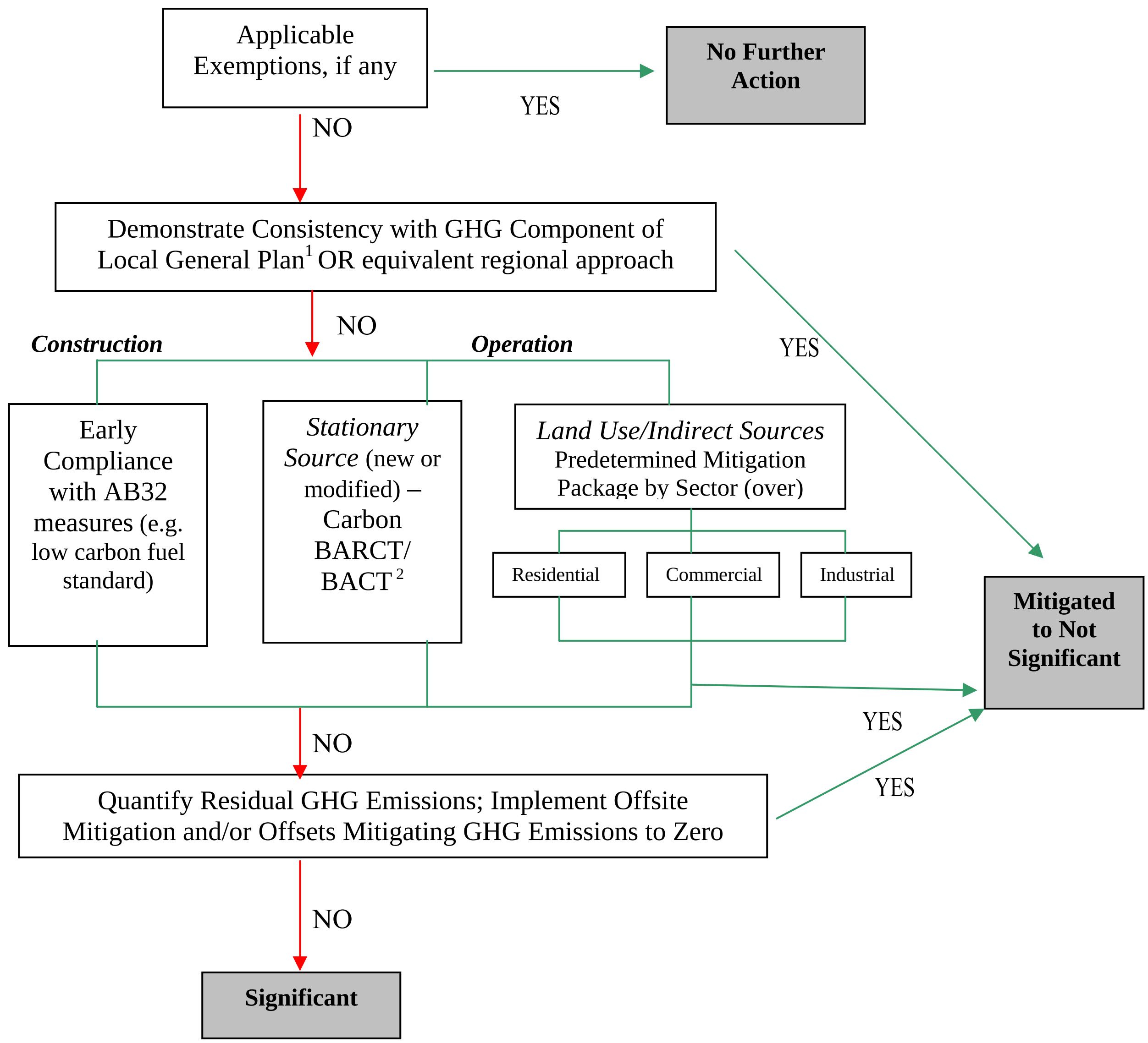
Finally, SCAQMD staff introduced the initial staff proposal. The initial staff proposal consisted of a tiered approach, similar to CAPCOA's Approach 2 with mandatory GHG mitigation measures. Each tier of this proposal is briefly described in the following bullet points and shown graphically in Figure B-1.

- The first tier consists of evaluating whether or not the project qualifies for any applicable exemption under CEQA. For example, SB 97 specifically exempts a limited number of projects until it expires in 2010. If the project qualifies for an exemption, no further action is required. If the project does not qualify for an exemption, then move to the next tier.

Figure B-1

Initial Staff Proposal – Proposed Tiered Approach – May 28, 2008

Significance determination of Cumulative Impacts from GHG emissions:



1. Local General Plans, at a minimum, must comply with AB32 reduction goals; have been analyzed under CEQA, and have a certified Final CEQA document; emission estimates approved by CARB or SCAQMD; include a GHG inventory tracking mechanism; and a commitment to remedy the excess emissions if AB32 goals are not met.

2. SCAQMD will work with CAPCOA to develop a list of mitigation measures.

- The second tier consists of determining whether or not the project is consistent with a GHG reduction plan that is part of a local general plan for example. The GHG reduction plan must, at a minimum, comply with AB 32 reduction goals; include emission estimates approved by CARB or SCAQMD, have been analyzed under CEQA, and have a certified Final CEQA document. Further, the GHG reduction plan must include a GHG inventory tracking mechanism; process to monitor progress in achieving GHG emission reduction targets, and a commitment to remedy the excess emissions if AB 32 goals are not met (enforcement). If the proposed project is consistent with the local GHG reduction plan, it is not significant for GHG emissions.

  The concept of consistency with a GHG reduction plan, is similar to the concept of consistency in CEQA Guidelines §15125(d). If the proposed project does not comply with the local GHG reduction plan or no GHG reduction plan has been adopted, then move to the third tier.

- Under the third tier there are three options that can be used to demonstrate that a project would not have significant emissions. The first significance option is early compliance with AB 32 Scoping Plan measures. The second significance option, primarily for stationary source equipment, would be to install carbon best available retrofit control technology (BARCT) or best available control technology (BACT). Carbon BARCT/BACT would be established by the SCAQMD. The third significance option for industrial, commercial, and residential land use projects would be to implement a menu of prescribed mitigation measures. Mitigation measures would be developed for each land use sector by SCAQMD staff. Implementing one of these three options would result in a determination that GHG emission impacts from the proposed project are not significant. If the proposed project is unable to implement any one of these three options or cannot fully implement any option, then it would move to the fourth tier.

- Under the fourth tier, the lead agency would quantify GHG emissions from the project and implement offsite mitigation (GHG reduction projects) or purchase offsets. Under this tier, GHG emission impacts the lead agency would be required to mitigate or offset GHG emissions to zero. If GHG emissions can be offset to zero, GHG emissions from the project are concluded to be insignificant. If GHG impacts cannot be reduced to zero, the project is concluded to be significant for GHGs.

WORKING GROUP MEETING #3 (JUNE 19, 2008)

Subsequent to Working Group meeting #2, SCAQMD staff received feedback on the initial staff proposal. Issues and concerns raised by the stakeholders on the initial staff proposal were addressed at the third Working Group meeting and are summarized in the following bullet points.

- The staff proposal does not explicitly state any quantitative or qualitative target objectives. If there are no explicit target objectives, how is it possible to determine whether or not a project is insignificant for GHG emissions?

- Concerns were raised regarding the lack of detail relative to the sector-specific mitigation measures and the potentially lengthy lag time between implementing the GHG significance threshold and developing the mitigation measures.

- For most projects, GHG emissions would not need to be calculated as long as the prescribed menu of sector-specific mitigation measures is implemented. Without quantifying GHG emissions and the control efficiencies of the mitigation measures, a project would be vulnerable to a "Fair Argument" that GHG emissions are still significant even after implementing prescribed mitigation measures.

- A CEQA document may be vulnerable in court if control efficiencies of mitigation measures are not identified.

- Is the staff proposal really a zero GHG significance?

Based on Working Group feedback, staff presented revised staff proposal #1, which consisted of a tiered decision tree approach. The components of revised staff proposal #1 are described in the following bullet points and shown graphically in Figure B-2. As shown in Figure B-2, some of the tier components of the revised staff proposal are similar to those in the initial staff proposal.

- **Tier 1 –** no change from the initial proposal.

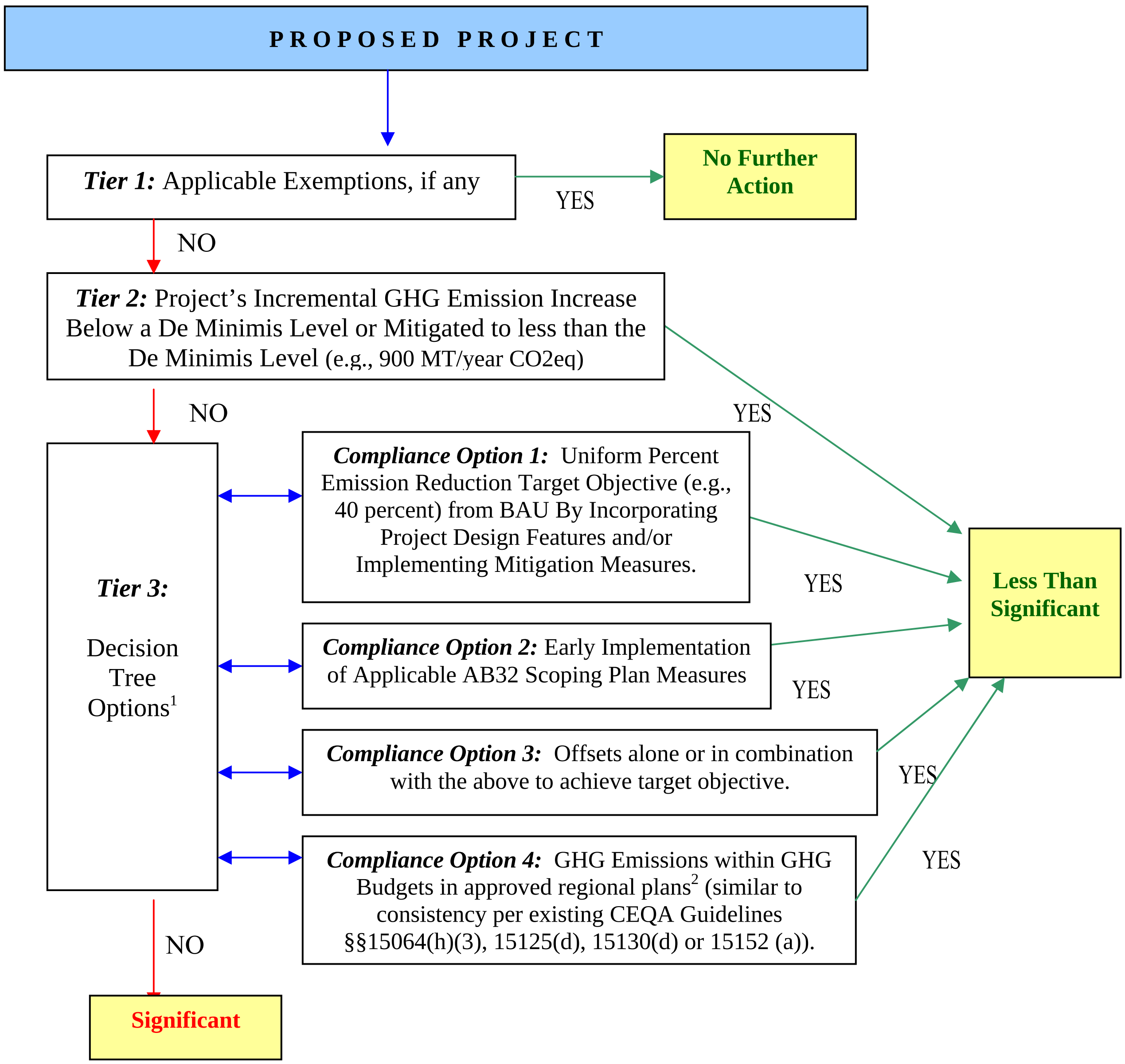
- **Tier 2 –** is a new component of the revised staff proposal. Tier 2 attempts to identify small projects that would not likely contribute to significant cumulative GHG impacts. The de minimis or screening level of 900 metric tons per year is the level that is estimated by CAPCOA to capture 90 percent of the residential units or office space in pending application lists7. CAPCOA infers that projects that emit less than 900 metric ton per year would not likely be considered cumulatively considerable. Further, the 900 metric ton per year level would capture 90 percent

[7] Although the CAPCOA White Paper implies that 900 metric tons per year equates to a 90 percent capture rate, there is no explicit information provided in the White Paper that demonstrates this correlation. Indeed, the CAPCOA authors state that 900 metric tons, which represents approximately 50 residential units, corresponds to widely divergent capture rate percentile rankings depending on the project location (see discussion on page 43 of the White Paper). Percentile rankings were based on a survey of four cities in California. A project of 900 metric tons per year representing a 90 percent capture rate appears to be a working assumption for which there appears to be no factual basis. Further, although not explicitly stated, it is assumed that the 900 metric tons were derived using the URBEMIS2007 model. It should be noted that that the URBEMIS2007 model only quantifies CO2 emissions and direct emissions primarily from on-road mobile sources. It does not capture other GHG pollutants or indirect GHG emissions such as emissions from energy generation, water conveyance, etc. Therefore, it is likely that a 50-unit residential project would actually generate higher GHG emissions than 900 metric tons per year.

Figure B-2

Revised Staff Proposal #1 Tiered Decision Tree Approach – June 19, 2008

Significance Determination of Cumulative Impacts from GHG Emissions:



1. Substitution for equivalent reductions allowed.
2. Local General Plans or other local plans local plans that, at a minimum, comply with the overall target objective or the sector-based CARB Scoping Plan; have been analyzed under CEQA, and have a certified Final CEQA document; emission estimates approved by CARB or SCAQMD; include a GHG inventory; tracking mechanism; enforcement; and a commitment to remedy the excess emissions if commitments are not met.

of all pending projects, which means that 90 percent of all projects would have to implement GHG reduction measures.

If a project is less than 900 MT/year CO2eq or can mitigate to less than 900 MT/year CO2eq, it would be considered insignificant for GHGs. Projects larger than 900 MT/year CO2eq would move to tier 3.

- Tier 3 Decision Tree Options – consists of four decision tree options to demonstrate that a project is not significant for GHG emissions. The four compliance options are as follows.

Compliance Option 1 – the lead agency would calculate GHG emissions for a project using a business-as-usual (BAU) methodology. Once GHG emissions are calculated, the project proponent would have to incorporate design features into the project and/or implement GHG mitigation measures to demonstrate a 40 percent reduction from BAU. A 40 percent reduction below BAU was selected for the following reason. To comply with the AB 32 requirement of reducing GHG emissions to 1990 levels, an approximately 30 percent reduction from current BAU is necessary.

Since CEQA is not applicable to all GHG emission sources, i.e., existing projects that are not undergoing expansion or modifications, staff chose a 40 percent reduction below BAU requirement, which goes beyond the target GHG reduction objective of AB 32, but is still a potentially feasible GHG reduction for a variety of different projects.

Compliance Option 2 – this option is the same as the early compliance with AB 32 option in the third tier of the initial staff proposal.

Compliance Option 3 – this option is similar to the fourth tier of the initial staff proposal where GHG emissions would be reduced through offsite GHG reduction projects and/or use of offsets. This compliance option, however, would require offsetting GHG emissions by the same target objective as compliance option 1, that is, 40 percent below BAU instead of reducing GHG emissions to less than the de minimis or screening level.

Compliance Option 4 – this option is the same as the consistency with the greenhouse gas reduction plan component in the second tier of the initial staff proposal.

If the lead agency or project proponent cannot implement any of the compliance options in Tier 3, GHG emissions would be considered significant.

WORKING GROUP MEETING #4 (JULY 30, 2008)

Subsequent to Working Group meeting #3, SCAQMD staff received feedback on the revised staff proposal #1. Issues and concerns raised by the stakeholders on the initial staff proposal were addressed at the third Working Group meeting and are summarized in the following bullet points.

- Compliance with a GHG reduction plan should not be a compliance option in Tier 3, but should be its own tier, earlier in the tiering process.

- There is a large disconnect between screening level and remaining emissions under the Tier 4 compliance options. For example, large projects that can reduce GHG emissions by the target objective of 40 percent would do so, which means GHG emissions would not be significant, could have substantially higher emissions than projects with GHG emissions less than the screening level.

- Compliance with a target objective should not be through offsets alone. Because of the uncertainties regarding the validity of offsets, preferred mitigation should consist of actual GHG emission reductions.

- The Tier 3 compliance option 1, GHG emissions reductions from BAU, is not the proper metric for determining significance. How can a lead agency be sure that the projected BAU emissions for a project are not artificially inflated to make it easier to achieve the required target objective?

- The Tier 3 compliance option 1, reducing GHG emission reductions from BAU, could penalize projects in environmentally progressive areas where BAU may be much lower than in other areas, thus, making it more difficult to achieve the target objectives.

Based on Working Group feedback and internal discussions, staff presented revised staff proposal #2, which further refined the previous tiered decision tree approach. The components of revised staff proposal #2 are described in the following bullet points and shown graphically in Figure B-3. As shown in Figure B-3, some of the tier components of the revised staff proposal are similar to those in the initial staff proposal.

- **Tier 1 –** no change from the initial proposal.

- **Tier 2 –** compliance option 4 in Tier 3 has been moved back a stand-alone tier.

- **Tier 3 –** the screening level that was previously Tier 2 has been moved to Tier 3. In response to feedback from the Working Group, the screening level has been increased to 6,500 MT/year CO2eq. The new screening level was derived using the SCAQMD's existing NOx operational threshold as a basis. The daily NOx operational significance threshold, 55 pounds per day was annualized, which results in 10 tons of NOx per year. Using the URBEMIS2007 model, staff initially modeled a mixed-use project that emits just under 10 tons per year to determine what the equivalent CO2 emissions would be. Resulting CO2 emissions from the mixed use project were approximately 6,500 MT/year CO2. To further corroborate the 6,500 MT/year CO2 staff performed 19 modeling runs on a variety of projects including residential, commercial, industrial, and various combinations of land uses. In addition, since the analysis was an annual analysis, a weighted trip rate was derived for each land use category to obtain a more accurate estimate of trip rates throughout the week. Although the results from the 19 modeling runs were approximately 16 percent higher than staff's original estimate of 6,500 MT/year CO2, 7,304 to 7,723 MT/year CO2, staff continued to recommend the 6,500 MT/year CO2 provides a margin of safety when deriving CO2 emissions based on the annualized NOx level of 10 tons per year and when evaluating different types of land use projects.

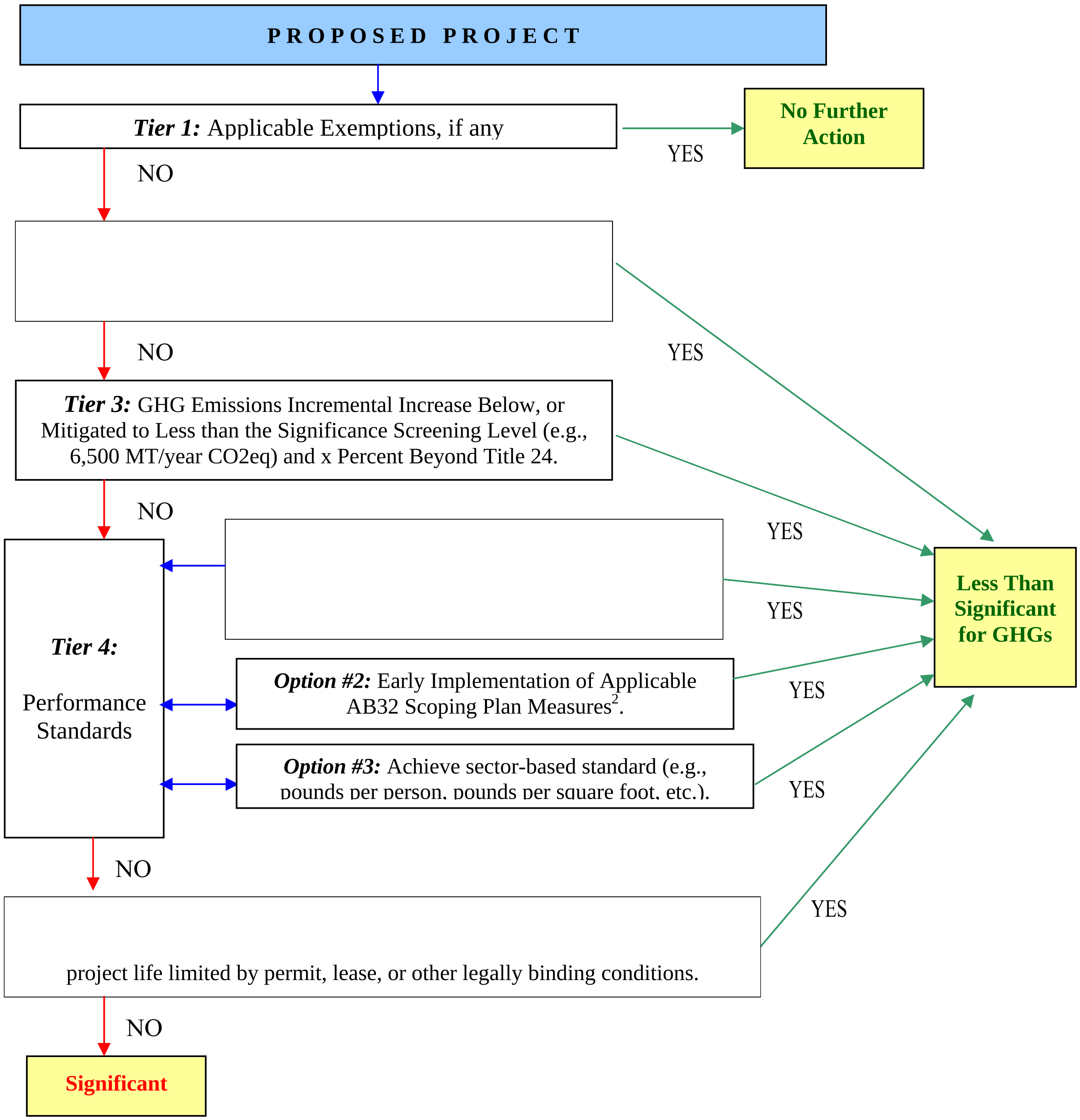
> Projects with GHG emissions less than the screening level are considered to be small projects, that is, they would not likely be considered cumulatively considerable. However, because of the magnitude of increasing global temperatures from current and future GHG emissions, staff recommended that all projects must implement some measure or measures to contribute to reducing GHG emissions. Therefore, Tier 3 includes a requirement that all projects with GHG emissions less than the screening level must include efficiency components that reduce to a certain percentage beyond the requirements of Title 24 (Part 6, California Code of Regulations), California's energy efficiency standards for residential and nonresidential buildings.

- Tier 4 Performance Standards – Tier 3 from the revised staff proposal #1 has been moved to Tier 4 and renamed.

Figure B-3

Proposed Tiered Decision Tree Approach – July 30, 2008

Significance Determination of Cumulative Impacts from GHG Emissions:



1. Local General Plans or other local plans local plans that, at a minimum, comply with the overall target objective or the sector-based CARB Scoping Plan; have been analyzed under CEQA, and have a certified Final CEQA document; emission estimates approved by CARB or SCAQMD; include a GHG inventory; tracking mechanism; enforcement; and a commitment to remedy the excess emissions if commitments are not met.
2. Substitution for equivalent reductions allowed.

Compliance Option 1 – is essentially the same as the previously recommended, except that the target objective has been changed from reducing GHG emissions 40 percent below BAU to 30 percent below BAU to be more consistent with AB 32 target objectives.

Compliance Option 2 - – no change from the previous proposal.

Compliance Option 3 – this is a new compliance option and consists of establishing sector-based performance standards. For example, it may be possible to use the 1990 inventory required under AB32 to establish an efficiency standard such as pounds per person, pounds per worker, pounds per square feet, pounds per item manufactured, etc. When calculating GHGs from a project, if they are less than the established efficiency standard the project would not be significant relative to GHG emissions, while projects exceeding the efficiency standard would be significant.

Projects that cannot comply with any of the compliance options in Tier 4 would then move on to Tier 5.

- **Tier 5 –** consists generally of the Tier 3 compliance option 3 from the previous staff proposal. The only difference is that the project proponent would be required to provide offsets for the life of the project, which is defined as 30 years. If the project proponent is unable to obtain sufficient offsets, incorporate design features, or implement GHG reduction mitigation measures, then GHG emissions from the project would be considered significant.

WORKING GROUP MEETING #5 (AUGUST 27, 2008)

Subsequent to Working Group meeting #3, SCAQMD staff received feedback on the revised staff proposal #2. Issues and concerns raised by the stakeholders on the initial staff proposal were addressed at the third Working Group meeting and are summarized in the following bullet points.

- A recommendation was made to modify the target objective of Tier 5 to be consistent with the target objective of Tier 4 compliance option 1, that is require emissions to be offset 30 percent from BAU rather than offset down to the screening level.

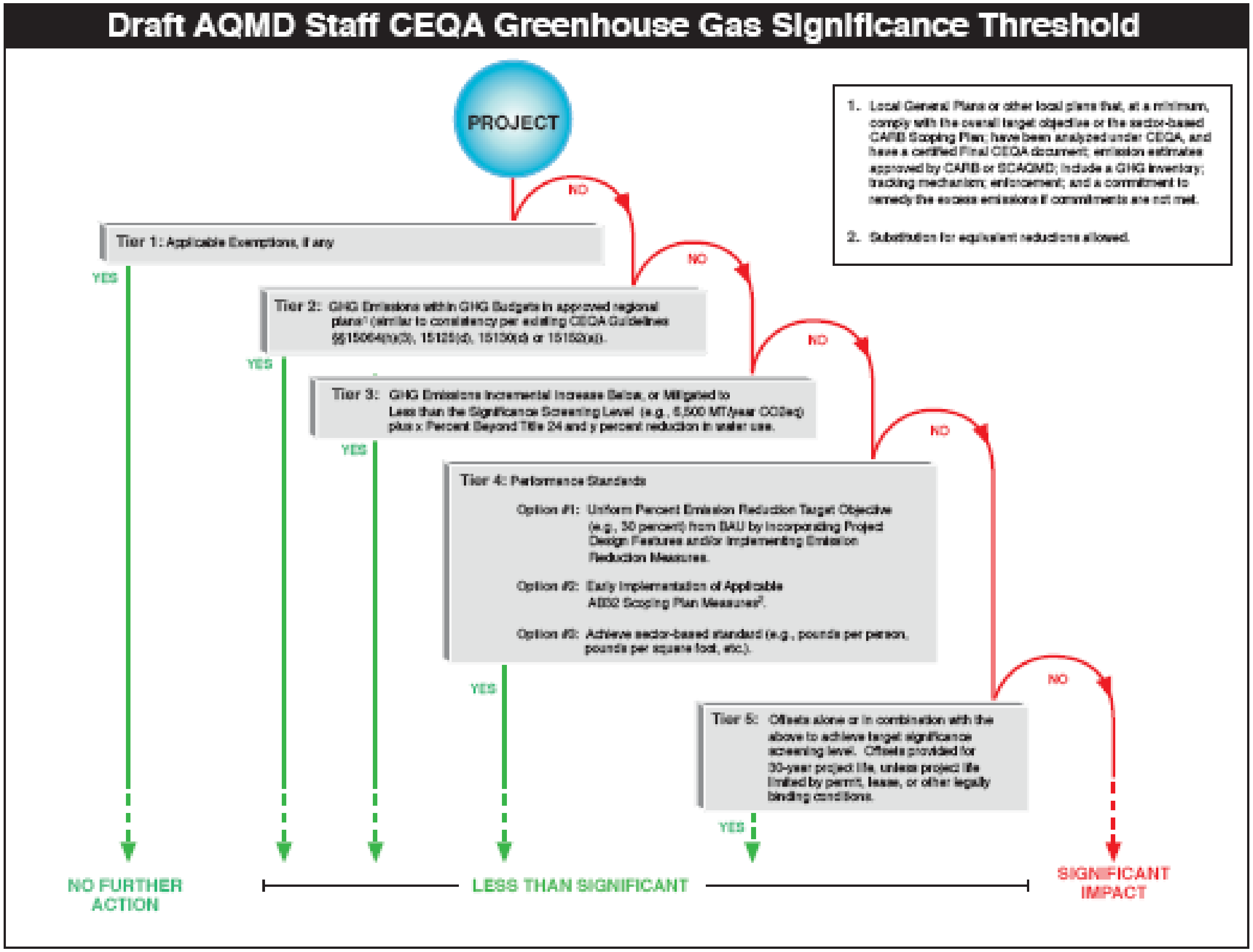
- A Working Group member asked for clarification on the early implementation of applicable AB 32 Scoping Plan measures in Tier 4-Option 2. In addition, a question was asked regarding whether or not this compliance option was applicable after the requirements of AB 32 have become effective.

At Working Group meeting #5, staff presented revised staff proposal #3, which consisted primarily of minor refinements to the previous tiered decision tree approach in revised staff proposal #2. The components of revised staff proposal #3 are shown graphically in Figure B-4.

Aside from changing the graphic layout of the staff proposal to make it easier to understand, revised staff proposal #3 has only one minor modification. A second energy efficiency requirement has been added to the screening level in Tier 3. In addition to requiring projects to go a certain percentage beyond Title 24, projects would also have to reduce by a specified percentage electricity demand from water use, primarily electricity used for water conveyance.

Figure B-4

Revised Staff Proposal #3 Tiered Decision Tree Approach – August 27, 2008



SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Final
Localized Significance Threshold Methodology

June 2003
Revised July 2008

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SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT GOVERNING BOARD

Acknowledgements

The following members of the Localized Significance Threshold Working Group and interested parties provided valuable input and their assistance was greatly appreciated.

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PREFACE

In accordance with Governing Board direction, SCAQMD staff has developed this methodology to assist lead agencies in analyzing localized air quality impacts from proposed project. This methodology is guidance and is **VOLUNTARY**. Localized significance threshold (LST) look-up tables for one, two and five acre proposed projects emitting carbon monoxide (CO), oxides of nitrogen (NOx), particulate matter less than 2.5 microns in aerodynamic diameter (PM2.5) or particulate matter less than 10 microns in aerodynamic diameter (PM10) were prepared for easy reference according to source receptor area. SCAQMD recommends that lead agencies perform project-specific modeling for larger projects in determining localized air quality impacts.

The LST methodology was developed to be used as a tool to assist lead agencies to analyze localized impacts associated with project-specific level proposed projects. The LST methodology and associated mass rates are not designed to evaluate localized impacts from mobile sources traveling over the roadways. Further, LSTs are applicable to projects at the project-specific level and are not applicable regional projects such as General Plans. The LST methodology and associated mass rate look-up tables will be included as an update to the SCAQMD CEQA Air Quality Handbook upon Governing Board's approval.

Subsequent to the adoption of the Final Significance Threshold Methodology, SCAQMD Governing Board adopted significant thresholds for PM2.5; the California Air Resources Board (ARB) revised the 1-hour nitrogen dioxide (NO2) Ambient Air Quality Standard (AAQS) from 0.25 ppm to 0.18 ppm, and established a new annual average standard of 0.03 ppm. The Final Significance Threshold Methodology was revised in July of 2008 to include the PM2.5 significant threshold methodology and update the LST Mass Rate Look-up Tables for the 1-hour NO2 AAQS.

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation/Acronym	Description
AAQS	Ambient Air Quality Standard
AQMD	South Coast Air Quality Management district
Avg	Average
Basin	South Coast Air Basin
C_{AAQS}	Ambient Air Quality Standard Concentration
C_{AIL}	Acceptable Impact Level Concentration
C_b	Background Concentration
C_u	Peak Predicted Concentration Estimated by ISC3
CARB	California Air Resources Board
CEQA	California Environmental Quality Act
DRI	Desert Research Institute
DRYDPLT	Dry Plume Depletion
EJ	Environmental Justice
EPA	United States Environmental Protection Agency
FY	Financial Year
Handbook	*SCAQMD Air Quality CEQA Handbook*
hr	Hour
ID	Identification
ISC3	Industrial Source Complex, version 3
lb	Pound
m	Meter
MET	Meteorological Correction Factors
mg	Milligram
NO	Nitric Oxide
NOCALM	No Calm Wind Processing
NO2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
OEHHA	Office of Environmental Health Hazard Assessment
PM	Particulate Matter
PM10	Particulate of Less Than 10 Microns in Aerodynamic Diameter
pphm	Parts per Hundred Million
ppm	Parts per Million
SIP	State Implementation Plan
SRA	Source Receptor Area
U	Unit Emission Rate
URBAN	Urban Dispersion Parameters
UTM	Universal Transverse Mercator
VOC	Volatile Organic Compound
µg	Microgram

CHAPTER 1
INTRODUCTION

In 1993, the South Coast Air Quality Management District (SCAQMD) Governing Board adopted the *CEQA Air Quality Handbook* (*Handbook*). This Handbook contains guidance for other public agencies when preparing an air quality analysis for California Environmental Quality Act (CEQA) or National Environmental Policy Act (NEPA) analyses. In addition to providing guidance for analyzing air quality impacts, the Handbook also contains indicators of significance recommended for use by other public agencies. The most widely used of the significance thresholds in the Handbook are the mass daily significance thresholds for construction and operation, which indicate that a project has significant adverse regional effects on air quality.

More recently as part of the SCAQMD's environmental justice program, attention has focused on localized effects of air quality. In accordance with Governing Board direction, staff has developed localized significance threshold (LST) methodology and mass rate look-up tables by source receptor area (SRA) that can be used by public agencies to determine whether or not a project may generate significant adverse localized air quality impacts. LSTs represent the maximum emissions from a project that will not cause or contribute to an exceedance of the most stringent applicable federal or state ambient air quality standard, and are developed based on the ambient concentrations of that pollutant for each source receptor area.

Use of LSTs by local government is **<u>VOLUNTARY</u>**. The staff proposal recommends using the LST mass rate look-up tables only for projects that are less than or equal to five acres. It should be noted that lead agencies are not precluded from performing project-specific modeling if they prefer more precise results. It is recommended that lead agencies perform project-specific air quality modeling for larger projects. LSTs are applicable at the project-specific level and generally are not applicable to regional projects such as local General Plans unless specific projects are identified in the General Plans.

The use of LSTs is VOLUNTARY, to be implemented at the discretion of local agencies. LSTs would only apply to projects that trigger a CEQA review. Therefore, projects that are statutorily or categorically exempt under CEQA would not be subject to LST analyses. Exemptions include infill projects that meet the H&S Code provisions or projects identified by lead agencies as ministerial. The methodology and screening tables are included as an appendix to this Handbook.

Staff has developed implementation tools to assist in evaluation of projects. Guidance information, such as typical scenarios and sample calculations are included as an appendix to this Handbook. The sample calculations and scenarios include estimations of both regional and localized impacts for ease of use. If the lead agencies decide to follow the LST methodology and determine that the proposed projects might exceed LSTs, please consult Chapter 11 of the CEQA Handbook (1993) for applicable mitigation measures. SCAQMD staff is available to assist lead agencies or project proponents in addressing implementation issues.

The LST mass rate look-up tables provided in Appendix C allow a user to readily determine if the daily emissions for proposed construction or operational activities could result in significant localized air quality impacts. If the calculated emissions for the proposed construction or operational activities are below the LST emission levels found on the LST mass rate look-up tables and no potentially significant impacts are found to be associated with other environmental issues, then the proposed construction or operation activity is not significant for air quality. Proposed projects whose calculated emission budgets for the proposed construction or operational activities are above the LST emission levels found in the LST mass rate look-up tables should not assume that the project would necessarily generate adverse impacts. Detailed air dispersion modeling may demonstrate that pollutant concentrations are below localized significant levels. The lead agency may choose to describe project emissions above those presented in the LST mass rate look-up tables as significant or perform detailed air dispersion modeling or perform localized air quality impact analysis according to their own significance criteria.

The LST mass rate look-up tables are applicable to the following pollutants only: oxides of nitrogen (NO_X), carbon monoxide (CO), particulate matter less than 2.5 microns in aerodynamic diameter (PM2.5) and particulate matter less than 10 microns in aerodynamic diameter (PM10). LSTs are derived based on the location of the activity (i.e., the source/receptor area); the emission rates of NO_X, CO, PM2.5 and PM10; and the distance to the nearest exposed individual. The location of the activity and the distance to the nearest exposed individual can be determined by maps, aerial and site photos, or site visits. The NOx, CO, PM2.5 and PM10 emission factors and/or rates are the same emission factors/rates identified in the Handbook, AP-42, EMFAC, Offroad, etc.

This document explains the methodology, specifically pollutant dispersion modeling used to develop the LST mass rate look-up tables and how one uses the procedures to determine the significance or insignificance of project activities for air quality. This document will become part of the revised Handbook.

LEGAL AUTHORITY

CEQA Guidelines §15022(a) states that a public agency shall adopt objectives, criteria, and specific procedures consistent with CEQA and these [State] Guidelines for administering its responsibilities under CEQA. CEQA Guidelines §15022(d) states further, "In adopting procedures to implement CEQA, a public agency may adopt the State CEQA Guidelines through incorporation by reference. The agency may then adopt only those specific procedures or provisions described in subsection [15022] (a) which are necessary to tailor the general provisions of the guidelines to the specific operations of the agency." At the December 11, 1998 Public Hearing the SCAQMD's Governing Board formally incorporated by reference the State CEQA Guidelines as the implementing guidelines for the SCAQMD's CEQA program. Adopting LSTs would be consistent with CEQA Guidelines §15022 provision to tailor a public agency's implementing guidelines by adopting criteria relative to the specific operations of the SCAQMD.

Specifically with regard to thresholds of significance, CEQA Guidelines §15064.7(a) states, "Each public agency is encouraged to develop and publish thresholds of significance that the agency uses in the determination of the significance of environmental effects." Subsection (b) of the same section states further, "Thresholds of significance to be adopted for general use as part of the lead agency's environmental review process must be adopted by ordinance, resolution, rule or regulation, and developed through a public review process and be supported by substantial evidence." The methodology for developing LSTs and the resulting LST mass rate look-up tables developed by the SCAQMD have undergone a public review process as part of stakeholder working group meetings that are open to the public. This methodology document provides the substantial evidence relative to the methodology for developing LSTs. After completion of the public process, the LST methodologies will be heard by the SCAQMD's Governing Board at a public meeting, where they will be considered for adoption by resolution, consistent with CEQA Guidelines §15064.7(b). This methodology and associated LSTs are recommendations only and not mandatory requirements. The methodology and LSTs may be used at the discretion of the local lead agency.

BACKGROUND

At the October 10, 1997 Board Meeting, the SCAQMD Governing Board adopted the Guiding Principles and Workplan to Implement Environmental Justice Initiatives. Environmental Justice (EJ) Initiative #4 – CEQA Commenting, directed the SCAQMD to reconstruct its CEQA commenting function, called intergovernmental review. As specified in the Workplan, EJ Initiative #4 included updating the CEQA Handbook by creating and working with a stakeholders' review group.

Consistent with EJ Initiative #4 staff began the formal Handbook revision process by creating a Handbook revision working group of stakeholders comprised of local government planners; representatives of local councils of government; environmental groups; the building and construction industries; and other interested individuals. In 1998, the SCAQMD started a series of Handbook revision working group meetings. One of the issues identified by the stakeholders was a request to address localized air quality impacts. With respect to criteria pollutants, the existing Handbook only discussed localized impacts as part of focused CO "hotspots" analyses prepared for mobile sources.

Assessing localized air quality impacts requires using complex dispersion models. Therefore, to address the issue of localized significance, yet be sensitive to the fact that other public agencies might not have the expertise or adequate financial resources to perform complex dispersion modeling, in addition to the methodology itself, SCAQMD staff began developing a proposal to establish localized significance thresholds in a form similar to the regional significance thresholds, that is, based on the amount of pounds of emission per day generated by a proposed project that would cause or contribute to localized air quality impacts.

After developing the methodology for deriving LSTs, staff presented the concept, methodologies, and a retrospective study on the use of LSTs at Governing Board Mobile Source Committee meetings. In the fourth quarter of 2001, staff presented the LST proposal to the Mobile Source Committee. Because of concerns and issues raised by committee members, the Mobile Source Committee recommended that staff seek approval from the Governing Board before proceeding with further development of the LSTs. On February 1, 2002, the Governing Board directed staff to continue developing LSTs and report back to the Board for consideration and possible incorporation into a revised Handbook.

On September 13, 2002, the Governing Board approved the implementation of the Environmental Justice Program Enhancements for FY 2002-03. In connection with approving the Environmental Justice Program Enhancement for FY 2002-03, the Board directed staff to implement 23 enhancements to the original Environmental Justice Program divided into three categories. Category I: Further-Reduced Health Risk, Enhancement I-4 included a proposal to "continue to develop localized significance thresholds for subregions of the air district, as another indicator of CEQA significance." Enhancement I-4 also directed staff to continue developing localized significance thresholds through a stakeholder working group. Staff has since met with the stakeholder working group two times and, with input from the stakeholder working group, developed a proposal to implement Enhancement I-4.

BASIC APPROACH

An air quality analysis typically separates a project's emissions into construction and operational activity emissions because these two activities are typically sequential. Relative to the staff proposal, the emissions of concern from construction activities are NO_x, CO and PM2.5 combustion emissions from construction equipment[1] and fugitive PM 2.5 and PM10 dust from construction site preparation activities. The primary emissions from operational activities include, but are not limited to NOx and CO combustion emissions from stationary sources and/or on-site mobile equipment. Some operational activities may also include fugitive PM2.5 and PM10 dust generating activities such as aggregate operations or earthmoving activities at landfills. Off-site mobile emissions from the project should NOT be included in the emissions compared to the LSTs.

LSTs are derived using one of three methodologies depending upon the attainment status of the pollutant. For attainment type pollutants, nitrogen dioxide (NO_2) and CO[2], the

[1] Construction equipment also emits PM10, but for simplicity these emissions should be combined with the fugitive PM10 dust when using the LST procedures provided below.

[2] Although the district was not designated as in attainment with the CO ambient air quality standards when the LSTs were developed, it was treated as an attainment pollutant since CO concentrations hadnot exceeded any CO ambient air quality standards for the two years prior to the adoption of the LSTs. ~~Therefore, for developing LSTs, the attainment pollutant approach is applicable.~~ The district was redesignated as in attainment for CO in 2002. The district was designated in NO_2 attainment by the State in 2003, and NO_2 concentration had been below the State AAQS for three years prior. The district has been designated as in NO_2 attainment for the federal standard since 1995. In 2007, the State AAQS standards

mass rate LSTs are derived using an air quality dispersion model to back-calculate the emissions per day that would cause or contribute to a violation of any short-term AAQS for a particular SRA. The most stringent of the federal and state standards for NO_2 is the 1-hour state standard of 18 parts per hundred million (pphm); and for CO it is the 1-hour and 8-hour state standards of nine parts per million (ppm) and 20 ppm, respectively.

LSTs are developed based upon the size or total area of the emissions source, the ambient air quality[3] in each source receptor area (SRA) in which the emission source is located, and the distance to the sensitive receptor. LSTs for NO_2 and CO are derived by adding the incremental emission impacts from the project activity to the peak background NO_2 and CO concentrations and comparing the total concentration to the most stringent ambient air quality standards. Background criteria pollutant concentrations are represented by the highest measured pollutant concentration in the last three years at the air quality monitoring station nearest to the proposed project site.

Construction PM 2.5 and PM10 LSTs are developed using a dispersion model to back-calculate the emissions necessary to exceed a concentration equivalent to 50 micrograms per cubic meter ($\mu g/m^3$) averaged over five hours, which is the control requirement in Rule 403. The equivalent concentration for developing PM 2.5 and PM10 LSTs is 10.4 $\mu g/m^3$, which is a 24-hour average.

Operational PM 2.5 and PM10 LSTs are derived using an air quality dispersion model to back-calculate the emissions necessary to make an existing violation in the specific SRA worse, using the allowable change in concentration thresholds in Table A-2 in Rule 1303. For PM 2.5 and PM10 the allowable change in concentration thresholds is 2.5 $\mu g/m^3$. These levels represent measurable impacts taking into account modeling sensitivity.

The staff proposal recommends using the LST mass rate look-up tables only for projects that are less than or equal to five acres. It should be noted that lead agencies are not precluded from performing project-specific modeling if they prefer more precise results. It is recommended that lead agencies perform project-specific air quality modeling for larger projects. Lead agencies have the discretion to identify appropriate thresholds and analysis methodologies.

If mitigation measures are needed, please refer to Chapter 11 of the *Handbook*. Lead agencies may use mitigation measures beyond those identified in the *Handbook* and District staff is available for technical consultation.

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were lowered to 0.18 ppm for the NO_2 1-hour standard and 0.030 ppm was established as the NO_2 annual average standard. Since the standards have become affective, the NO_2 concentrations have been below the new 1-hour standard. However, there was a single location (SRA 10 – Pomona/Walnut Valley) that exceeded the NO_2 annual average standard in 2007 (0.0318 ppm). The LSTs were developed based on short-term standards (less than 24 hour concentration standards). Since all NO_2 concentrations in the district are less than the new one-hour standard, NOx is still treated as an attainment pollutant.

[3] Ambient air quality information is based on the pollutant concentrations measured at the SCAQMD's monitoring stations in or near the specified SRA.

The concepts inherent in the above staff recommendations are generally consistent with the modeling requirement in SCAQMD Rule 1303(b)(1), which states that the Executive Officer shall deny a Permit to Construct for any new or modified source with an emission increase unless, "The applicant substantiates with modeling that the new facility or modification will not cause a violation, or make significantly worse an existing violation… of any AAQS at any receptor in the district." It should be noted that there are some modeling assumptions used to derive mass rate LSTs that are unique for this purpose and not intended for Regulation XIII permitting applications. Therefore, the modeling methodology described in this document should not be used to comply with Rule 1303 modeling requirements. The actual methodology used to derive the mass rate LSTs is described in more detail in Chapter 2.

CHAPTER 2
METHODOLOGY

This chapter describes the technical approach used to derive the mass rate LSTs. The models used to derive the mass rate LSTs are briefly described, including adjustments to the outputs, which attempt to incorporate more realistic parameters into the modeling results.

MODEL

Two distinct modeling approaches were used to develop the mass rate LSTs for the gaseous pollutants (i.e., NO_2 and CO) and particulate matter (i.e., PM10). A U.S. Environmental Protection Agency (EPA)-approved dispersion model was used for NO_2, CO, and PM 2.5. For PM10, a combination of a U.S. EPA-approved dispersion model and an empirical equation, developed by Desert Research Institute (DRI)[4] were used to describe concentration changes as a function of downwind distance.

NO_2, CO and PM2.5

Version 3 of the U.S. EPA approved air quality model called Industrial Source Complex (i.e., ISC3) was used to develop the mass rate LSTs discussed here for NO_2, CO, and PM2.5. The short-term version of the model was applied using hourly meteorological data from numerous sites in the district. Important model options employed include: urban dispersion parameters (i.e., URBAN) and no calm wind processing (i.e., NOCALM). All other model options assumed the model default values.

PM10

For PM10, the short-term version of ISC3 was used to estimate PM10 concentrations at 25 meters from the boundary of the construction area, 1,000 meters from the boundary of the construction area, and beyond. Since fugitive dust consists of a significant fraction of large particles greater than 10 microns, plume depletion due to dry removal mechanisms was assumed (i.e., DRYDPLT). The fugitive PM10 emissions are separated into the three particle sizes of less than one micron (μm), 1.0 to 2.5 μm, and 2.5 to 10 μm in aerodynamic diameter, which have the assumed weight fractions of 7.87, 12.92, and 79.22 percent, respectively. The particle density for all three size bins is 2.3 grams per cubic centimeter.

For downwind distances from the boundary of the construction area to 100 meters, the following equation was used to describe the change in PM10 concentration versus downwind distance:

$$C_x = 0.9403\ C_o\ e^{-0.0462\ x} \qquad \textbf{Eq. 1}$$

Where: C_x is the predicted PM10 concentration at x meters from the fence line;
C_o is the PM10 concentration at the fence line as estimated by ISC3;
e is the natural logarithm; and
x is the distance in meters from the fence line.

[4] Desert Research Institute, 1996.

Equation 1 was developed from the 1996 DRI study of fugitive dust control measures for unpaved roads. Concentrations are linearly interpolated between the two approaches for downwind distances from 100 to 500 meters.

SOURCE TREATMENT

Mass rate LSTs for construction and operational activities for one-, two-, and five-acre sites have been developed. Exhaust emissions from construction equipment are treated as a set of side-by-side elevated volume sources. These volume sources are illustrated in Figure 2-1. The number and dimensions of the volume sources for each analyzed acreage are shown in Table 2-1. The release height is assumed to be five meters. This represents the mid-range of the expected plume rise from frequently used construction equipment during daytime atmospheric conditions. All construction exhaust emissions are assumed to take place over the eight-hour period between 8 a.m. to 4 p.m. Mass rate LSTs may be used for operational sources with parameters similar to the construction parameters presented above.

Fugitive dust emissions are treated as a ground-based square area source with the dimension of the acreage analyzed. For example, the one-acre construction site is 63.6 meters on a side and the five-acre construction site is 142.2 meters on a side. An initial vertical dimension of one meter is assumed to represent the initial vertical spread of the emissions. Based on this assumption, the initial vertical dimension resulted in a vertical concentration profile that closely matched the vertical profile observed by DRI (1996), as shown in Figure 2-2. As with the construction equipment, all the fugitive dust emissions are assumed to be emitted over the eight-hour period, 8 a.m. to 4 p.m. Area sources are illustrated in Figure 2-1.

RECEPTOR GRID

A radial receptor grid is used to determine impacts. The grid is centered on the source and is built in ten degree increments at the following downwind distances from the hypothetical proposed project boundary: 25, 50, 100, 200, and 500 meters. Flat terrain is assumed, since emissions sources from construction activities are primarily ground-based. All receptors are placed within the breathing zone at two meters above ground level. Figure 2-1 illustrates the relationship between the source and receptors.

METEOROLOGY

For modeling purposes, the SCAQMD uses 1981 meteorological data (i.e., hourly winds, temperature, atmospheric stability, and mixing heights) from 35 sites in the district, as shown in Figure 2-3 and listed in Table 2-2. The 1981 meteorological data are used because this data set represents the most complete and comprehensive data set currently compiled. These data are available at the SCAQMD's web site (www.aqmd.gov/metdata) and is in a format that can be directly read by ISC3. Using this meteorological data set, LSTs are developed for each of the 37 source receptor areas (SRAs) within the SCAQMD's jurisdiction (see Figure 2-4). LSTs were not developed for SRA 14, because it is outside of the SCAQMD's jurisdiction. Site-specific meteorological data may also be used the concurrence from the District staff. A projects located close to the boundaries of another SRA may use the LSTs for that SRA if the monitored concentrations better represent the ambient air quality surrounding that project..

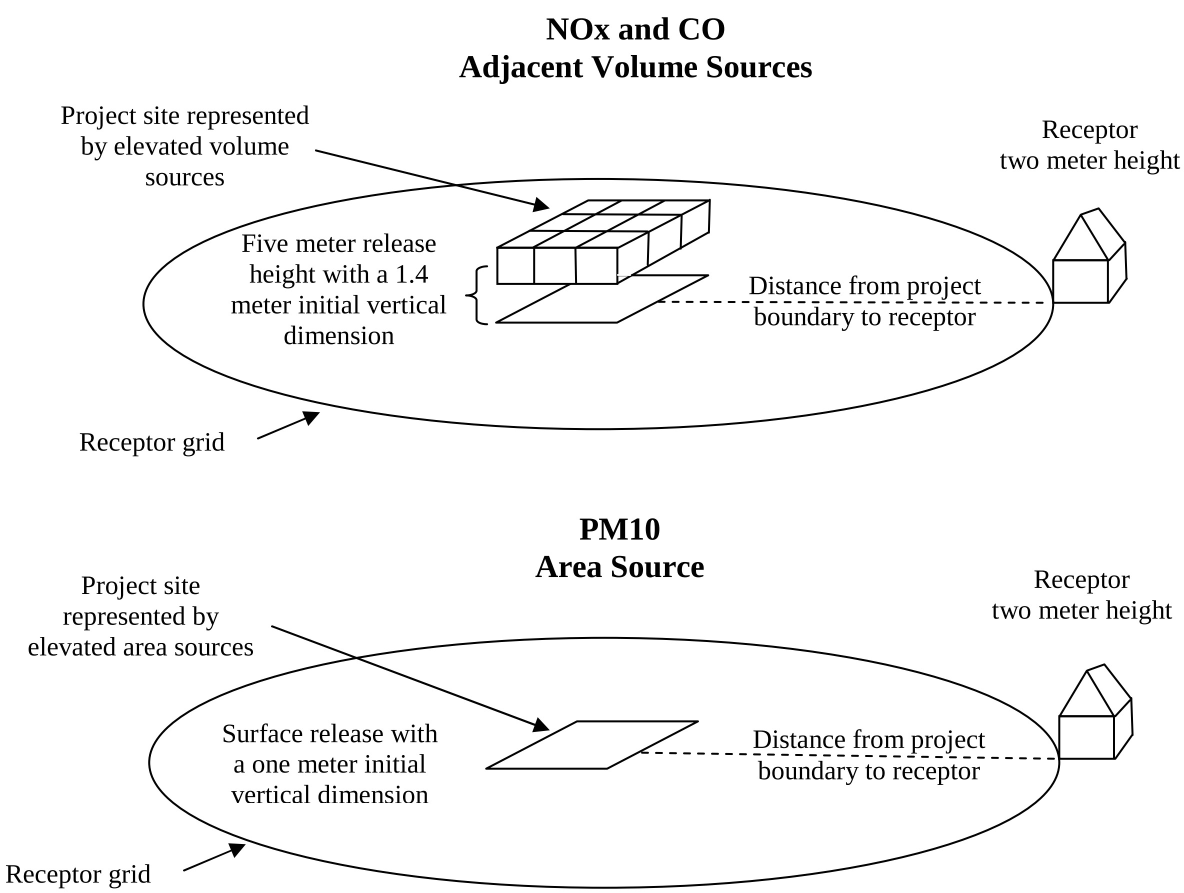


Figure 2-1. Volume and Area Sources

Table 2-1. Number and Dimensions of Volume Sources

Area	***Number of volume sources***	***Dimensions of volume source***
1 acre	36	10 by 10 meters
2 acres	81	10 by 10 meters
5 acres	49	20 by 20 meters

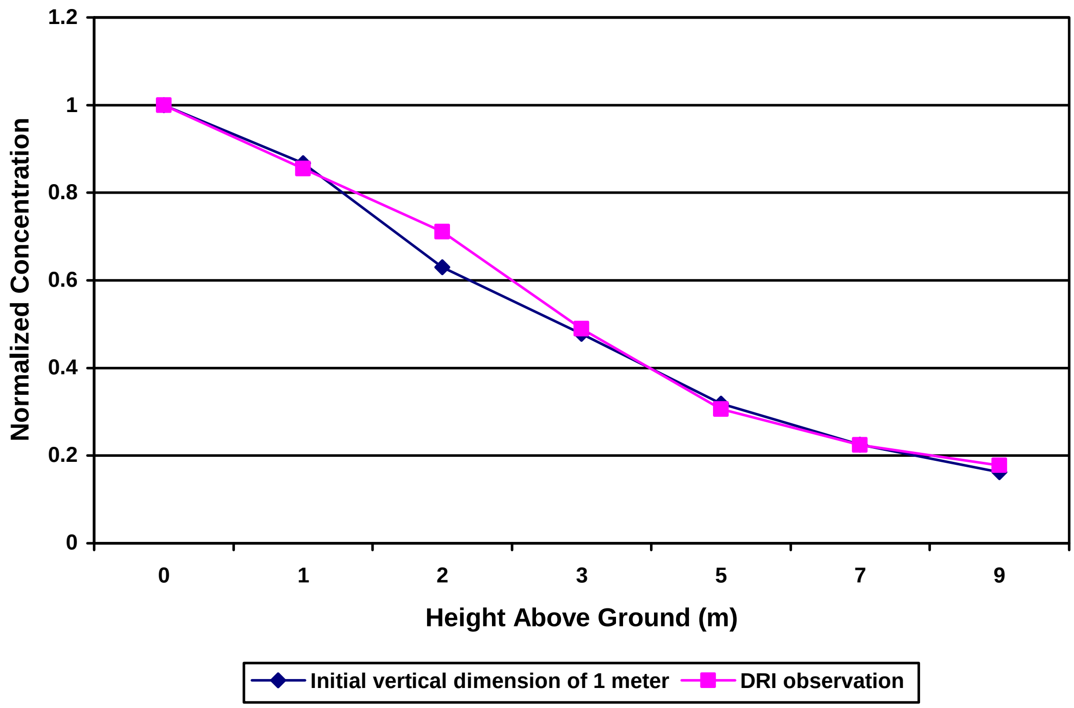


Figure 2-2. Comparison of Vertical Concentration Profiles

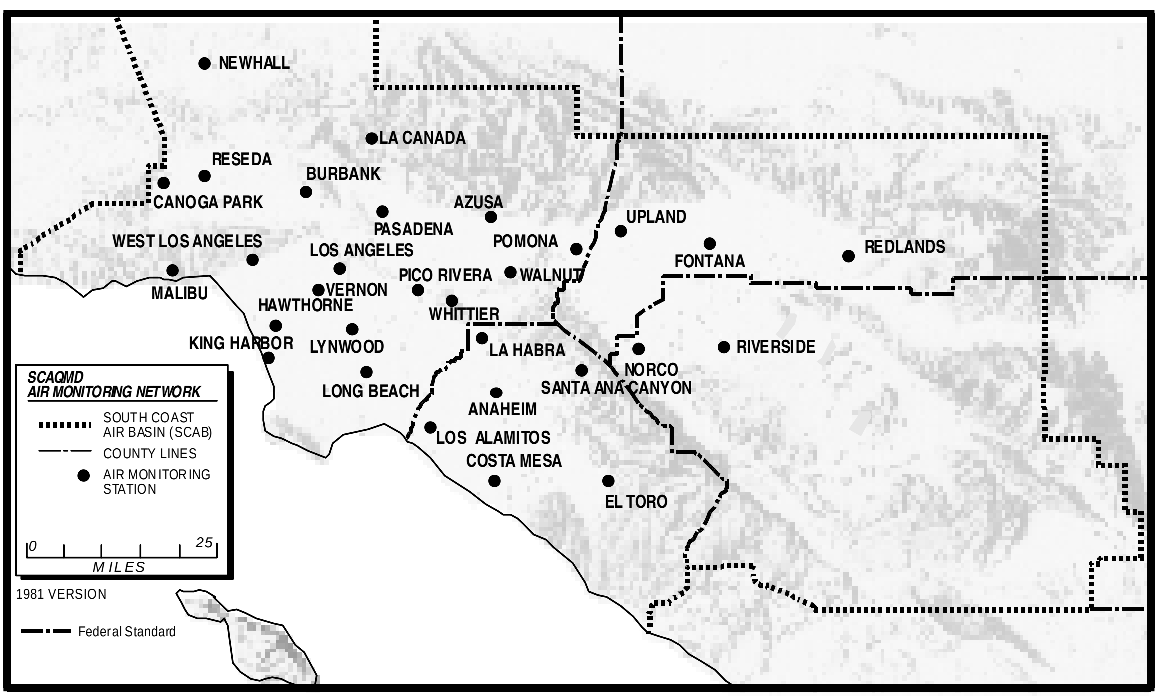


Figure 2-3. 1981 District Meteorological Sites

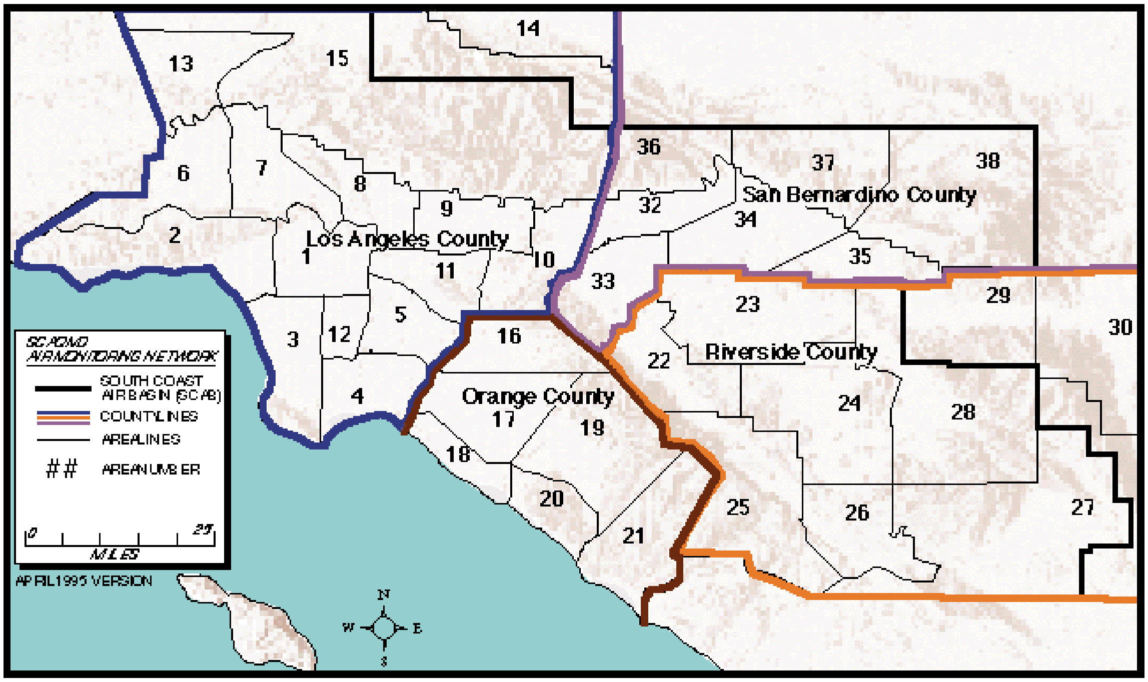


Figure 2-4. Source/Receptor Areas in the District

BACKGROUND CO AND NO_2 AIR QUALITY

To determine whether or not construction activities create significant adverse localized air quality impacts, the emissions contribution from the project is added to ambient concentrations and the total is then compared to the most stringent applicable state and/or federal ambient air quality standards for CO and NO_2. In order to be able to make this determination, it is necessary to know the background concentrations in the vicinity of the proposed project site. The modeled incremental impacts from project activities are added to the background values to estimate the peak impacts downwind of the activities. The LST concentrations are derived by ensuring that the total concentrations (i.e., background plus project contribution) are just less than the most stringent applicable state and federal ambient air quality standards. The methodology for identifying the background concentrations is outlined in the following paragraphs.

Table 2-3 lists the SCAQMD air quality monitoring stations that measure CO or NO_2 in the district. At the time of LST adoption, a database of annual concentrations was assembled for the period 1999 to 2001. Peak one-hour CO and NO_2, and peak eight-hour CO concentrations for the three-year period were identified.

The observed peak one-hour CO, one-hour NO_2, and eight-hour CO concentrations for the three-year period are given in Appendix A for each available station. The peak concentrations for each year and for the three-year period as a whole are provided. The difference between the peak concentrations and the relevant state and federal standards determines the allowable mass emissions for the construction activities that would not result in significant adverse localized air quality impacts.

Table 2-2. 1981 Meteorological Data for Dispersion Modeling

Station ID			UTM (kilometer)	
Surface	**Upper air**	**Site Name**	**Easting**	**Northing**
53071	91919	Anaheim	415.0	3742.5
54097	99999	Azusa	414.9	3777.4
54144	99999	Banning	510.5	3754.5
51100	99999	Burbank	379.5	3783.0
51067	99999	Canoga Park	352.9	3786.0
53112	91919	Compton	385.5	3750.3
53126	91919	Costa Mesa	413.8	3724.2
52075	91919	Downtown Los Angeles	386.9	3770.1
53128	91919	El Toro	436.0	3720.9
54149	99999	Fontana	455.4	3773.9
54146	99999	Indio	572.3	3731.0
53012	91919	King Harbor	371.2	3744.4
51108	99999	La Canada	388.2	3786.1
53099	91919	La Habra	412.0	3754.0
51117	99999	Lancaster	396.0	3839.5
52118	91919	Lennox	373.0	3755.0
53101	91919	Long Beach	390.0	3743.0
53127	91919	Los Alamitos	404.5	3739.8
52130	91919	Lynwood	388.0	3754.0
52104	91919	Malibu	344.0	3766.9
51115	99999	Newhall	355.5	3805.5
54167	99999	Norco	446.8	3749.0
54145	99999	Palm Springs	542.5	3742.5
51122	99999	Pasadena	396.0	3778.5
53134	91919	Pico Rivera	402.3	3764.1
54109	99999	Pomona	430.8	3769.6
54161	99999	Redlands	486.2	3769.4
51107	99999	Reseda	359.0	3785.0
54139	99999	Riverside	464.8	3758.6
53137	91919	Santa Ana Canyon	431.0	3748.4
54147	99999	Upland	440.0	3773.1
52132	91919	Vernon	387.4	3762.5
54106	99999	Walnut	420.0	3761.7
52158	91919	West Los Angeles	372.3	3768.6
53114	91919	Whittier	405.3	3754.0

UTM = Universal Transverse Mercator

Table 2-3. SCAQMD Stations Measuring CO or NO_2

Station	Pollutant measured	
	CO	NO_2
Central LA	X	X
Northwest Coastal LA County	X	X
Southwest Coastal LA County	X	X
South Coastal LA County	X	X
West San Fernando Valley	X	X
East San Fernando Valley	X	X
West San Gabriel Valley	X	X
East San Gabriel Valley 1	X	X
East San Gabriel Valley 2	X	X
Pomona/Walnut Valley	X	X
South San Gabriel Valley	X	X
South Central LA County 1	X	X
South Central LA County 2	X	X
Santa Clarita Valley	X	X
North Orange County	X	X
Central Orange County	X	X
North Coastal Orange County	X	X
Saddleback Valley 1	X	
Saddleback Valley 2	X	X
Norco/Corona		
Metropolitan Riverside County 1	X	X
Metropolitan Riverside County 2	X	X
Perris Valley		
Lake Elsinore	X	X
Banning Airport		X
Coachella Valley 1	X	X
Coachella Valley 2	X	X
Northwest San Bernardino Valley	X	X
Southwest San Bernardino Valley		
Central San Bernardino Valley 1		X
Central San Bernardino Valley 2	X	X
East San Bernardino Valley		
Central San Bernardino Mountains		
East San Bernardino Mountains		

PM2.5 AND PM10 AIR QUALITY

PM2.5 and PM10 impacts are treated differently than CO and NO_2, since, as mentioned earlier, nearly the entire district exceeds the state or federal PM2.5 and PM10 standards. Therefore, the incremental PM2.5 and PM10 impacts from construction are derived based on the change in concentration threshold of 10.4 $\mu g/m^3$ (24-hour average), which is comparable to the requirement in paragraph (d)(4) in SCAQMD Rule 403, which prohibits fugitive dust concentrations beyond a project's boundary that exceed 50 $\mu g/m^3$ (averaged over five hours) (see footnote #3). PM2.5 and PM10 impacts from operational activities are derived based on the allowable change in concentration threshold of 2.5 $\mu g/m^3$ in Table A-2 of Rule 1303 (see footnote #4). Because the entire district is nonattainment for PM2.5 and PM10, determining background PM2.5 and PM10 concentrations is unnecessary. However, meteorological conditions in the source receptor areas will ultimately affect the PM2.5 and PM10 LSTs.

NO_2-TO-NO_X RATIO

Combustion processes occurring from equipment yield NO_X emissions. The two principal NO_X species are nitric oxide (NO) and nitrogen dioxide (NO_2), with the vast majority (95 percent) of the NO_X emissions being comprised of NO. Adverse health effects are associated with NO_2, not NO. NO is converted to NO_2 by several processes, the two most important of these are (1) the reaction of NO with ozone and (2) the photochemical reaction of NO with hydrocarbon radical species. Destruction of NO_2 occurs with its photodissociation into NO and molecular oxygen.

NO_X emissions are simulated in the air quality dispersion model and the NO_2 conversion rate is treated by an NO_2-to-NO_X ratio, which is a function of downwind distance. Initially, it is assumed that only five percent of the emitted NO_X is NO_2. At 500 meters downwind, 100 percent conversion of NO-to-NO_2 is assumed. The assumed NO_2-to-NO_X ratios between those distances are presented in Figure 2-5. The NO_2 conversion rates are adapted from work by Arellano et al.[5].

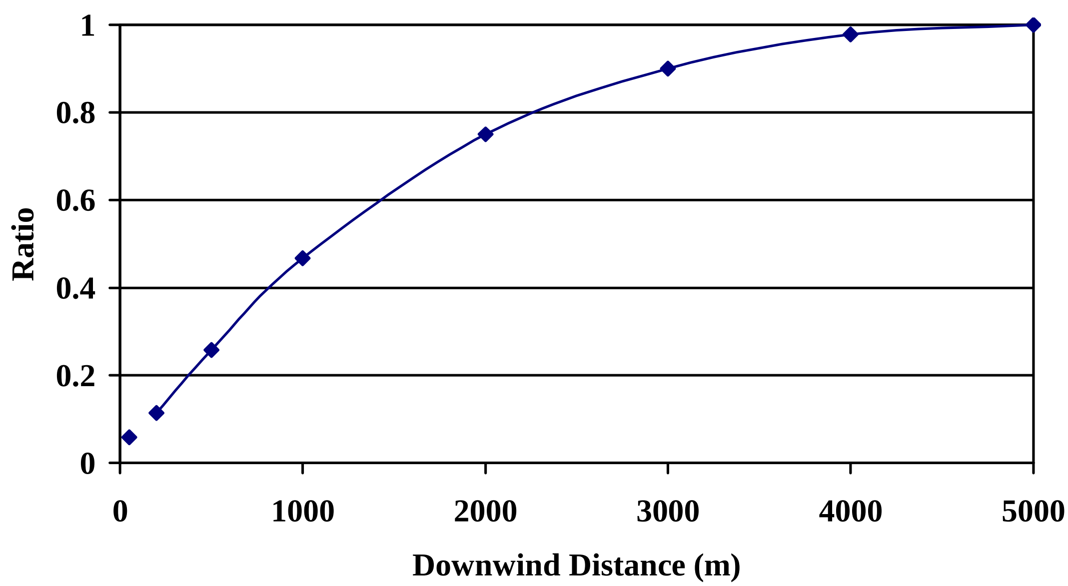


Figure 2-5. NO_2-to-NO_X Ratio as a Function of Downwind Distance

5 Arellano, J.V., A.M. Talmon, and P.J.H. Builtjes, 1990.

Table 2-4. NO_2-to-NO_X Ratio as a Function of Downwind Distance

Downwind Distance (m)	NO2/NOx Ratio
20	0.053
50	0.059
70	0.064
100	0.074
200	0.114
500	0.258
1000	0.467
2000	0.75
3000	0.9
4000	0.978
5000	1

DERIVING LOCALIZED SIGNIFICANCE THRESHOLDS

Localized Significance Thresholds by Concentration

LSTs by concentrations were used to develop mass rate LSTs. Project proponents, who choose to perform project specific air quality dispersion modeling, should use LST concentrations to determine adverse air quality impacts. Project proponents can either follow the procedures presented below to develop LSTs by concentration or use the tables in Appendix B, and Rules 403 and 1301.

Gaseous Pollutants (NOx and CO)

To derive the LST concentrations it is necessary to know the concentration of the most stringent ambient air quality standard and the ambient concentration for the pollutant under consideration in a specified SRA. The difference between the ambient air quality standard and the peak ambient concentration in the SRA produces a concentration that is then converted into mass emissions. The mass emissions result is the maximum amount of emissions a project can emit, when added to ambient concentrations, without causing or contributing to an exceedance of the most stringent applicable ambient air quality standard (i.e., background + project contribution). The resulting mass emissions amount is the LST for the pollutant under consideration for the specified SRA. The LST concentrations for NOx and CO, which are the differences in concentration between the most stringent ambient air quality standard and the peak ambient concentrations for each SRA are shown in Appendix B. The project contribution emissions level is derived using the following equation:

$$C_{PC} = C_{AAQS} - Cb \qquad \textbf{Eq. 2}$$

Where: C_{PC} is the project contribution emission levels in micrograms per cubic meter;

Cb is the background concentration measured at the closest air quality monitoring station in micrograms per cubic meter; and

C_{AAQS} is the limiting state or federal standards in micrograms per cubic meter.

Particulate Matter

The LST concentrations for particulate matter are the concentration thresholds presented in Rules 403 and 1301. The Rule 403 threshold of 10.4 microns per cubic meter applies to construction activities, and may apply to operational activities at aggregate handling facilities. The Rule 1301 threshold of 2.5 microns per cubic meter applies to nonaggregate handling operational activities.

Localized Significance Thresholds by Mass Rate

LSTs represent the maximum emissions from a project that will not cause or contribute to an exceedance of the most stringent applicable federal or state ambient air quality standard, and are developed based on the ambient concentrations of that pollutant for each source receptor area. The mass rate LSTs are estimated using an air dispersion model.

Air Dispersion Modeling

A unit emission rate is the single unit of mass over time or emissions rate (e.g., one gram per second, one kilogram per second, one pound per hour, one ton per year, etc.). Unit emission rates are typically developed over established AAQS averaging times or daily operating hours (i.e., one-hour, eight-hour, 24-hour, etc.). Unit emissions rates are used to normalize the resulting concentration produced by a dispersion model for ease of calculation. Therefore, ISC3 modeling was performed assuming a one pound per day emission rate over the eight-hour construction period of 8 a.m. to 4 p.m. The units of the results are in grams per cubic meter, per pound per day ([$\mu g/m^3$]/[lb/day]). ISC3 provides peak predicted concentrations at the downwind distances for the receptor for one-hour, eight-hour, and 24-hour averaging periods.

Calculating Localized Significance Thresholds

Gaseous Pollutants (NOx and CO)

Multiplying the unit emission rate of one-pound per day by the ratio of the project contribution level to the peak predicted concentration using ISC3 yields the mass rate LST in pounds per day.

$$E_{max} = U \text{ x } (C_{PC})/C_u \qquad \textbf{Eq. 3}$$

Where: E_{max} is the daily mass rate LST emissions in pounds per eight-hour day;

U is the unit emission rate of one-pound per eight-hour day (one-lb/day);

C_{PC} is the acceptable impact levels in micrograms per cubic meter; and

C_u is the peak predicted concentration in micrograms per cubic meter estimated by ISC3 for a unit emission rate of one-pound per day.

The daily mass rate LSTs in pounds per day are the emission rates that with the background concentration would equal but not exceed the most stringent AAQS. These allowable maximum daily emissions are presented in the mass rate Localized Significance Threshold Screening Tables in Appendix C.

Particulate Matter

The predicted PM2.5 or PM10 concentration at a given distance in meters from the fence line is estimated from Equation 1 using the PM2.5 or PM10 concentration at the fence line estimated by ISC3 for sources with combined unit emission rate of one-pound per day. Equation 4 estimates the daily mass rate LST emission in pounds per day from the predicted PM2.5 or PM10 concentration at a given distance from the fence line.

$$E_{max} = (C_{rule})/C_x \qquad \textbf{Eq. 4}$$

Where: E_{max} is the daily mass rate LST emissions in pounds per eight-hour day;

C_{rule} is the concentration threshold presented in Rule 403 (construction) or 1301 (operation); and

C_x is the predicted PM2.5 or PM10 concentration at x meters from the fence line in micrograms per cubic meter for a unit emission rate of one-pound per day. (see Eq. 1);

The concentration threshold is taken from either Rule 403 (10.4 microns per cubic meter) for construction activities or from Rule 1301 (2.5 microns per cubic meter) for operational activities. These allowable maximum daily PM2.5 or PM10 emissions are presented in the mass rate Localized Significance Threshold Screening Tables in Appendix C.

CHAPTER 3
SCREENING TABLES AND THEIR USE

The LST lookup tables provided in Appendix C allow a user to readily determine if the daily emissions for proposed construction or operational activities could result in significant localized air quality impacts. If the calculated emissions for the proposed construction or operational activities are below the LST emission levels found on the LST lookup tables, then the proposed construction or operation activity is not significant. Proposed projects whose calculated emission budgets for the proposed construction or operational activities are above the LST emission levels found in the LST lookup tables should not assume that the project would necessarily generate adverse impacts. Detailed emission calculations and/or air dispersion modeling may demonstrate that pollutant concentrations are below localized significant levels.

The CO, NO_X, PM2.5 and PM10 LST lookup tables for each source receptor area are provided in Appendix C for the 37 source receptor/areas. The CO and NOx LST lookup tables can be utilized for both construction and operational activities. There are two sets of PM2.5 and PM10 LST lookup tables: one for construction emissions and one for operational emissions. The operational emission PM2.5 and PM10 LST lookup tables were developed based on the allowable change in concentration threshold of 2.5 µg/m3 in Table A-2 of Rule 1303. It is recommended that operational emissions associated with fugitive dust area sources (e.g., landfills, aggregate material operations) use the PM10 LST lookup tables for operational activities. A lead agency can contact the SCAQMD staff (ceqa_admin@aqmd.gov) if there are any questions regarding which is the appropriate PM10 LST lookup tables for area source operational activities.

The tables are first organized by pollutant and then by source/receptor area. Within the tables, the distance to the nearest receptor is required to properly choose the correct allowable emission rate. The estimated maximum daily construction and operational emissions are compared to the allowable emissions to determine significance. If the projected emission budgets are less than the allowable emissions then significant local impacts are not expected.

Therefore, the information needed to use the LST lookup tables is as follows:

- Maximum daily emissions of CO, NO_X, PM2.5 and PM10 in pounds per day (lb/day)
- Distance from the boundary of the proposed project site to the nearest off-site receptor
- Geographic location of the construction site in terms of district source/receptor area

This information directs the user to the correct table and table cell. Additional guidance in each of these three areas is given below:

ESTIMATE EMISSIONS

The first step in the process is to estimate the maximum daily emissions of CO, NO_X, PM2.5 and PM10. The emissions include only on-site activities and the emission rate must be expressed in pounds per day. The PM2.5 and PM10 emissions should include both fugitive dust and exhaust from the stationary/mobile equipment on-site. The emission rates can be estimated based on project specific equipment categories and proposed controls.

DETERMINE THE SOURCE/RECEPTOR AREA OF THE PROPOSED CONSTRUCTION/OPERATIONAL ACTIVITY

On the SCAQMD website is a utility that provides the district source/receptor area for a given street address (www.aqmd.gov). The user is advised to follow the instructions on the use of this utility.

ESTIMATE THE RECEPTOR DISTANCE

Receptor locations are off-site locations where persons may be exposed to the emissions from project activities. Receptor locations include residential, commercial and industrial land use areas; and any other areas where persons can be situated for an hour or longer at a time. These other areas include parks, bus stops, and side walks but would not include the tops of buildings, roadways, or permanent bodies of water such as, oceans or lakes.[6]

For the purposes of a CEQA analysis, the SCAQMD considers a sensitive receptor to be to be a receptor such as residence, hospital, convalescent facility were it is possible that an individual could remain for 24 hours. Commercial and industrial facilities are not included in the definition of sensitive receptor because employees do not typically remain onsite for a full 24 hours, but are present for shorter periods of time, such as eight hours. Therefore, applying a 24-hour standard for PM10 is appropriate not only because the averaging period for the state standard is 24 hours, but because, according to the SCAQMD's definition, the sensitive receptor would be present at the location for the full 24 hours.

Since a sensitive receptor is considered to be present onsite for 24 hours, LSTs based on shorter averaging times, such as the one-hour NO_2 or the one-hour and eight-hour CO ambient air quality standards, would also apply. However, LSTs based on shorter averaging periods, such as the NO_2 and CO LSTs, could also be applied to receptors such as industrial or commercial facilities since it is reasonable to assume that a worker at these sites could be present for periods of one to eight hours. This assumption is consistent with the CO hotspots modeling protocol, which requires modeling at receptors that may also include commercial and industrial sites. It is for this reason that the Methodology paper included commercial and industrial sites when discussing receptor locations as opposed to sensitive receptors.

[6] SCAQMD, *Risk Assessment Procedures for Rules 1401 and 212*, Version 6.0, 2000. p 8.

The receptor distance is measured from the boundary of the proposed project site to the nearest receptor location. Care should be taken when estimating these distances since allowable emissions increase rapidly with increasing downwind distance. It is acceptable to linearly interpolate to estimate the allowable emissions between the downwind distances given in the tables.

The closest receptor distance on the mass rate LST look-up tables is 25 meters. It is possible that a project may have receptors closer than 25 meters. Projects with boundaries located closer than 25 meters to the nearest receptor should use the LSTs for receptors located at 25 meters.

MITIGATION MEASURES

If project emissions exceed the mass rates presented in the LST look-up tables or allowable air quality impacts based on modeling, CEQA requires lead agencies to implement feasible mitigation measures, if available, to reduce adverse air quality impacts. Lead agencies may use the mitigation measures presented in Chapter 11 and its appendix in the Handbook (1993), other sources, or develop their own mitigation measures. The CEQA Handbook can be accessed on line at www.aqmd.gov/eg/I-4/I4.htm. AQMD staff is available for consultation on mitigation measures to provide updates or new information, if available, on a project-by-project basis.

LIMITATIONS OF THE SCREENING TABLES

The LST lookup tables were developed to assist lead agencies with a simple tool for evaluating the impacts from small typical projects. Table 3-1 includes a list of typical projects. Large industrial projects, such as installation of turbines at power plants are beyond the scope of these LST lookup tables. LSTs are applicable at the project-specific level and generally are not applicable to regional projects such as local General Plans unless specific projects are identified in the General Plans. Regional analyses are more applicable to the scope of General Plans. Table 3-2 includes typical projects where the LST lookup tables may not apply.

Table 3-1. Typical Projects

Apartments	Medical Office Building
Banks	Mobil Home Park
City Parks	Nursing Home
Condo/Townhouses	Office Buildings
Convenience Market	Pharmacy/Drug Store
Day-Care Center	Places of Worship
Discount Clubs	Racquet/Health Clubs
Discount Stores	Regional Shopping Center
Electronics Store	Residential Planned Unit Development (PUD)
Hardware/Paint Store	Restaurants
Home Improvement Store	Retirement Community
Hospital	Schools (Elementary, Junior High /Middle, High)
Hotels/Motels	Single Family Housing
Industrial Building	Strip Mall
Libraries	Supermarket
Manufacturing	University/College

Table 3-2. Typical Projects Where Screening Tables May Not Apply

Project Sites Larger than 5 acres	Projects that require more than one shift
Projects at RECLAIM facilities	Project sites where emissions are distinctly non-uniform across site
Projects at Title V facilities	Operational sources where fumigation or building downwash is anticipated
Large Combustion Sources	General Plans

The LST lookup tables are limited to projects with the following parameters:

- Five acres or smaller in size
- Limited to eight-hours of operation per day
- Limited to operations during the day
- It is assumed emission sources are distributed evenly across proposed site

Proposed projects that exceed the above limitations should complete a site specific localized significance analysis.

SAMPLE CALCULATIONS

Based on stakeholder comments to ease concerns on potential resource impacts due to necessary quantification of emissions, a separate technical document was prepared to illustrate how construction emissions can be calculated for LST impact analysis. The sample calculations can be used by lead agencies for simlar projects if the projects fall within the general parameters assumed for the sample projects. A copy of this report can be found at www.aqmd.gov/eg/I-4/I4.htm. Additional scenarios can be added upon request for general use and AQMD staff is also available to provide technical assistance to lead agency staff.

CHAPTER 4
CONCLUSION

Environmental justice initiatives and revision of the Handbook have focused attention on localized adverse effects of proposed projects on air quality. In order to address potential localized impacts this proposal attempts to establish the thresholds reflecting existing air quality. The cleaner the air is in a local area, the greater emissions increment it can afford without causing or contributing to an exceedance of the most stringent ambient air quality standard. If the existing air quality is not yet in compliance with the air quality standards, all areas are subject to generally equivalent LSTs

Historically assessing localized air quality impacts required using complex dispersion models. Therefore, to address the issue of localized significance, yet be sensitive to the fact that other public agencies might not have the expertise or adequate financial resources to perform dispersion modeling, in addition to the methodology itself, SCAQMD staff developed localized significant threshold similar to the regional significance thresholds, that is, based on the amount of pounds of emissions per day generated by a proposed project that would cause or contribute to adverse localized air quality impacts. These projects are assumed to be less than five acres in size. Emissions were assumed to be uniformly distributed across a flat proposed project site over an eight-hour workday. Receptors distances are measured in meters from the proposed project boundary. The same emissions estimated for regional significant thresholds should be compared to allowable emissions presented the LST lookup tables for the source/receptor area closest to the proposed project.

Screening procedures are by design conservative, that is, the predicted impacts tend to overestimate the actual impacts. If the predicted impacts are acceptable using the LST approach presented here, then a more detailed evaluation is not necessary. However, if the predicted impacts are significant, then the project proponent may wish to perform a more detailed emission and/or modeling analysis before concluding that the impacts are significant. Project proponents are not required to use this LST procedure; and may complete site specific modeling instead.

CHAPTER 5
REFERENCES

Arellano, J.V., A.M. Talmon, and P.J.H. Builtjes, "A Chemically Reactive Plume Model for the NO-NO_2-O_3 System," *Atmospheric Environment* **24A**, 2237-2246

Desert Research Institute, *Final Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads*, DRI Document No. 685-5200.1F1, prepared for CARB CRPAQS, December 31, 1996.

SCAQMD, *CEQA Air Quality Handbook*, April 1993.

SCAQMD, *Risk Assessment Procedures for Rules 1401 and 212*, Version 6.0, August 18, 2002.

USEPA, *User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume I and II*, EPA-454/B-95-003, September, 1995.

APPENDIX A

PEAK BACKGROUND CONCENTRATIONS
FOR THE 1999–2001 PERIOD

The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table A-1
Peak Background Concentrations for the 1999-2001 Period[a]

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	Units	1999 Conc.	2000 Conc.	2001 Conc.	Max Conc.
1	Central LA	NOx	1-hr	ppm	0.21	0.16	0.14	0.21
		CO	1-hr	ppm	7.00	7.00	6.00	7.00
		CO	8-hr	pphm	6.30	6.00	4.57	6.30
2	Northwest Coastal LA County	NOx	1-hr	ppm	0.13	0.16	0.11	0.16
		CO	1-hr	ppm	6.00	6.00	4.00	6.00
		CO	8-hr	pphm	3.80	4.30	3.00	4.30
3	Southwest Coastal LA County	NOx	1-hr	ppm	0.13	0.13	0.11	0.13
		CO	1-hr	ppm	10.00	9.00	7.00	10.00
		CO	8-hr	pphm	8.40	7.00	5.14	8.40
4	South Coastal LA County	NOx	1-hr	ppm	0.15	0.14	0.13	0.15
		CO	1-hr	ppm	7.00	10.00	6.00	10.00
		CO	8-hr	pphm	5.40	5.80	4.71	5.80
6	West San Fernando Valley	NOx	1-hr	ppm	0.12	0.11	0.09	0.12
		CO	1-hr	ppm	9.00	11.00	7.00	11.00
		CO	8-hr	pphm	7.60	9.80	6.00	9.80
7	East San Fernando Valley	NOx	1-hr	ppm	0.18	0.17	0.25	0.25
		CO	1-hr	ppm	9.00	8.00	6.00	9.00
		CO	8-hr	pphm	9.00	6.10	4.88	9.00

a) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table A-1 (Continued)
Peak Background Concentrations for the 2000-2002 Period[a]

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	Units	2000 Conc.	2001 Conc.	2002 Conc.	Max Conc.
1	Central LA	NOx	1-hr	ppm	0.16	0.14	0.14	0.16
		CO	1-hr	ppm	7.00	6.00	5.00	7.00
		CO	8-hr	pphm	6.00	4.57	4.00	6.00
2	Northwest Coastal LA County	NOx	1-hr	ppm	0.16	0.11	0.11	0.16
		CO	1-hr	ppm	6.00	4.00	4.00	6.00
		CO	8-hr	pphm	4.30	3.00	2.70	4.30
3	Southwest Coastal LA County	NOx	1-hr	ppm	0.13	0.11	0.10	0.13
		CO	1-hr	ppm	9.00	7.00	7.00	9.00
		CO	8-hr	pphm	7.00	5.14	6.10	7.00
4	South Coastal LA County	NOx	1-hr	ppm	0.14	0.13	0.13	0.14
		CO	1-hr	ppm	10.00	6.00	6.00	10.00
		CO	8-hr	pphm	5.80	4.71	4.60	5.80
6	West San Fernando Valley	NOx	1-hr	ppm	0.11	0.09	0.09	0.11
		CO	1-hr	ppm	11.00	7.00	6.00	11.00
		CO	8-hr	pphm	9.80	6.00	4.80	9.80
7	East San Fernando Valley	NOx	1-hr	ppm	0.17	0.25	0.26	0.26
		CO	1-hr	ppm	8.00	6.00	6.00	8.00
		CO	8-hr	pphm	6.10	4.88	4.60	6.10

a) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table A-1 (Continued)
Peak Background Concentrations for the 2000-2002 Period[a]

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	Units	2000 Conc.	2001 Conc.	2002 Conc.	Max Conc.
8	West San Gabriel Valley	NOx	1-hr	ppm	0.17	0.15	0.15	0.17
		CO	1-hr	ppm	9.00	7.00	6.00	9.00
		CO	8-hr	pphm	7.40	5.00	4.00	7.40
9	East San Gabriel Valley 1	NOx	1-hr	ppm	0.15	0.12	0.12	0.15
		CO	1-hr	ppm	5.00	3.00	4.00	5.00
		CO	8-hr	pphm	4.90	2.88	2.40	4.90
9	East San Gabriel Valley 2	NOx	1-hr	ppm	0.13	0.12	0.10	0.13
		CO	1-hr	ppm	4.00	3.00	5.00	5.00
		CO	8-hr	pphm	3.10	2.50	2.30	3.10
10	Pomona/Walnut Valley	NOx	1-hr	ppm	0.14	0.13	0.11	0.14
		CO	1-hr	ppm	7.00	5.00	6.00	7.00
		CO	8-hr	pphm	4.90	3.43	3.30	4.90
11	South San Gabriel Valley	NOx	1-hr	ppm	0.14	0.14	0.12	0.14
		CO	1-hr	ppm	7.00	6.00	5.00	7.00
		CO	8-hr	pphm	5.30	4.00	4.00	5.30
12	South Central LA County 1	NOx	1-hr	ppm	0.14	0.15	0.14	0.15
		CO	1-hr	ppm	13.00	12.00	16.00	16.00
		CO	8-hr	pphm	10.00	7.71	10.10	10.10

a) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table A-1 (Continued)
Peak Background Concentrations for the 2000-2002 Period[a]

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	Units	2000 Conc.	2001 Conc.	2002 Conc.	Max Conc.
12	South Central LA County 2	NOx	1-hr	ppm	0.11	--	--	0.11
		CO	1-hr	ppm	13.00	--	--	13.00
		CO	8-hr	pphm	9.50	--	--	9.50
13	Santa Clarita Valley	NOx	1-hr	ppm	0.10	0.10	0.10	0.10
		CO	1-hr	ppm	6.00	6.00	3.00	6.00
		CO	8-hr	pphm	4.90	3.14	1.90	4.90
16	North Orange County	NOx	1-hr	ppm	0.12	0.13	0.12	0.13
		CO	1-hr	ppm	14.00	11.00	10.00	14.00
		CO	8-hr	pphm	6.10	4.71	4.40	6.10
17	Central Orange County	NOx	1-hr	ppm	0.13	0.12	0.10	0.13
		CO	1-hr	ppm	8.00	8.00	7.00	8.00
		CO	8-hr	pphm	6.80	4.71	5.40	6.80
18	North Coastal Orange County	NOx	1-hr	ppm	0.11	0.08	0.11	0.11
		CO	1-hr	ppm	8.00	6.00	5.00	8.00
		CO	8-hr	pphm	6.30	4.57	4.30	6.30
19	Saddleback Valley 1	NOx	1-hr	ppm	--	--	--	0.00
		CO	1-hr	ppm	5.00	--	--	5.00
		CO	8-hr	pphm	2.30	--	--	2.30

a) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table A-1 (Continued)
Peak Background Concentrations for the 2000-2002 Period[a]

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	Units	2000 Conc.	2001 Conc.	2002 Conc.	Max Conc.
19	Saddleback Valley 2	NOx	1-hr	ppm	--	--	--	0.00
		CO	1-hr	ppm	4.00	3.00	3.00	4.00
		CO	8-hr	pphm	3.30	2.38	3.60	3.60
22	Norco/Corona	NOx	1-hr	ppm	--	--	--	0.00
		CO	1-hr	ppm	--	--	--	8.00
		CO	8-hr	pphm	--	--	--	4.30
23	Metropolitan Riverside County 1	NOx	1-hr	ppm	0.10	0.15	0.10	0.15
		CO	1-hr	ppm	5.00	5.00	8.00	8.00
		CO	8-hr	pphm	4.30	3.43	3.00	4.30
23	Metropolitan Riverside County 2	NOx	1-hr	ppm	--	--	--	0.00
		CO	1-hr	ppm	9.00	6.00	7.00	8.00
		CO	8-hr	pphm	4.30	4.50	3.90	4.50
24	Perris Valley	NOx	1-hr	ppm	--	--	--	0.00
		CO	1-hr	ppm	--	--	--	8.00
		CO	8-hr	pphm	--	--	--	4.50
25	Lake Elsinore	NOx	1-hr	ppm	0.08	0.09	0.07	0.09
		CO	1-hr	ppm	4.00	2.00	3.00	4.00
		CO	8-hr	pphm	2.00	2.00	2.00	2.00

a) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table A-1 (Continued)
Peak Background Concentrations for the 2000-2002 Period[a]

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	Units	2000 Conc.	2001 Conc.	2002 Conc.	Max Conc.
29	Banning Airport	NOx	1-hr	ppm	0.21	0.24	0.15	0.24
		CO	1-hr	ppm	--	--	--	3.00
		CO	8-hr	pphm	--	--	--	0.00
30	Coachella Valley 1**	NOx	1-hr	ppm	0.07	0.08	0.10	0.10
		CO	1-hr	ppm	3.00	2.00	2.00	3.00
		CO	8-hr	pphm	1.60	1.50	1.20	1.60
30	Coachella Valley 2**	NOx	1-hr	ppm	0.06	0.00	--	0.06
		CO	1-hr	ppm	3.00	--	--	3.00
		CO	8-hr	pphm	2.10	--	--	2.10
32	Northwest San Bernardino Valley	NOx	1-hr	ppm	0.15	0.13	0.12	0.15
		CO	1-hr	ppm	4.00	3.00	4.00	4.00
		CO	8-hr	pphm	2.60	1.75	1.60	2.60
33	Southwest San Bernardino Valley	NOx	1-hr	ppm	--	--	--	0.00
		CO	1-hr	ppm	--	--	--	4.00
		CO	8-hr	pphm	--	--	--	2.60
34	Central San Bernardino Valley 1	NOx	1-hr	ppm	0.12	0.13	0.12	0.13
		CO	1-hr	ppm	--	--	--	4.00
		CO	8-hr	pphm	--	--	--	2.60

a) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table A-1 (Concluded)
Peak Background Concentrations for the 2000-2002 Period[a]

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	Units	2000 Conc.	2001 Conc.	2002 Conc.	Max Conc.
34	Central San Bernardino Valley 2	NOx	1-hr	ppm	0.10	0.11	0.11	0.11
		CO	1-hr	ppm	5.00	4.00	5.00	5.00
		CO	8-hr	pphm	4.30	3.25	3.30	4.30
35	East San Bernardino Valley	NOx	1-hr	ppm	--	--	--	0.00
		CO	1-hr	ppm	--	--	--	5.00
		CO	8-hr	pphm	--	--	--	4.30
37	Central San Bernardino Mountains	NOx	1-hr	ppm	--	--	--	0.00
		CO	1-hr	ppm	--	--	--	5.00
		CO	8-hr	pphm	--	--	--	4.30
38	East San Bernardino Mountains	NOx	1-hr	ppm	--	--	--	0.00
		CO	1-hr	ppm	--	--	--	5.00
		CO	8-hr	pphm	--	--	--	4.30

a) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

APPENDIX B

DIFFERENCES BETWEEN THE MOST STRINGENT AMBIENT AIR QUALITY STANDARD AND AMBIENT CONCENTRATIONS FOR EACH SRA FOR THE 1999–2001 PERIOD

The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

The current NO2 State AAQS is 0.18 ppm as of March 20, 2008. Table B-1 was prepared when the NO2 State AAQS was 0.025.

Table B-1
Difference in Concentration for the 2000-2002 Period

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	AAQS[a] (ppm)	Observed[b] (ppm)	Difference (ppm)	Difference (ug/m^3)
1	Central LA	NO_2	1-hr	0.25	0.16	0.09	170
		CO	1-hr	20	7	13	14,950
		CO	8-hr	9	6	3	3,444
2	Northwest Coastal LA County	NO_2	1-hr	0.25	0.16	0.09	170
		CO	1-hr	20	6	14	16,100
		CO	8-hr	9	4.3	4.7	5,396
3	Southwest Coastal LA County	NO_2	1-hr	0.25	0.13	0.12	226
		CO	1-hr	20	9	11	12,650
		CO	8-hr	9	7	2	2,296
4	South Coastal LA County	NO_2	1-hr	0.25	0.14	0.11	207
		CO	1-hr	20	10	10	11,500
		CO	8-hr	9	5.8	3.2	3,674
6	West San Fernando Valley	NO_2	1-hr	0.25	0.11	0.14	264
		CO	1-hr	20	11	9	10,350
		CO	8-hr	9	9.8	0.45	517
7	East San Fernando Valley	NO_2	1-hr	0.25	0.26	0.01	19
		CO	1-hr	20	8	12	13,800
		CO	8-hr	9	6.1	2.9	3,329

a) The current NO2 State AAQS is 0.18 ppm as of March 20, 2008. Table B-1 was prepared when the NO2 State AAQS was 0.25 ppm.
b) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table B-1 (Continued)
Difference in Concentration for the 2000-2002 Period

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	AAQS[a] (ppm)	Observed[b] (ppm)	Difference (ppm)	Difference (ug/m^3)
8	West San Gabriel Valley	NO_2	1-hr	0.25	0.17	0.08	151
		CO	1-hr	20	9	11	12,650
		CO	8-hr	9	7.4	1.6	1,837
9	East San Gabriel Valley 1	NO_2	1-hr	0.25	0.15	0.1	189
		CO	1-hr	20	5	15	17,250
		CO	8-hr	9	4.9	4.1	4,707
9	East San Gabriel Valley 2	NO_2	1-hr	0.25	0.13	0.12	226
		CO	1-hr	20	5	15	17,250
		CO	8-hr	9	3.1	5.9	6,773
10	Pomona/Walnut Valley	NO_2	1-hr	0.25	0.14	0.11	207
		CO	1-hr	20	7	13	14,950
		CO	8-hr	9	4.9	4.1	4,707
11	South San Gabriel Valley	NO_2	1-hr	0.25	0.14	0.11	207
		CO	1-hr	20	7	13	14,950
		CO	8-hr	9	5.3	3.7	4,248
12	South Central LA County 1	NO_2	1-hr	0.25	0.15	0.1	189
		CO	1-hr	20	16	4	4,600
		CO	8-hr	9	10.1	0.45	517

a) The current NO2 State AAQS is 0.18 ppm as of March 20, 2008. Table B-1 was prepared when the NO2 State AAQS was 0.25 ppm.
b) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table B-1 (Continued)
Difference in Concentration for the 2000-2002 Period

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	AAQS[a] (ppm)	Observed[b] (ppm)	Difference (ppm)	Difference (ug/m^3)
12	South Central LA County 2	NO_2	1-hr	0.25	0.11	0.14	264
		CO	1-hr	20	13	7	8,050
		CO	8-hr	9	9.5	0.45	517
13	Santa Clarita Valley	NO_2	1-hr	0.25	0.1	0.15	283
		CO	1-hr	20	6	14	16,100
		CO	8-hr	9	4.9	4.1	4,707
16	North Orange County	NO_2	1-hr	0.25	0.13	0.12	226
		CO	1-hr	20	14	6	6,900
		CO	8-hr	9	6.1	2.9	3,329
17	Central Orange County	NO_2	1-hr	0.25	0.13	0.12	226
		CO	1-hr	20	8	12	13,800
		CO	8-hr	9	6.8	2.2	2,526
18	North Coastal Orange County	NO_2	1-hr	0.25	0.11	0.14	264
		CO	1-hr	20	8	12	13,800
		CO	8-hr	9	6.3	2.7	3,100
19	Saddleback Valley 1	NO_2	1-hr	0.25	0	--	264
		CO	1-hr	20	5	15	17,250
		CO	8-hr	9	2.3	6.7	7,692

a) The current NO2 State AAQS is 0.18 ppm as of March 20, 2008. Table B-1 was prepared when the NO2 State AAQS was 0.25 ppm.
b) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table B-1 (Continued)
Difference in Concentration for the 2000-2002 Period

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	AAQS[a] (ppm)	Observed[b] (ppm)	Difference (ppm)	Difference (ug/m^3)
19	Saddleback Valley 2	NO_2	1-hr	0.25	0	--	264
		CO	1-hr	20	4	16	18,400
		CO	8-hr	9	3.6	5.4	6,199
22	Norco/Corona	NO_2	1-hr	0.25	0	--	189
		CO	1-hr	20	8	12	13,800
		CO	8-hr	9	4.3	4.7	5,396
23	Metropolitan Riverside County 1	NO_2	1-hr	0.25	0.15	0.1	189
		CO	1-hr	20	8	12	13,800
		CO	8-hr	9	4.3	4.7	5,396
23	Metropolitan Riverside County 2	NO_2	1-hr	0.25	0	--	189
		CO	1-hr	20	8	12	13,800
		CO	8-hr	9	4.5	4.5	5,166
24	Perris Valley	NO_2	1-hr	0.25	0	--	189
		CO	1-hr	20	8	12	13,800
		CO	8-hr	9	4.5	4.5	5,166
25	Lake Elsinore	NO_2	1-hr	0.25	0.09	0.16	302
		CO	1-hr	20	4	16	18,400
		CO	8-hr	9	2	7	8,036

a) The current NO2 State AAQS is 0.18 ppm as of March 20, 2008. Table B-1 was prepared when the NO2 State AAQS was 0.25 ppm.
b) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table B-1 (Continued)
Difference in Concentration for the 2000-2002 Period

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	AAQS[a] (ppm)	Observed[b] (ppm)	Difference (ppm)	Difference (ug/m^3)
29	Banning Airport	NO_2	1-hr	0.25	0.24	0.01	19
		CO	1-hr	20	3	17	19,550
		CO	8-hr	9	0	9	10,332
30	Coachella Valley 1**	NO_2	1-hr	0.25	0.1	0.15	283
		CO	1-hr	20	3	17	19,550
		CO	8-hr	9	1.6	7.4	8,495
30	Coachella Valley 2**	NO_2	1-hr	0.25	0.06	0.19	358
		CO	1-hr	20	3	17	19,550
		CO	8-hr	9	2.1	6.9	7,921
32	Northwest San Bernardino Valley	NO_2	1-hr	0.25	0.15	0.1	189
		CO	1-hr	20	4	16	18,400
		CO	8-hr	9	2.6	6.4	7,347
33	Southwest San Bernardino Valley	NO_2	1-hr	0.25	0	--	189
		CO	1-hr	20	4	16	18,400
		CO	8-hr	9	2.6	6.4	7,347
34	Central San Bernardino Valley 1	NO_2	1-hr	0.25	0.13	0.12	226
		CO	1-hr	20	4	16	18,400
		CO	8-hr	9	2.6	6.4	7,347

a) The current NO2 State AAQS is 0.18 ppm as of March 20, 2008. Table B-1 was prepared when the NO2 State AAQS was 0.25 ppm.
b) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

Table B-1 (Concluded)
Difference in Concentration for the 2000-2002 Period

Source/ Receptor Area	Air Quality Site	Pollutant	Averaging Time	AAQS[a] (ppm)	Observed[b] (ppm)	Difference (ppm)	Difference (ug/m^3)
34	Central San Bernardino Valley 2	NO_2	1-hr	0.25	0.11	0.14	264
		CO	1-hr	20	5	15	17,250
		CO	8-hr	9	4.3	4.7	5,396
35	East San Bernardino Valley	NO_2	1-hr	0.25	0	--	264
		CO	1-hr	20	5	15	17,250
		CO	8-hr	9	4.3	4.7	5,396
37	Central San Bernardino Mountains	NO_2	1-hr	0.25	0	--	264
		CO	1-hr	20	5	15	17,250
		CO	8-hr	9	4.3	4.7	5,396
38	East San Bernardino Mountains	NO_2	1-hr	0.25	0	--	264
		CO	1-hr	20	5	15	17,250
		CO	8-hr	9	4.3	4.7	5,396

a) The current NO2 State AAQS is 0.18 ppm as of March 20, 2008. Table B-1 was prepared when the NO2 State AAQS was 0.25 ppm.
b) The peak concentrations in this appendix were the most recent concentrations available at the time the LSTs were developed. The CEQA practitioner should refer to the peak concentrations in the most recent three-year period.

APPENDIX C

LOCALIZED SIGNIFICANCE THRESHOLD TABLES

The LST mass rate look-up tables are updated annually with the most recent air quality monitoring data. The latest version of the tables can be downloaded from the SCAQMD website at http://www.aqmd.gov/ceqa/handbook/LST/LST.html. Original hard copies of the mass rate LST look-up tables can be obtained through the SCAQMD Public Information Center at the Diamond Bar headquarters or by calling (909) 396-2039.

APPENDIX A

BACKGROUND

Since the late 1970's, the Air Quality Management Plan (AQMP) has been used to guide the development of the AQMD's regulatory program and reduce the emission of smog precursors and other air contaminants. Since that time, a growing focus has been on air toxic emissions and the health effects associated with their release into the air. The AQMD conducted a study in 1987 to assess air toxics levels in the Basin. That study, called the Multiple Air Toxics Exposure Study (MATES I), integrated measured ambient concentrations, population distribution, and health risk data for 20 Toxic Air Contaminants (TACs) to estimate regional inhalation exposure, risk, and number of potential excess cancer cases.

The concept for a final draft Air Toxics Control Plan was an outgrowth of the Environmental Justice principles and the Environmental Justice Initiatives adopted by the Governing Board in October 1997. Extensive air monitoring under Environmental Justice Initiative #2 (MATES II) and work under Environmental Justice Initiative #10 (related to air toxics rules for new and existing sources) highlighted the need for a more systematic approach to reducing air toxics emissions. The Air Toxics Control Plan was approved by the Governing Board in March 2000 as a further tool to addressing air toxic emissions and reducing exposure. The Air Toxics Control Plan relies upon the findings of MATES II relative to focusing efforts to maximize public health protection. MATES II is further discussed below.

Local Programs

AQMP

The first AQMP was prepared and approved by the AQMD in 1979 and has been updated and revised many times. The California Clean Air Act (CCAA) requires a three-year plan review and update to the AQMP. Implementation of the AQMP has resulted in significant progress towards meeting federal and state air quality standards over the last several decades and has contributed to the overall reduction of cumulative impacts of air pollution (criteria as well as air toxic pollutants) throughout the Basin.

The 2003 AQMP will provide an updated air pollution control strategy to attain federal ambient air quality standards. In addition, the AQMP will include an initial analysis of the estimated emission reductions needed to achieve new federal eight-hour and fine particulate ambient air quality standards.

Air Toxics Control Plan

The final draft Air Toxics Control Plan was approved by the AQMD Governing Board in March 2000 and utilized valuable information developed as a part of the MATES II monitoring and modeling study. This planning document was designed to examine the overall direction of the AQMD's air toxics control program. Development and implementation of strategic initiatives have required partnerships with other agencies, the regulated community, environmental groups, and the public. The plan is not required by state or federal law, so it was not submitted as a part of the State Implementation Plan (SIP).

The final draft Air Toxics Control Plan identifies potential strategies to reduce toxic levels in the Basin over the next ten years. To the extent the strategies are implemented by the relative agencies, the plan will improve public health by reducing health risks associated with both mobile and stationary sources.

To date, the majority of strategies have been implemented, making significant progress in many areas. These include increased emission reductions, and therefore health risk reduction, from sources such as gas stations, dry cleaners, motion picture film processing, metal plating, and on road motor vehicles. In addition, AQMD Rules 1401 and 1402 have been strengthened to reduce air toxic exposures from new and existing stationary sources, respectively. In addition, ARB will be implementing CARB Phase III gasoline production requirements after January 1, 2004, which is anticipated to significantly lower motor vehicle emissions. Appendix B contains a table summarizing the progress made in implementing the March 2000 Air Toxics Control Plan.

Rule 1401 – New Source Review of Toxic Air Contaminants

Permits for new, modified or relocated equipment that emits toxic air contaminants must meet limits for cancer and non-cancer impacts. Rule 1401 is updated periodically to reflect new information on air toxics that is developed by the state. Individual equipment must meet one-in-one million or use Toxic Best Available Control Technology (T-BACT) to reduce their health risk below ten-in-one million in order to obtain a permit. Equipment must also be below a hazard index of 1.0 (for acute and chronic impacts). Rule 1401 has been amended numerous times in the last five years to implement risk values approved by the state and now encompasses more than 200 compounds.

Rule 1402 – Control of Air Toxic Emissions from Existing Sources

Existing facilities that emit TACs must meet facility-wide limits for cancer and non-cancer impacts. This rule utilizes the same list of compounds as Rule 1401. Rule 1402 impacts are assessed every time the state introduces new risk values. Rule 1402 was amended in March 2000 and the action risk levels of the rule were lowered to a facility-wide cancer risk level of 25 in 1 million or a non-cancer hazard index of 3.0.

AB 2588 Program

The AB 2588 program requires certain facilities to inventory their TACs. Public notifications are required by companies whose facility-wide cancer risk exceeds 10-in-one million or a noncancer hazard index (chronic or acute exposure) of 1.0. Risk reductions are required through Rule 1402 if their cancer risk is above 25 in one million or the hazard index (HI) exceeds 3.0. Through this program, public notification and disclosure have proven to be a valuable tool in reducing air toxic emissions and many companies make changes at their facilities to reduce below notification thresholds. Voluntary reductions undertaken by these facilities are responsible for significant toxic reductions.

AQMD Regulation XIII and BACT

This regulation is designed to meet state and federal statutory requirements and ensure that the construction and operation of new or modified sources will not interfere with progress towards attainment of National Ambient Air Quality Standards (NAAQS). Permits for new, modified, or relocated equipment must meet offset and BACT requirements. Reductions in volatile organic compound (VOC) and particulate matter (PM) often result in concurrent toxic reductions. Review of permits at the new source review stage ensures that adequate controls are installed to meet rule requirements.

Source Specific Rules

AQMD has, over the years, adopted prohibition rules (Regulation IV) and rules for Best Available Retrofit Control Technology, or BARCT, (Regulation XI) to reduce criteria pollutants, largely as part of AQMP implementation. Reductions of emissions from VOC and PM sources can also result in toxic reductions through reformulation, add-on controls or process changes. Adopted rules with future compliance dates and continuous implementation of the 1999 Amendment to the 1997 AQMP are expected to further reduce VOC emissions. Zero or near-zero coating and solvent technologies, and enhanced controls on VOC fugitive emissions from industrial processes will benefit air toxics emission reductions as well. During the rule development of future AQMP measures, corresponding air toxics impacts will be closely examined to maximize potential air toxics reductions.

AQMD Regulation XIV

In addition to the programmatic rules, Regulation XIV contains a number of source-specific air toxics rules applicable to existing sources. The regulation contains fifteen rules, including asbestos abatement, dry cleaning operations, chrome plating, and motion picture film processing.

Technology Incentive Programs

The AQMD manages several technology incentive programs that use monies from several different sources to fund projects that not only lower emissions of criteria air pollutants, but toxic air contaminants as well. These programs lower diesel particulates from school and transit buses, heavy duty on/off road vehicles, and marine vessels. Included in these programs are the Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program), the Lower-Emission School Bus Program, the State Emissions Mitigation Program, the Air Quality Investment Program (AQIP), and the Mobile Source Air Pollution Reduction Review Committee (MSRC). These programs fund, in whole or in part, retrofit or replacement of higher emitting diesel engines that significantly reduce diesel particulate emissions, as well as other programs that directly benefit the public's health through reduction of air toxic emissions.

Relative to these programs, a state law was signed by the Governor in October 2001 on the distribution of state funds (AB 1390, Firebaugh). Each air district must spend at least 50% of their allotted funds to directly benefit communities that are disproportionately impacted by air pollution.

2002-03 EJ Enhancements

In September 2002, the Governing Board approved a series of enhancements to the AQMD's Environmental Justice Program. Several of those enhancements will contribute to reduce cumulative impacts in the Basin. These EJ Enhancements include:

- Subregional analysis (I-3);
- Localized impact thresholds via the CEQA process (I-4);
- Lowest feasible air toxics emissions alternative for rules with significant impacts under CEQA (II-1)
- Electronic posting of air toxic emissions (II-4)
- Off-road Intermodal equipment (III-1)
- Super mitigation (III-2)

EJ Enhancement I-3 focuses on subregional studies. AQMD staff conducted an air quality impact study on the Mira Loma area to analyze cumulative emissions impacts from distribution centers/warehouse facilities (especially due to diesel exhaust), and to identify potential control opportunities. The study encompassed a three-step process, including: 1) the development of a land use map and data base per the local General Plan along with facility permit activity, 2) estimation of diesel truck emissions from these activities, and 3) computer modeling to estimate cumulative impacts from air toxics and fine particulate. The analysis also includes working on methodology to separate out transported and locally generated PM.

This enhancement calls for the continuance and expansion of these subregional analyses to other areas of the Basin which may be specially impacted by hazardous air pollutants (HAPs) and/or fine particulates in a manner that poses a potential environmental justice concern. The end product of these efforts will likely be refined emission inventory data, improved air quality modeling estimates of pollution levels, and proposed mitigation measures, if needed. Staff anticipates that one of these studies might be conducted on an annual basis, as needed. The next subregional analysis is anticipated to be conducted for the Alameda Corridor. Any proposed mitigation measures will be within current legal authority of AQMD or other responsible agencies.

EJ Enhancement I-4 calls for AQMD staff to continue pursuing the Governing Board direction of February 2002, to develop and evaluate the implications of localized significance thresholds (primarily for NO_2, PM10, and CO) for potential inclusion in a revision of AQMD's CEQA Air Quality Handbook. The Handbook serves as a guidance document to assist local government agencies and consultants in developing the environmental analysis required pursuant to CEQA.

Currently, significance is based on regional thresholds (except for CO hot-spots analysis for mobile sources). Localized analysis would provide a second test of significance, and provide additional information to decision-makers who are considering a proposed project for approval. A working group has provided feedback to the staff analysis regarding potential significance threshold values and public workshops have been conducted to solicit additional comments and suggestions.

The purpose of CEQA is to require public disclosure of potential impacts to the air, as well as other environmental media, due to projects and to require mitigation measures, as necessary, to limit risk and public health exposure. CEQA mitigation measures can include actions affecting mobile sources, as well as measures to be taken by stationary sources. Appendix D contains a summary of how cumulative impacts are analyzed as a part of the CEQA process. Significant cumulative impacts from air toxic emissions are, for the purposes of AQMD's local CEQA program, set at a cancer risk equal to or greater than 10 in 1 million or a noncancer health impact equal to or greater than a Hazard Index (HI) of 3.0.

EJ Enhancement II-1 calls for AQMD staff, in CEQA documents comparing specific project alternatives, to include a least toxic alternative, where feasible, which considers the proposed project or rule from a "least harmful" perspective with regard to hazardous air emissions. Such alternative would pertain to major equipment or processes under review that create a significant environmental impact and would feature the lowest feasible air toxics emissions and/or exposure of the alternatives being analyzed, and would present comparative impacts and potential trade-offs for the particular project.

EJ Enhancement II-4 calls for AQMD to streamline and expedite the electronic posting of its own information on the Basin air toxics and health risk assessments, to be publicly available on the internet. Such posting would be similar to the access given to the federal Toxics Release Inventory (TRI) reporting data for interested members of the public. This tool would allow more direct monitoring of environmental performance by permit-holders.

EJ Enhancement III-1 calls for developing a rule to require emission reductions from off-road intermodal fleets, such as those operating at ports or large distribution centers, through use of low emission and clean equipment technologies. As a part of rule development, staff will examine the feasibility of additional emission reductions from the on-road vehicles visiting such facilities.

EJ Enhancement III-2 included a proposal to expedite the CEQA analysis process for any major project which contains commitments and milestone schedules for implementation of "super mitigation" actions.

This proposed enhancement would offer the incentive of an expedited CEQA review in return for emission reduction components to a project that are not otherwise legally required.

EPA Programs

Since the 1990 Clean Air Act Amendments were enacted, federal Environmental Protection Agency has promulgated NESHAPs to reduce Hazardous Air Pollutants. In addition, EPA has been developing programs to further address urban air toxics, the residual risk after federal standards have been implemented, and cumulative impacts associated with multiple sources. These are summarized below.

National Emission Standards for Hazardous Air Pollutants (NESHAPS)

Under Section 112 of the Clean Air Act (CAA), EPA is required to regulate sources that emit one, or more, of the 188 federally listed HAPs. More than 55 NESHAPs have been promulgated by EPA and more than twenty more source categories have had standards proposed, many of which were proposed in 2002. EPA develops standards that require the application of Maximum Achievable Control Technology (MACT) to control emissions from "major sources," those sources emitting greater than 10 tons per year of a single HAP or greater than 25 tons per year of multiple HAPs. To implement NESHAPs, AQMD adopts a rule, or rule amendment, or directly implements the NESHAP. AQMD rules must contain requirements that are at least as stringent as the NESHAP requirements. However, the NESHAPs are often based on controlled sources in the Basin. On this basis, many of the sources that would have been subject to the federal requirements already comply or are exempt.

Integrated Urban Air Toxics Strategy

The Urban Air Toxics Strategy is a program developed by EPA that will seek to reduce emissions of 30 key TACs from 70 area source categories. This includes mobile sources using diesel engines. Thirty of these HAPs have been identified as coming from small industrial sources (or area sources). Development and implementation of the Urban Air Toxics Strategy includes a series of reports, development of vehicle and fuels standards, and promulgation of standards for new area source categories.

Residual Risk

The residual risk program is a requirement of the federal CAA and applies to all source categories for which a federal MACT standard has been promulgated by EPA. Residual risk refers to the public health and environmental risk remaining after technology-based standards have been promulgated and applied to emission sources of HAPs. The Residual Risk Report to Congress was prepared by the Office of Air Quality Planning and Standards, Research Triangle Park, March 1999, and contains EPA's general framework for assessing risks to public health or the environment. Under the program, each MACT standard is to be revisited 10 years after promulgation to assess the residual risk after full implementation. EPA has begun the residual risk review process, such as that for halogenated solvent cleaning.

Cumulative Exposure Project

This strategy will address adverse health impacts due to cumulative TAC exposures if toxic hot spots are identified. This program will likely include a multi-government approach to address the issue of cumulative impacts, dependent on the source and type of toxic hot spots identified. Additional data and support programs may require development as a part of this strategy, including, but not limited to, improved database and air quality modeling development, and source-specific rule adoptions or amendments.

Regional Air Impact Modeling Initiative (RAIMI) Pilot Study – Initial Phase

The purpose of the RAIMI pilot study is to establish a program for a region-wide prioritization of potential for community-level health risks as a result of exposure to multiple air contaminants from multiple sources through multiple exposure pathways. Also, RAIMI is designed to complement concurrent federal air toxics programs, including the Cumulative Exposure Project, Integrated Urban Air Toxics Program, and residual risk. The RAIMI pilot study is a two phase process. Under the initial phase EPA investigated test methods for source prioritizations based on risks resulting from direct inhalation. The initial phase has been completed and EPA recently completed assessment on three entire counties at the same level of detail as the pilot study (see Appendix E for more details). EPA is currently examining the results from these assessments from an implementation and enforcement standpoint to lower community level inhalation risks. The intent is to have all counties in the major areas of the region (primarily Texas and Louisiana) fully mapped in the next five years. Under the second phase, EPA is studying indirect exposures resulting from air-related sources. Here, the focus of this stage of the pilot study is indirect exposures resulting from air-related sources. This element of the pilot project will focus on other pathways of exposure besides inhalation, such as ingestion. Work on this phase is anticipated for completion by the end of 2003, to be followed by a review stage prior to publishing. Under this phase, EPA will be examining surrogates to effectively and accurately determine the impacts from indirect exposures.

State Programs

CARB has several programs that reduce the impact of cumulative emissions. Two key programs are summarized, as follows:

California Airborne Toxic Control Measures (ATCM)

In 1983, the California Legislature adopted the Toxic Air Contaminant Identification and Control Act (AB 1807, Tanner), which established a two-step process of risk identification and risk management to protect Californians from the health effects of toxic substances in the air. The first step is the identification of a toxic air contaminant (TAC). In the risk identification phase, staff of the Air Resources Board (ARB) and California's Office of Environmental Health Hazard Assessment (OEHHA) evaluates the potential for human exposure to a suspect air contaminant (from a prioritized list of substances) and health effects of exposure to the contaminant. The staff's evaluation is subject to the Scientific Review Panel (SRP) approval of the report. The SRP develops specific scientific findings that are officially submitted to CARB. CARB uses this information to determine whether to identify a substance as a TAC.

Once a substance is identified as a TAC, CARB determines if regulatory action is needed to reduce the risk associated with that substance through a risk management evaluation. In this evaluation, CARB investigates the need, feasibility, and cost of reducing emissions of that substance. If controls are feasible and needed, CARB adopts airborne toxic control measures (ATCMs) and local Districts are then required to adopt and enforce equivalent or more restrictive measures to reduce emissions of the TAC. In some instances, AQMD adopts rules to implement these state ATCMs. To date, the state has adopted 11 ATCMs.

ARB's Community Health Program – EJ & Neighborhood Assessment Program

The Environmental Justice Policies and Actions adopted by the ARB in December 2001 include the consideration of cumulative health risks in our programs. Among those specific actions is the development of technical tools for performing assessments of cumulative emissions, exposures, and health risks on a neighborhood scale. Since that time, the ARB staff is developing a visualization tool for mapping emission sources on the Internet that will allow the public to view a map of a community and the spatial array of facilities and emissions in that community.

Other ARB efforts include developing statewide cumulative impact maps that will allow the public to view cumulative risk at a much more refined scale than is currently available. The ARB staff is also assessing microscale and regional inventories and modeling, as well as tracer and toxics studies as part of the ARB's Neighborhood Assessment Program (NAP) in Barrio Logan (San Diego) and Wilmington (Los Angeles).

Tools such as the ARB's Air Quality Handbook for Land-Use Planners are also under development that will provide local decision-makers with information for assessing cumulative air pollution impacts of proposed projects. Upon completion, all newly developed models and methods will be subject to a peer review process as routinely followed by the ARB.

APPENDIX B

AIR TOXIC CONTROL PLAN IMPLEMENTATION PROGRESS

Air Toxics Control Plan
Implementation Progress

The final draft Air Toxics Control Plan was approved by the AQMD Governing Board in March 2000. It is a comprehensive plan that was designed to examine the overall direction of the AQMD's air toxics control program and listed potential strategies to reduce toxic levels in the Basin over the next ten years. To the extent the strategies are implemented by the relative agencies, the plan will improve public health by reducing health risks associated with both mobile and stationary sources. The plan is not required by state or federal law, so it was not submitted as a part of the State Implementation Plan (SIP).

To date, a number of strategies have been implemented that will increase protection of the public's health from the emission of air toxics. These include increased emission reductions, and therefore health risk reduction, from sources such as gas stations, motion picture film processing, and on road motor vehicles. In addition, AQMD Rules 1401 and 1402 have been strengthened to reduce air toxic exposures from new and existing stationary sources, respectively. The following table provides an implementation status of the Air Toxic Control Plan control strategies. Shaded rows indicate those control strategies which have been completed. Unshaded rows indicate those control strategies that are in progress.

RULE	Title	Scheduled Adoption Date	Adoption date	TAC	Estimated Reductions	Implementation date
461	Gasoline Transfer and Dispensing	Apr-00	4/21/2000	Benzene, hexane	27.3 tpd (total VOC)	2001
1401	New Source Review of TACs	As needed	8/18/2000	Chronic Compounds	Cannot be determined	8/18/2000
1401	New Source Review of TACs	As needed	6/15/2001	Chronic Compounds	Cannot be determined	6/15/2001
1401	New Source Review of TACs	As needed	5/3/2002	Chronic Compounds	Cannot be determined	5/3/2002
1401	New Source Review of TACs	As needed	2/7/2003	Chronic Compounds	Cannot be determined	2/7/2003
1401	New Source Review of TACs	As needed	5/2/2003	Cancer Compounds	Cannot be determined	5/2/2003
1402	Control of TACs from Existing Sources	As needed	3/17/2000	Numerous	Cannot be determined	3/17/2000
1402	Control of TACs from Existing Sources	As needed	8/18/2000 report*	Chronic Compounds	Cannot be determined	5/19/2001
1402	Control of TACs from Existing Sources	As needed	6/15/2001 report*	Chronic Compounds	Cannot be determined	3/16/2002
1402	Control of TACs from Existing Sources	As needed	5/3/2002 report*	Chronic Compounds	Cannot be determined	3/1/2003
1402	Control of TACs from Existing Sources	As needed	2/7/2003 report*	Chronic Compounds	Cannot be determined	11/1/2003
1402	Control of TACs from Existing Sources	As needed	5/2/2003 report*	Cancer Compounds	Cannot be determined	3/7/2004
CARB	Phase 3 California Gasoline Regulation	None given		Benzene,MTBE	6 tpd	begin 12/31/03
431.2	Sulfur Content of Liquid Fuels	None given	8/18/2000	Diesel PM	1.1 tpd	2005 (?)
1122	Emission Reductions from Degreasing Operations	None given	9/21/2001	Perchloroethylene, 1,1,1-trichloroethane, trichloroethylene, methylene chloride	0.81tpd	2003

RULE	Title	Scheduled Adoption Date	Adoption date	TAC	Estimated Reductions	Implementation date
1421	Control of Perchloroethylene Emissions from Dry Cleaning Operations	Mar-01	12/6/2002	Perchloroethylene	849 tons - cumulative	2021

RULE	Title	Scheduled Adoption Date	Adoption date	TAC	Estimated Reductions	Implementation date
1425	Motion Picture Film Labs	Mar-01	3/16/2001	Perchloroethylene	39.5 tons per year (including NESHAP)	2003
1426	Metal Finishing	Mar-01	May-03	Nickel, Cadmium, Lead, Copper, Chromic Acid	No reductions realized - recordkeeping only	N/A
1427	Rubber Manufacturing	Mar-01	N/A	various	staff recommended that this rule is not necessary due to limited emissions	
1437	Furniture Stripping	Mar-03	Jun-03	Methylene chloride	tbd	tbd
1469	Hexavalent Chromium Emissions	Mar-01	5/2/2003	Hexavalent Chromium	48 lbs/year	5/5/2005

* The list of Toxic Air Contaminants was updated in conjunction with amendments to Rule 1401.

Note: Shaded rules have been adopted or determined to not be necessary

APPENDIX C

CONFIRMED ODOR-COMPLAINTS AND NOVs ISSUED

Notice of Violation (NOV) data shown on the following table cover the period from January 1, 1988 to June 30, 2003. A brief explanation of each column heading is as follows:

- **SIC Code** – This table includes standard industrial categories that had complaints which resulted in the issuance of an NOV. There are several additional industrial categories that received complaints (usually fewer than 10 complaints were received) that were not issued a NOV.
- **Confirmed Odor Complaints** – This refers to the number of complaints that were received that could be traced back to a permitted facility that has an AQMD facility ID number. There were approximately 104,000 total complaints logged, although these were not all confirmed.
- **Notices of Violation (NOVs) Issued** – This is the number of Notices of Violation that were issued as a result of complaints received that were tied to a valid facility ID or SIC code.

There is not a one-to-one correspondence between complaints and NOVs. An NOV may be issued for one or more incidences that generated multiple complaints.

SIC Code	Description	Confirmed Odor Complaints	Notices of Violation (NOVs) Issued
2911	PETROLEUM REFINING	8399	109
4953	REFUSE SYSTEMS	4099	120
4952	SEWERAGE SYSTEMS	3039	48
1794	EXCAVATING AND FOUNDATION WORK	1188	26
1311	CRUDE PETRO AND NATURAL GAS	803	18
2077	ANIMAL & MARINE FATS AND OILS	691	57
7538	GENERAL AUTO REPAIR SHOPS	634	34
2992	LUBRICATING OILS AND GREASES	598	14
7532	TOP & BODY REPAIR/PAINT SHOPS	543	44
9511	AIR WATER & SOLID WASTE MANAG	461	1
4214	LOCAL TRUCKING AND STORAGE	410	40
3341	SECONDARY NONFERROUS METALS	364	15
2824	ORGANIC FIBERS, NONCELLULOSIC	363	21
2819	INDUSTRIAL INORGANIC CHMLS,NEC	352	10
4911	ELECTRIC SERVICES	285	1
3088	PLASTICS PLUMBING FIXTURES	243	9
2821	PLASTICS MATERIALS AND RESINS	240	12
5093	SCRAP & WASTE MATERIALS	233	5
7216	DRY CLEANING PLANTS, EXC RUG	230	13
3089	PLASTICS PRODUCTS, NEC	228	8
3479	METAL COATING/ALLIED SERVICES	209	10
2399	FABRICATED TEXTILE PROD, NEC	199	10
5541	GASOLINE SERVICE STATIONS	173	36
3792	TRAVEL TRAILERS AND CAMPERS	173	16
5171	PETRO BULK STATIONS/TERMINALS	157	8
3471	PLATING AND POLISHING	152	12
2951	PAVING MIXTURES AND BLOCKS	144	5
7261	FUNERAL SERVICE & CREMATORIES	139	9
5199	NONDURABLE GOODS, NEC	119	9
3365	ALUMINUM FOUNDRIES	111	13
3599	INDUSTRIAL MACHINERY, NEC	107	3
2047	DOG AND CAT FOOD	106	8
1761	ROOFING AND SHEET METAL WORK	103	6
2099	FOOD PREPARATIONS, NEC	101	5
3079	MISC PLASTICS PRODUCTS	100	4
3321	GRAY IRON FOUNDRIES	85	3
2295	COATED FABRICS, NOT RUBBERIZED	85	1
3714	MOTOR VEHICLE PARTS/ACCESORIES	82	1
2434	WOOD KITCHEN CABINETS	78	2
7699	REPAIR SERVICES, NEC	68	4
3711	MOTOR VEHICLES AND CAR BODIES	57	1
2499	WOOD PRODUCTS, NEC	55	5
4959	SANITARY SERVICES, NEC	54	3
4011	RAILROAD, LINE-HAUL OPERATING	53	7

SIC Code	Description	Confirmed Odor Complaints	Notices of Violation (NOVs) Issued
3061	MECHANICAL RUBBER GOODS	51	1
3412	METAL BARRELS, DRUMS, & PAILS	50	5
2759	COMMERCIAL PRINTING, NEC	49	1
2833	MEDICINALS AND BOTANICALS	48	2
3444	SHEET METALWORK	45	3
2431	MILLWORK	40	1
3354	ALUMINUM EXTRUDED PRODUCTS	39	2
2095	ROASTED COFFEE	37	3
3672	PRINTED CIRCUIT BOARDS	35	1
3086	PLASTICS FOAM PRODUCTS	34	5
5511	NEW AND USED CAR DEALERS	33	1
2851	PAINTS AND ALLIED PRODUCTS	32	5
1799	SPECIAL TRADE CONTRACTORS, NEC	30	4
2511	WOOD HOUSEHOLD FURNITURE	29	4
7534	TIRE RETREADING & REPAIR SHOPS	29	2
3621	MOTORS AND GENERATORS	29	1
5169	CHEMICALS & ALLIED PRDCTS, NEC	28	1
7218	INDUSTRIAL LAUNDRERERS	27	1
3999	MANUFACTURING INDUSTRIES, NEC	26	3
3334	PRIMARY ALUMINUM	26	2
3826	ANALYTICAL INSTRUMENTS	25	4
3356	NONFERROUS ROLLING/DRAWING,NEC	24	1
3799	TRANSPORTATION EQUIPMENT, NEC	22	2
2999	PETROLEUM & COAL PRODUCTS, NEC	20	1
3441	FABRICATED STRUCTURAL METAL	19	5
2261	FINISHING PLANTS, COTTON	19	3
181	ORNAMENTAL NURSERY PRODUCTS	17	2
3721	AIRCRAFT	16	3
3543	INDUSTRIAL PATTERNS	14	2
2299	TEXTILE GOODS, NEC	14	1
3261	VITREOUS PLUMBING FIXTURES	13	1
3273	READY-MIXED CONCRETE	9	1
3295	MINERALS, GROUND OR TREATED	9	1
7389	BUSINESS SERVICES, NEC	9	1
7535	PAINT SHOPS	8	2
5211	LUMBER & OTHER BLDG MATERIALS	8	1
7531	TOP & BODY REPAIR SHOPS	8	1
2541	WOOD PARTITIONS AND FIXTURES	6	2
2599	FURNITURE AND FIXTURES, NEC	5	2
2426	HARDWOOD DIMENSION & FLOORING	5	1
2519	HOUSEHOLD FURNITURE, NEC	5	1
3716	MOTOR HOME MANUFACTURE	5	1
7359	EQUIPMENT RENTAL & LEASING,NEC	5	1
7819	SERV ALLIED TO MOTION PICTURES	5	1
7542	CAR WASHES	4	1

SIC Code	Description	Confirmed Odor Complaints	Notices of Violation (NOVs) Issued
3761	GUIDED MISSILES AND SPACE VEH	2	1
134	IRISH POTATOES	1	1
1389	OIL/GAS FIELD SERVICES, NEC	1	1
3572	COMPUTER STORAGE DEVICES	1	1
3695	MAGNETIC & OPTICAL RECDG MEDIA	1	1
5039	CONSTRUCTION MATERIALS, NEC	1	1
5411	GROCERY STORES	1	1
8744	FACILITIES SUPPORT SERVICES	1	1
9999	UNKNOWN	773	52
Total		**27,906**	**936**

APPENDIX D

CUMULATIVE IMPACT ANALYSIS REQUIREMENTS PURSUANT TO CEQA

CUMULATIVE IMPACT REQUIREMENTS
PURSUANT TO THE CALIFORNIA ENVIRONMENTAL QUALITY ACT

The following summarizes the requirement to analyze cumulative impacts pursuant to the California Environmental Quality Act (CEQA), and the procedures by which the AQMD complies with the requirement.

CUMULATIVE IMPACTS DEFINED

"Cumulative impacts" refers to two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts. The individual effects may be changes resulting from a single project or a number of separate projects. The cumulative impact from several projects is the change in the environment that results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects.

REQUIREMENT TO ANALYZE CUMULATIVE IMPACTS

An Environmental Impact Report (EIR) shall discuss cumulative impacts of a project when the project's incremental effect is cumulatively considerable.

An adequate discussion of significant cumulative impacts requires:

(1) Either:

(A) A list of past, present, and probable future projects producing related or cumulative impacts, including, if necessary, those projects outside the control of the agency. Factors to consider include the nature of each environmental resource being examined, the location of the project and its type. Or

(B) A summary of projections contained in an adopted general plan or related planning document, or in a prior environmental document which has been adopted or certified, which described or evaluated regional or area-wide conditions contributing to the cumulative impact.

Lead agencies should define the geographic scope of the area affected by the cumulative effect and provide a reasonable explanation for the geographic limitation used.

(2) A summary of the expected environmental effects to be produced by those projects with specific reference to additional information stating where that information is available.

(3) A reasonable analysis of the cumulative impacts of the relevant projects. An EIR shall examine reasonable, feasible options for mitigating or avoiding the project's contribution to any significant cumulative effects.

REQUIREMENTS WHEN CUMULATIVE IMPACTS ARE LESS THAN SIGNIFICANT

Where a lead agency is examining a project with an incremental effect that is not "cumulatively considerable," a lead agency need not consider that effect significant, but shall briefly describe its basis for concluding that the incremental effect is not cumulatively considerable.

An EIR may determine that a project's contribution to a significant cumulative impact will be rendered less than cumulatively considerable and thus is not significant. A project's contribution is less than cumulatively considerable if the project is required to implement or fund its fair share of a mitigation measure or measures designed to alleviate the cumulative impact.

An EIR may determine that a project's contribution to a significant cumulative impact is de minimus and thus is not significant. A de minimus contribution means that the environmental conditions would essentially be the same whether or not the proposed project is implemented. Note that this provision (CEQA Guidelines Section 15130(a)[4]) was challenged by Communities for a Better Environment and has not been resolved. Therefore, the SCAQMD does not rely on this provision to conclude that a project does not have cumulatively significant impacts.

CONSIDERATIONS WHEN CONDUCTING CUMULATIVE IMPACT ANALYSES

"Probable future projects" may be limited to those projects requiring an agency approval for an application which has been received at the time the notice of preparation is released; projects included in an adopted capital improvements program, general plan, regional transportation plan, or other similar plan; projects included in a summary of projections of projects (or development areas designated) in a general plan or a similar plan; projects anticipated as later phase of a previously approved project (e.g. a subdivision); or those public agency projects for which money has been budgeted.

If a cumulative impact was adequately addressed in a prior EIR for a community plan, zoning action, or general plan, and the project is consistent with that plan or action, then an EIR for such a project should not further analyze that cumulative impact.

When analyzing the cumulative impacts of a project, the Lead Agency is required to discuss not only approved projects under construction and approved related projects not yet under construction, but also unapproved projects currently under environmental review with related impacts or which result in significant cumulative impacts. The analysis should include a discussion of projects under review by the Lead Agency and projects under review by other relevant public agencies, using reasonable efforts to discover, disclose, and discuss the other related projects.

The discussion of cumulative impacts shall reflect the severity of the impacts and their likelihood of occurrence, but the discussion need not provide as great detail as is provided for the effects attributable to the project alone. The discussion should be guided by standards of practicality and reasonableness, and should focus on the cumulative impact to which the identified other projects contribute. An EIR should not discuss impacts that do not result in part from the project evaluated in the EIR.

With some projects, the only feasible mitigation for cumulative impacts may involve the adoption of ordinances or regulations rather than the imposition of conditions on a project-by-project basis.

AQMD COMPLIANCE WITH CEQA CUMULATIVE IMPACT ANALYSIS REQUIREMENT

The AQMD has two primary roles under CEQA. As a Lead Agency, the AQMD is responsible for preparing environmental analyses in the form of EIRs, Negative Declarations, or Environmental Assessments. As a Commenting Agency, the AQMD is responsible for review and comment on air quality analyses prepared by other public agencies.

The AQMD, as Lead Agency, complies with all cumulative impact analysis requirements when preparing CEQA documents. As a Commenting Agency, the AQMD recommends that other public agencies perform cumulative impact analyses relative to air quality in the same manner as does AQMD. The following discussion focuses on how AQMD complies with the cumulative impact analysis as a Lead Agency.

The SCAQMD's regulatory program (i.e., development of rules and regulations) has been certified by the Secretary of the Resources Agency per Public Resources Code Section 21080.5. This means the SCAQMD prepares environmental analyses, including cumulative analyses, in documents other than EIRs and Negative Declarations. AQMD documents are always called Environmental Assessments.

As Lead Agency preparing Environmental Assessments for rule projects, AQMD evaluates requirements of the proposed rule as well as other AQMD rules with future compliance dates and AQMP control measures to determine if the proposed project may significantly contribute to cumulative impacts.

When AQMD is Lead Agency for a non-SCAQMD project (i.e., permit projects), standard CEQA requirements apply and Negative Declarations and EIRs are prepared. By definition, projects that qualify for a Negative Declaration do not have cumulative impact.

For permit projects, AQMD evaluates cumulative impacts relative to other projects within a geographical sphere of influence as well as other related projects. While cumulative impact analyses include projects undergoing a CEQA review, AQMD also typically requires the consultant to contact the city/county in which the project is located to identify projects where applications have been submitted, but the project has not yet undergone an environmental analysis. For these projects, general plan growth projections are applied to estimate impacts as applicable.

As Lead Agency, the AQMD uses the same significance thresholds for project specific and cumulative impacts for all environmental topics analyzed in an Environmental Assessment or EIR. The only case where the significance thresholds for project specific and cumulative impacts differ is the Hazard Index (HI) significance threshold for toxic air contaminant (TAC) emissions. The project specific (project increment) significance threshold is HI $\geq$ 1.0 while the cumulative (facility-wide) is HI $\geq$ 3.0. It should be noted that the HI is only one of three TAC emission significance thresholds considered (when applicable) in a CEQA analysis. The other two are the maximum individual cancer risk (MICR) and the cancer burden, both of which use the same significance thresholds (MICR of 10 in 1 million and cancer burden of 0.5) for project specific and cumulative impacts.

Projects that exceed the project-specific significance thresholds are considered by the SCAQMD to be cumulatively considerable. This is the reason project-specific and cumulative significance thresholds are the same. Conversely, projects that do not exceed the project-specific thresholds are generally not considered to be cumulatively significant.

References

Title 14, California Code of Regulations. Chapter 3 - Guidelines for Implementation of the California Environmental Quality Act. Article 9 - Contents of EIRs, Section 15130 - Discussion of Cumulative Impacts and Article 20 – Definitions, Section 15355 - Cumulative Impacts.

Governor's Office of Planning and Research. Discussion relative to CEQA Guidelines Section 15130 (http://ceres.ca.gov/topic/env_law/ceqa/guidelines/art9.html).

Note: Authority cited for CEQA Guidelines Section 15130: Sections 21083 and 21087, Public Resources Code. Reference: Sections 21083(b), 21093, 21094, and 21100, Public Resources Code; Whitman v. Board of Supervisors (1979) 88 Cal.App.3d 397; San Franciscans for Reasonable Growth v. City and County of San Francisco (1984) 151 Cal.App.3d 61; Kings County Farm Bureau v. City of Hanford (1990) 221 Cal.App.3d 692; Laurel Heights Homeowners Association v. Regents of the University of California (1988) 47 Cal.3d 376; Sierra Club v. Gilroy (1990) 220 Cal.App.3d 30; Citizens to Preserve the Ojai v. County of Ventura (1985) 176 Cal.App.3d 421; Concerned Citizens of South Cent. Los Angeles v. Los Angeles Unified Sch. Dist. (1994) 24 Cal.App.4th 826; Las Virgenes Homeowners Fed'n v. County of Los Angeles (1986) 177 Cal.App.3d 300; San Joaquin Raptor/Wildlife Rescue Ctr v. County of Stanislaus (1994) 27 Cal. App.4th 713; and Fort Mojave Indian Tribe v. Cal. Dept. Of Health Services (1995) 38 Cal.App.4th 1574.

APPENDIX E

RAIMI PILOT STUDY, INITIAL PHASE

Cumulative Impacts Summary of the
Regional Air Impact Modeling Initiative (RAIMI) Pilot Study – Initial Phase
By: USEPA, Region VI

Purpose: To establish a Regional Air Impact Modeling Initiative (RAIMI) program for a region-wide prioritization of potential for community-level health risks as a result of exposure to multiple air contaminants from multiple sources through multiple exposure pathways. Also, to complement concurrent federal air toxics programs including Cumulative Exposure Project, Integrated Urban Air Toxics Program, and residual risk after the establishment of standards for maximum achievable control technology (MACT).

Process: Conduct a pilot study comprised of 2 phases: 1) investigate test methods for source prioritizations based on risks resulting from direct inhalation; and 2) study indirect exposures resulting from air-related sources. (The Region VI report addresses the initial phase of the pilot.)

Goals: The RAIMI pilot project has five stated goals, summarized as follows:

1. Use as a permitting tool, independently or combined, applicable for cross media permitting.
2. Provide a standardized and consistent means by which permitting authorities could account for and assess aggregate health effects from multiple contaminants from multiple sources, which are often subject to multiple permitting schemes (local, RCRA, CAA, etc.) but cumulatively impact the same receptor area.
3. Provide necessary level of detailed information, at a community level, to prioritize, and identify potential solutions, for sources subject to unacceptable risks by estimating combined health effects resulting from multiple contaminants and sources.
4. Calculate and track potential risks from numerous sources and contaminants based on actual emissions data. New data can be directly entered into the program for real time risk updates.
5. Serve as a versatile and dynamic platform, allowing for rapid use of the program tools.

Design: RAIMI is designed to provide a prioritization based on the estimate of potential health risks resulting from multiple air contaminants and sources (point, area, and mobile sources) within a pre-defined geographical area and to a community level of resolution. The level of detail is intended to be sufficient enough to allow association of risk to a specific contaminant, source, and exposure pathway. The intent is to have a flexible and dynamic platform that would allow active updates to data for rapid identification, characterization, assessment, and management of aggregate environmental exposures based on relevant and current exposures. Data completeness and accuracy that are contained within the platform are of greatest importance.

Benefits: The potential for RAIMI, under complete and successful implementation, is that it can be used by EPA, state, and local agencies to provide input on risk management decisions, policies regarding cumulative health risks, permitting, regulatory development, land use decisions and planning, and contribute to cross media regulatory protections.

Results: The Phase I RAIMI Pilot Study successfully demonstrated its stated design objectives. The most significant limitation and uncertainty is the potential lack of complete emissions characterization. Complete, accurate, and timely data are crucial to successful use of the

RAIMI platform. Uncertainties also exist relative to air and risk modeling programs and respective inputs.

Next Steps: The initial phase of the pilot study was a test for application to larger areas. USEPA Region VI has recently completed an assessment on three entire counties at the same level of detail. EPA is currently examining the results from the assessments from an implementation and enforcement standpoint to lower community level inhalation risks. The intent is to have all counties in the major areas of the region (primarily Texas and Louisiana) fully mapped in the next five years.

The second phase of the pilot is to study indirect exposures resulting from air-related sources. This element of the pilot will focus on other pathways of exposure besides inhalation, such as ingestion. Work on this phase is anticipated for completion by the end of 2003, to be followed by a review stage prior to publishing. Under this phase, EPA will be examining surrogates to effectively and accurately determine the impacts from indirect exposures.

APPENDIX F

COMMUNITY FORUM SUMMARY

Summary

Community Forums
For Addressing Cumulative Impacts

In May and June 2003, staff held a series of 5 evening and weekend Community Forums. The meetings were held in Mira Loma, Santa Ana, Sun Valley, Fontana, and Wilmington. The intent of the meetings were to seek input for addressing cumulative impacts from sources of air pollution. One of the primary goals was to receive feedback on a list of 19 options (see attached) developed by the Cumulative Impacts Working Group. The meetings were attended by about 150 individuals representing environmental and community groups, local government, and neighboring residents.

A summary of key comments and concerns raised at the individual meetings follows:

- Mira Loma: The primary concerns raised related to the heavy rail and diesel truck traffic and lengthy idling associated with the large number of warehouses and distribution centers. These structures are located in and around the 15/60 freeway interchange, which are in close proximity to schools. Concerns were also raised regarding proposed increased numbers of warehouses in the same vicinity. Another major concern was regarding a particular facility that conducts manufacturing of foam, plastic, and rubber products.

- Santa Ana: Although there were several questions on the cumulative impact effort, no specific concerns regarding local issues were raised.

- Sun Valley: A number of concerns were raised relative to the high local concentration of landfills and waste processing, strip mining (quarries), vehicle scrap yards, plating facilities, and rail and freeway transportation corridor. Due to the dust, odors, and other emissions, concerns were raised regarding the high incidence of asthma in children in the area. A number of requests were specifically made for air monitoring in the local area, particularly around schools. Therefore, requests for increased inspector field presence. This community also wanted AQMD staff to come back to this area.

- Fontana: The major concern raised was increased vehicle traffic due to relocated and new businesses, including manufacturing, into the area.

- Wilmington: Attendees stressed that a strong cumulative impacts program should be developed and implemented, and should include indicators other than cancer risk only. Several attendees testified that the program should address both stationary and mobile sources. Concerns were raised regarding the high incidence of asthma and nose bleeds of local residents. The rail and diesel truck traffic associated with the ports and the Alameda Corridor are of key concern, as well as density of local facilities, such as refineries, auto body shops, plating facilities, and vehicle scrap yards. Requests were made for increased localized monitoring and neighborhood assessment modeling. Several groups offered to support the AQMD regarding legislation to increase its authority over ships, trucks, and trains. Several concerns were also raised by residents located near the runway of the Santa Monica airport, citing high exposure to airplane emissions due to the increased number of planes idling prior to take-off.

Specific suggestions from the combined meetings included:

- Legislation to mandate disclosures of environmental problems in the community by landlords when leasing or selling residential or commercial real estate.
- Information was requested on whether screens or trees around schools would decrease particulate pollution.
- Request for notices to schools in areas of high pollution at levels lower than traditionally notified based on the Air Quality Index ratings.
- Inspectors are requested to respond to all complaints during the middle of the night.
- The AQMD should have more involvement in the 710 freeway expansion project.
- Reduced idling of trucks, trains, and ships when near residential communities should be required;
- Thresholds in Rules 1401 and 1402 should be reduced;
- Rail traffic along the Alameda Corridor should be electrified;
- Enforcement programs should be stronger, including greater field presence and penalties;
- AQMD should exert more and better influence on land use decisions;
- Require controls on small diesel engines;
- Require a buffer zone around certain types of factories or do not allow more new sources;
- Provide incentives for air purification systems for homes;
- Incentives and requirements for pollution prevention and reduction should be pursued;
- The AQMD should help the community with resources to address localized issues; and
- Repeat visits to the community should be made regarding this and other subjects.

Appendix A - FN_35_International Energy Agency (IEA), Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings, IEA Information Paper (2008)

INTERNATIONAL ENERGY AGENCY
AGENCE INTERNATIONALE DE L'ENERGIE

ENERGY EFFICIENCY REQUIREMENTS IN BUILDING CODES, ENERGY EFFICIENCY POLICIES FOR NEW BUILDINGS

IEA INFORMATION PAPER

In Support of the G8 Plan of Action

MR. JENS LAUSTSEN
INTERNATIONAL ENERGY AGENCY

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-seven of the OECD thirty member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To promote international collaboration on energy technology.
- To assist in the integration of environmental and energy policies.

The IEA member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. Poland is expected to become a member in 2008. The European Commission also participates in the work of the IEA.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.
The European Commission takes part in the work of the OECD.

International Energy Agency (IEA),
Head of Communication and Information Office,
9 rue de la Fédération, 75739 Paris Cedex 15, France.

ABSTRACT

The aim of this paper is to describe and analyse current approaches to encourage energy efficiency in building codes for new buildings. Based on this analysis the paper enumerates policy recommendations for enhancing how energy efficiency is addressed in building codes and other policies for new buildings. This paper forms part of the IEA work for the G8 Gleneagles Plan of Action.

These recommendations reflect the study of different policy options for increasing energy efficiency in new buildings and examination of other energy efficiency requirements in standards or building codes, such as energy efficiency requirements by major renovation or refurbishment.

In many countries, energy efficiency of buildings falls under the jurisdiction of the federal states. Different standards cover different regions or climatic conditions and different types of buildings, such as residential or simple buildings, commercial buildings and more complicated high-rise buildings.

There are many different building codes in the world and the intention of this paper is not to cover all codes on each level in all countries. Instead, the paper details different regions of the world and different ways of standards. In this paper we also evaluate good practices based on local traditions. This project does not seek to identify one best practice amongst the building codes and standards. Instead, different types of codes and different parts of the regulation have been illustrated together with examples on how they have been successfully addressed.

To complement this discussion of efficiency standards, this study illustrates how energy efficiency can be improved through such initiatives as efficiency labelling or certification, very best practice buildings with extremely low- or no-energy consumption and other policies to raise buildings' energy efficiency beyond minimum requirements.

When referring to the energy saving potentials for buildings, this study uses the analysis of recent IEA publications, including the World Energy Outlook 2006 (WEO) and Energy Technology Perspective (ETP). Here, we based the estimates of potentials on the scenarios presented, in particular on the predictions of consumption in the residential and commercial sectors in the WEO 2006.

Finally, this paper recommends policies which could be used to realise these large and feasible energy saving potentials in new buildings, and the use of building codes by renovation or refurbishment.

The paper addresses as well experts as policy makers and interest groups with particular interest in energy efficiency in new buildings. Some parts might hence seem simplified and known for some experts, such as the discussions on barriers or the climatic impact on efficiency. Other parts might on the other hand seem a little technical for the policy oriented reader or for some interest groups. But there are large and compelling opportunities, this is recognised by many experts as well as there is a will to act by many policymakers and governments. But still too little happen because there are barriers and low understanding also in the institutional parts or little communications between different layers of the implementation process.

The paper hence aims to bridge these gabs by addressing several different groups at the same time. So hopefully the reader will accept these inconveniences.

TABLE OF CONTENTS

Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings

1 Introduction

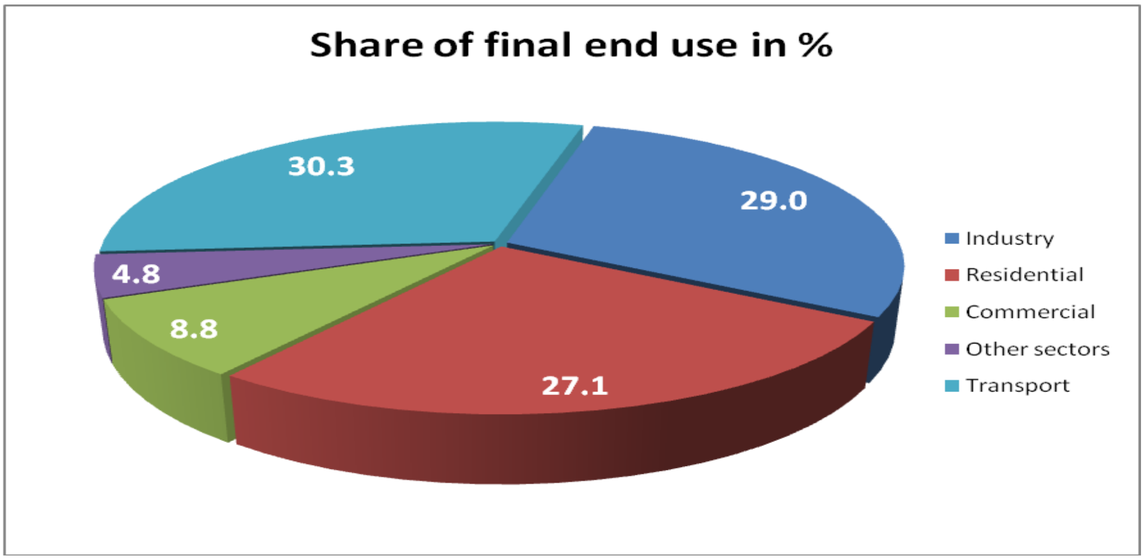
1.1 The rationale for energy efficiency in building codes

The use of energy in buildings accounts for a large share of the total end use of energy.

In sectors such as residential and the commercial sector the major part of the energy consumption takes place buildings. This includes energy used for controlling the climate in buildings and for the buildings themselves, but also energy used for appliances, lighting and other installed equipment.

In other sectors a small part of the energy consumption is similar used for similar purposes in relation to the buildings. This is for instance the case for some buildings in the industry used for administration or some buildings agriculture or forestry.

Figure 1. Energy consumption in different sectors.



According to the IEA statistics for energy balance for 2004-2005,(2007 edition), the total final energy use globally accounts for 7209 Mtoe (Mega Tonnes Oil Equivalents).The residential and commercial sectors account for respectively 1951 Mtoe and 638 Mtoe, which is almost 40 % of the final energy use in the World[1]. The major part of this consumption is in buildings.

The energy efficiency of new buildings determines the building sector's energy consumption for far longer than other end-use sectors components determine their sector's efficiency. Buildings will typically be constructed to be used for many decades and, in some cases, for more than a hundred years. In other energy end uses, the capital lifetime for efficiency improvement will be, at most, a few decades.

Improvement of buildings' efficiency at planning stage is relatively simple while improvements after their initial construction are much more difficult: decisions made during a building's project phase will hence determine consumption over much, if not all, of a building's lifetime. Some measures to improve efficiency are possible only during construction or by major refurbishment, likely to happen only after several decades. Other

[1] The end use of energy alone in the residential and the commercial sector is equivalent to 108.4 Ej (exajoules). 1 single exajoule equals 1000 Pj (petajoules) or 10^{18} joules.

improvements will be very cost effective or maybe even free or at negative costs when implemented at project stage, but can be expensive at a later stage.

Energy efficiency requirements in building codes or energy standards for new buildings are therefore among of the most important single measures for buildings' energy efficiency. This is in particular the case in times of high construction activity or in fast developing countries.

The importance of energy efficiency requirements in building codes or standards extends beyond their role in new buildings. Building codes and efficiency standards often serve as the efficiency target for refurbishment or other improvements of existing buildings. Buyers and renters of buildings or units will often compare new and existing buildings. With increased interest for efficiency will high requirements in building codes therefore spur the demand for refurbishment or general improvements of existing buildings.

As buildings have a relatively long life major refurbishments will necessarily take place during their lifespan – which can be around every 30 – 40 years for residential buildings. This will take place because major parts of the buildings and installations will be worn-out and have to be replaced, and because lifestyle and demands for comfort are constantly changing in a modern society. Replacements and smaller refurbishments might even occur more often. These refurbishments or change of equipment provide a compelling opportunity to improve a building's efficiency. Energy saving can often be obtained at lower costs when other construction take place; in some cases, additional improvements require only small or no additional funding if the basic construction requires work or equipment is replaced, in other cases it can save construction costs, scaffolding etc. Requirements for energy efficiency by refurbishment are therefore an important issue which should be included in building codes.

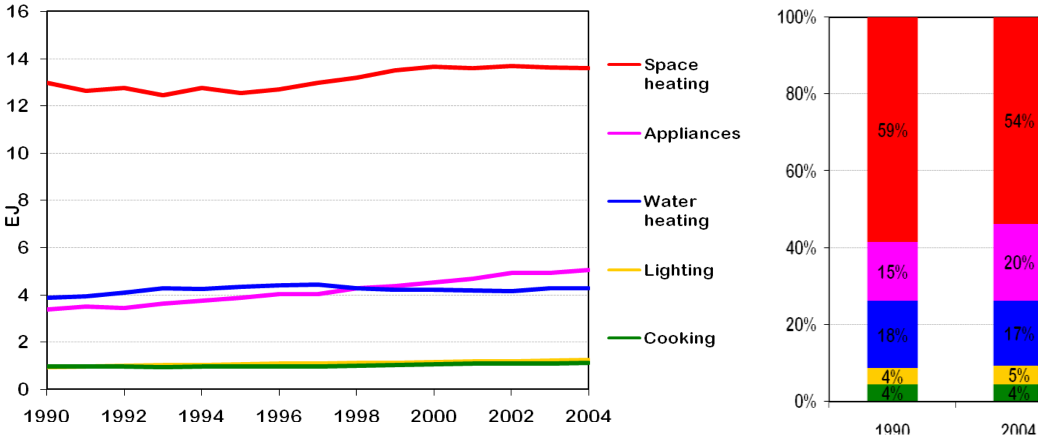
1.2 Energy use in buildings

Energy is used in buildings for various purposes: heating and cooling, ventilation, lighting and the preparation of hot sanitary water among them. In residences and commercial buildings, installed equipment and appliances require energy, as do removable devices like mobile phone chargers and portable computers. However, identification of fixed and fluctuating demand for energy rarely appears in a building's consumption metric, as most measurement consider only the total amount consumed by the whole building.

Subdivision of energy consumption can be particularly difficult in the cases of electricity, where air-conditioners, appliances, lights, pumps and heating installations all draw electricity and often from the same metering. Natural gas, too, can serve several end uses at once, including heating, cooking, and the provision of sanitary hot water.

Given the difficulty in subdividing buildings' energy requirements and the use of different fuel types, most analysis examines energy use in building as defined by end-use: space heating, cooling, cooking, etc. The split in use of energy will be due to uncertainties and it will vary with different types of building and also with the age and use of the buildings.

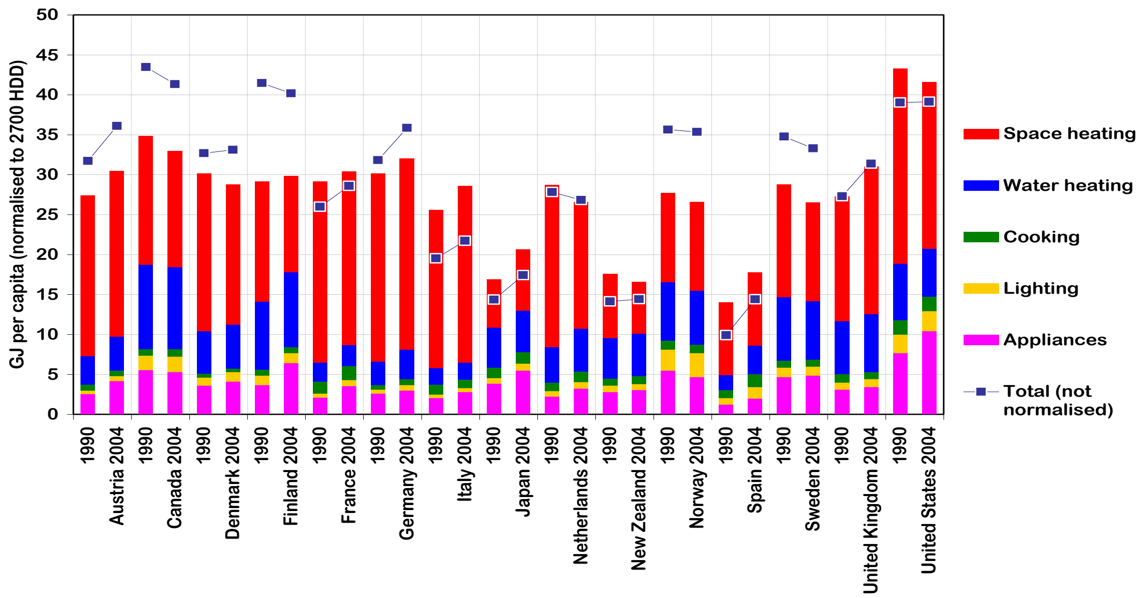
Figure 2. ***Energy use in residential buildings.***



Source: 30 Years of Energy Use in IEA countries. A large part of the energy consumption in residential buildings are used for direct building related use such as space heating, which accounts for more than 50 % in selected IEA Countries.

These differences in the use of energy in different countries can best be illustrated by a subdivision of energy consumption in residential buildings, which is the most homogenous type of buildings.

Figure 3. ***Subdivision of energy consumption in residential buildings in select IEA countries.***



Source: 30 Years of Energy Use in IEA countries[2]. As illustrated, the use of energy is different in individual countries both in concern of level as in the subdivision. The graph also shows issues on comparison and normalisation, which will be targeted later in this paper.

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[2] The different indicators set by the Energy Use in the new Millennium in IEA Countries are currently being re-examined in the context of an ongoing IEA indicator study. The consumption in buildings is highly dependent on price levels and local traditions and some of these are further discussed in the study.

Building-related end-uses - heating, cooling, ventilation and the preparation of hot sanitary water - require approximately 75% of a residential building's energy demand. Building codes generally address these drivers of building-related consumption. Only more occasionally, codes cover other end-uses like lighting in service buildings, though this varies by country, as discussed later in this paper. For service buildings, the share of energy use for other purposes will often be larger and for some types of service buildings it can be more than 50%.

1.3 Energy efficient buildings benefits society

Energy consumption in buildings is a large share of the world's total end use of energy. In member states of the OECD, residential and commercial buildings require approximately 35 % of the end use of energy in addition to this energy is used for buildings also in the industry. Globally, buildings account for close to 40% of total end use of energy. Given the many possibilities to substantially reduce buildings' energy requirements, the potential savings of energy efficiency in the building sector would greatly contribute to a society-wide reduction of energy consumption. The implications of such potential reduction should not be underestimated, as the scale of energy efficiency in buildings is large enough to influence security policy, climate preservation and public health on a national and global scale.

By reducing buildings' energy consumption, a nation can reduce dependency on imported energy and strengthen its strategic position. In the 2000 Green Paper setting forth a strategy to secure energy supply[3], the European Union named energy efficiency as the best way to establish energy security over a longer term. Different IEA scenarios show similar trends.

Moderation of energy-end use in buildings will also reduce greenhouse gas emissions and pollution produced by the combustion of fossil fuels. This environmental benefit appears on two scales, local and global. Because much of buildings' demand for energy requires local energy combustion in individual heating systems or district heating, reduced energy demand improves air quality at the local level. In particular in developing countries a reduced demand for energy requires fewer power plants, thereby delaying or obviating the construction of new generation and grid capacity and enabling communities to devote public funds elsewhere.

Given the potential scale of energy savings across the building sector, reduced demand for energy and fossil fuels can substantially contribute to a nation's compliance with domestic or supranational targets for the reduction of greenhouse gas emissions.

When adequately ventilated, energy efficient buildings are generally healthier than traditional buildings. Relative to traditional buildings, energy efficient buildings offer a more stable indoor climate, with less draught from windows, walls, floors, and ceiling constructions. Because residents of energy efficient buildings must spend relatively less to heat and cool their homes to within the margins of acceptable comfort, energy efficient construction reduces fuel poverty[4] across society. As households demanding less energy for building-related uses, they burn less fuel locally, thus doubling the potential to improve public health and otherwise benefit local communities.

Among these potential public benefits of energy efficiency in buildings, employment in the construction sector should not be dismissed. As extensively documented on the European

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[3] European Union, Green Paper of 29 November 2000, "Towards a European strategy for the security of energy supply".

[4] Fuel Poverty describes the dynamic in which the high cost of creating a standard level of indoor comfort requires an unsustainable portion of a household's budget. Rather than pay the energy costs, households choose to instead reduce indoor comfort to below normally-accepted limits.

level for instance by EURIMA/Ecofys studies, energy efficiency in buildings creates jobs – an estimated half-million new positions in the European construction sector, were higher efficiency to be regulated.[5]

1.4 Energy efficiency in new buildings

Many means to save energy in new buildings also offer the potential to save money. Individual homeowners and building users investing in energy efficiency will often recover costs in a short period through lower energy expenses. This "payback time" on energy efficiency investment can be as short as a few years. These energy savings are similarly profitable from the macro-economic perspective of national policy. Increased efficiency in new buildings is hence profitable for individual building owners and society as a whole.

Though the construction activity in OECD countries is relatively low, the energy saving potential of new buildings remains large. This potential accumulates year by year because of the long lifetime of buildings: most buildings constructed today will remain in use until after 2050. Logically, new buildings present a good opportunity to save energy over the long term.

In many developing countries, new constructions accounts for a larger share of the buildings. In these countries, such as China and India, the energy savings by energy efficiency in new buildings will have a larger and faster impact on the economy and result in larger savings than in OECD nations. In developing countries a high consumption in new buildings will increase the demand for new supply and grid capacity. In these nations, the general benefit of improved efficiency in new buildings can be seen more quickly and will be felt more profoundly.

1.5 Energy efficiency is not just a choice for the individual owner

Because the efficiency of a new building will influence its energy consumption until renovation or even the whole lifetime, the decisions taken during design and construction will influence decades of building use. Lost opportunities in the construction phase will lead to increased costs if done at a later stage and can wildly inflate the running costs for future users. While individuals continue to determine much about a building's fate, the energy efficiency of a new building should not be viewed only as a matter for individual choice but as a more collective issue, influencing society at large and a future generation of building users.

Some improvements of energy efficiency in new buildings might require a need for development of new solutions or for training of builders or installers, which it is too complicated or costly for the individual owner or constructor to carry in connection to one or a few projects. These solutions might still be cost efficient when first developed and training has taken place. There is therefore a need for overall actors to take the responsibility to drive the development of efficient technologies and buildings, which will reduce costs in the long term and increase the potentials when improved solutions or products penetrate the market.

1.6 Efficient new buildings make efficient existing buildings

New buildings become existing buildings and all existing buildings were once new, hence will the efficiency of new buildings determine the efficiency of existing buildings over time. Exactly when a new building enters into the stock of existing buildings varies by legislation. In some jurisdictions, the "new" designation applies to a building only until the first day of

[5] Several EURIMA reports on Cost-Effective Climate Protection in the EU Building Stock, WWW.EURIMA.org.

its use; in other areas, certification of a "new" building is valid for up to 10 years.[6] A change in legislation, such as increased energy efficiency requirements, will typically force the conclusion that buildings constructed before the date of promulgation must be considered to be existing buildings.

New buildings are rarely improved or renovated in the first years. The efficiency of new buildings will therefore directly influence the consumption for many years and they will be the standard for improvement of existing buildings, since renovation projects often aim to bring buildings up to the present standard. Efficiency demands for new buildings then becomes the driver also for existing buildings. This dynamic is in particular visible in countries with a long tradition of energy efficiency requirements for new buildings, where there is a substantial supply of more efficient existing buildings on the market. This process can be supported by energy labelling or certification schemes where new and existing buildings are compared as required in most members states of the European Union[7].

The presence of efficient new buildings also influences the decisions made for. Occurring at 30-40 year intervals during a building's lifespan, major renovations or refurbishment aim to repair and replace parts of a building, such as windows and installed equipment following decades of use and in the context of new technology and demands for functionality. In general, these renovations aim to meet the energy efficiency requirements currently in force and applied to new constructions. Thus, strong regulations for highly efficient constructions influence the efficiency of both new and existing buildings. In recognition of this, building codes sometimes include energy efficiency requirements specific to renovations or major refurbishment and enlargements of the buildings[8].

Requirements for highly-efficient new constructions also influence the market for products typically installed in buildings, promoting energy efficient models of windows, boilers, pumps and air-conditioners. Once on the market, these products may become standard in both new and renovated buildings. The way in which energy efficiency regulations for new buildings can open the product market to efficient equipment and catalyse the eradication of inefficient products can be observed in the disappearance of single-glazed windows and non-condensing gas boilers from German, Dutch and Danish markets.

1.7 Conclusion - The need for energy efficiency requirements for new buildings

Given the long lifespan of most buildings, the relative energy efficiency of new buildings will influence energy consumption for many years. Construction of buildings offers compelling opportunities for energy efficiency, as decisions made during a building's design phase entail smaller costs with greater potential energy savings relative to later intervention.

If decided upon in the early design phase, energy efficiency is often considerable less expensive since increased insulation will have only marginal costs for the increased layers of insulation, increased thickness of construction or increased efficiency in appliances. Some efficiency improvements may even reduce construction costs because the efficient solutions are more cost effective or because the need for heating or cooling systems might be reduced.

Decisions which entail no or very low cost at the early project stage include the form of the building, its orientation, the orientation of its windows, and its structural materials. When

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[6] Certification for new buildings is valid for 10 years according to the European Directive on Energy Performance in Buildings.

[7] It is a demand in the directive on Energy Performance of buildings that all new buildings have to be certified.

[8] California building codes and the EU Directive on the Energy Performance of Buildings both specify efficiency requirements for building refurbishment. The International Model Building Codes, used in the US and Canada, also include requirements for renovation.

included during the design phase, energy efficiency improvements can reduce the demand for and costs of cooling and heating systems. These same decisions, when made after construction, can be prohibitively costly to enact. In other cases, improvement of energy efficiency late in a building's construction would involve irreparable damage to its structure. Examples of this are rebuilding massive concrete floors placed directly on the ground, hidden pipes or foundations with heat losses. Even when energy improvements are suggested at the late planning phase of a building, it is still preferable compared to introducing them after construction.

2 Building codes and standards

Energy efficiency requirements in building codes can ensure that concern is taken for energy efficiency at the design phase and can help to realise the large potentials for energy efficiency in new buildings. Energy efficiency requirements for new buildings are set in different ways. Based on national or local traditions they can either be integrated in the general building codes or standards for new buildings, or they can be set as separate standards for energy efficiency.

This paper addresses both energy requirements set in building codes and in separate energy standards for buildings. It is generally not the intention to differentiate between requirements in building codes and requirements set in legislation specifically concerning the energy efficiency of buildings. The terms “building codes” or “energy standards” for new buildings generally refer to energy efficiency requirements for new buildings whether they are set in building codes, specific standards or other ways, unless otherwise stated.

This analysis does not support the superiority of either method. Instead, this paper indicates the implications of each type of code for its enforcement. When energy efficiency requirements are set as part of the general rules, it is natural to include their enforcement in the general system for building approval, while separate energy standards impose a separate system for energy efficiency enforcement.

2.1 National or regional levels

In some countries, building codes and standards for energy efficiency are set at a national level. In countries with large climatic differences the national building codes might includes values which are adjusted to the local conditions. These are referred to as national building codes. In other countries, local states or regions establish energy efficiency requirements in buildings. This applies in particular to large countries with a federal government. In this case, a model building code is often developed to cover the whole country, either on a public or as a private initiative[9]. Individual states or regions then modify the national model standard to local conditions; and must adopt this legislation, before it becomes mandatory.

Finally, some countries delegate the establishment of energy efficiency requirements for buildings to local authorities. In this case, the city council, regional government or federal state may autonomously set and enforce standards. This independent governance is now quite rare, particularly in OECD countries, where energy efficiency is seen to be far too important from a national perspective. Countries where codes are set on a local level will usually have a standard set on national level and the recommendation to adopt or adjust the standard locally.

[9] In US the ASHRAE and IECC codes are developed by private organisations but with a large participation from the national authorities. See later in the paper for a further description of these model codes.

3 Energy efficiency requirements in building codes

Building codes are not a new invention and building codes or standards for new buildings address several concerns, such as construction safety, fire safety and occupants' health. One of the earliest examples of regulations for buildings is Hammurabi's law from Mesopotamia, established around 1790 BC. Among the 282 rules or contracts, which regulated every part of society, six concern the construction of houses and the penalties for builders.

Many countries or cities have hence a long tradition of setting rules for constructing of new buildings, often initiated in response to disasters such as a large urban fire, an epidemic or a natural catastrophe such as an earthquake. Requirements for constructing buildings were then set in order to avoid or minimise future disasters. Compared to this energy efficiency regulation for new buildings is relatively new in most countries.

Early energy efficiency requirements for buildings responded to poor insulation levels which could lead to health problems because of moisture or air-infiltration. Most regulations for energy efficiency in buildings before the oil crises in 1973/74 are from northern regions with cold winters, where the climate can considerably influence public health. Requirements on specific constructions with some thermal characteristics in these regions first appeared during the period between the two World Wars, when some countries regulated the introduction of simple insulation in the form of air layers in cavity walls or double layer floors of timber beam.

The first real insulation requirements for U-values[10], R-values[11] and specific insulation materials or multi-glazing, date back to the late 1950s and the early 1960s in Scandinavian countries. These national requirements were intended to improve energy efficiency and comfort in buildings. Comfort was the prime motivation for raising the requirements – in a reflection of increasing standard of living, people wanted better and improved living conditions.

In many countries, the oil supply crisis of the early 1970s catalysed the development of energy efficiency requirements for buildings. Those countries already enforcing efficiency regulations generally raised their requirements during the early 1970s to further reduce energy consumption and decrease dependency on oil. During the 1980s and 1990s, energy efficiency requirements were set or increased in most OECD countries. In part, this new legislation responded to the Kyoto Protocol, or other targets to reduce or stabilise CO_2 emissions.

Today, mandatory minimum energy efficiency requirements in the form of building codes or standards exist in nearly all OECD countries. However, substantial differences persist between legislation of the states, regions and cities.

Regulations for energy efficiency in buildings in developing countries, and especially in rapidly developing countries such as India and China, seeks to improve comfort and to reduce the dramatic increase in energy consumption in this sector with the economic capacity to install cooling or heating systems.

3.1 Setting energy efficiency requirements

When requirement for energy efficiency are set in a separate standard they are less bound by other building rules and can contain more samples and specific documentation of

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[10] U-value: *thermal transmittance* is a technical value describing how much energy passes through one m^2 of a construction by a difference of one degree in temperature, measured in W per K per m^2.

[11] R-value: *thermal resistance* describes how well a construction or insulation material resists the penetration of heat, measured in K * m^2 per W. The (U value) = 1 / (R value).

potential use for contractors or building designers. However, as separate standards, they require their own enforcement system.

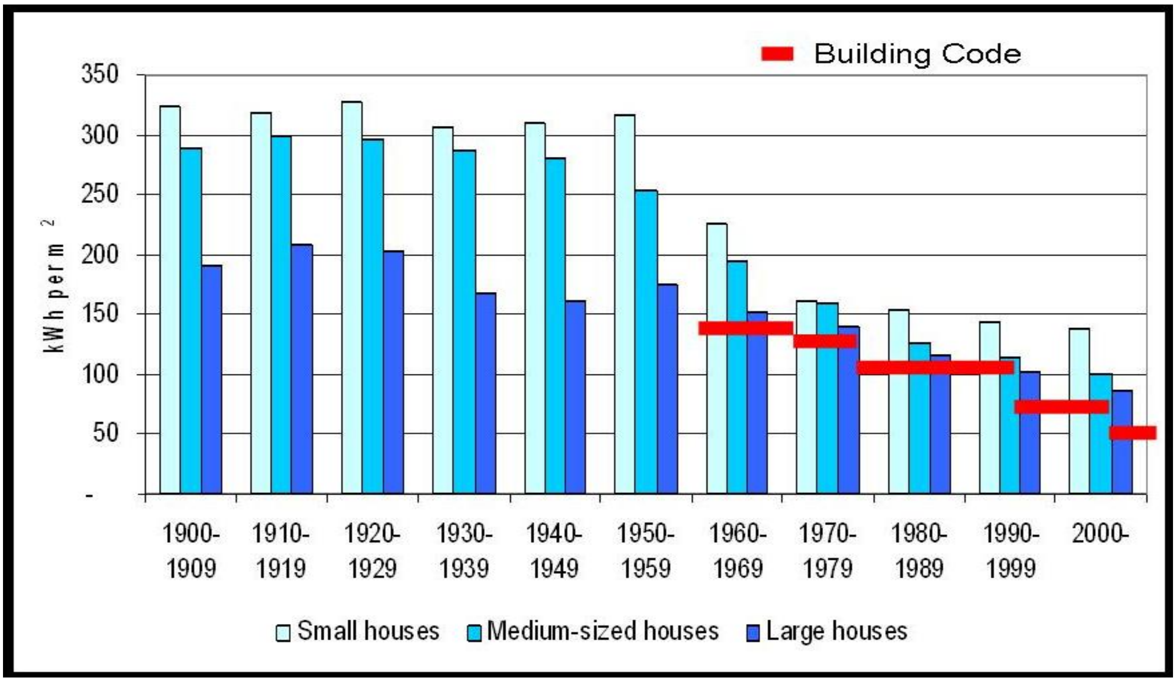
Energy efficiency requirements included in buildings codes are usually set in a specific chapter and enforced along with the general rules of the building codes. If the building industry is familiar with general requirements in the building codes, integrating efficiency requirements can efficiently inform industry actors of energy conservation measures. Energy efficiency requirements included in building codes are often brief, while specific standards are typically longer and more comprehensive.

Some countries mix both approaches by referring to standards. For example, in Germany, general building regulations refer to many specific DIN[12] standards. In many other countries specific guidelines to describe calculation rules and possible use accompany building codes such that the general rules appear in the building code, while standards contain specific details. Many jurisdictions refer to national, CEN[13] or ISO standards.

Impact of minimum energy efficiency standards

Most OECD countries regulate energy consumption in new buildings by setting minimum energy efficiency requirements in buildings codes or in a separate regulation. Several examples illustrate these regulations' impact on energy efficiency in new buildings.

Figure 4. Actual energy consumption in single family houses in Denmark, relative to energy efficiency requirements in building codes.



The results of energy certification of more than 200.000 buildings the average consumption over each decade are compared with energy efficiency requirements in the building codes. [14]

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[12] DIN is "Deutche Institut für Normung": German institute for norms and standards.

[13] CEN, European Committee for Standardisation, is currently developing 31 international standards for calculation of energy performance in buildings to be used in connection with directives from the European Union.

[14] SBI rapport om Varme Besparelser i Boliger, 2003 – heat savings in residential buildings. Information energy consumption in new buildings is also calculated by SBI, The National Building Research Institute in Denmark.

In 1961 Denmark established one of the first building codes which systematically regulated energy consumption. Since then, building codes have been updated several times, including major changes in 1972, 1979, 1997, and in 2006. As illustrated in Figure 4, studies of existing buildings track the trend of declining energy consumption in the context of rising efficiency requirements. The results of early regulations to improve thermal comfort, policies taken in the 1930s and 1940s to ensure construction of cavity walls and double layer beam floors in large residential buildings can be seen too. The lapse between lapse between promulgation of new requirements and their full implementation in the building sector can be seen too, evidence of insufficient enforcement and information.

A similar trend is shown in other countries: buildings' improved energy performance follows the introduction and strengthening of building codes with lapse between promulgation and improvement corresponding to the strength of local law enforcement.

3.2 International trends in energy efficiency requirements for new buildings

Though most energy efficiency requirements in building codes followed local, state or national tradition, the past decade has shown a trend in supranational collaboration to develop international energy efficiency requirements or standards. Examples are the US based Energy Efficiency standards (IECC 2004[15] and ASHRAE 2004[16]) which are used in US and Canada, and the European Energy Performance in Buildings Directive (EPBD) that required member states of the European Union to establish requirements for energy efficiency in new buildings, effective January 2006. To supplement the EPBD, the European Union aims to establish a model building code for energy efficiency for the European region (2006 EU Action Plan for End-use Efficiency) and to develop CEN standards for energy performance calculation. These CEN standards are on the way to be amended and adopted as ISO standards too.

Most countries have started with one common standard for energy efficiency, but have over time developed separate standards for small and simple residential buildings and for large, complex or non residential buildings, in consideration of the dissimilar energy performance.

4 Barriers to energy efficiency in new buildings

4.1 If it is feasible, why is it not done?

Many barriers impede energy efficiency in buildings, and perfect function of the building sector market in economic terms. Insufficient information, insufficient finance for efficiency improvement, split incentives, users' lifestyle choices and multiple decision makers all hamper buildings' efficient performance. Among the building sector's barriers to efficiency, some are specific to new buildings.

When buildings are designed and constructed, energy efficiency is but one concern amid many, some considered more urgent by decision-makers. These can be structural or fire safety, room size, and even the view from the windows. Energy efficiency in buildings may hence be low on the list of requirements.

Focus on incremental costs

Those involved in building projects tend to emphasize investment and construction costs without due consideration of buildings' future running costs. Often these involved parties only have a direct interest in the construction budget and not the total budget, and may be

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Each of the 200.000 buildings was inspected by energy consultants and energy consumption calculated based on similar conditions as are used in building codes.

[15] IECC 2004, International Energy Conservation Code for residential buildings.

[16] ASHRAE 2004, American Society of Heating Refrigerating and Air Conditioning Engineering.

unwilling or unable to evaluate future costs, including those for energy and other resources. Few actors involved in a building's construction have the training required to analyse a building's lifecycle costs and guide construction practices to improve future efficiency. The known costs of construction are thus considered more carefully than unknown future costs.

Construction decision makers not interested in future costs

Many large buildings are constructed by professional developers and most single family houses by construction companies. After construction, developers sell the buildings to future occupants or users. Those who make decisions regarding energy performance will most commonly not pay the energy bills. Building occupants, who pay energy bills, are rarely involved in the building design.

Insufficient efficiency awareness among consumers, designers and banks

Many different decision makers takes decisions, which can influence the energy efficiency of new buildings such as designers, financers, builders, installers and buyers, but most of these know very little about energy efficiency of buildings. Lack of knowledge in just one of these chains can block for energy efficiency in new buildings.

Most buyers of buildings only buy a few times during their lives. Unpractised buyers may not be mindful of the implications and costs of low energy efficiency and, even if aware, may intervene too late during building construction to promote energy efficiency in new buildings. Energy efficiency might therefore be left up to other actors in the construction of buildings. However, most designers, builders and installers know or care little about energy efficiency.

Because designers and contractors make the initial decisions that influence energy performance, both groups can craft an efficient structure. Too often, however, neither engineers nor efficiency advisors are extensively involved in the early design process.

When evaluating a potential construction project a lending financial institution generally focuses on construction costs without attention to implied future costs for energy. Banks may hence be reluctant to fund investments in measures to improve efficiency, even if these investments are feasible and profitable. Insufficient awareness among financiers of efficiency's benefits may prove prohibitive to the construction and operation of efficient buildings and the limited scope of this valuation can frame a budget unresponsive to potential reductions in future costs. Consumers and builders that seek energy efficient construction may not be able to obtain the loans to finance efficiency investment.[17]

Cost structures and lack of capacity

Some energy efficiency measures involve special equipment or expertise not readily available on all markets. Lack of capacity, possible delays due to delivery time or extra fees paid to an expert can deter contractors' interest in efficient construction and further reduce market interest in efficient products or techniques. In addition, some builders are unwilling to invest in training.

Split incentives, brief occupancy and efficiency's marketing difficulties

Decisions regarding the energy performance of many buildings are often split between building owners or constructors, who would be required to pay for efficiency investments, and building occupants, who would reap the rewards of lower running costs for energy. Total costs might be reduced by efficiency, but because it is split on different persons it might be rejected.

[17] Financing Energy Efficient Homes: Existing Policy Responses to Financial Barriers, Philippine de T'Serclaes, IEA 2007.

In buildings such as shops or flats, occupancy time can be short: some buildings are seen as short term investments. Since investments in energy efficiency in buildings are often only profitable over a longer term, few of these conservation options are explored when buildings or units are rented or even bought for a short period.

Transaction of new and existing buildings too rarely considers the avoided costs of energy efficiency. In part, this reticence is due to the fact that the complex calculation of future savings includes several uncertainties, such as future energy prices and real estate market fluctuations. Owners who invest in higher energy efficiency cannot be sure of making a profit or even just recovering initial investments when re-selling the building.

4.2 Inertia against efficient buildings

In addition to these classic economic barriers there is also inertia in the building sector, in which economically-irrational attachment to aspects of a consumer's lifestyle biases a consumer against energy efficient choice in buildings. For reasons of status, marketing and social ritual, individuals and companies use more energy than basic comfort might require. Relative to these conditions, economic optimisation may have a far lower rank in the mind of the energy consumer or building owner.[18]

Energy is invisible

The use of energy is often physically invisible to consumers. Only the status and comfort of using energy will be visible to the energy buyers themselves and to others. A building that does not require air-conditioning might be comfortable and cheap to run, but only by installing air-conditioning can owners or developers demonstrate that indoor comfort is a high priority. Some installations or ineffective energy use signal that the users and owners of the building can afford to make a comfortable indoor comfort and care about the well-being of building occupants. Even the noise from air-conditioning units can be seen as an added value because this makes comfort visible for owners and guests in hotels or in workplaces.

Some might consider a reduction of energy consumption and increase in efficiency as a decrease in comfort or status. For energy users with a good economic foundation ineffective energy use will not usually influence the lives substantially since energy costs will only be a small part of the overall budget. Increasing energy prices might help to reduce this barrier.

Mistaken beliefs in energy efficiency

Owners of buildings or buyers of new buildings may mistakenly believe that the efficiency of a certain building is very good even if it is not. In particular, buyers may mistakenly believe that new constructions automatically are so much more efficient that there is no need to take any further action. Increased energy efficiency in new buildings will hence not be of concern even despite of feasible and compelling opportunities. This might hamper increased efficiency in new buildings, because more efficient buildings and products will not penetrate the market since consumers believe that the existing products and building are already efficient enough.

Slogans such as "energy efficient buildings" or "low energy buildings" have been misused in application to new buildings that only just fulfil the energy minimum standards. However, when buyers feel satisfied with their putatively-efficient building, they are less likely to take further action to improve efficiency.

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[18] Danish Building Research Institute, SBI, Ole Michael Jensen, "Barrierer for realisering af energibesparelser i bygninger" (Barriers to the realisation of energy savings in buildings).

Building codes set the minimum standard and the maximum

Many building buyers interpret the mere existence of building codes to be sufficient warranty for the efficiency of new buildings, but the efficiency standards appearing in building codes rarely represent the optimum for efficiency. Building codes often tend to be the exact level as those for new buildings and not the minimum - which was the original intention of the authority - because builders and designers rarely find an incentive to exceed these efficiency standards which might increase initial costs.

Instead building codes should serve as a common and sure baseline from which to gauge progress and initiatives should be taken to ensure that better energy efficiency would be considered in new buildings.

Barriers work together

Most barriers to energy efficiency in new buildings interact and strengthen each other. Many initiatives for improved energy efficiency in buildings have returned small or limited results because some barriers have been overlooked or insufficiently addressed. For example, a change in legislation and subsequent information campaigns will fail if building constructors and installers do not have access to sufficient funds for efficiency investment. A successful policy, or package of initiatives, will simultaneously have to address all major barriers to buildings' energy efficiency.

Conclusion: Barriers

Many barriers hamper energy efficiency in new and existing buildings. When new buildings are designed and constructed, energy efficiency is but one concern among many factors in construction. Energy efficiency in buildings may be low on the list of requirements for the building. The development of most buildings focuses on construction costs with very little concern for running costs. Different people and budgets may govern the operation of a building, often entailing split incentives for energy conservation. Very rarely will any single decision maker participate in all aspects of a buildings construction, operation and financing. Most decision makers will not have the data or capability to calculate a building's lifetime costs and estimate the consequences of early design decisions. Consumer inertia regarding buildings' energy performance stems from the fact that energy is invisible, that the energy costs of new buildings seem imaginary and that improved efficiency can decrease prestige.[19]

There is hence need to increase awareness of energy efficiency and possibilities for further improvements in new buildings at all levels and to address all barriers simultaneously. Comprehensive policies are best suited to overcoming these self-compounding barriers.

5 Regulation of energy efficiency in new buildings

Since many barriers hamper energy efficiency in new buildings, there is a strong request for policies which address energy efficiency in new buildings. Energy efficiency requirements for new buildings effectively reduce energy consumption in buildings. Building codes or standards for energy efficiency regulate on the efficiency of the building envelope, including the structures around heated or cooled parts of the building, but often they also regulate the efficiency of different part of the heating, cooling and ventilation system and maybe even other energy using equipment,.

The energy efficiency requirements of the building shell or envelope have historically been the first to be regulated and they are today an essential part of nearly all regulations for energy efficiency in new buildings. The other segments of constructions and installations

[19] Further work under the Gleneagles Plan of Action will examine barriers and inertia relative to energy efficiency in buildings. A specific paper will address these barriers in the context of existing buildings.

that influence a building's energy performance[20] can be addressed in the regulation of energy efficiency, but these parts are more rarely included in the requirements.

5.1 Building envelope

The building envelope is a term for the parts of the building which surround the heated and cooled parts of the building. This includes external walls, floors or ground deck, roofs or constructions towards unheated ceilings, windows and doors. If a cellar is heated then the cellar walls and the cellar floor are part of the building envelope. If it is unheated, the building shell includes the floor between the ground floor and the cellar. The building envelope may also address heat loss through foundations or other thermal bridges.[21]

Requirements for energy efficiency in external parts of the building, the building envelope, are generally set based on resistance to heat transparency through a unit of the construction, R-values, or a value for the heat transparency through a unit by a specific temperature, a U-factor or a U-value.[22] In cold climates, low U-values or high R-values prevent heat from escaping from buildings, and in hot climates they prevent heat from entering buildings. U-values or U-factors will typically be given in w/m^2 per °C or as Btu / ft^2 per °F.[23]

Windows

Windows, doors and other parts of buildings that include glass areas require special attention: beyond its role in insulation, glass provides buildings with daylight and heat from sunlight. In cold climates, solar heat gains can reduce a building's need for active heating. In hot climates, however, the heat from sunlight needs to be removed by cooling. The orientation of windows and glass areas should suit the different amounts of light approaching the building from the north, south, each and west and complement a building's needs for heating and cooling.

Special glass constants (G-values) for windows indicate the amount of sunlight that can penetrate each pane of glass. Calculations for windows can be rather complex and in US and Canada standards for windows include a range of solar heat gain coefficients (SHGC), visible light transmission (VLT) and shading constants (SC).[24]

There are several methods to improve the efficiency of windows or other glass areas. These include increasing the layers of glazing to double- or triple-glazing, coating the glass, or filling the space between glass plates with an inert gas or a vacuum to reduce heat transfer. Window frames that position the glass and separate panes also offer the potential for thermal efficiency improvement. The thermal dynamics and lighting potential of windows and glass areas should be considered in specific rules or in calculation procedures.

Shading

Shading, shutters and reflection can greatly reduce sun penetration of windows and other glass areas. Shading is a rather complicated issue which often requires complicated models

[20] The energy performance of a building describes the overall energy efficiency of the building in terms of energy consumption by a standardised use.

[21] A Thermal Bridge is a construction or a part of a construction that conducts heat more efficiently than the surrounding construction. Cold bridges can be foundations or massive parts of a construction that normally include insulation materials.

[22] U-value and R-values are inversely proportional $U = 1/R$.

[23] SI units watt per square meter per degree Kelvin (or degree Celsius) - W/m^2 per °C - and IP units in Btu per square foot per degree Fahrenheit – Btu/ft^2 per °F - can be compared because values in SI equals values in IP multiplied by a factor k = 5.6783

[24] For further description of window calculations and values such as SHGC, VLT, and SC see the US National Fenestration Council (NFCR). Homepage http://www.nfre.org/.

which simulate three dimensions. For simple building these models can be complicated to use since they will require many information on the building for and shading parts which have to be calculated with concern of the movement of the sun on the sky in the actual building sight.

Some countries have developed simplified guidelines to be used in connection with more simple buildings and by builders. Figure 5 shows such an example from California.

Figure 5. Solar protection in California

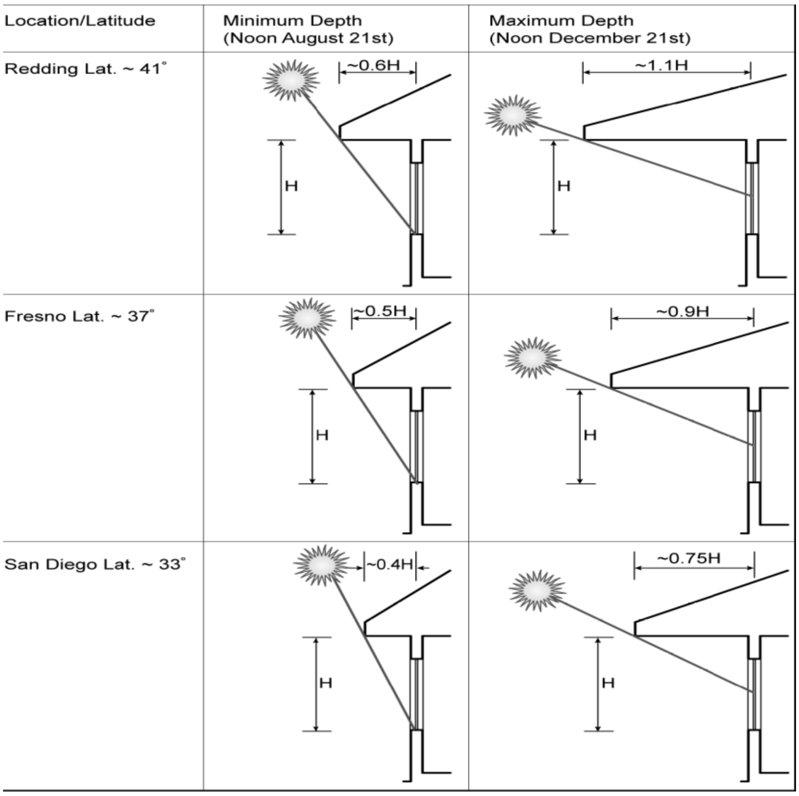

Illustration of solar penetration and shading from the California Energy efficiency standards for low-rise residential buildings.

Air Filtration

Air filtering around windows and glass areas[25] creates an indoors draught. When considered thermally, the undesired air filtration is a loss of energy as it requires redundant heating or cooling. Similar filtrations come from the connection of building parts in general and for some constructions such as boards, which have contracted allowing small openings to appear.

Natural air filtration can provide some – in the past maybe even all - required ventilation. However, ventilation with natural air currents can entail large heat losses from constant air exchange and inconvenient timing and intensity. Natural air filtration is difficult to control and evaluate. Air tightness is often treated separately in building codes and can be assessed in a “blower door test”.[26] As buildings become more efficient, air filtration can be one of the major conduits for heat loss in an otherwise highly-insulated building.

[25] Filtration of air is used as term for the uncontrolled infiltration of air from outside. This air comes in around windows, in connection between building parts, connection between plates or boards. In old buildings this exchange of air can be substantial.

[26] In such a test, a door is replaced with a special device which can put pressure inside the building. It is the metered how to keep the pressure as a value for the filtration.

5.2 HVAC systems

HVAC systems maintain a building's comfortable indoor climate through Heating, Ventilation and Air Conditioning (Cooling). These systems profoundly influence energy consumption in buildings. Without heating, cooling and ventilation systems there would be no energy consumption in the building, since it would be totally dependent on outdoor conditions. There is an inverse correlation between the efficiency of the building and the need for HVAC systems: highly efficient building envelopes reduce the need for heating and cooling systems. Good and intelligent designed buildings can reduce or even avoid the need for heating and cooling and reduce the need for ventilation.

Efficiency improvements in HVAC systems can lead to substantial savings, but these savings will also depend on the efficiency of the building in general. If, for instance, energy efficiency is improved in a heating boiler or an air-conditioner, total savings will depend on the total need for heating or cooling in the building. Higher requirements for the building envelope might reduce the potential for savings in HVAC systems. Finally the HVAC systems need to be in a good balance with the buildings in general and they need to be of a proper size which fits with the actual heating, cooling and ventilation needs.

Ventilation

Well-insulated, airtight buildings often require active ventilation to remove used air and introduce fresh air for occupants. Natural ventilation, like the flow of air through open windows, and mechanical ventilation both circulate air. Ventilation can also be included in air-conditioners which combine simultaneous heating and cooling. There are many technologies to improve the efficiency of ventilation systems, including heat exchangers and heat pumps.

For ventilation systems there is a need to be aware of both the energy use in ventilation system it self for fans and preheating of the air etc. but there is also a need to take concern for the heat losses which comes with the exchange of the air. Ventilation systems should hence effectively ensure the necessary air exchange, not more and not less.

Heating systems

Many possible systems can heat a building. Collective heating can include a combined system based on a heating supply in the building such as a boiler or on an external supply in the form of district heating or heating from combined heat and power production. Buildings can also draw heat from individual systems such as electric heaters, heat pumps or individual ovens. Finally, heating can be integrated in the ventilation and air-conditioning systems.

Centralised heating systems include a distribution system in the building such as pipes[27], ducts[28], tanks, pumps, fans, or exchangers. The efficiency of the overall system depends on the efficiency of all its components, and an efficient boiler can become an inefficient heating system if parts are poorly connected and badly calibrated. In individual systems, the efficiency often depends alone on the efficiency in the heating source only.

Building Codes will often address the efficiency in the system in general and in the components of the system. Some buildings might have multiple systems with a mix of functions, which should all be addressed.

Cooling

To maintain a comfortable and healthy indoor climate, the heat must be removed from overheated buildings. Cooling systems can be centralised or decentralised into small units

[27] All pipes for transportation of heated water for the heating of the building and for heating of hot sanitary water.

[28] Ducts, all canals to transport air in a cooling, ventilation or air conditioning system.

installed in every room for instance with small split units which are installed in each room. For split units, it is mostly the efficiency of the cooling device and the control system which are of importance for the overall efficiency. Within centralised systems, the dimensions and control of the system itself and the distribution ducts both determine energy efficiency. Air tightness is especially important for building cooling, as air leakage can substantially reduce the efficiency of mechanical cooling. Some buildings work with natural cooling or with night cooling, both of which reduce the need for active cooling.

Air Conditioning

Air conditioning systems generally combine the capacity to ventilate, cool, and heat. In a basic definition, an air conditioning system will supply the building with heated air if outdoor temperatures are cold, with cooled air during hot days and with plain air if the building requires only ventilation. For air condition systems, it is primary the efficiency of the overall system and / or components which are regulated, including the heating, cooling and ventilation components.

Dehumidification

In humid climates and in buildings producing much humidity, like swimming halls or other indoor bathing facilities, moisture may need to be removed from inside buildings. Itself an often energy-intensive process, dehumidification can be integrated into air conditioning systems. Building regulations in humid climates, should account for the energy involved in humidity control.

Hot sanitary water

Many buildings' occupants require hot sanitary water for hygiene, food preparation, cleaning and commercial purposes. The central heating system can provide this water, as can a separate system using electricity, oil, gas, solar thermal energy, heat pumps or district heating. Efficiency regulations often address hot sanitary water.

Ducts and pipes

Because ducts and pipes determine much of the energy efficiency of heating and cooling system, ducts and pipes should be carefully dimensioned, assembled, insulated and placed in the most efficient manner inside or outside the building shell.

Automatic controls

Automatic controls of systems can largely determine or influence the efficiency of these systems. Individual systems as heating, cooling, ventilation or lighting systems can have individual automatics or the overall system can be controlled by one overall central system, which controls all the functions. If the systems are controlled by individual systems this can in some cases lead to conflicts between for instance the heating and the cooling systems. Good and efficient automatics can ensure the optimal use of the HVAC systems can be addressed.

5.3 Renewable Energy

The use of local sources of renewable energy can be either passive or active. In passive systems the renewable energy is used to avoid the need for heating or cooling while the active systems will transform the energy from for instance the sun or the wind into electricity, heat or cooled energy carriers from which energy is used, as if it came from a non renewable HVAC system.

With a decreasing energy demand in buildings these sources become an important part of the energy performance of the buildings and the more advanced standards include these sources.

Requirements for energy efficiency in buildings and the calculation of energy performance can both address integrated renewable energy systems. These requirements can either be set for the renewable energy sources themselves – for example, in a demand for solar heating of sanitary water, as in the case for Spain - or as part of an overall energy performance (see below), where the demands are set for the maximum delivered energy.

Passive Solar

In a building heated by passive solar energy, glass areas are oriented and arranged so as to optimise the capture of solar light and heat. When buildings are highly insulated and energy efficient, passive solar energy can meet a substantial share of the heating demand, even in cold climates.

Because a building's exposure to solar energy varies over the year and during the day, constructions must be able to store and balance solar energy. Buildings capturing too much heat may require cooling, offsetting the efficiency gains of passive heating. Passive solar heating of buildings requires good models for balancing heating in multiple zones[29] to provide even temperatures throughout the building.

Passive cooling and ventilation

In passive cooling systems natural cool resources for instance in water or in the ground can be used to reduce the need to cool the buildings. Passive cooling systems can also use the fact that the temperature might be colder at night or use different phenomena's which will cool air or building parts.

In natural or passive ventilation different options are used to avoid active ventilation systems. Natural ventilation is often used in small residential buildings and often these buildings are constructed with out or with very limited use of active or mechanical ventilation. In larger buildings and in particular in service buildings the use of natural ventilation requires a high emphasis in the design phase.

When natural ventilation or passive ventilation is used in large buildings natural sources of wind or airstreams because of difference in temperatures are used to drive the ventilation. This is typically achieved through an intensive design phase where the shape of the building is adjusted or where specific elements such as special designed windows are introduced.

Passive cooling and ventilation can reduce energy consumption substantially but is difficult and complicated to address in building codes or standards for new buildings.

Active renewable energy systems

In active renewable energy systems the energy from the renewable energy sources are actively transformed into heating, cooling or electricity and the used as energy supply which comes from non renewable HVAC systems. Some of these systems can often be integrated in the buildings or in the building shell.

Solar water heaters are one of the most commonly used renewable energy supplies in buildings and in these systems water is heated by the sun and the heat is stored until used. Similar systems can be used to heat the building but this increase the need for storage and sometimes even from one season to another.

Photo voltaic (PV) is another example on active use of solar energy in buildings, where solar energy is transformed into electricity and used for the buildings supply of electricity. Solar energy can also be transformed directly into cooling and used as a cooling source. These systems will often require little storage, because they produce when needs for cooling are high.

Other renewable energy sources in building can be small building integrated windmills or systems that use biomass or waste products from the buildings and heat pumps can be used

[29] By multiple zones the building is shared in parts, which are treated individually in the calculations.

to increase the use of renewable energy supplies for instance in the ground, in air or in water.

5.4 Installed equipment

Installed systems other than HVAC systems can influence a building's energy performance in two different ways: through their own energy demand and through their production of waste heat which can result in increased cooling loads or decreased heating loads. Given their connection with buildings, some appliances fall under the auspice of building energy efficiency requirements in building codes and appear in the calculation of energy efficiency performance of buildings[30].

Some equipment and electrical appliances have more loose connection to the building and can more or less simply be removed or exchanged without interfering actively with the building itself. Other IEA studies examine the efficiency of these appliances.

Lighting

Lighting requirements respond to a building's design. The need for lighting, especially during daytime, will depend on the size and placement of a building's windows, and the building's situation. The need for lighting can be reduced by the use of automatic controls which depends on the orientation of buildings windows, the supply of daylight, use of the room etc.

Indoor lighting systems produce heat, in form of waste energy depending on the actual type of installations, that can reduce energy demand for indoor heating in cold climates or during winter and raise demand for indoor cooling in hot climates or by summer. Building regulations can govern lighting systems general or more commonly only the built-in lighting systems. Assessment of highly energy efficient buildings should also consider lighting. [31]

Appliances

Many electrical appliances such as white goods device or televisions and computers will have an interaction with the building in which they are installed, since they will contribute to waste energy for the building. This will influence the need for heating and cooling. In particular in cooled building waste energy from inefficient appliances can lead to double energy loss, first because they use more energy themselves and second because they create waste energy, which has to be cooled away by the cooling or ventilation system.

In highly efficient buildings, heat from installed appliances can substantially influence the need for heating and cooling. Around the world, programmes such as FEMP and Energy Star in North America, EU appliance labelling schemes and Japan's Top Runner promote energy efficient appliances[32].

Efficient appliances are treated in a special study as a part of the Gleneagles Plan of Action and in IEA publications such as Saving Electricity in a Hurry and Cool Appliances.[33]

5.5 Zoning of buildings

Zoning of a building means that the building is divided up into separate areas, each with the potential for uniquely-calculated requirements for energy efficiency and indoor climate.

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[30] As specified in the European Directive on Energy Performance in Buildings, lighting for non-residential buildings and the heat gains from other appliances must be calculated in general energy performance.

[31] Lighting is treated in depth in the IEA study: Light Labour's Lost: Policies for Energy Efficient Lighting. 2006

[32] Top Runner is a Japanese system where producers are encouraged to develop and implement energy efficient systems. Further description of Top Runner later in this paper under building codes in Japan.

[33] Cool Appliances, Policy Strategies for Energy Efficient Homes, 2003. An update of this publication is under preparation.

There might be transfers of energy from one zone to another, if there are differences in the indoor temperatures. Zoning can be needed for passive solar conditions, for building ultra low energy consumption and for complex buildings that have multiple functions, to ensure that suitable indoor climatic conditions are obtained in different parts of the building.

5.6 Integrated design

Integrated design is a term used for a process where all the elements described above are used to reduce the energy consumption in a building.[34] In this process actions are taken to reduce the energy consumption as well through insulation or efficiency as through the design of the buildings and the HVAC systems. Passive use of renewable energy and other natural sources is an integrated part of the design and development process and there is an interactive process between the design of building and systems.

Integrated design requires more emphasis on energy efficiency and systems in the early planning phase than traditional design and it is difficult to regulate through building codes and energy efficiency standards, but the most advanced standards or energy performance calculation includes options for integrated design. Some examples where the integrated design process is used are described later.[35]

5.7 Conclusion

Many elements influence the energy performance of a building; building codes often address the most integrated of these elements: the building envelope and HVAC systems. Other appliances and Renewable Energy are more rarely included.

Many building energy efficiency regulations started with requirements for the building shell, and nearly all efficiency regulations for new buildings include requirements for the building envelope. As the building's envelope improves, regulations focus on the energy efficiency of HVAC systems. Finally, when all parts of building and HVAC systems are covered, regulations address other installations and renewable energy.

For some regulations, energy efficiency requirements are primarily set for buildings and the building shell. While some building codes include the energy consumption of installed equipment and appliances, some include lighting and others do not. The treatment of renewable energy systems in building codes also varies.

The most advanced building codes or standards for energy efficiency in buildings today include all of these aspects. It should be the aim to include most of these elements in building codes or the calculation of energy performance, especially when requirements are high, since this will increase the saving potentials and will prevent sub-optimisation of the demands for some parts of a building.

6 Types of regulation

Energy efficiency requirements can be set in different ways and the basic types are:

- **Prescriptive.** This method sets separate energy efficiency requirements for each building part and for each part of the equipment. Individual components must achieve compliance with their specific targets.

[34] In the integrated design other use of resources will also be evaluated and the process will also include the consideration of costs by different options.

[35] Examples where an integrated process is used can be Passive Houses, Zero Energy or Carbon Buildings and Green Buildings.

- **Trade-off.** Values are set for each part of the building, but a trade-off can be made so some values are better and some are worse than the requirements.
- **Model building.** Values are set as in the trade-off, and a model building with the same shape is calculated with those values. A calculation has to demonstrate that the actual building will be as good as the model building.
- **Energy frame.** An overall framework establishes the standard for a building's maximum energy loss. A calculation of the building has to show that this maximum is respected.
- **Performance.** Energy performance requirements are based on a building's overall consumption of energy or fossil fuel or the building's implied emissions of greenhouse gas.

6.1 Prescriptive

When using the prescriptive method, energy efficiency requirements are set for each component of the building. This could be a thermal value (U-value) for windows, roofs or walls. The prescriptive method can include efficiency values for technical installation, ventilation, orientation of buildings, solar gains, the number and size of windows. To comply with a prescriptive standard, each part of a building must meet its specific value.

A simple version of a prescriptive building code set thermal values for the essential 5–10 building parts. In the most complicated systems, energy efficiency requirements are set for all parts of building and installations, including heating installation, cooling units, pumps, fans, and lighting. In some cases, these requirements are even adjusted according to size of the equipment or the size of or percentage of windows based on floor area or the outer wall.

In general, instructions for the prescriptive method are easy to implement. U-values can be followed by descriptions of typical constructions which fulfil the requirements and requirements for equipment can be combined with the labelling of products. A prescriptive method could require an appliance to be labelled A or B, or rated with energy stars.

6.2 Trade-off

The trade-off method sets values for individual building parts and / or for parts of the installations, akin to the prescriptive method. However, in meeting a general standard for efficiency, a trade-off can be made between the efficiency of some parts and installations such that some values are exceeded while others are not met.

The trade-off is generally made in simple terms. Trade-off can be made between U-values for the building shell[36] or between building shell and the energy efficiency requirements for heating and cooling installations. The trade-off model provides more freedom and flexibility than the prescriptive method. The calculations are normally simple and possible to do by hand or in a simple spreadsheet.[37]

6.3 Model Building

In the model building method, values are set for each building part and / or for the parts of the technical installations. Based on the values and the characteristics of the actual building a model building is calculated with all the set values for losses and efficiency. This calculation follows a clearly defined method. The actual building is then calculated by the same method using the actual values for the individual building parts, heating, cooling, and

[36] For instance U-values are balanced according to the area, so 10 m² with + 0.2 in one value can be exchanged to 20 m² with – 0.1 in another value.

[37] By trade off models a special attention should be taken for systems with a long lifetime such as insulation and building structures and systems with short or medium lifetime, such as most HVAC systems.

ventilation systems. The total result of the calculation is compared with the model building and the actual building must perform as well as or better than the model building.

The most complicated models include all parts of the technical systems in these calculations, including all parts of heating systems, ventilation, cooling, lighting, built in equipment etc. Renewable energy can be included in the calculations, to make a solar collector, for instance, reduce the general efficiency requirements for the heating system or even the insulation level.

The model building gives more freedom and flexibility for building designers and constructors than a prescriptive model. Expensive systems can be changed with improved efficiency in parts of the building or installations where efficiency will be more cost effective.

6.4 Energy Frame

The Energy Frame for a building sets a maximum of energy loss from the building. This is usually set as a total frame for the building, a value pr. m^2 building area or as a combination. The energy frame will then be followed by a procedure on how to calculate the energy losses from simple values such as the u-values, temperature, surface and heat gains from sunlight etc. Values for the individual parts are not set in this model but only for total loss or use of energy.

This method enables the constructor to build parts of the buildings that are less energy efficient when other parts are made better than typical constructions. This method can as example also avoid limiting the size window area, as improved windows or increased insulation can adjust for the additional heat losses or larger sun gains by having a larger surface of windows. As long as the overall value is met, the building is approved.

The energy frame can also be defined as an overall thermal value (adjusted u-value), pr. square meter of building floor area or similar. Again it will be the constructor's decision to document that the building is built up to the standard of the model building given by the overall values.

Similar to the model building this gives more flexibility in the fulfilment of the requirements and this can easily be adapted to the most economic solution. On the other hand it increases the need for calculation.

6.5 Energy Performance

With the energy performance method, a total requirement for the building is set based on the supply of energy or the resulting environmental impact, for instance in form of CO_2 emissions. This method requires a comprehensive method for calculating the energy performance of a building, with standard values for climate and use of the different types of buildings. Constructors are required to use an advanced computer based model for the calculations, which integrate all the different parts and installations of the building.

Values for energy performance are set on the basis of an overall value, consumption pr. m^2 or a mixture, for different types of use or different types of buildings etc. Installations as renewable energy in the building will usually be calculated as improvement in performance, meaning that a solar collector or solar cells can substitute insulation, efficiency in boilers or air conditioners. The performance model requires handling multiple factors as solar gains, recovery of energy losses, shading and efficiency in installations.

In the energy performance, comparing the use of different energy forms such as heating (gas, oil or district) with the use of electricity is necessary. Depending on local energy conditions, there may be adjustments, where some kWh's or Gj are valued higher than other or the comparison can be based on energy costs.

In performance calculations, the maximum value is often set for the use of fossil fuels, primary energy use or as a maximum CO_2 emission. Free trade-offs can be made between insulation and installation of efficient equipment, but also based on the selection of fuels, the use of renewable energy, the primary design (form) of the building, use of daylight, and intelligent installations or automatics. Windows with better thermal values can be used to increase the window area or negative losses can be out balanced with positive gains as passive heating.

Energy performance standards give optimal freedom for constructors or designers to reduce energy consumption within the frame. If efficient boilers or air conditioners are more cost effective than improved insulation, the constructors can choose this alternative to improve performance. Similarly, it will be possible to substitute more expensive solutions in the building envelope with efficient renewable energy systems or heat recovery. The model adapts to a change in prices, technical development and allows new solutions and products. There is a need to develop and maintain sophisticated calculation methods and computer tools that take all these important factors into account.

6.6 Mixed models, hybrids

Some countries use a mix of the above models. For example, an energy frame for the building might be combined with prescriptive values for installed products. Another typical mixture is when building codes allow a choice between the simple approach with prescriptive values, an energy performance or an energy frame. The designers can therefore use a model which is simple to calculate, or choose a more complicated model, which offers more freedom and flexibility. Sometimes both performance values and prescriptive values are set, where the prescriptive values are tighter than the value for the overall calculation, which ensures that buildings constructed after the prescriptive values, automatically fulfil the energy frame or energy performance requirements.

Some countries or states have two or more models which have to be fulfilled at the same time; in this case, energy efficiency requirements will grow from the prescriptive models over the energy frame to energy performance. The target is to ensure that no building part or component of the heating or cooling system is too poor, but rather to base the overall calculation on a model that gives more flexibility. The aim may also be to avoid moisture problems if building parts without insulation result in condensation, or to compensate for different lifetimes of components.

6.7 Development

Most countries have started with prescriptive values. When energy efficiency requirements increased and more elements included, trade-offs or an overall frame allowing adjustments of the individual values was required. Today, energy performance models and computer tools are being developed in many regions. International standardisation has been introduced with the aim of developing and harmonising models to calculate energy performance.[38]

At the same time, countries have decided to have several methods for compliance with norms which allow builders and constructors to choose. This is especially the case for small residential buildings where there is a general effort to make simple and comprehensive rules.

6.8 How to compare

In order to compare building codes, the different types can be simplified into two basic forms. Building codes which are set based on energy efficiency requirements for individual

[38] Standards have been developed under CEN and are now under adoption and development in the ISO.

building parts - “U-value based building codes” - and the codes for which these requirements set the overall frames in order to calculate energy consumption - “Performance based building codes”.

U-value based building codes

The Prescriptive Method, the Trade-off Method and the Model Building Method are all based on standard maximum values for transmission (U-values)[39], coefficients, energy efficiency values and similar values which can easily be compared. Whether trade-offs are possible will accordingly influence the level of the values.

Calculation or performance based building codes

The Model Building, Energy Frame and Energy Performance methods are all based on calculated energy consumption and all require calculation models and computer tools.

The calculation procedures are normally set national, regional or local. However, CEN[40] / ISO[41] are developing international standards which will ease future comparisons. These types of regulations have to be compared based on total performance or the total frame, but again climate conditions must be taken into account.

6.9 Conclusion

Energy efficiency requirements can be set in different ways, prescriptive, trade off, model building, energy frame or energy performance. Requirements are basically set either on a building part or component level or as an over all maximum for a calculated value.

The different methods have different advantages and disadvantages. U-value and efficiency based codes, in particular for the prescriptive model, is generally the easiest to understand for constructors, since the values are given on a disaggregated level. Standard constructions and installations can be given which fulfil the energy efficiency requirements, and buildings can be constructed without calculations or the use of computer models.

The prescriptive method develops standard solutions that can help to reduce costs on sight, but may lead to over optimisation of particular parts of the buildings or installations, which can lead to increased costs for energy efficiency. However, the trade-off allows some flexibility and freedom in selecting methods and solutions or in optimising energy efficiency without requiring too many calculations. With the energy frame, and finally with energy performance, these possibilities for flexibility and optimisation of costs for efficient solutions will increase. Using the performance model requires computer-based models and a deeper understanding of some of the principles.

It is not easy to determine which type of code is best as it often depends on the actual experience in the country and the development of the construction industry. Often several types of energy efficiency requirements exist side by side as alternatives.

Comparison of building codes are difficult between the different types of codes and can only be justified for codes based either on individual values or performance and frame based values.

[39] Or minimum values for resistance (R-values).

[40] CEN European Organisation for Standardisation, which have developed standards for the implementation of the European Energy Performance in Buildings directive. Homepage www.cen.eu.

[41] ISO is the International Organization for Standardization, which is currently working on the development of further international standards for energy performance calculations for buildings, Homepage www.iso.org.

7 Conditions for Building Codes, Comparison

Local conditions greatly influence the energy performance of buildings. When comparing building codes, the most significant considerations are climatic conditions, including local temperature, humidity and ambient natural light.[42]

Heating

In cold climates or in the heating season heating is the most important energy issue, and there is a direct link in the difference in temperatures and the loss of energy from buildings. Energy losses through a wall, floor, ceiling, and window or by ventilation are directly proportional to the difference in indoor and outdoor temperature. Similarly will the savings obtained by insulation or improved efficiency.

A simple value to define the need for heating in cold climates is Heating Degree Days[43] (HDD). Heating will be reduced through the positive use of energy from the sun that comes into the building through windows, from body heat, or waste energy in appliances. This is adjusted by using the heating degree days based on a temperature lower than 20 °C, for example 18°C or 17°C[44].

Cooling

In hot climates cooling is the most important energy use in buildings and outdoor temperatures will have a large impact on cooling needs. Cooling needs also depends on the hours of sunlight, the intensity and how much the sunlight penetrates the building. A simple value to show the need for cooling is Cooling Degree Days.[45] Solar radiation based on the penetration of sunlight in the building will increase the need for cooling. Heat gains from people and appliances in buildings increase the need for cooling too. This is addressed by using a colder temperature than the designated indoor temperature for the calculation of Cooling Degree Days.[46]

Higher cooling needs will lead to higher consumption in the same building, and at the same time larger saving can be obtained from a particular measure such as insulation, better glazing or improved efficiency in the air-conditioning or ventilation systems.

Humidity

Humidity is another climatic condition that influences buildings' energy consumption. In areas with a high rate of humidity, especially when both hot and humid, air-conditioning must reduce indoor humidity both for comfort and to prevent moisture damage in buildings and installed equipment.

There are other parts of energy consumption that are influenced by climatic conditions, such as lighting, which depends on the hours of light and the intensity of the sunlight etc. Less daylight in polar areas during winter will require more energy for lighting. For a

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[42] For further explanation, see the IEA Working paper Comparing Building Codes and Selecting Best Practices (September 2006.)

[43] One Heating Degree Day is a day during which the average difference between inside and outside temperature is one degree Celsius. A day during which the indoor temperature is 5 degrees higher than the average outdoor temperature is counted as 5 Heating Degree Days. Heating Degree Days are commonly used in OECD countries.

[44] Heating Degree Days are named by the indoor temperature used as the baseline for calculation: for instance, HDD20 if the baseline temperature is 20 °C or HDD18 for 18 °C. HDD 18 or HDD 17 are most commonly used.

[45] Cooling Degree Days, CDD, are calculated like Heating Degree Days, though using only days where outdoor temperature exceeds a certain temperature. The CDD metric is not as commonly used as HDD figures; CDD data are available for all countries.

[46] Some countries use a temperature much below 20 °C to adjust for solar radiation and other heat gains. For example, the ASHRAE codes use as low a temperature as (10 °C) for the calculation of CDD.

general comparison of codes and standards and a selection of best practices, heating and cooling and to some extend humidity are important parameters to be considered.

Different influences of appliances

Heat losses from inefficient lighting systems and installed appliances will have a different impact on energy performance in cold and hot climates. In cold climates, waste energy from heating appliances or light installations can, to some extent, be used to substitute heating – at least during the cold part of the year – while in hot climates this waste energy leads to increased cooling. Savings in efficient appliances and lighting in hot climates will therefore count twice in the energy performance, while they count less in cold climates. In hot climates, it is hence even more important to be careful with the wasted energy from such systems.

7.1 Climatic classifications

There is a clear need to take climatic conditions into consideration when Building Codes or other measures for buildings are evaluated, compared or when Best Practices are selected. Buildings act different in cold and hot climates. It is therefore not possible directly to compare the heating requirements, for instance in north European countries with the cooling requirements in Australia or in Southern India[47].

Some countries with more climate zones use a system of classification for different areas and set different energy efficiency requirements for insulation and energy efficiency based on the climatic conditions in these areas. This is, for example, the case for the USA and China where a climatic correction is built into the energy efficiency codes based on degree-days.

Köppen Climate Classification

Climate classifications are often based on the Köppen Climate Classification system, which proposes six general climate types: A) tropical, B) dry, C) mild latitude, D) serves latitude, E) polar and H) for highland. Each of these classes is divided into sub categories according to the type of winter or summer. The 6 basic climates is subdivided at least 23 different sub-climates. The Köppen climate classification has been the basis for different systems of building energy efficiency regulations setting up different requirements for different climatic zones.

The 6 basic climates in the Köppen Classification are not sufficiently homogeneous to evaluate and compare building codes since some climates include a large variety of conditions in which buildings will perform differently in term of heating and cooling. The sub-climates are more homogeneous, but it seems on the other hand too complicated to work with 23 different classes when comparing energy efficiency in buildings.

The standard building codes

The ASHRAE standard for commercial and large complex buildings uses 8 zones and 17 sub zones (A, B, C) alone for the US. They follow calculations of Heating Degree-Days, Cooling Degree-Days and moisture (Marine, Dry, and Moist zones) and are adopted according to state borders[48].

The latest version of the International Energy Conservation Code, IECC – a model code for low rise residential and simple commercial buildings - has been simplified, and in this code the US is shared in 10-12 zones (8 general zones 1-8 and some sub zones A, B and C for

[47] Climatic classifications and the need for simplification are discussed in further details in the IEA Working Paper on Comparing Building Codes and Selecting Best Practices.

[48] These climatic zones for US were developed by DOE's Building Energy Code Program specifically for use in the US codes and standards. Both ASHRAE and IECC use heating degree-days 65°F (18°C) and cooling degree-days 50°F (10°C).

some of the general zones). The zones in IECC are based on the number of Heating degree-days and cooling degree-days. The major part of the zones is based either on heating or degree-days, but 2 zones are based on both heating and cooling degree-days[49].

7.2 Simplifications of climatic conditions

The systems mentioned above seem too complicated for a general evaluation and comparison of building codes. For a valuation and comparison of building codes around the world, it is preferable to work with more simplified conditions. In this model the different climatic conditions are split 6 different basic climatic zones based on heating and cooling requirements. There might be a need to add one further zone based on extreme humidity, which results in a need to reduce humidity[50]. In general, the climates could be described as follows:

- **Cold climate –** a climate where winter is cold and summer temperatures never or only rarely reach a level above comfort level (22 - 25 °C). In this climate, there will hardly ever be a need for cooling. This is the case for large parts of Russia, Scandinavia and Canada.
- **Heating based climate –** where the need for heating in winter is large, but where summer temperatures can reach a level where cooling becomes an option at least for comfort reasons. This is the case for Central and North of Europe, most of Canada and central US.
- **Combined climate –** where winter is cold and summer is hot. Heating is necessary in winter as well as cooling in summer. This applies to Moscow and central parts of Russia, Shanghai region and other parts of in China.
- **Moderate climate –** where both summer and winter are mild and the need for heating and cooling is quite limited. Portugal and central parts of California, as examples.
- **Cooling based climate –** where summer is hot with a need for cooling in the summer but where there can be a need for heating in the winter. Greece, Italy, southern California, Australia.
- **Hot climate –** a climate where summer is hot and winter warm where winter temperatures never get below comfort level (16 - 18 °C). Florida, northern Australia, Central Africa.

Table 1. Simplified climate zones, heating and cooling degree days

	Heating	Cooling
Cold Climate	2000 ≤ HDD 18 °C	CDD 18 °C < 500
Heating based	2000 ≤ HDD 18 °C	500 ≤ CDD 18 °C < 1000
Combined Climate	2000 ≤ HDD 18 °C	1000 ≤ CDD 18 °C
Moderate Climate	HDD 18 °C < 2000	CDD 18 °C < 1000
Cooling Based	1000 ≤ HDD 18 °C < 2000	1000 ≤ CDD 18 °C
Hot climate	HDD 18 °C < 1000	1000 ≤ CDD 18 °C

Proposal for simplified climatic zones based on heating degree days and cooling degree days.

[49] Both ASHRAE and IECC standards will be further describe in paragraph on building codes in North America.

[50] A further discussion and description on these zones can be found in the working paper on Comparing Building Codes and Selecting Best Practices from September 2006.

The allocation of climate into these 6 basic zones could be based on Heating Degree Days and Cooling Degree Days as proposed in Table 1.

7.3 Valuation of building codes

For a comparison of thermal regulations for new buildings and installations this can be further simplified into 3 different main areas:

Cold climate and heating based climates

In both Cold Climates and Heating Based Climates, the comparison can be based mainly on heating needs and efficiency in heating and ventilation installations. In both types of climates, heat gains from the sun and internal sources will reduce the need for heating and benefit energy efficiency, although concerns should be taken primarily in heating based climate to avoid over heating in the summer. Windows and other openings should be constructed mainly to benefit from the sun's free energy. Efficiency of heating systems should also be addressed. In a simplified comparison, regulation can be compared based on heating degree days.

Hot climates, cooling based climates

In Hot Climates and Cooling Based Climates the comparison can be based mainly on cooling needs and on efficiency of cooling installations. In both types of climates, energy from the sun the internal heat gains will increase the need for cooling. Solar radiation in the building and the internal loads should be reduced and controlled as much as possible as this will have energy savings in appliances and installation as well as in cooling. Windows and other openings should be protected for heat gain from the sun through shading etc. Efficiency of cooling systems should be addressed too. In a simplified comparison, regulation can be compared based on cooling degree days.

Mixed climates

In a Combined Climate or a Moderate Climate it is impossible to make a simplified comparison based only on heating degree days and cooling degree days as it is necessary to balance heat gains from the sun and internal resources with cooling and heating demands over the year. The best solutions will be highly dependent on actual local conditions. Shading, clever and integrated solutions are essential in these regions to allow solar penetration in winter and reduce heat gains in summer are needed in order to balance heat and cooling needs.

Shading, orientation of windows and openings are of major importance for the total energy balance of the buildings. Comparison of building codes and valuation or selection of best practices is rather complicated.

8 Least Lifetime Costs

Since climatic conditions have such a large impact on the building codes and there are different ways to set buildings codes, it is difficult to compare these energy regulations for new buildings in different countries or regions. At the same time it can be interesting to compare the code with general optimum for the energy efficiency level for the requirements.

One possible comparison of building codes is to look at the least total costs seen over time (LCA). In this comparison the costs for the investments will be compared with the economic benefits for the owner or user of the building in terms of savings.

For buildings, most savings have a long life time and for some savings it might even be the whole lifetime of the building. For buildings in general, it is reasonable to look at a 30-year timeframe as this is a typical interval before a new building requires the first major renovation and which also fits with maximal mortgage or loan periods in many countries.

8.1 Methodology

Energy efficiency improvement often have an initial cost – seen as an investment – which is carried by the owner or constructor of the buildings. This increases the total investment and this will lead to a need for larger loans for the construction of the building. In new buildings investments costs can either be additional costs if building parts are improved or technical equipment replaced with more efficient equipment or it can be full costs for new systems.

Many decisions are taken mostly based on the initial costs. Instead of looking only at incremental costs, the total costs should be addressed including the energy use. For new buildings should be valued over 30 years seems rational. Interest rates should be estimated and the annual payment for the improvement should be calculated. In some cases, this timeframe is longer than a first occupier or owner might stay in or use a building, but in the event the property is sold the improved efficiency should lead to a higher resale price, which will enable the first owner to recover the investment.

At the same time investment in energy efficiency will lead to reduced energy consumption in the building and maybe changed costs for maintenance. Based on estimated savings, energy prices and prognoses for development over the next 30 years, the savings for the first year and in the following 30 years can be calculate.

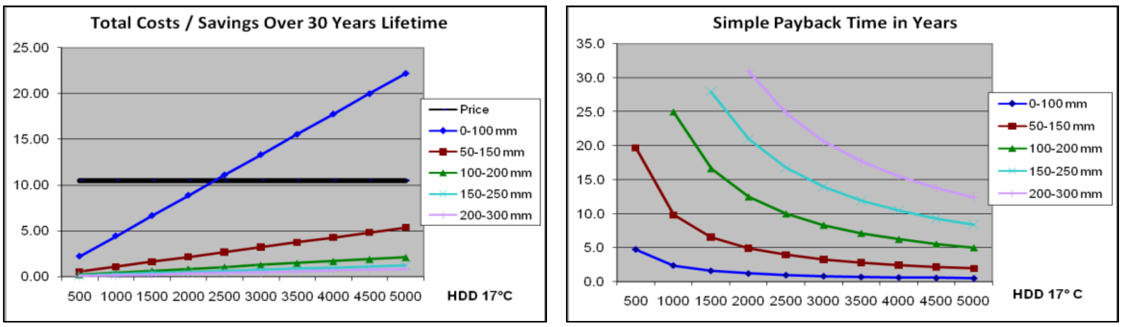
If savings over 30 years are larger than investment costs and costs for financing the improvement is said to be feasible, since it reduces the total cost for the use of in the building over 30 years. This should in general reduce costs for owners and users of these buildings.

Costs for investments, maintenance and savings can either be calculated summarised over 30 years or it can be calculated as a yearly average value for the costs and savings per year.

8.2 Energy efficiency optimum

Energy savings depend on climatic conditions. In cold and heating based climates this will mainly depend on heating needs given by the Heating Degree Days, in hot and cooling based climate this will mainly depend on cooling needs given by Cooling Degree Days.

Figure 6. Saving potentials and investments depending on the heating degree-days



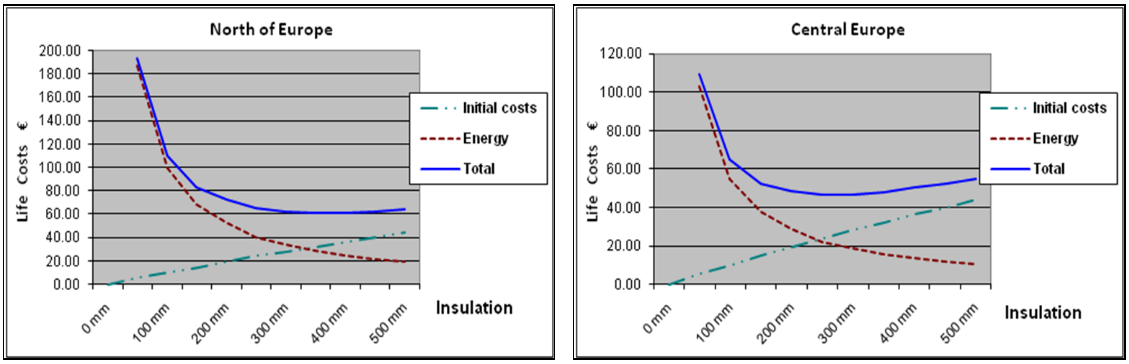
Example of a simple insulation of a ceiling construction shows that the saving potential for improvement of the building envelope is proportional with the increase in heating degree-days, but the savings for additional insulation will also decrease with increased insulation. First part shows the costs while part two shows the simple payback time for additional insulation.

For different climatic conditions, the optimum for part of the building or heating, cooling and ventilation system can be assessed for the optimal size of insulation or energy efficiency that would be the cheapest over a longer term (30 years).

Increased insulation will have the same costs independent of the climatic conditions. The savings will on the other hand depend highly on the climate and the amount of heating degree days, but will also be different for the first part and for the following insulation. A simple example on costs and saving is illustrated in figure 6.

Since savings from insulation is highly dependent of the climatic conditions, while costs for additional insulation is nearly independent of the climate, this will give a different feasibility of insulation in different climates similar will the optimal level of insulation is seen over lifetime[51]. A simple calculation for two different parts of in Europe is illustrated in figure 7.

Figure 7. Lifetime Costs for insulation in North of Europe and for Central Europe.



Life Cost Analysis for simple roof insulation in a climate with 4500 HDD 17°C [52] and for a climate with 2200 HDD 17 °C.[53] Cooling need is expected to be very low in these regions and savings on cooling are not included in the calculation.

Based on this example a least cost curve for insulation thickness depending on Heating Degree Day can be drawn for Europe. As shown in this graph, quite substantial levels of insulation in North Europe show the lowest costs over 30 years.

Such curves can be drawn for different parts of the building and for the heating, cooling and ventilation systems. However, the different types of insulation (glazing, heating, cooling or ventilation systems) will to some extent interfere and improved insulation might reduce the improvement benefits of a boiler and vice-versa. Reductions in total costs can also occur as energy savings will be greatly reduced that a smaller or no heating system will be required.

In a curve for insulation or efficiency there may also be points where additional costs appear because of increased thickness of constructions or changed solutions. Similar might the curves be influenced by local price levels and traditions[54].

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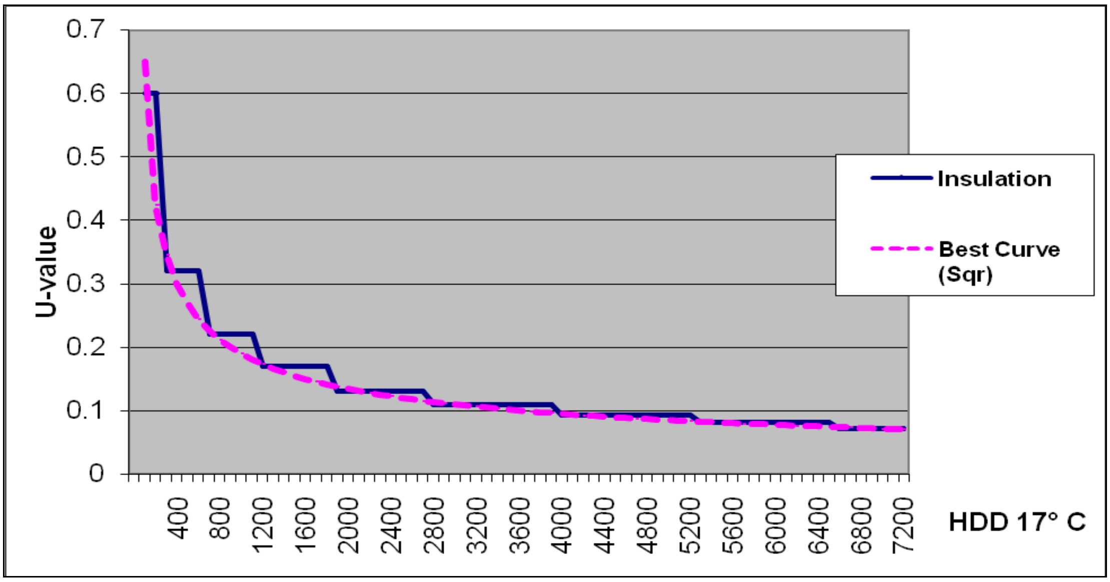
[51] The lifetime costs are calculated over 30 years and the savings in energy costs and maintenance costs are compared with the incremental investment. Interest rates are taken into account and so are expectations for future energy costs and so is inflation in general and for maintenance in particular.

[52] 4500 HDD 17 °C is climatic conditions similar to Scandinavia or central Canada.

[53] 2200 HDD 17°C is climatic conditions similar to Central Europe or Seattle or similar northern regions in US.

[54] An example on a curve based on local traditions is given in the following chapter on building codes in the European Union.

Figure 8. Curves for the optimum of life costs for simple insulation



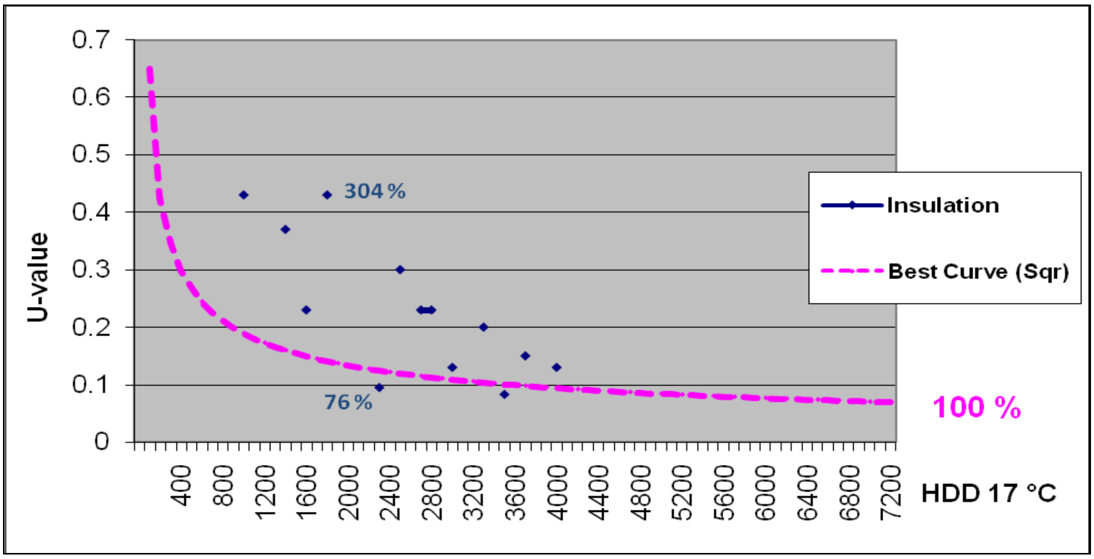
Least Cost Optimum for simple roof insulation based on additional layers of 50 mm each and a continuous best line. Curve estimates depending on the Heating Degree Days. This curve doesn't include savings from reduces heating or cooling systems[55].

An overall solution to this problem would be to estimate the least cost optimum for the overall energy performance of the building, although this is complicated.

8.3 Indicators for efficiency in new buildings

Based on the least cost curve above, an indicator can be developed. This indicator can show how far the demands in building code are from the least costs optimum for different parts of the building and the installations. A theoretical graph with this indicator is shown in Figure 9.

Figure 9. Graph on the indicator according to HDD



U-values for roof insulation compared to life cost optimum.

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55 Reduced need for heating and cooling can reduce total costs (principle of Passive Houses); this will reduce the optimum u-values even further, see paragraphs on passive houses.

Based on this least cost curve and indicator will also show how much of the optimum is achieved in individual countries. The optimum achievement could be set to 100 %. A value above 100 % would then show that the u-value is over the optimum. Values below 100 would indicate that the level for the building code is stricter than the optimum.

There could be good reasons to go beyond the least cost optimum for instance by setting a value for reduced CO_2 (in certificates or by subsidy), or because these requirements could be used to reduce the costs for energy efficient solutions in general or could be a part of a national policy to obtain greenhouse gas emissions. Similar will improved U-values be able to reduce the need for heating or cooling installations and this might reduce the total costs of the building[56].

9 General status in regions

9.1 Europe

In the European Union, the regulation for energy efficiency in buildings is based on directives, which have to be implemented in all the member states. The most important directive for energy efficiency in buildings is that on Energy Performance in Buildings.[57]

Energy Performance in Buildings Directive

According to this directive, all member states have to set standards for energy efficiency in new buildings based on the energy performance of the building. The performance has to take into account the building shell including air-tightness, heating and cooling installations, ventilation, the orientation and position of the building, passive solar systems and solar protection and the indoor climate according to the annex to the directive. For non residential buildings built-in lighting systems has also to be included. The positive influence of Active solar systems and other renewable energy systems, CHP[58], district heating or cooling and natural light also have to be taken into account.

Table 2. Annex with calculation elements required in the EPBD

Annex 1 1. The methodology of calculation of energy performances of buildings shall include at least the following aspects: (a) Thermal characteristics of the building (shell and internal partitions, etc.). These characteristics may also include air-tightness; (b) Heating installation and hot water supply, including their insulation characteristics; (c) Air-conditioning installation; (d) Ventilation; (e) Built-in lighting installation (mainly the non-residential sector); (f) Position and orientation of buildings, including outdoor climate; (g) Passive solar systems and solar protection; (h) Natural ventilation; (i) Indoor climatic conditions, including the designed indoor climate.

The requirements for the calculation are set in the annex of the directive. It is left up to the subsidiarity of the member states to set and develop models for energy performance.

It is up to member states to decide the level of energy efficiency requirements, but these levels have to be revised at least every 5 years and updated, based on technological development. In general, it is left up to the member states to set up the calculation

[56] See under passive houses later in this paper.

[57] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on Energy Performance in Buildings

[58] Electricity produced by combined heat and power.

method based on these conditions, but the European Commission has initiated an initiative where the European Standardisation Organisation[59] develops standards to calculate the different parts of the energy performance. 31 standards are under preparation for the calculation of heat loses, heat gains, efficiency in heating, ventilation, air-condition systems, lighting and automatics, etc.[60]

The European Directive on Energy Performance sets standards for major refurbishments or renovations of large buildings with more than 1000 m^2.[61]

The directive on energy performance further claims that buildings must have a certificate when constructed, sold, rented out. Large public buildings must be certified regularly. All new buildings have, therefore, to be certified. There have been discussions between member states during the implementation as to whether the best time for this certification is during design or after construction. During design certification can influence decisions and ensure that energy efficiency concerns are taken into consideration at an early design stage. Certification after construction can control the actual state of the building and guarantee that the energy efficiency requirements have been fulfilled. A few countries go for both types of certification[62].

Finally the directive on energy performance in buildings sets demands for inspection of heating and cooling systems.

A special homepage “Buildings Platform”[63] is supported by the European Commission giving information on the progress of implementation in member states and the directive in general.

Other directives

There are other directives that have a large impact on energy performance or energy efficiency of buildings. This includes the Eco-Design Directive[64] indicates the top set demands or demands for labelling of different appliances and products and the directive on Energy end-use and Energy Services[65] setting targets and demands for energy services and energy efficiency activities, and different labelling or energy minimum standard directives etc.

The Eco-design directive is aimed at the energy efficiency of products and appliances including many products installed in buildings such as household electrical appliances. This directive will, therefore, have an impact on the energy performance of buildings.

The Eco-design directive is a framework directive, defining the principles, conditions and criteria for setting environmental requirements for energy-using appliances (Eco-design). It therefore makes no direct provision for mandatory requirements for specific products; this will have to be done at a later stage for given products. The framework directive applies to all energy-using products that are placed on the market. It also covers parts that are intended to be incorporated into products, if the environmental performance can be

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[59] CEN, European Committee for Standardization.

[60] An overview of the standards can be found on the homepage www.builidngsplatform.org

[61] Larger renovations are defined as renovation, which costs more than 25 % of the buildings value or which concern more than 25 % of the building shell.

[62] Information from the project Concerted Action EBPD can be found on www.buildingsplatform.org.

[63] The buildings platform, http://www.buildingsplatform.org, is a project supported by the European commission to inform on the energy performance directive and the implementation in the European Countries.

[64] Directive 2005/32/EC of the European Parliament and the Council on the eco-design of Energy-using Product.

[65] Directive 2006/32/EC of the European Parliament and the Council on energy end-use efficiency and energy services.

assessed independently. All energy sources are covered, in particular electricity and solid, liquid and gaseous fuels.

General status

The European Union has set up a directive outlining basic requirements for energy efficiency standards for new buildings and by refurbishment, but many details are left up to the individual member state. In particular, the individual member state has to define the level of the minimum requirements for new buildings.

The European Commission has set up different facilities to work for harmonisations of the rules in the countries and among these are: The Concerted Actions EPBD[66], which is a cooperation project aimed at converging regulations in the countries. The Buildings Platform[67], which aims to share information on the implementation. Different frame programmes support projects providing input to develop rules in individual countries. These activities will include a project to develop a common building code standard for Europe based on different climates.

Most countries in the European Union have updated their energy efficiency requirements for buildings within the last 2 years or are in the process of setting up new requirements based on energy performance of buildings. The levels for these standards vary substantially.

Sweden

Sweden has very long tradition of energy efficiency requirements for new buildings. Already in the late 1970s stringent requirements was introduced in Sweden. Although they have only been slightly changed over time they are still today among the highest energy efficiency requirements in the world.

Table 3. Main values for the building envelope for new buildings in Sweden.

Building Code in Sweden	U-value W/K per m2	
	South	North
External Walls	0.13-0.14	0.12-0,13
Ceilings / roofs	0.15	0.13
Grown deck	0.16	0.13
Floors with heating	0.12	0.10
Floor over open air	0.10	0.08

The Swedish building regulation requires that individual values depend on the type of construction, and where the building is situated. All of the values for efficiency are high and comparable with the values for passive houses in central Europe.

Rules are set for ventilation and other thermal comfort and for efficiency in installed products, such as boilers and air conditioners. At the same time, values are set for the overall energy performance and consumption for the building. Values depend on whether the building is in the north or south of Sweden with different values for commercial and residential buildings.

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[66] Concerted Actions EPBD was a project formed in 2005 and ending in June 2007, but expected to continue in 2007 – 2010 with 29 states as members. Concerted Action conducts workshops and information share among the member states. Homepage www.EPBD.org.

[67] An information activity supported by the European Commission to inform on the implementation of the EPBD directive in general and in the individual member states on the homepage http://www.buildingsplatform.org/cms/

Table 4. Maximum overall performance values for new buildings in Sweden.

Building Code in Sweden	Overall performance values kW / m² per year	
	South	North
Residential buildings	110	130
Commercial buildings	100	120
Electrically heated Buildings	75	95

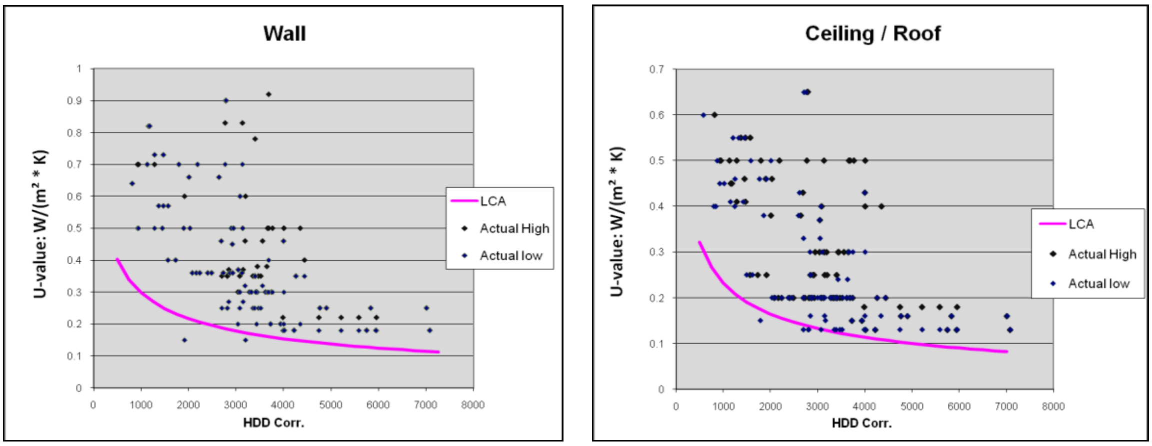
Energy performance values are set as maximum per m² floor area per year for the different types of buildings.

As well the values for maximal energy performance and the requirements for insulation of the building envelope are close to those for the Passive House standard[68]. The compliance with these values has to be documented with the actual consumption after construction.

Comparison U-values

If the values set by the member states of the European Union are compared with the least cost optimum over 30 years for the different types of energy efficiency requirements in the building regulation, then these requirements are shown to be quite far from this optimum.[69]

Figure 10. Comparison of energy efficiency requirements in the building codes and LCA



Wall and ceiling insulation is compared here with the Least Costs optimum (LCA).[70] The values for LCA values are estimated based on the actual climatic conditions in major cities in all the countries and with actual costs in this region.[71]

[68] Passive house standard sets vales for buildings with ultra low energy consumption and they are treated more deeply in a separate chapter later in this document.

[69] The costs for energy efficiency improvements in many cases are highly depend on weather there are only additional costs or if the whole costs have to be covered by the improvement. By construction of new buildings there will typically only be additional costs for efficiency requirements in building codes, since improvements can be planed before the actual products are purchased or installed.

[70] Values are calculated as annual costs based on a formula: $A + (1+j)^n * i / (1+n)^{n-i}$, where a = annuity factor, I = interest rate, n = lifetime. Lifetime for insulation is set to maximum 30 years even if savings by some types of insulation might last longer, because a new refurbishment of change of use might occur over time.

[71] The values for the LCA are based on the EURIMA and Ecofys study on building codes: U-values for better Energy Performance of Buildings.

There is a big difference in how close the values in the building codes are to the least cost optimum. Only a few countries have values, which are close to these values. Additional savings from reduction of heating and cooling installations not are included in the calculation. If these savings were taken into account the result would show lower values for the optimum and a larger distance between actual values and the LCA optimum[72].

The graphs also show that some countries have regions where some larger cities might be close to the line while other cities in the country are far from the LCA optimum. This would infer different energy efficiency requirements for different regions[73].

9.2 North America

Setting standards for energy efficiency in buildings in the US and Canada is the responsibility of individual states, but there is substantial difference between the systems in the two countries.

In the US state codes are generally based on model codes which are developed by private organisations in collaboration with US Department of Energy (DOE); International Energy Conservation Code (IECC)[74] by the International Code Council (IECC) and the ASHRAE standard[75] by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Inc. The DOE participate in upgrading the model codes and on publication the DOE is required to make on published a determination as to whether these new codes or revisions would save energy in buildings relative to the previous edition. By a positive determination for a new or revised IECC codes states are required to report and certify to DOE whether it is appropriate to update their residential codes to meet the new requirements, or they have to explain why it is inappropriate to do so. By a positive determination regarding the ASHRAE standard, states are required to update their commercial energy codes to meet the standard and demonstrate that they have done so.

The DOE is required to provide financial and technical assistance to assist states to upgrade, implement, and enforce their energy codes[76] and DOE provides information on the implementation of building codes in the individual states[77].

In Canada there is a similar situation where requirements for energy efficiency are set by the states based on model codes, National Building Code for Canada 2005[78]. Rules for energy efficiency for heating, ventilation and air conditioning are set in Part 6 of this code including calculation procedures for energy performance. The code is developed by the National Research Council, Canada and the Canadian Commission on Building and Fire Codes.

Two different standards

The ASHRAE and the IECC standard codes are both built on prescriptive efficiency requirements for each part of the building and installations or trade off models where

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[72] Least cost optimum is calculated with an oil price on 70 USD per barrel. After the calculations were done the price increased substantially. If this price level is used the least cost optimum would be lower and the distance between the actual level and the LCA even larger.

[73] The IEA seek to involve in a project wit EURIMA and ECOFYS in order to develop and test a model to estimate least cost options for energy performance in buildings.

[74] International Energy Conservation Code (IECC) 2004 supplement set by the ICC.

[75] ASHRAE/IESNA Standard 90.1-2004, Energy Standard for Buildings except Low-Rise Residential Buildings, set by the American Society of Heating Refrigerating and Air-Conditioning Engineers.

[76] 42 USC 6833

[77] Homepage http://www.energycodes.gov/implement/state_codes/

[78] Further information on the Canadian National Building Code and requirements and calculation procedures on http://www.nationalcodes.ca/nbc/index_e.shtml

buildings are compared to a model building. The ASHRAE's residential high-rise[79] and non-residential energy standards as well as the IECC, use four different methods for specifying climate dependent energy efficiency requirements.

Both standards are based on US traditions but in the last few years there has been a work to merge and complement the codes and a declaration to prepare the codes for use in other parts of the world. Both ASHRAE and IECC are model codes, which are intended to be adjusted to local conditions. Most states use the IECC for low-rise residential and simple buildings while the ASHRAE is used for large and complex buildings and for trade and service buildings.

Both the ASHRAE and the IECC includes requirements for existing buildings by refurbishment. The ICC has also developed a specific standard for energy efficiency in existing buildings IEBC, International Existing Building Code and the model code for residential buildings IRC, International Residential Code. The IEBC basically references the provisions of the IECC and the IRC. The IRC has a specific energy chapter which is substantially the same as select residential low rise portions of the IECC. However, the IECC and IRC are developed separately and there are some differences.

International Energy Conservation Code

The International Energy Conservation Code 2004 (IECC 2004) is a model building code or standard for energy efficiency of new buildings. It was devised by the International Code Council (ICC), and is based on US conditions and traditions for energy efficiency regulation. This code IECC 2004 sets rules for residential (with less than 4 floors) and for small and less complicated commercial buildings while it contains a reference for the ASHRAE for large and complex buildings[80]. There is an emphasis on new buildings.

Rules are based on climatic zones, which are set based on cooling degree days CDD and heating degree days HDD and some humidity conditions. In general, the US is split into 8 different zones, based on the level of cooling and heating. Some humidity conditions divide the zones into dry, humid and marine areas.

Rules are set as prescriptive values for building parts, heating and cooling systems, ventilation and lightning. Insulation requirements are set as R-values or U-factor where U = 1/R for each climatic zone separately. These values have to be fulfilled for each building part in the prescriptive model. Some specific regulations are given for pipe and duct insulation, air tightness, sealing, hot water systems, mechanical ventilation and circulation of hot water. Rules for heating and cooling equipment are only given as sizing requirements.

IEEC also includes a trade-off model where some parts can be made with less energy efficiency as long as the total building still fulfils the same overall requirements which would be the result of fulfilling each single demand. In this model the same values are used for the trade off model as reference values for the model building. The trade-off model is based on energy costs which take into account the different energy costs for gas, oil or electricity. Specific and more detailed values are set for some steel solutions. Finally it contains a frame with an overall assessment where total values have to be obtained.

The energy efficiency requirements for residential buildings and those for new commercial buildings are indicated in two separate chapters.

The prescriptive model is described as Mandatory Requirements, while the trade-off model is referred to as Performance Based requirements. Finally there are some requirements for the use of software for the Performance based model. Some basic assumptions are set for

[79] ASHRAE only address residential buildings with 4 floors or more above grade.

[80] According to the IECC small commercial buildings or parts shall either fulfil the requirements in the specific chapter for non residential buildings or the requirements in the ASHRAE.

the reference buildings used in the trade off model such as amount of windows (18 % of floor area) and calculation values.

Table 5. IECC 2004, Climatic zones

1	9000 < CDD50°F	5000 < CDD10°C
2	6300 < CDD50°F ≤ 9000	3500 < CDD10°C ≤ 5000
3A and 3B	4500 < CDD50°F ≤ 6300 and HDD65°F ≤ 5400	2500 < CDD10°C ≤ 3500 and HDD18°C ≤ 5400
4A and 4B	CDD50°F ≤ 4500 and HDD65°F ≤ 5400	CDD10°C ≤ 4500 and HDD18°C ≤ 5400
3C	HDD65°F ≤ 3600	HDD18°C ≤ 3600
4C	3600 < HDD65°F ≤ 5400	3600 < HDD18°C ≤ 5400
5	5400 < HDD65°F ≤ 7200	5400 < HDD18°C ≤ 7200
6	7200 < HDD65°F ≤ 9000	7200 < HDD18°C ≤ 9000
7	9000 < HDD65°F ≤ 12600	9000 < HDD18°C ≤ 12600
8	12600 < HDD65°F	12600 < HDD18°C

Climatic zones in the IECC 2004 are basically based on Heating and Cooling Degree Days although some also take into account the humidity. The zones are adjusted to the state limits to simplify the administration[81].

The IECC apply for major renovation and refurbishment projects too. The values R-values and U-factors (prescriptive) in the regulation have to be fulfilled in some renovation projects, for example a full exchange of windows must comply with the energy efficiency requirements for windows. A special standard is developed for refurbishment of existing buildings, International Existing Building Code (IEBC). [82]

Table 6. IECC 2004, U-factors in SI units

Climatic Zone	Fenestration U-factor	Skylight U-factor	Ceiling U-factor	Wood Frame Wall U-factor	Massive Wall U-factor	Floor U-factor	Basement Wall U-factor	Crawl Space Wall U-factor
1	6.81	4.26	0.20	0.47	1.12	0.36	2.04	2.71
2	4.26	4.26	0.20	0.47	0.94	0.36	2.04	2.71
3	3.69	3.69	0.20	0.47	0.80	0.27	2.04	0.77
4 Except Marine	2.27	3.41	0.17	0.47	0.80	0.27	0.34	0.37
5 and Marine 4	1.99	3.41	0.17	0.34	0.47	0.19	0.34	0.37
6	1.99	3.41	0.15	0.34	0.34	0.19	0.34	0.37
7 and 8	1.99	3.41	0.15	0.32	0.32	0.19	0.34	0.37

IECC 2004 U-factors for different climatic zones in SI units. [83]

[81] These zones were developed in a special project financed by DOE.

[82] Conversion factor Btu / (h * ft^2 * °F) => W / (m^2 * °K) for the U-factor = 5.678263337

[83] Implementation depends on legislation in the individual state.

ASHRAE

The ASHRAE 90.1 Standard 2004 is developed by the American Society of Heating, Refrigeration and Air-conditioning Engineers, Inc. This standard applies particularly to large and complex buildings, mainly in the commercial sector, but minimum efficiency requirements are set for all building types exempt for low-rise residential buildings. There is a small overlap between buildings covered by the IECC code and the ASHRAE standard as large residential, small or less complicated commercial buildings are covered by both.

In order to check the compliance with the standard, there is a requirement for labelling of installed equipment or components and also for building parts such as windows, walls and roof. The labelling of built constructions has to be made by the installer or constructor.

The requirements can be fulfilled either by prescriptive values or by calculation of energy consumption. As part of the ASHRAE standard there are normative appendices with values and calculation rules. Some parts are partly mandatory while others are only informative. There are links to different reference standards that have to be applied to the calculations.

Compliance

Compliance with the ASHRAE standard can be achieved in three different ways:

1. The Prescriptive Approach where all individual requirements for Building Envelope, HVAC systems, Service Water Heating, Power, Lightning and Other Equipment are achieved.
2. The Energy Cost Budget, where the energy consumption must be below a value calculated based on a calculation for the building and fixed values for efficiency.
3. The Design Energy Cost where all parts of the building and the installations have the same energy or better energy efficiency than the figures used for the calculation of the Energy Cost Budget.

The Prescriptive Method

Rules are set in ASHRAE section 5, 6, 7, 8, 9 and 10 and each part of this must be fulfilled individually. If compliance with one part is fails, the whole project is rejected.

Building envelope

The values for insulation and fenestration are given for the similar climatic zones as the International Energy Conservation Code IECC 2004, with 8 general zones of which some which are shared into A, B and C. All in all the code has 17 different conditions for the US while only the general 8 zones are used for Canada.

Values are set for the different parts of the building as U-factors or as R-values (U = 1/R).[84] Values are set for separation from conditioned space, heated and/or cooled, to outdoor, to semi-conditioned or unconditioned space and between semi-conditioned spaces and outdoor or unconditioned spaces.[85] Values are set for fenestration too, giving R-values or U-factors, solar heat gain coefficients (SHGC), visible light and transmittance (VT), shading coefficients (SC) for windows and glass areas. Finally values are given for air leakage.

The energy efficiency requirements for the zones are further shared in values for Non-residential, Residential and for Semi-heated areas. Some values for walls, floors and roof etc. depend on the type of construction – steel, massive, wood construction etc. Values for windows depend on the share of windows.

[84] Values are set in IP units, Btu / (h * ft^2 * °F).

[85] Also called the building envelope.

For the building shell it is possible to make a trade off, where some parts can be improved to a better standard thus allowing other parts to be of a lower standard as long as the total value is still fulfilled.

Heating, ventilation, and air-conditioning

Requirements for HVAC systems[86] are set for air-conditioners, Condensing Units (De-humiliation), Heat Pumps, Water Chilling Package, Package Terminals, Room Air Conditioners, Heat Pumps, Furnaces, Duct Furnaces, Unit Heaters, Boilers and Heat Reinjection Equipment in individual tables.

Values for insulation of ducts and pipes depend on the type of room in which they are located as the expected temperature inside the pipes and ducts. Requirements and instructions are set for automatics to control HVAC systems as well as for Freeze Protection, Humidification, Dehumidification, Leakage and Sealing. Compliance for HVAC systems are set based on the calculation method.

Service water heating

Requirements are set for commercial water heaters, sizing, efficiency, insulation of pipes and tanks, automatics, circulation pumps, pool heaters, heat traps etc. These are based on the size of the system in kW for electric systems and the Btu/h for gas or oil fired equipment. Compliance can be in the prescriptive method or in conjunction with the calculation method.

Lighting Other Equipment

Commercial lighting efficiency requirements are set as prescriptive values, including controls for the lighting system, such as automatic shutoff and space control and tracking. Values are set for efficiency in Luminary Wattage and for sizing. A special method is described for the calculation of lightning power density based on the type of functions used in the building (in W/ft^2). Values for electric motors are set depending on the horse power for the output.

General

The ASHRAE standard covers new buildings and their systems, new portions of buildings and new systems or equipment in existing buildings. Special rules apply to refurbishment of buildings if this includes extension or increase of the building outside the original building shell. Alterations of the building envelope shall then fulfil the prescriptive requirements.

In an annex to the ASHRAE, standard values for Heating Degree Days and Cooling Degree Days and other climatic information are given for the US and Canadian states, as for major cities. The ASHRAE standard is a very comprehensive standard for energy efficiency in buildings and values are set for different parts of the building, HCAC systems and other installed equipment at a very detailed level and for multiple climatic zones.

General status US and Canada

As it is up to the federal states in both US and Canada to set and enforce minimum standards for energy efficiency in buildings the energy efficiency requirements for buildings vary substantially over the North American continent. Most states have implemented regulations based on the ASHRAE standards for commercial and larger residential buildings and the IECC codes for small residential buildings.

Many states have chosen levels based on the recent levels in ASHRAE and IECC while other states have based the regulations on older versions of these standards or set standards at a lower level. Some states have chosen to take the energy standards further that the ASHRAE and IECC codes, this is in particular the case for California and Florida where substantial

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[86] HVAC systems are Heating, Ventilation and Air-Conditioning systems.

resources have been used to develop individual energy efficiency standards. Both the US and Canada provide web homepages with information on the standards in individual states.[87]

***California*,**

California has probably the most comprehensive minimum energy efficiency standards for buildings in the world. The standards are very detailed, and they regulate nearly every part of energy consumption in buildings including valuable explanations and examples. The Californian codes are shared in a relative simple[88] but comprehensive code for small residential buildings[89] similar to the IECC code and for non commercial and high-rise buildings[90] based on the ASHRAE standard.

The California energy efficiency standards for buildings set efficiency requirements which in many ways are higher than those of IECC and ASHRAE. The standards have specific values for efficiency for all parts of the building and for most energy consuming appliances and installations included in the energy performance in buildings are set in the standards and on a very detailed level.

The energy efficiency requirements can either be fulfilled in part (prescriptive rules) or by a calculation based on a comparison with fixed values and the fulfilment of the prescriptive rules (energy model building or a trade of model). The codes include some instructions for installers or constructors on how to fulfil the requirements. Energy efficiency requirements are set for different regions from very hot areas to cold areas in the mountains in the north. Values are set for different climatic zones.

In particular, minimum energy efficiency requirements compliance manual for non-residential and high-rise buildings are voluminous (more than 1000 pages), but it contains values which can be useful for many regions in the world.

Ontario

The energy efficiency requirements in Ontario were increased from 1st January 2007, leading to a reduction of an estimated 21.5 % of consumption in new small residential buildings and 16 – 18 % in large residential and non-residential buildings. This is achieved through an increase in the requirements for insulation, windows and efficiency in gas boilers. At the same time it was announced that these requirements for houses would be further strengthened with insulation levels increased in 2010, and that buildings from 2012 would have to meet a national guide line for energy efficient buildings. For non-residential buildings a further increase in energy efficiency will be implemented in 2012. Actual costs and the pay back times for building owners were calculated for these new demands.

Estimates over the costs and feasibility of increased requirements for new buildings shows that the first increase in 2007 were paid back in only 3-4 years, while the large reductions of 35 % for small residential and 25 % for non residential and buildings from 2012 would be paid back in only 5 – 8 years for typical new buildings.[91]

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[87] For US especially the http://www.energycodes.gov/implement/state_codes/ DOE homepage is giving an overview of the implementation in the individual state and it includes links to most of these standards. Additional proposals for energy efficiency are given by the Insulation industry, NAIMA, on WWW.NAIMA.org

[88] The Californian Code for small residential are more complicated than the IECC and most other codes for small residential buildings in other states in US and in Europe.

[89] California's energy efficiency standards for low-rise residential buildings.

[90] California's Energy efficiency Standards for Non-residential Buildings, High-Rise Residential Buildings and Hotels/Motels.

[91] More information can be found in The Power of Building Better, Increasing the Energy Efficiency Requirements of the Ontario Building Code to Create a Culture of Conservation.

Table 7. Estimated increased capital costs, savings and payback periods for houses, Ontario.

	Estimated energy savings	Estimated Increased Capital Costs	Simple Payback Periods
December 31, 2006	21.5 %	$ 1.600	3.0 years
December 31, 2008	28 %	$ 2.700	4.4 years
December 31, 2011	35 %	$ 5.900 – 6.600	6.9 – 7.9 years

Compared to the 1997 Building Codes and calculated for a typical 2000 square feet gas-heated house in Centre Toronto Area.[92]

This example shows that increase of energy efficiency requirements in new buildings can be very cost effective because seen over a 30 years period these savings will be a very profitable investment for the building owner[93]. It is planned that the new regulation will be followed by a labelling scheme which should make the improvements visible in the market.

Table 8. Estimated increased capital costs, savings and payback periods for non-residential and large residential buildings, Ontario.

	Estimated energy savings	Estimated Increased Capital Costs	Simple Payback Periods
December 31, 2006	16 - 18 %	$ 0.98 – 1.11 / ft^2	3.3 – 4.7 years
December 31, 2011	25 %	$ 1.40 – 3.46 / ft^2	5.0 – 7.7 years

Compared to the 1997 Building Codes and calculated for a typical high-rise residential and office buildings. The range depends on size, type, location and method of construction.

9.3 Japan

Energy efficiency in buildings in Japan is set by two different standards; Criteria for Clients on the Rationalization of Energy Use for Buildings for non residential buildings, and Design and Construction Guidelines on the Rationalisation of Energy Use for Homes for residential buildings. Both standards are part of the national Energy Conservation Law that was first adopted in 1979.

Mandatory schemes are set for the reporting on energy efficiency measures and for labelling of buildings. This includes that buildings with more than 2000 m^2 building have to report on the efficiency and compliance with these standards. Information on buildings that do not fulfil the requirements can be published by the relevant ministry. For small and medium sized buildings the energy efficiency requirements are not set as mandatory standards and there are no penalties for non compliance, but the Design and Construction Guidelines on energy efficiency, request the owners of small and medium sized buildings to make attempts to comply with these measures. [94] The jurisdiction of both the standards is

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[92] Background information from the Ministry of Municipal Affaires and Housing, Ontario. Source for estimates of Costs, Savings and Payback Periods http://www.mah.gov.on.ca/scripts/index_.asp

[93] Background information from the Ministry of Municipal Affaires and Housing, Ontario Source for estimates of Costs, Savings and Payback Periods http://www.mah.gov.on.ca/scripts/index_.asp

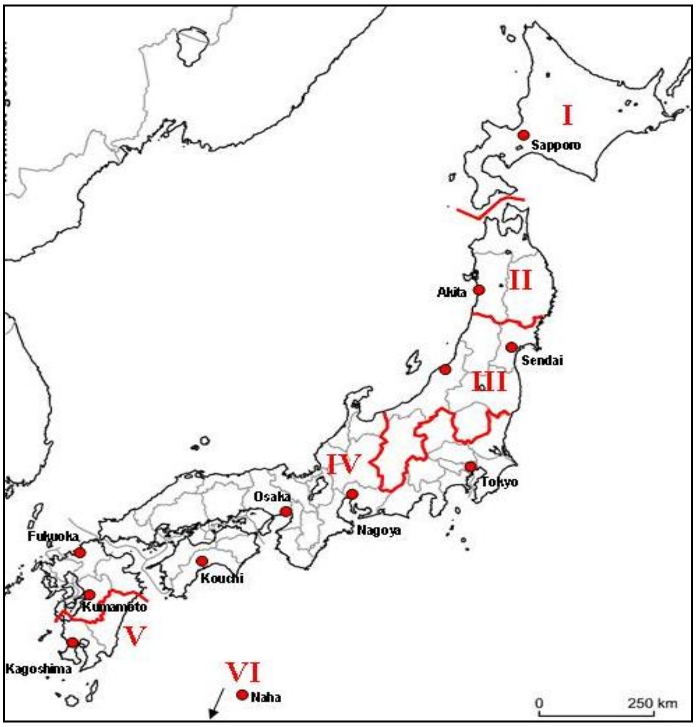
[94] Even though that the guidelines and the request to make attempts to fulfil these guidelines to some extend equals obligatory in nature in Japan's legal system it is the impression that the compliance rate is very low compared with other OECD countries.

in the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the Japanese government are preparing a change of the regulation which will make the standards mandatory for a larger part of the buildings and which will increase the enforcement of the standards.[95]

Residential buildings

The energy efficiency requirements for residential buildings are set in Design and Construction Guidelines on the Rationalisation of Energy Use for Homes. These requirements are in two parts of which one is prescriptive and the other is a performance model. The requirements for residential buildings are set for 6 different climatic regions.

Figure 11. The climatic regions in Japan



Values for buildings in Japan are set for 6 different climatic zones.

Energy efficiency in buildings can be based on a performance model as an option to the prescriptive model, where the values for the building are set based on the volume of the building.

Table 9. Maximum allowable space conditioning loads for houses by climatic areas

Area classification	I	II	III	IV	V	VI
Standard annual heating and cooling load (unit: $MJ/m^3/year$)	390	390	460	460	350	290

Values for the maximal energy use indifferent areas set per cubic meter or space in a residential building.

There is a specific calculation procedure, which has to be followed.

[95] The MLIT informed IEA in February 2008, that the revision will include mandatory requirements for all new buildings with more than 300 m² and that a further lowering of the threshold is still being discussed.

Values can also be based on a prescriptive model maximum where maximum values are set for energy loss through construction, U-values, for individual building parts depending on the type of construction and whether insulation is inside or outside the construction. These values vary for different parts of Japan.

Table 10. Energy efficiency requirements for heat transfer coefficients in residential buildings

Houses of reinforced concrete structure, etc.	Constructions using interior insulation	Roof or ceiling		0.27	0.35	0.37	0.37	0.37	0.37
		Wall		0.39	0.49	0.75	0.75	0.75	1.59
		Floor	Portions exposed to open air	0.27	0.32	0.37	0.37	0.37	-
			Other portions	0.38	0.46	0.53	0.53	0.53	-
		Floor edge in contact with earth	Portions exposed to open air	0.47	0.51	0.58	0.58	0.58	-
			Other portions	0.67	0.73	0.83	0.83	0.83	-
	Constructions using exterior insulation	Roof or ceiling		0.32	0.41	0.43	0.43	0.43	0.43
		Wall		0.49	0.58	0.86	0.86	0.86	1.76
		Floor	Portions exposed to open air	0.38	0.46	0.54	0.54	0.54	-
			Other portions	-	-	-	-	-	-
		Floor edge in contact with earth	Portions exposed to open air	0.47	0.51	0.58	0.58	0.58	-
			Other portions	0.67	0.73	0.83	0.83	0.83	-
Other houses		Roof or ceiling		0.17	0.24	0.24	0.24	0.24	0.24
		Wall		0.35	0.53	0.53	0.53	0.53	0.53
		Floor	Portions exposed to open air	0.24	0.24	0.34	0.34	0.34	-
			Other portions	0.34	0.34	0.48	0.48	0.48	-
		Floor edge in contact with earth	Portions exposed to open air	0.37	0.37	0.53	0.53	0.53	-
			Other portions	0.53	0.53	0.76	0.76	0.76	

Values for the different parts are set in W per °C pr sec. Different values are set for different types of constructions and for reinforced concrete structures, and other types of buildings.

Commercial buildings

The Criteria for Clients on the Rationalisation of Energy for Buildings sets rules for energy efficiency in commercial buildings and high-rise residential buildings. This standard is based on energy performance or energy frame values. These values are mainly set for two types of values PAL, Perimeter Annual Load for the performance of the building envelope and values CEC, for the Coefficient or Energy Consumption for the Equipment.

The two values are calculated by the following formulas:

$$PAL = \frac{\text{Annual space conditioning load in the perimeter zone (MJ/year)}}{\text{Area of perimeter zone } (m^2)}$$

$$CEC = \frac{\text{Actual Energy Consumption (MJ/year)}}{\text{Standard Energy Consumption (MJ/year)}}$$

PAL values are set in general for the whole building using the Perimeter Zone, which is set as perimeter spaces, that is 5m within the exterior wall, plus the top story just under the roof. There are also some correction factors to account for differing surface to volume ratios.

The CEC values are set for different parts of the HVAC systems. The values for PAL and CEC are set for different types of buildings and for different climatic regions of Japan. CEC values are set for the HVAC system in general, and specific for ventilation (V), lighting (L), hot water (HW) and the elevator (EV).

Table 11. PAL and CEC requirements by commercial building types

Building type	Hotel	Hospital or clinic	Retail	Office	School	Restaurant	Hall
PAL	420	340	380	300	320	550	550
CEC/AC**	2.5	2.5	1.7	1.5	1.5	2.2	-
CEC/V**	1.0	1.0	0.9	1.0	0.8	1.5	1.0
CEC/L**	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CEC/HW**	1.5 – 1.9 (depending on Ix)						
CEC/EV**	1.0	-	-	1.0	-	-	-

*The PAL values are set in MJ/m² per year, while the CEC values are factors for efficiency of specific appliances. Ix means sum of circulation pipeline length and primary pipeline length (m) over averaged daily water consumption rate (m^3). ** AC: Air-Conditioning, V: Ventilation, L: Lightning, HW: Hot Water, EV: Elevator.*

For V, L, HW and EV, equations are set by MLIT for the calculation of the actual and the standards of energy consumption.

Supporting measures

The voluntary standards for energy efficiency of residential and commercial buildings are supported by different measures including the Housing Qualification Assurance Law of 2000, setting rules for a voluntary housing performance labelling system for new buildings for the protection of consumers. This is based on many different aspects including safety, stability, and indoor air quality and energy efficiency. Building efficiency is rated in this system.

A voluntary system is set up for Green Building Rating; this system is called the CASBEE system, Comprehensive Assessment System for Building Environmental Efficiency.

The building efficiency standards for new buildings in Japan are also supported by the top runner program for energy efficiency in appliances including air conditioners and by energy efficiency standards for many appliances. The Top Runner Programme sets a high energy efficiency target for different products. Companies – who want to be a Top Runner – have to show that the average efficiency of their products is better than the minimum efficiency value. This helps to ensure that products of high energy efficiency standards are available on the market, including HVAC products such as heaters, coolers, water heaters and fans.

Conclusion

The Japanese regulations have lead to very high energy efficiency in appliances and other equipment installed in buildings. As well the building codes, the supporting initiatives promote the development of very efficient installations. In the building regulations the CEC values are set for the HVAC system in general and for the individual parts.

Energy efficiency in installed products is also highly promoted through the labelling standards and the top runner schemes, which has lead to highly efficient appliances in general.

9.4 Australia, New Zealand

In Australia the regulations for energy efficiency in new buildings are set by the national government, but to be enforced have to be adopted by the federal states. In the present building regulations there is a 5 star system for rating energy efficiency in both residential and commercial buildings. These stars have been quite successful and have been used to drive the market towards higher efficiency than minimum requirements. The fifth star was introduced in order to include a rating for buildings beyond the old 4 star system.

In the state Victoria the local government has decided to use 5 stars as the mandatory minimum requirement, and this way promotes and ensures highly efficient buildings. For the construction industry the energy stars function as a warning for future building regulations and gives the industry time to test new standards and develop appropriate solutions.

10 Developing Countries

10.1 China

Energy efficiency standards in China have been adopted in separate standards over time:

- Energy efficiency standard for residential buildings in the Heating Zone in north China, from 1986 and revised in 1995. (Heating Based Climate)
- Standard for the residential buildings in the Hot-Summer and Cold-Winter region in central China, from 2001. (Mixed Climate)
- Standard for the hot summer- Warm Winter in South of China, from 2003. (Cooling Based Climate)
- Standard for tourist hotels, from 1993.
- Standards for public buildings, from 2003.

Some of the major cities such as Beijing and Shanghai have special standards.

In the past, compliance with the existing regulations was a large problem. Although today this situation has improved, there is still need for further improvement.

Energy efficiency requirements are set based on U-values for constructions and these vary in different codes. The codes also set different rules for the HVAC systems for energy efficiency requirements for boilers, air-conditioners, insulation of pipes etc.

A new building code for all of China is under development and expected to be issued in 2008. Values will be set for 5 different climatic regions and are set separately for residential and for public (commercial) buildings. In some regions the energy efficiency requirements are further split in 2 – 3 different sets of requirements based on the Heating and Cooling Degree Days[96].

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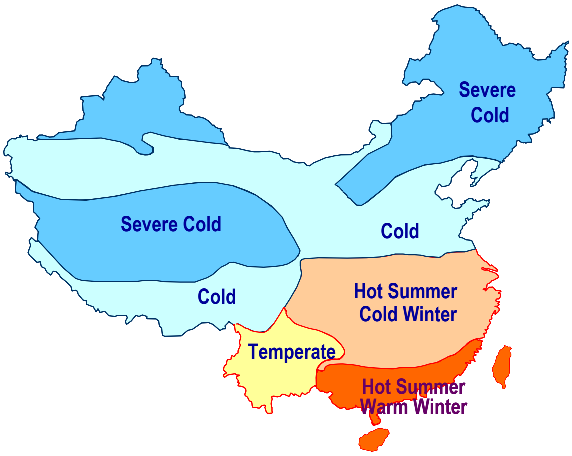
[96] Heating Degree Days 18 °C are used for heating and Cooling Degree Days 26 °C are used for the cooling.

The energy efficiency standard is developed by the Central Ministry of Construction, MOC, but the implementation and enforcement are to the responsibility of the regional governments.

China already has a green Building Rating System but is interested in establishing a certification or labelling system for buildings to help ensure the efficiency of new buildings and the visibility of energy efficiency in the market place.

Figure 12. China climate regions as defined by the Ministry of Construction.



Climatic zones in China as indicated by the Ministry of Construction. Severe Cold and Cold zones are the heating based regions, Hot Summer and Warm Winter and the Cooling based zones. Hot Summer Cold Winter and Temperate are the mixed zones where both cooling and heating is used.

Energy efficiency in new buildings in China is important as a substantial part of the world's new construction is in China. According to the Ministry of Construction in China, more than 2 billion m^2 are constructed in China every year, which accounts for more than 40% of all new constructions in the world.

10.2 India

Until 2007 there were no energy efficiency requirements for new buildings in India, but a new regulation for large commercial buildings were adopted June 2007. The building code target large commercial buildings, defined as buildings with a connected load of 500 kW or greater or a contract demand of more than 600 kVA or with a conditional area of more than 1.000 m^2.

The energy efficiency building code includes both a prescriptive and an energy performance method. The values for efficiency in the prescriptive part are very detailed and include many options. The building code is inspired by the ASHRAE code and the building code in California.

The building code was issued in 2007, but will be voluntary at first as it has to be adopted by each of the individual federal states to become mandatory. It may take further time before the code is enforced and controlled as this is the first time such a system is introduced in India. The Ministry of Power has estimated that it will take 1 year for the code to become mandatory and further 1 – 2 years before sufficient control and sanction systems are in place.[97]

[97] In the final communiqué from the joined India and IEA workshop on Buildings Codes and Energy Efficiency in Buildings held in Delhi the 4 and 5 November 2006.

The introduction and enforcement of a building code for large commercial buildings in India is very important as it is projected that India will build more commercial buildings in the next 5 – 7 years than exist at present.[98] Some of India's recent buildings have extremely high energy consumption for cooling owing to large glass surfaces with very little sun protection. Shading is an important part of the proposal for the energy efficiency building code.

11 Comparison of U-values in OECD countries

Comparison of energy efficiency demands in Building Codes, or standards for energy efficiency in new buildings, are as discussed earlier in the paper complicated, because the demands will dependent on local traditions and on the climatic conditions in the individual country or state. Sometimes the conditions even vary substantial within one country or state.

Since it is impossible to compare regulations between climates which are fundamentally different, comparison will only be made alone in heating-based climates or alone in cooling-based climates. In combined climates with extensive needs for both heating and cooling the comparison is difficult and different elements for cooling and heating have to be added or compared.

Much experience with setting requirements for energy efficiency exists in cold and heating based climates, as the lack of insulation or efficiency can lead to substantial health problems for residents. Energy efficiency regulations to reduce the need for heating are well-known in these parts of the OECD. This comparison will, therefore, concentrate on cold and heating based climates, where there little or no need for cooling or where cooling is only used to a minor extent and is of less concern. This climatic situation exists for the majority of Europe and a large part of the US and Canada, but also for a significant area of Japan, a part of southern Australia and for New Zealand.

As discussed in the chapter on different types of codes, the demands in energy requirements (Building Codes) can be set in fundamentally different ways; some codes set demands for the whole buildings energy performance while other codes have requirements on the individual parts of the building and the heating and cooling systems etc.

This comparison will therefore focus on values set on the individual building parts – prescriptive values – and will only include the building itself. The aim will be to compare u-values for different building parts and building regulations with the major aim of reducing heating.

11.1 Methodology

By this comparison, u-values for the individual building parts are compared separately. This includes values for ceilings, external walls, floors and windows. Different values are set in different states or regions. In North America, the values are set as R-values for building some parts as ceilings, walls and floors, while values are set in u-values for windows. All values are recalculated into u-values and the comparison is made in SI units.[99]

Some building codes sets values for different constructions such as timber frame walls, heavy massive walls or cavity walls. In this case both the lowest and the highest values are used and compared

[98] Information given at the joined India and IEA workshop on Buildings Codes and Energy Efficiency in Buildings held in Delhi the 4 and 5 November 2006

[99] Other values for windows, such as light transmission and shading, are not taken into account.

In the US, u-values for windows are often set as different values, depending on the amount and size of windows. Larger areas of window imply lower u-values for the windows and often these values are dependent on the ratio of windows to floor area – in this case both lowest and highest maximal values for windows are used for the comparison[100]. This can give multiple points for the same location in the same state and will hence spread the values further.

In Europe, u-values are in some cases only set as absolute minimum values, because the real values are determined by the total energy performance of the buildings. This gives to some extent a difference in the representation of the values. Hence, stricter values could have been used for the comparison, since the u-values in actual typical houses will need to be lower to fulfil the energy performance demands.

Values in the comparison mainly focus on those for residential buildings – where these values are mostly common - and in some cases only small residential buildings such as one and two family houses. For many countries these values are similar to those for non-residential buildings. However, in some countries these values for non-residential buildings are different or compliance demands are set different for these buildings.

The u-values are illustrated based on the climate in the countries, states or the cities. This is based on heating degree days. Values are calculated on base 18 °C and US values for 65 °F which are quite similar.

The comparison is made only for countries, regions or areas with major heating needs the so called cold climates and the heating based climates. This includes some states the US and some parts of other states,[101] Canada, most of Europe although only parts of some southern European countries, parts of Japan[102], southern parts of Australia and for New Zealand.

Cooling is taken into account for the areas within the heating based climates and 50 % of the cooling degree days base 18 °C or 65 °F are added to the heating degree days used for the comparison. This gives a modified number of heating degree days for the comparison, which is a little different from the values which can be obtained from the national weather databases.[103] All modified heating degree days are recalculated into HDD 18 °C.[104]

The calculation of corrected heating degree days can be illustrated as:

$$\mathbf{HDD_{corr} = HHD_{18^\circ C} + 0.5 * CDD_{18^\circ C}}$$

By the selection of u-values and climatic data major cities or a representative range of values are chosen for the individual countries and states. In the US, Japan and some European federal states, values are set for different zones in the states or the country. In this case some cities are chosen to illustrate different zones in the individual states or countries. Therefore, not all cities and all parts of states and countries are illustrated in

[100] Values can for instance indicate the level if the windows account for 12 % of the floor area and the graduated until they account for 25 %. Stricter levels are typically set by large are of windows. In this case minimum and maximum values are used in the comparison.

[101] Only countries, states or cities where the cooling needs in term of CDD 18° are less than 60 percent of the HDD 18 °C are included in the comparison

[102] The requirements for Japan are only set as guidance. These values are not mandatory, but are still included in the comparison.

[103] For the model building code – International Energy Conservation Code – the values for cooling degree days were only given for base 50 °F and these values are substantial higher than the values for 65 °F. The modified heating degree days for this code are hence only modified with 25 % of the cooling degree days to be comparable with the other values.

[104] Heating degree days in HDD 65°F are 1.8 times higher than values set in 18°C.

the graphs, only the representative areas and those parts representing cold or heating based climates.

Values for the individual building parts are set in many countries. These graphs only illustrates part of these – around 60 states and nations are represented in the graphs with more than 200 sets of u-values and modified heating degree days,

11.2 Possible misinterpretation of the values

Even when limited to u-values for building parts there is a big difference in the way these values are set in the different regions. Some countries set different values for different types of walls or floors and maybe there are even some types of constructions, which are not regulated. Other countries set one common fixed value, which cover all types of walls. This is also the case for ceilings and roofs or different types of floors, depending on whether these floors are placed on grown or over air.

Some countries only use u-values to support an overall demand for the energy performance, where the real requirements for insulation and efficiency are set. Hence, u-values only represent the absolute minimum for the constructions – maybe only for health reasons or to prevent moisture or lack of comfort - while the real values normally will have to be higher to ensure compliance with the overall performance requirement. In this case the u-values represent a kind of “a lower minimum requirement”. This is often the case in Europe, where the Energy Performance in Buildings Directive requires that building codes are set based on the energy performance of buildings. In other states or countries values are set either on prescriptive u-values or as an overall frame for the building. This means that values can often be lower than the maximum u-values given in the building code, and that these values represent “a minimum requirement”. This will in general underestimate the demands in some European countries, since the actual u-values have to be lower.

For some countries or states there is a possible trade off between the values, but this only influences the actual levels to a very limited extent. This is the case for most North American values. In the US, values for windows are often set depending on windows area in the building and different values are set based on the percentage of windows in relation to floor area. In some cases increased area of windows even increase the requirements for other building parts too. In this case multiple values are presented in the graphs.

In other states and countries the values are the absolute minimum, while the stricter demands by increased area of windows are regulated trough the demands for the overall performance of the buildings, which automatically will increase the demands for the windows or for other parts of the buildings with increasing area of windows.[105] This gives a difference in the values and the best US values should hence be lower than the European values.

In some regulations u-values are set to take into account losses in thermal bridges, in other regulations specific values are set for thermal bridges while the u-values for the construction only covers the general value. This can influence the values to a minor extend. Similar, separate values for transmission constants, thermal bridges, light transmission etc. can be set in building codes, while other codes only include only one single value.

These differences have to be taken into consideration when values are compared and the results are analysed.

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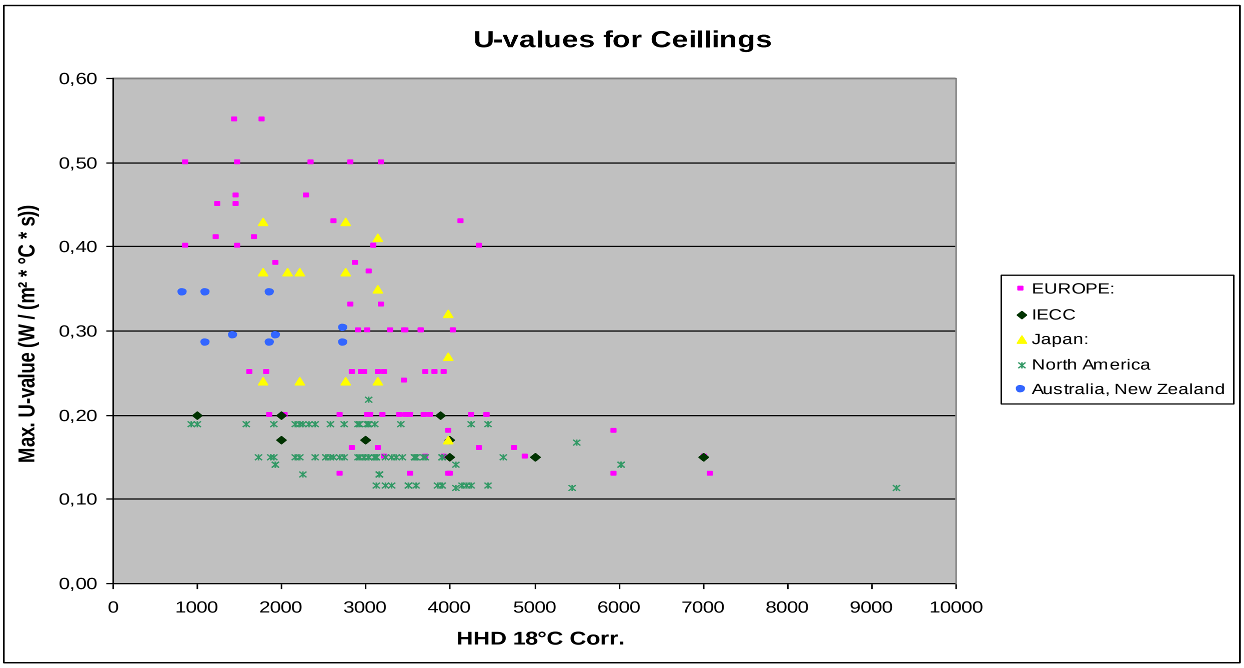
[105] When windows are included in overall energy performance requirement, larger surface of windows increase the heat loss and this will automatically raise the demands for windows or for other parts of the building. In countries with energy performance requirements there will hence typically be no differentiated demand for windows.

11.3 Comparison ceilings

Figure 13 illustrates the u-values for ceilings, roofs or used attics. Values are shown as a function of modified heating degree days.

Figure 13. U-values for ceilings for selected OECD countries with cold or heating based climates.



Heating degree days for heating based countries are modified for cooling. Values for ceilings also include values for insulation around heated attics or in roofs. One location can be represented by if more different values are set for different types of constructions.

There are large differences in the level of requirements for u-values for ceilings in the OECD countries. The requirements for ceilings are rather high in North America compared to other regions meaning that the u-values are substantially lower than Europe, Japan and Australia. In general, U-values in the US and Canada are close to or slightly better than the IECC 2004 standard and u-values are typically under 0.20 W per m² per second and per °C.

In Europe the values are quite spread and there is a substantial difference between south and north. Values for northern Europe are close to the US values, while level for the values for southern Europe varies substantially and generally is higher than values from similar climates in the US.

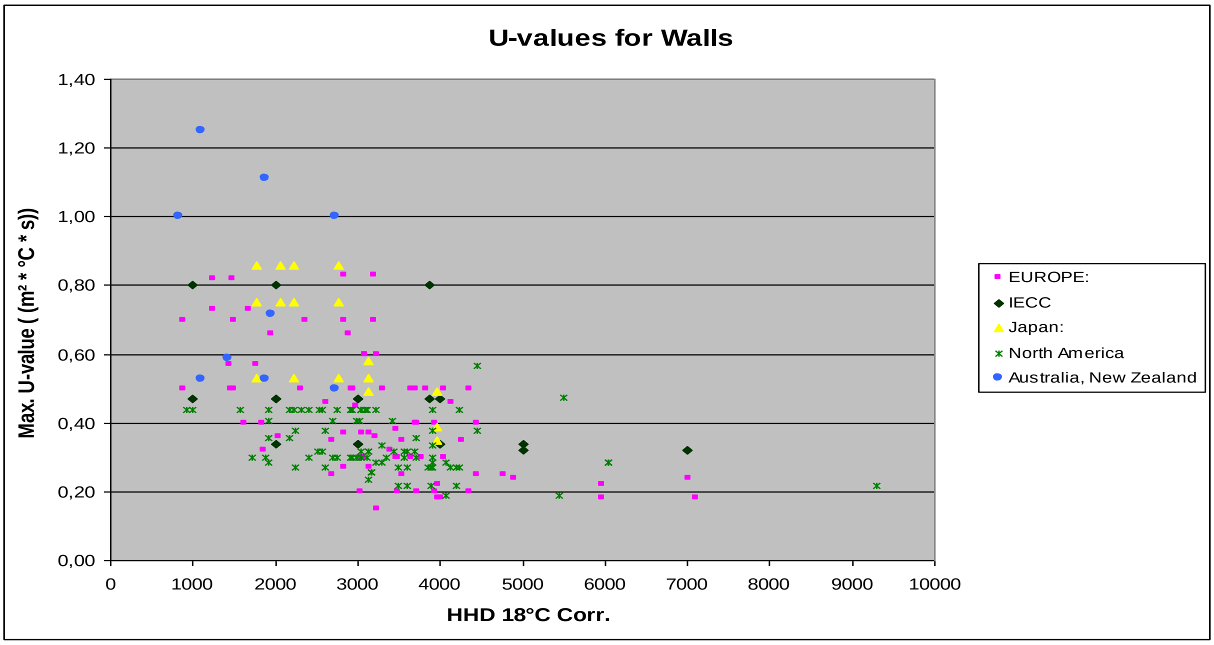
11.4 Comparison walls

U-values for walls for three construction types: timber frame, massive or cavity walls are shown in Figure 14. Values are shown as a function of modified heating degree days.

U-values for walls are rather diverse in all regions and there are large regional differences. These values vary, especially in Europe, and there is a large difference between the north and south of Europe. Values from north of Europe seem to be slightly stricter than for similar climates in North America. Values from the south of Europe are often substantially higher than for similar climates in North America. Japanese values are in general higher both for concrete enforced buildings and for wooden constructions.

Most states in the US and Canada have implemented higher demands for external walls than the values in the mode building code IECC. For some codes only certain types of walls are included or there are different values for timber frame and heavy constructions. Many states in North America are represented by more values for different types of walls.

Figure 14. U-values for external walls for selected OECD countries with cold or heating based climates.



Heating degree days for heating based countries are modified for cooling. Values include values for timber frame constructions, massive walls and cavity walls. One location can be represented by multiple dots.

11.5 Comparison floors

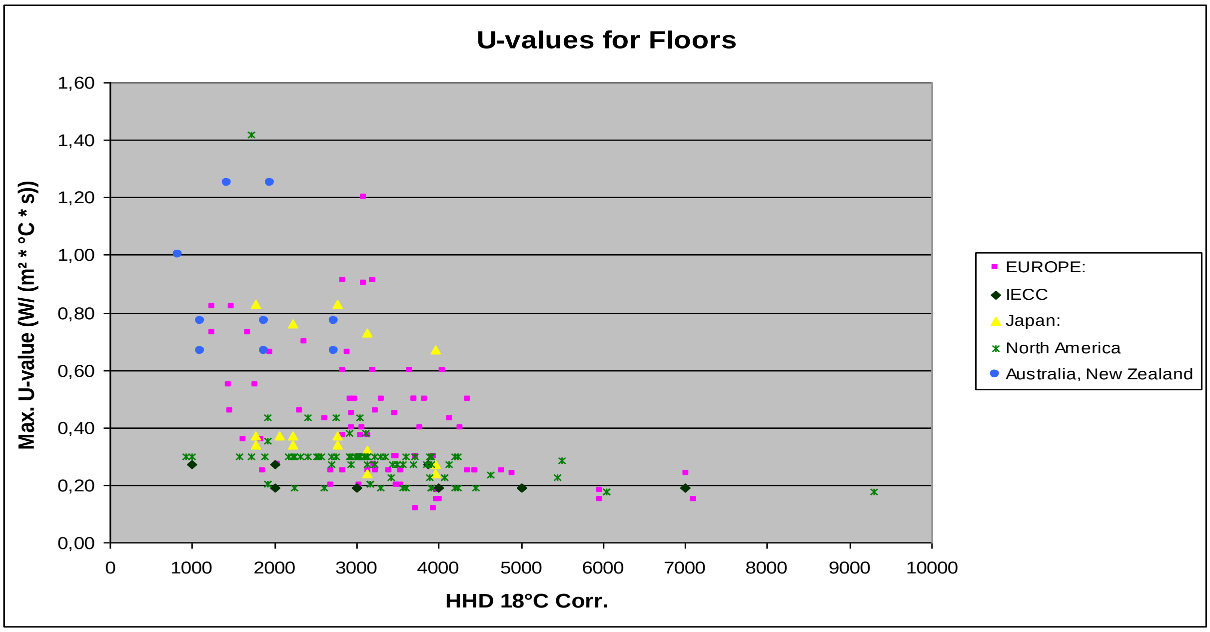
Figure 15 illustrates the u-values for floors on slab ground, over unheated cellars or over open air. Values are shown as a function of modified heating degree days.

U-values for floors in heating based regions of North America are in general lower than the similar values in Europe. In particular, this is the case when values from southern Europe are compared with similar climates in the US. In some northern countries in Europe the values are, however, stricter than the similar climates in the US and Canada. Japanese values are rather consistent with the European values. The Japanese values for timber frame constructions are even close to American values. U-values in North American states tend to be at level or higher than the model standards IECC.

11.6 Comparison windows

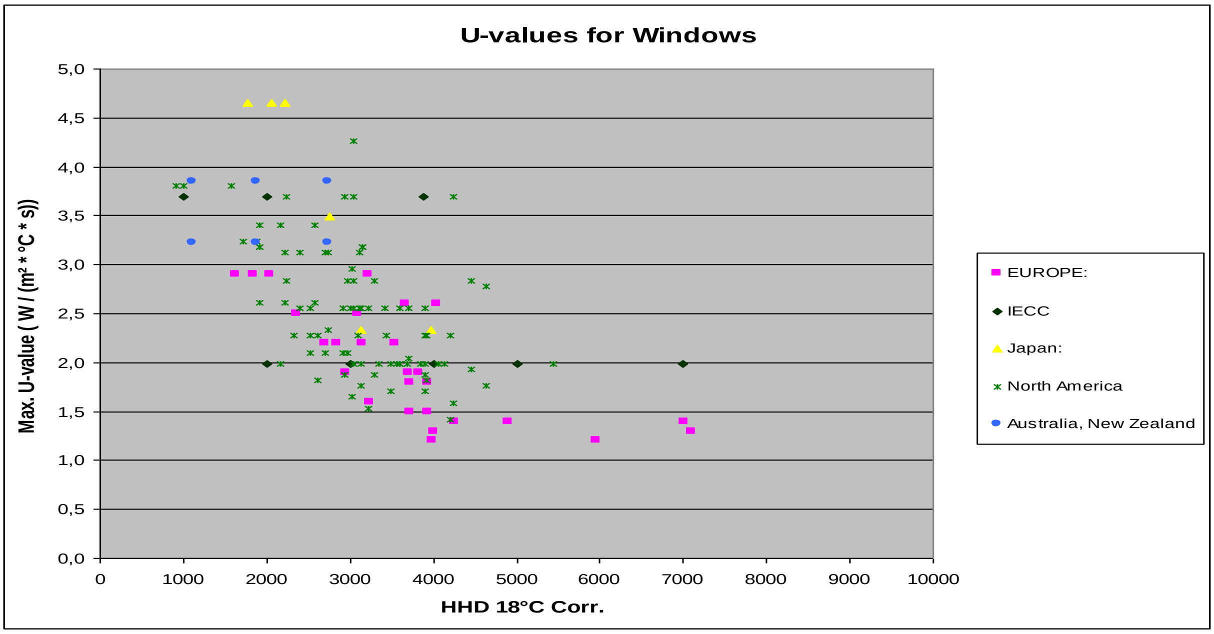
U-values for windows are illustrated in Figure 14. Values are shown as a function of modified heating degree days.

Figure 15. U-values for floors for selected OECD countries with cold or heating based climates.



Heating degree days for heating based countries are modified for cooling. Values include values for floors on the ground, over air or over unheated heated cellars. One location can be represented by multiple dots.

Figure 16. U-values for windows for selected OECD countries with cold and heating based climates.



Heating degree days for heating based countries are modified for cooling. One location can be represented by multiple dots if different values are set depending on the area of windows.

The u-values for windows vary substantially and there is up to a factor 3 between the most efficient and the less efficient windows in similar climates. Requirements for windows are stricter in Europe than in the US and Canada, and some states in North America do not have requirements for u-values in windows. Some states set requirements for types of windows, for instance double glass or for energy efficient glassing.[106]

Values for North America are rather diverse and several states have implemented values, which are stricter than the requirements in the model building codes. For some US states, there are different values dependent on the surface of windows meaning that a larger surface of windows will lead to a higher demand for the windows.[107] Several values can be shown for these states and this adds to the diversity.

11.7 Overall comparison of prescriptive values

As can be seen from the comparison of the individual parts of the buildings there are substantial differences between the different regions of the OECD. These results do not point in favour of one single region, but show that lessons can be learned in all regions and that there is still room for improvements of the requirements.

To valuated the total efficiency of the building envelopes of these prescriptive regulations a common over all u-value could be developed. This overall value would take into account the values for ceilings, walls, floors and windows. A simple overall u-value adds the u-values for ceilings, walls and floors with a modified value for windows. Windows are in this value only calculated with 20% since the area of windows for small residential buildings normally will be less than 20 percent of the floor, ceiling and wall areas, and because the values for windows would otherwise totally dominate the overall u-value.

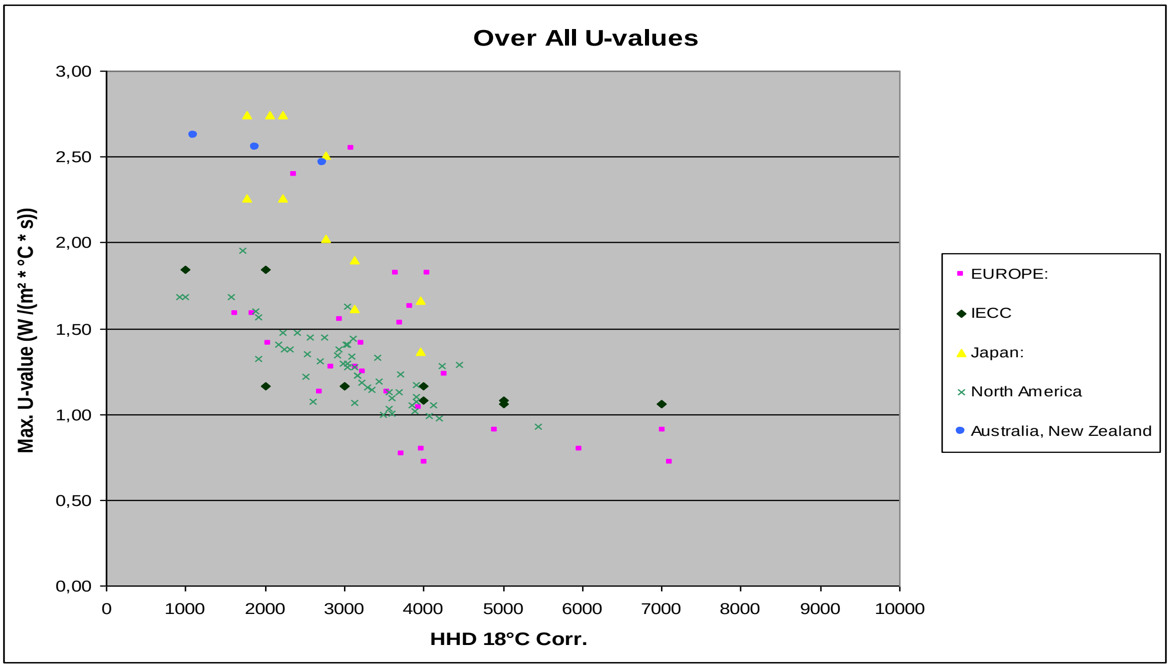
$$U_{overall} = U_{ceiling} + U_{wall} + U_{floor} + 0.2 * U_{window}$$

The overall U-values for requirements, which include all these u-values, are shown in Figure 17. In case there are different u-values for the same construction part the value is calculated as a mean between the maximal and the minimal value for these parts giving only one value for each city, state or country.

[106] Energy efficient glazing could be low energy glassing with double or triple layers of glass windows, and / or where the room between the windows is filled with gasses with thermal reduction and where the glass is covered with foil to reduce the transmission of heat or sunlight.

[107] These values can be set a window area on 12 % of the floor area, with additional and gradually stricter values for 15 %, 18 %, 21 % and up to 28 %. In case of several values highest and lowest value are plotted on the graph.

Figure 17. Overall u-values for selected OECD countries with cold or heating based climates shown as function of heating degree days.



Heating degree days for heating based countries are modified for cooling. Values include values for ceilings, walls, floors and windows. One location, state or country is only represented by one dot.

There is a big difference in how the prescriptive requirements are implemented in the different regions. In Europe there are substantial differences between the northern and the southern parts. In the north of Europe the requirements are quite strict, while the picture is more mixed in the South.

In North America the requirements seems to be more homogenous, probably because of the model codes for energy efficiency of buildings the IECC and the ASHRAE. Values for the states are in quite good compliance with especially the International Energy Conservation Code, IECC.

The most strict code in terms of overall u-value was found in Sweden with an overall value close to 0.7, followed by Denmark (0.77) for renovation or extensions, while u-values are not set for totally new constructions[108], and Norway (0.84) and then followed by Finland (0.94) and Ontario for the coldest part of the climate with more than 5.000 HDD 18°C (0.93).

The Swedish building code is in fact based on energy performance and the values for individual building parts are only set to support these values. Buildings will, therefore, typically have to be built to even stricter requirements than these u-values in order to fulfil the over all values.[109]

The main level for prescriptive values in the building codes in Central Europe and North America are approximately at the same level.

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[108] Values for new constructions in Denmark are only set as an overall performance. U-values will typically need to be lower than the above values for extensions and refurbishment. Some u-values for new buildings are set to avoid condensation and loss of comfort and some standardisation.

[109] The actual level of u-values in Sweden based on the energy performance demand is shown earlier in this paper.

Passive houses[110] would be substantial lower than these values and would have a value close to or less than 0.5 compared to the Swedish values on 0.7 and other values, which with few exceptions are larger than 1.0. Using passive house standards as building codes would, therefore, typically more than halve the energy losses in new buildings alone by better requirements for the building envelope.[111] For some countries this is even a reduction by up to 75 – 80 %.[112]

11.8 Comparisons Cooling Based Climates and Energy Performance

There are less data available to compare for hot and cooling based climates and a different valuation needs to be made concerning the different building parts, since the ceiling insulation is highly efficient and needed, while there would be less concern on insulation of floors, because floors can have a cooling effect in the hot seasons.[113] Windows would also need a special treatment and this should include shading as well as light transmission, which needs to be taken in account in the overall evaluation.

Comparison of energy performance will require more details on the calculation methods including which consumptions are included and how the calculation is performed. When requirements are set as energy performance or an overall frame this is calculated in different ways in different countries and regions since only regional or national calculation methods exists so far. A complicated model or method needs to be established to compare performance values. This will require many decisions and an agreement on the right model on how to compare and treat different elements, which will influence the comparison substantial.

11.9 Conclusion

When prescriptive values in building codes are compared based on heating degree days there are some differences between the regions. Requirements for ceilings and floors are relatively high in North America, and values for ceilings are higher than comparable climates especially in Southern Europe and Japan.

Requirements for walls are higher in Northern Europe than in North America and Japan, while the values for walls are higher in the US than in similar climates in Southern Europe. Requirements for windows are higher in Europe than in North America.

In the US and Canada most values are close to or slightly better than the model building codes for energy efficiency and they seem to be quite homogenous. Values in Europe vary substantial and especially there is a large difference between high demands in the North and more differentiated and lower demands in the South of Europe.

The highest requirements for u-values are found in the Nordic countries and in Ontario in Canada. Sweden has the highest requirements found in this comparison of u-values closely followed by Denmark and Norway.

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[110] See the information paper on Energy Efficiency Requirements in Building Codes and Energy Efficiency Policies for New Buildings.

[111] In passive houses the supply of energy from sun as from persons and appliances will take a much larger share than in traditional buildings. This will mean that such standards – based on passive houses - would dramatically reduce consumption in cold and heating based climates, where these buildings are well tested and often feasible.

[112] In passive houses the energy demand would be further reduced through efficient heating and ventilation systems, from heat recovery and other energy efficiency measures.

[113] Different studies indicate that floors can have a cooling effect in the hot seasons. This indicates that floors should be less insulated in cooling based climates. See for instance the ECOFY studies on energy potentials in Europe. Roof will on the other hand have a larger impact since the roof is both heated by outdoor temperature and direct sun radiation. In cooling based climates there is hence an increased need to balance the values and to use energy performance in the regulation

Lessons can be learned in all regions of the OECD and there is a substantial room for convergence especially in Europe. Compared to passive houses, there is still quite some room for improvement of building standards.

12 Enforcement, encouragement

12.1 Why are carrots and sticks needed?

High requirements for energy efficiency in new buildings will only have an impact if new buildings are actually constructed in accordance with the requirements.[114] Since there are so many barriers and as the construction of new buildings is complicated, there is a need for enforcement of efficiency regulations for new buildings.

Often there is a high interest in the incremental costs of a new building, and during design and construction to keep down the costs even if this increases the final cost for the users of the building. This will as mentioned under barriers for energy efficiency normally work against energy efficiency because the gain of low energy consumption will only show with time while the increased costs are immediately evident.

The building process in general is complicated and complex for the ordinary builder and difficult for buyers of new buildings to ensure that the rules for energy efficiency are fulfilled. Good building codes should therefore be combined with strong enforcement systems.

12.2 Enforcement systems

Enforcement systems will depend on the type of building regulation that is used. If building efficiency is a part of the general building codes and rules for buildings it will often be enforced in the same system as other requirements in the building codes. If the code is set in a specific standard it may be decided to leave the control up to a specific system for energy efficiency or to combine this with other types of control. In many cases, it is up to the local authority to control the compliance on building regulations.

Both systems have advantages; if the control is combined with that of other building regulations this will typically imply systems to deny buildings to be taken into use or other sanctions which also apply for safety reasons etc. But, on the other hand, if compliance is controlled by energy efficiency specialists this may ensure that these controllers have the necessary knowledge.

In some countries control of efficiency is based on accreditation systems where responsible experts can loose the right to construct or to apply for permits if the rules are violated.

Examples on enforcement

One example of an initiative to support building codes is an energy inspection of buildings. According to the European Directive on Energy Performance all new buildings must be certified by an independent expert. Some countries use this to ensure that energy efficiency requirements are fulfilled, for example both Portugal and Denmark have introduced new regulations. In both countries the buildings energy efficiency must be declared before the building is constructed. This can be done by the architect or the company responsible for the construction. After construction, a certificate has to be issued by independent consultants including review of the self declaration. If the building fails to

[114] The compliance of building codes is a major problem in many countries both in the OECD and in the developing countries. IEA will conduct further studies on compliance with energy efficiency requirements in 2008 and this will include building codes.

comply with the regulations, the use of the building can be denied until an adequate efficiency level has been obtained[115].

In Denmark these requirements are based on investigations which showed that as many as 67 % of all new buildings failed on the energy efficiency requirements for insulation of pipes and tanks, and that up to a 1/6 of general construction costs was used to repair constructions and installations, which were incorrectly carried out in the first place.

Several countries use certificates of compliance of energy efficiency requirements for new buildings, including many European countries, Japan and Australia.

12.3 Encouragement systems

Another incentive to fulfil building codes or efficiency standards can be given through encouragement systems, which support compliance with requirements. This can be a subsidy, which will only be obtained if certain energy efficiency requirements are fulfilled. These can either be based on the pure compliance with requirements in the codes or it can be requirements, which are stricter than the energy efficiency requirements in these codes.

Examples on encouragement

In different regions of Austria there are subsidies combined with energy efficiency requirements, which are stricter than the minimum requirements in the building codes. This can be additional insulation, improved windows or installation of renewable energy sources such as solar collectors, photo voltage or biomass ovens or boilers. In some Austrian provinces this has lead to nearly all buildings being constructed with an energy efficiency which is better than the requirements in the codes, but as a minimum the requirements are fulfilled.

In US tax incentives have been given in the last years to increase the level of insulation and to encourage the constructer and building owners to go further than the minimum requirements. These incentives have probably also helped to increase the compliance with the codes.

13 Beyond the Building Codes

Building codes and energy standards for minimum energy efficiency set minimum requirements for energy efficiency for all new buildings. In many cases it is as shown above possible and feasible to build with a much higher efficiency thereby improving the economy over the long term. No building codes or energy standards found in this study limit constructors or future owners to go for higher energy efficiency. But still the vast majority of new buildings are constructed exactly with minimum requirements of energy efficiency.

However, some buildings aim for much higher efficiency standards and among these are:

- Low Energy Buildings
- Passive Houses
- Zero Energy Buildings and Zero Carbon Buildings
- Plus Energy Buildings

Other types of buildings also aim at higher standards beyond the requirements in energy efficiency standards and buildings codes, for example, Green Buildings, Intelligent Buildings, Integrated Design, Sustainable Buildings or Ecological Foot Print.

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[115]The requirement to deliver a certificate is a part of the building code and the control of the certificate is a part of the general compliance check done by the local authorities. The consultants responsible for the certificates are certified and controlled through the national certification scheme.

13.1 Low Energy Buildings

This term is generally used to indicate that buildings have a better energy performance than the typical new building or the energy efficiency requirements in building regulations, and that the building hence will have a low energy consumption compared to a standard building.

In some countries or regions, low energy buildings are defined by the building codes or in relation to the energy standard. The low energy buildings can be defined as having half the energy consumption or a specific percentage of those constructed according to the standards. Unfortunately there is a large variety in how efficient this will be. First of all it will depend on how this percentage is set and on the actual energy efficiency requirements for buildings or the general standards for new buildings. A building which can be classified as low energy in one country may use more energy than a standard building from another neighbouring country. In some countries the definition of low energy buildings is vague and may be used for all buildings that are better than the minimum standard.

Over time standards have improved and what was low energy standards some years ago may be standard today. If there is no protected definition for low energy buildings this may lead to all new buildings being called low energy, and that consumers will be presented with a low energy building even if it hardly fulfils the actual energy efficiency requirements.

In some countries, therefore, the term low energy buildings can be a little confusing since it has no clear definition. In other countries it is clearly defined and a useful guide for those who want a buildings with efficiency above the standard.

Energy Star, positive labelling

For many countries in the European Union a level beyond the building code is defined as a part of the certification of new buildings, which has to be implemented as part of the Energy Performance in Buildings Directive. Typical specific classes such as A or B on a scale from A-G or A+ and A++ are used to indicate that these buildings are built better than standard. Some countries have used a large part of the scale or even the whole scale to show the difference in new buildings using all the letters from A-G to classify new buildings.

In Germany, Austria, Denmark and Switzerland special standards exists for low energy buildings. Niedrigenergihäuser (G, Au) 30 W/m² per year, Minergie® (Sw) 42 W/m² per year[116] of heat demand for space heating and sanitary hot water and Low Energy Class 1 on 50 % and 2 on 25 % reduction of the energy needs in the building code (Denmark).

In Australia different stars are used to show the efficiency of buildings. As many as 5 stars are awarded for maximum energy efficiency. With the increase in energy efficiency requirements over time, the minimum requirements in the state of Victoria are equivalent to 5 stars.

In the US a label called ENERGY STAR is used for buildings which use 15 % less energy than the requirements in efficiency standards for new buildings as defined in ASHRAE and IECC 2004.

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[116] The 1.1.2009 the maximal transmission value for Minergie is reduced from 42 W/m² to 38 W per m².

13.2 Passive Houses

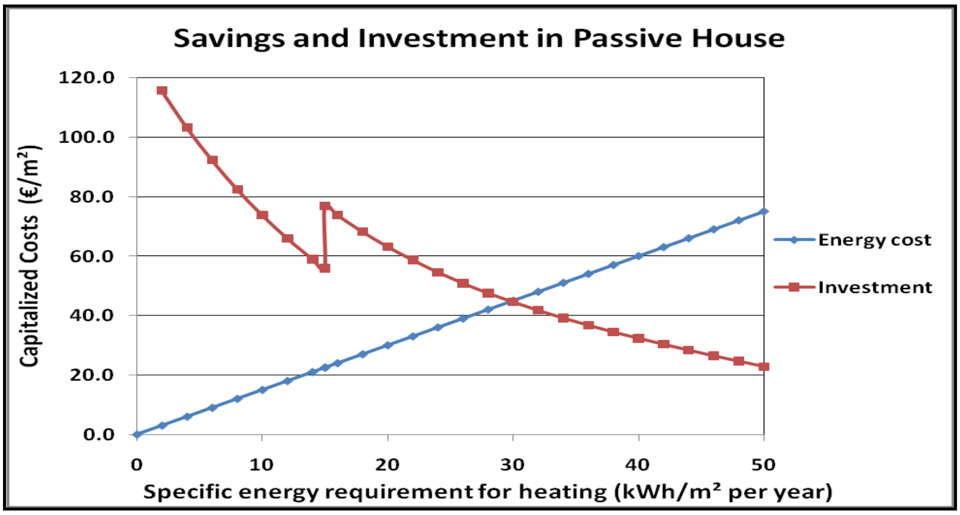
A passive house is a building in which a comfortable indoor climate can be obtained without a traditional heating or cooling system. Compared to traditional building they use far less energy. For most countries these demands are 70–90 % reduced compared to the actual energy efficiency requirements for heating and cooling, but this depends on the actual energy standards. For countries with high energy efficiency requirements it is less.

The principle of a passive house

With increasing efficiency the additional costs for energy efficiency measures will increase. In general the most cost effective measures will be used first. The closer the building comes to zero energy consumption the more costly measures are hence needed to increase energy efficiency and reduce the consumption. At the same time there will be different options where savings will occur, because some installations or equipment is no longer needed.

One of the most interesting reductions in costs is when the energy consumption is getting so low that a traditional heating system is no longer needed and building relationally can be heated alone with the passive solar gains and the ventilation systems.

Figure 18. The additional costs and savings in a Passive House.



Passive house, with increasing efficiency the consumption decrease, but the costs for construction goes up. At a certain point the heating system can be saved and this gives a substantial reduction in costs – this point is close to 15 kWh/m² per year.[117]

When increased investment costs and capitalised costs for energy over lifetime are added, the final costs for the improved energy efficiency can be found. These total costs are shown in figure 19 together with the capitalised costs for energy.

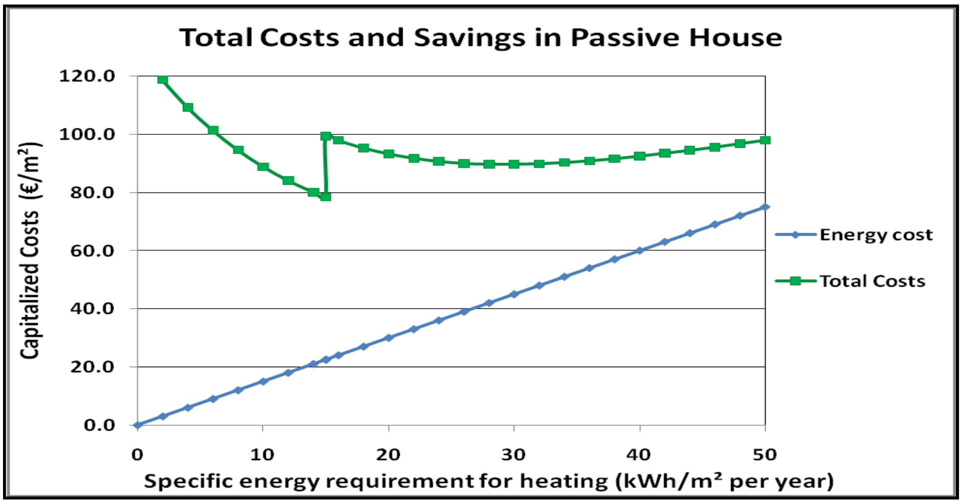
It can be seen from the graph that the total costs for a building, with 15 kWh/m² per year is lower than the total costs for buildings, which are built to a standard, which require 50 kWh/m². With higher consumption the savings are even higher and at no point the costs are lower than the passive house.

In the example shown in the graph in Figure 19 the costs for a house, which requires only 7 kWh/m² per year, would be same costs as a house build with the demands in the building

[117] Based on costs and estimates from the Passive House institute in Darmstadt. Costs are for central Europe (Germany).

regulation with 50 kWh/m², when the costs are seen over lifetime (30 years). Over time there are no additional costs for the owners or users of passive houses.

Figure 19. The total for improved efficiency in a Passive House.



When additional costs and savings in by improved efficiency in buildings are added, the costs will show a drop by 15 kWh/m² per year. The total costs for a building over lifetime for a passive house will hence be cheaper in a passive house (15 kWh/m² per year) compared to a house build according to a building regulation which require 50 kWh/m² per year.[118]

Similar principles can be used in hot and heating based climates. In this case shading and orientation of building and windows and passive cooling techniques are essential. The points for reduction of costs in passive cooling buildings are different and more dependent on the local conditions and there is no similar specific standard as for the passive heating buildings (Passive Houses).

Definition

To be a passive house a building must fulfil different conditions:[119]

- The building must not use 15 kWh/m²/a or less (≤) in heating energy[120].
- The specific heat load for heating source at design temperature must be less than 10 W/m².
- With the building pressurised to 50Pa by a blower door, the building must not leak more air than 0.6 times the house volume per hour (n50 ≤ 0.6/h).
- Total primary energy consumption (primary energy for heating, hot water and electricity) must not be more than 120 kWh/(m²a).[121]

The passive house standard was defined in 1988 [122] and the first passive house was built in Darmstadt in Germany in 1990.

[118] Based on costs are based on an oil price around 60 USD per barrel. With higher oil price the savings are substantial higher and the benefits from the passive house is larger.

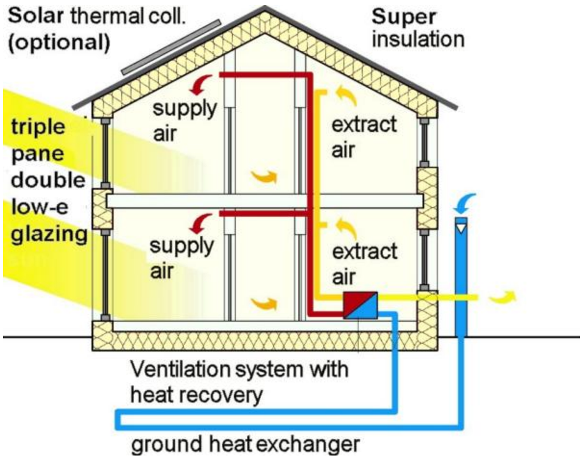
[119] These are set and controlled by the passive house institute in Darmstadt. The values are particular adopted for the central European countries.

[120] The maximum value for heating on 15 kWh/m² per is equivalent to 4.8 Btu/ft² per yr.

[121] The maximum energy consumption on 120 kWh/m² per is equivalent to 38.0 Btu/ft² per yr.

[122] The passive house standard was defined by Dr. Wolfgang Feist from Institute für Wohnen un Umwelt Darmstadt and Professor Bo Adamson from Lund University of Sweden.

Figure 20. Principles for a Passive House.



A passive house or a passive building uses the passive solar gains to an optimum and often this needs to be balanced between cooling and heating. The passive house has an extreme degree of insulation – which vary with the local climate conditions – very efficient windows and efficient HVAC systems with natural pre-cooling of air.

Passive houses in practice

Certain construction requirements are necessary for passive houses. They must be:

- **Highly insulated.** All the building parts for walls, roofs and floors are insulated with U-values within 0.10 – 0.15 W/m² per K.
- **Designed without thermal bridges.**[123] All thermal bridges in construction have to be avoided. A construction of a passive house is set to be "Thermal Bridge Free" if the maximum bridges are under 0.01 W/m per K.[124]
- **With comfort windows.** Windows in a passive house are especially efficient and have three layers of glass, coating on multiple sides and are filled with gas. They will also have warm edges and special energy efficient frames. Overall, U-values for these windows are 0.70 – 0.85 W/m² per K.
- **Very air tight.**[125] The building must be constructed so it is particularly air tight and special care for this must be taken.
- **Supplied with efficient mechanical ventilation.** To ensure sufficient ventilation passive houses are supplied with mechanical ventilation which will secure a controlled air exchange on 0.40 times per hour.
- **Using innovative heating technology.** The heating and cooling of these buildings are typically supplied by innovative systems which include a heat exchanger.[126] Typically this will be combined with a heat pump or a highly efficient small heating system.

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[123] A *thermal bridge* is a part of the construction which leads energy better than the rest of the construction. This can be the connection between building parts or the foundation of the building.

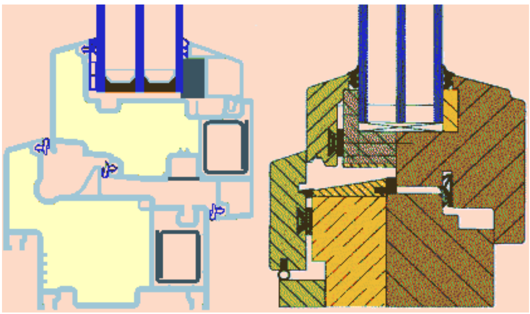
[124] Thermal bridges are typically measured by the amount of energy which will pass trough the thermal bridge per meter of length.

[125] That a building is air tight is meaning that no draft can pass trough constructions or between different construction parts.

[126] A heat exchanger takes the heat from the indoor air and heats the outdoor air before it is supplied in a heated building and takes the heat out of the out door air if the building is cooled.

All the details of the building envelope and the HVAC systems in a passive house are made with a high emphasis on energy efficiency. Building details are different from a traditional house, more insulation is added, special care taken with connections, steam tight components used systematically and some constructions changed substantially, such as windows.

Figure 21. Two different examples on comfort windows solutions



Constructions for passive houses are substantially different. Comfort windows were developed especially to the requirements in passive houses with u-values below 0.85. This requires 3 layer of glass, filling with gas, coating of the glass, hot separation of the glasses and special frames.

Passive houses are not bound to a specific type of constructions and examples have been designed based on different types of buildings, such as concrete, bricks, wooden frame houses and totally new construction types similar can comfort windows be of different types.

Even if the standard is called passive house it is also used for large residential buildings, commercial and public buildings such as schools, shops or office buildings.

Cooling – limitations

The passive house standard is basically defined for the central European climate, typically a heating based climate where there is only a limited cooling need for comfort reasons. It has moved north to the Cold Climates. A specific project – CEPHEUS[127] - supported by the European Commission has tried to take the passive houses out in different countries Germany, Austria, Switzerland, France and Sweden. 14 construction projects with 221 units were built as passive houses and monitored in this project. Some initiatives have been taken to extend the Passive House concept to cooled climates in southern Europe too.

Passive houses is mainly an European phenomena and there is a need to define a further standard, which define the standards and clever solutions for the cooling based and hot climates and which can be useful in all climates.

Benefits and costs comparison

Passive houses will have a comfortable indoor climate; because air is fresh and dry due to the mechanical ventilation and heat exchange of air. Due to thick insulation, there are no "outside walls", which are colder than other walls; floors and windows are not cold either.

Since there are no radiators, there is more room on the walls. The temperature are stable and change very slowly - with ventilation and heating systems switched off - a passive house might looses less than 0.5° centigrade per day (in winter).

In many countries passive houses use 70-80 % less energy for heating compared to other new buildings. Costs for new buildings are only slightly higher than those for traditional

[127] CEPHEUS – Cost Effective Passive Houses as European Standard, from 1998 – 2001.

buildings because the additional costs for insulation and ventilation systems are outbalanced with savings since it is unnecessary to install a traditional heating system.

The result from the CEPHEUS project showed that the additional incremental costs for houses on average was paid back in 20-21 years in simple payback time, and with interest they were paid back in 25 years.[128] Since 2001 energy prices have gone up and the costs for special units for passive houses are reduced, because these components become more mature building components. Seen over a 30 years lifetime, passive houses will therefore be a feasible alternative in central and northern Europe compared to houses with standard energy efficiency.

Example on policies to promote passive houses

In Austria and some parts of southern Germany passive houses are generally available on the market. Different programmes to promote these buildings have been very successful. In the Upper Austria province, the passive houses had a market share of 7 % of the market for one family houses in 2006.

The trend for passive house to penetrate the market have been going on in Upper Austria at the same time as low energy buildings have overtaken the major part of the market for one family houses and residential buildings in general. It is expected in Upper Austria that traditional houses will disappear from the market in a few years from now and that the voluntary standard will have moved to low energy. Upper Austria is in general favoured by a relative mild climate with mild winters and a modest need for cooling, but the development towards passive houses has been driven by a very active policy.

Table 12. Low energy buildings and passive house in Upper Austria

One Family Houses in Upper Austria	2003	2004	2005	2006
Traditional new Buildings	67 %	45 %	24 %	15 %
Low energy buildings	31 %	52 %	71 %	79
Passive houses	2 %	3 %	5 %	7 %

Passive houses have taken a major market share in upper Austria. At the same time low energy buildings, which use less than 30 kWh/m² per year for heating, have taken the major market for new buildings.

Parts of the policy to promote passive houses in Austria are subsidies, which can only be obtained by the owner, who constructs passive or low energy houses, certification schemes for buildings document the passive house or low energy class and different promotion initiatives and some very active energy agencies in these states. In Vorarlberg in Austria Passive Houses are now standard for all buildings with public subsidy. Passive houses in Austria are estimated to be around 4 % of all new one family houses.

The increased use of passive houses has made these technologies widely known by constructors and users in Austria. The passive houses standard is also used to an increasing extent, for other types of buildings such as schools, shops and office buildings.

In southern parts of Germany passive houses have taken approximately 2% share of the market for new one family houses, and the standards are becoming commonly known by constructors and installers. Also in Germany there are different programmes to promote passive houses and the passive house standard in general.

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[128] Average for the 14 projects with 221 residential units in 5 different countries, Austria, Germany, France, Switzerland and Sweden based on 2001 prices.

The passive house concept is spreading in Europe and passive houses are constructed in Germany, Austria, Switzerland, France, Belgium, Holland, Denmark and Sweden. Some experiments with passive houses are also taken in northern Italy and in Spain, where the cooling needs have to be addressed.

13.3 Zero Energy Buildings

Zero Energy Buildings are buildings that do not use fossil fuels but only get all their required energy from solar energy and other renewable energy sources.

Although this seems quite obvious, there is still need for further definition and agreement on clear international standards etc. In particular there is a difference in how the Zero Energy Buildings are used in Northern America and in other parts of the world.

Definitions

Zero energy buildings can be defined in various ways, including:

- **Zero Net Energy Buildings** are buildings that over a year are neutral, meaning that they deliver as much energy to the supply grids as they use from the grids. Seen in these terms they do not need any fossil fuel for heating, cooling, lighting or other energy uses although they sometimes draw energy from the grid.
- **Zero Stand Alone Buildings** are buildings that do not require connection to the grid or only as a backup. Stand alone buildings can autonomously supply themselves with energy, as they have the capacity to store energy for night-time or wintertime use.
- **Plus Energy Buildings** are buildings that deliver more energy to the supply systems than they use. Over a year, these buildings produce more energy than they consume.
- **Zero Carbon Buildings** are buildings that over a year do not use energy that entails carbon dioxide emission. Over the year, these buildings are carbon neutral or positive in the term that they produce enough CO_2 free energy to supply themselves with energy.[129]

Defining Zero Energy Buildings

Compared to the passive house standards there is no exact definition for the way to construct or obtain a zero energy building. In principle this can be a traditional building, which is supplied with very large solar collector and solar photo voltage systems. If these systems deliver more energy over a year than the use in the building it is a zero net energy building.

Traditionally it is normal to substantially reduce energy consumption use passive solar energy[130], install highly energy efficient equipment and lighting, mechanical ventilation with heat recovery and then use renewable energy to supply the buildings. In cooling based or hot climates intelligent shadowing will prevent the building from being overheated.

Most programmes for Zero Energy Buildings built on these principles; reduce energy demands, use energy gains and reduce need for cooling by shading etc, supply with highly efficient HVAC systems, install highly efficient equipment and lighting and supply the remaining need for energy by renewable sources such as solar collector for heating and PVH or small windmills for electricity. A Zero Energy Building can be a passive house where the remainder of energy is supplied from solar collectors, PVH and other renewable energy.

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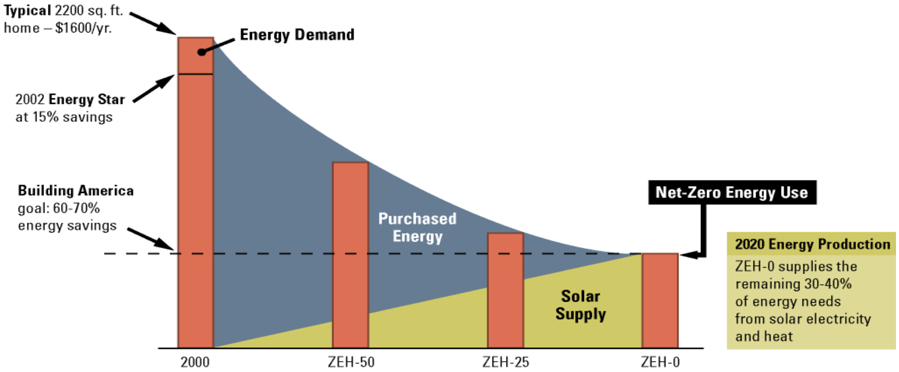
[129] Zero Carbon Buildings differ from Zero Energy Building in the way that they can use for instance electricity produced by CO2 free sources, such as large windmills, nuclear power and PV solar systems which are not integrated in the buildings or at the construction sight.

[130] Energy gained from the sun trough windows and glass areas without active solar systems.

Figure 22. US figure on zero energy buildings



The way to net zero energy buildings in US.[131] *Best practice for low energy or zero energy homes are expected to be real Net Zero Energy Buildings from 2020.*

Normally all energy use in the buildings will be included in the calculation of a zero energy building and this includes installed white goods, lighting, ventilation, air conditioning etc. In high rise buildings energy use for elevators will be included too.

In hot or cooling based climates in particular, there is a strong emphasis on energy efficient equipment because first these appliances have to be supplied by renewable energy but secondly the waste energy has to be removed by ventilation and cooling.

Examples on programmes for low energy buildings

Zero energy homes. The US program Zero Energy Homes defines the target for the program as the construction of zero energy buildings, but so far the buildings only have to be below 50 % of the energy consumption in the building regulations. In real terms the houses should be called “on the Way to Zero Energy Buildings”. These buildings are in fact to be classified as low energy buildings.

An interesting aspect of the programme is that the defined goal is zero energy use. Special programmes are set up to promote and support these buildings. Help for Finance is provided through the tax credits. Experience from the programme is that buildings cost a little extra but that this can be compensated by the reduction of other installations, for instance in the type of kitchen or by reduced living space. Energy efficiency improvement in these buildings is paid back through traditional loans for new buildings and there will be a positive balance already the first year because the savings more than out balance the additional cost for loans.

When Zero Energy Homes are constructed they are normally sold faster that other similar buildings with traditional energy standard[132].

Examples of true net zero energy buildings as well as stand alone zero energy buildings have been built in the past. In Germany zero energy stand alone building was built by the Frauenhofer Institute in 1998 and it was occupied for 3 years by a small family without being connected to any energy grids nor having any energy supply except from the sun. In this example energy was stores in a hydrogen fuel cell.[133]

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[131] Graph from Zero Energy Buildings and Zero Energy Homes presentations. David Goldsteen, DOE, on the workshop on Energy Efficient Buildings Meeting the Gleneagles Challenge, Paris 27-28 November 2006.

[132] Information from DOE Zero Energy Homes program.

[133] Zero energy Stand alone Building. The Solar House in Freiburg, from a self-sufficient solar house to a research platform. Frauenhofer Institute.

The WBCSD[134] has defined a project on Zero Energy Buildings. The aim of this project is to develop and construct Zero Energy High-rise Buildings and to promote zero energy buildings in general. Another aim is also to change the buildings industry and to make zero energy buildings and technologies commonly available.

13.4 Green Buildings and Sustainable Buildings

Green Buildings are those with increased energy efficiency, but at the same time reductions are made on water consumption, use of materials and assessment of the general impact on health and environment. Green buildings can include a long list of requirements including resources, indoor air quality and requirements that all products for the building must come from a local region.

Very often Green Buildings will be supported by Life Circle Assessment of the buildings in which there will be a high emphasis on all elements in the life circle, where all phases are assessed. This includes production and transport of materials used for the building, use of resources for the running of the building, but also the disposal or the demolition of buildings are included.

The standards for Green Buildings can vary from region to region and some countries have set up their own definitions for Green Buildings. Some of the more known standards are in U.S, Canada, Australia and U.K, but many other countries have standards.

LEED Buildings

In US and Canada a specific standard LEED[135], Leadership in Energy and Environmental Buildings is set up, setting the requirements for the buildings to fulfil. The LEED standard can be obtained on different levels; Certified, Silver, Gold and Platinum with increasing requirements for the different requirements for the building. The LEED standard is set and controlled by the US Green Building Council, USGBC.[136]

The LEED standard includes Sustainable Sites, Water Efficiency, Energy and Atmosphere, Material Resources, Indoor Climate, Innovation and design. Energy and Atmosphere is the most important criteria for the buildings, but far from the only one and major other areas give the possibility of points too. In connection to the LEED buildings ASHRAE is developing a special standard for the Design of High-Performance Buildings – ASHRAE standard 189P, this work is supported by the DOE.[137] This will lead to further stringency of the LEED requirements in US.

Canada has established its own LEED standards which is set and controlled by the Canadian Green Building Council (CaGBC). There are other Green Building Rating Systems, including the Japanese CASBEE system.[138] Coordination and share of information between the different Green Buildings organisations are done by the World Green Building Council, WorldGBC.[139]

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[134] WBCSD – the World Business Council of Sustainable Development is an organisation of more than 180 multinational companies. See www.wbcsd.org

[135] LEED standard Leadership in Energy and Environment Design sets demands for all the different parts of the life circle of the building. A certain number of these demands must be fulfilled and the building must obtain a certain amount of points to be classified.

[136] USGBC – US Green Building Council, see homepage www.USGVC.org. Similar organisations exist in other countries.

[137] The ASHREA 189P standard is a codified version of the USGBC standard for LEED V2.2 and is in public review.

[138] The CASBEE system is also mentioned under Japan.

[139] World Green Building Council, WorldGBC,[139] is an international umbrella organisation, with the homepage www.worldBGC.org, with connection to Green Buildings Organisations in different parts of the world.

Sustainable Buildings are similar to the Green Buildings, but there are often small differences in the definitions. Often buildings will fall under both the Green Building and the Sustainable Buildings category

14 Dynamic Building Codes

14.1 Building codes have to be changed over time

The construction market is under constant change. New products come into the market and existing products become improved and/or more cost effective. Examples of products, which have come into the market and have gained a market share over the last decades, are low energy windows, condensing gas boilers and highly efficient heat pumps. Today new energy products come in to the market such as Photo Voltaic components, passive solar house heating system units, and comfort windows[140].

The energy prices and solutions for heating and cooling change; this will change the limits for what is feasible and rational to set as minimum requirements in building codes. Similarly will families and companies have new requirements for comfort in buildings and new appliances come in the buildings and will use energy and increase losses from all these appliances.

The energy efficiency requirements for new buildings are one of the drivers for these changes in the markets. With the changed possibilities and the changed conditions for the products and prices will change the feasibility for different solutions. New and more efficient products will lead to the possibility of increasing the requirements for energy efficiency over time.

Examples on dynamic building codes

The increased requirements for energy efficiency in building codes will similarly lead to the development of intelligent solutions and improvements of products. Buildings codes and energy efficiency requirements can be a driver for further development, in particular if they are announced in advance, giving the construction industry time to prepare and develop the right solutions to make the new requirements as cost effective as possible.

The European Directive on Energy Performance in Buildings requirements from all the member states that building standards are set and regularly reviewed and updated. These requirements shall be reviewed at regular intervals, which should not be longer than five years and, if necessary, updated in order to reflect technical progress in the building sector.

The ASHRAE standards and the International Energy Conservation Code, IECC, are also updated regularly and the borders for these standards meet regularly to ensure that the standards are kept up to date, and that new improvements are prepared. New versions are constantly under preparation.

Some buildings codes are set way in advance or some of the energy efficiency requirements in the building codes are phased in slowly to ensure that the industry is prepared for the new solution. One example is the building code for Ontario in Canada, where the new buildings codes, which were introduced in 2006 includes that requirements will be strengthened in 2009 and again in 2012.

Setting energy demands and announcing these years before the change in the demands gives the industry time to adjust and prepare for the new regulation. This reduces the costs by the change and also reduces the criticism from industry or from constructors.[141]

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[140] Comfort Windows see under paragraph for Passive Houses.

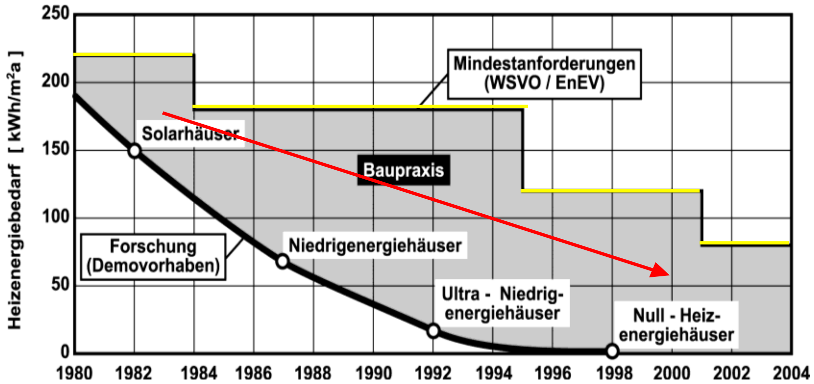
[141] Was the experience by the introduction of "Mindestanforderungen" (WSVO/EnEV) in Germany in the 1980s where this was announced years before and the same did the major changes.

14.2 Toward Zero energy as building code

Zero Energy Buildings, Passive Houses, LEED buildings and other low energy buildings are driving the best part of the market and help to demonstrate new technology as to develop new energy efficiency solutions and products. Building Codes on the other hand will remove the least efficient part of the new buildings and force these to be more efficient. A strong policy on both building codes and ultra low energy buildings can play together and be a common driver for highly energy efficient buildings.

In Germany such a double sided policy has been working since the 1980s, where research has developed more and more efficient buildings, which have been used to develop, test and demonstrate new solutions. At the same time Passive Houses and other low energy buildings have been used, and subsidised, to move the most efficient buildings towards ultra low energy consumption. This has created a small market for the most efficient products, which has helped the products to mature and be ready for the building market.

Figure 23. Development of ultra low buildings and building codes in Germany.



From Frauenhofer Institute 2006, H.E.

Demonstration projects in Germany have been used to move the limits for the possible energy efficiency and this has opened the way to strengthen the general energy requirements for new buildings. Hans Erhorn from Frauenhofer Institute at the workshop on Energy Efficient Buildings Meeting the Gleneagles Challenge, Paris 27-28 November 2006.

Today passive houses are taking up a small share of the market and this helps new products to be developed for efficient heating with small heat load, ultra efficient windows, building construction without cold bridges and all of this also helps to train constructors and installers to produce these efficient solutions. Then these solutions can then slowly move into the traditional buildings, where for instance thermal bridges today is a major problem for both efficiency and comfort.

In some areas of Austria such as Upper Austria and Vorarlberg[142] a similar development towards Passive Houses and other very low energy consuming buildings takes place and passive houses uptake increasingly parts of the new constructions.

Examples on building codes on the way to Zero Energy Buildings

In the long term, buildings need to have an energy consumption which is ultra low (Passive House level) or even Zero Energy Building level to be sustainable. Some countries have taken initiatives and have defined this as the target for building codes already in 10 years from now.

In the beginning of 2006 new demands for energy efficiency in building codes was introduced in Denmark for new buildings both for small residential buildings and for large

[142] In Voralberg the passive house standard is mandatory for all public subsidized buildings.

and complex buildings. These building codes are based on energy performance of the buildings but special demands are set for the building envelope too. With these demands new buildings have an energy demand for heating and hot water, which are around 55 kWh / m^2 per year.

In the new building code 2 new low energy classes are defined at less than 75 % (class 2) and less than 50 % (class 1) of the building code. Parliament have agreed on an action plan where building codes shall be strengthened to low energy class 2 level in 2010 and to low energy class 1 in 2015. This will bring the demands in the building codes in 2015 on the level of the demands in Passive House both for the over all consumption as for heating load in the building.

In UK the government decided an action plan in December 2006 setting a target that all new buildings should be Zero Carbon Buildings in 2016. This includes and action with movement in steps; in 2010, a 25% improvement in the energy/carbon performance set in building regulations; then in 2013, a 44% improvement; then, finally, in 2016, to zero carbon buildings.[143] The UK action plan includes steps to be taken to tighten building regulations over the next decade to improve energy efficiency of new homes and to publish a Code for Sustainable Homes, which includes a green star rating for properties.[144]

15 Potentials for energy efficiency in new buildings

For new buildings most regulations are far from the least cost optimum if costs are calculated for 30 years based on investment, interest rates, mortgage costs, and accumulated energy costs.

Experience in the US shows that energy consumption in new one family houses can be halved (Zero Energy Homes) and that this will lead to reduced overall costs for the owners already from the first year. This reduction in costs will increase over time.

Comprehensive studies in the US[145] show that energy consumption can be reduced by 75 % without additional total costs for the owners. They also show that Zero Net Energy Buildings can be built today with only relative small additional total costs for the owners in terms of higher total annual costs.

In Europe estimates are highly dependent on the building regulations at the present state, but studies show that in many countries the efficiency can be improved by a 70-75% reduction in energy consumption without additional costs or with very limited additional costs for owners.[146] A reduction of 70-75 % will in often correspond to a Passive House.

IEA studies on scenarios in 2006 [147] show the possibility of a 70 % reduction in most OECD countries over longer time. These results are also supported by the Findings in this study. However in some countries such as Sweden, Denmark and the Netherlands the demands for new buildings are closer to the least cost optimum and the possible reduction is smaller.

In developing countries the possibilities for savings in new buildings are even larger than in OECD since the present standards for energy efficiency – if they exist – are lower.

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[143] Zero carbon means that, over a year, the net carbon emissions from all energy use in the home would be zero.

[144] Building A Greener Future: Towards Zero Carbon Development, December 2006.

[145] Studies described by ICF International consultants and documented in Building a Path Towards Zero Energy Homes with Energy Efficiency Upgrade. Dean Camble, Brian Dean and David Meiesegeier. ACEEE 2006.

[146] These savings are documented for instance in the CEPHEUS project on Cost Effective Passive Houses as European Standard.

[147] In the scenarios in Energy Technology Policy Perspective, Scenarios & Strategies to 2050.

If passive houses became more commonly adopted on the market these technologies would become less expensive[148] and this could increase the cost effectiveness of these houses and increase the saving potentials even further.

A targeted policy to increase the development of more efficient solutions through demonstration projects, research and development could accelerate this development[149]. Such a policy could help Zero Energy Buildings to become a feasible solution.

The conclusion is that passive houses are already a feasible alternative in many cases, and while zero net energy buildings will increase costs, they are not dramatic and it must be expected that these building can become feasible in the within the next 1-2 decades.

15.1 Conclusion on potentials in new buildings

The possibilities for savings in new buildings are calculated based on the figures and forecast from WEO[150] and from the forecasts of new constructions and estimates of the efficiency of new buildings and the feasibility. The efficiency forecasts for China and India are of particular importance since approximately half of all the worlds new constructions are in China and India[151].

If energy consumption in new buildings is halved compared to the base scenario in WEO this would lead to savings in the size of 10-15 EJ[152] (10000-15000 PJ) in 2030 or 230 - 350 Mtoe. These savings would be feasible both for the owners and for society as a whole.

By a strong policy for ultra low or even net Zero Energy Buildings such as building standards demanding these efficiencies could increase these potentials even further. Saving potentials by Zero Energy Buildings and Passive Houses will therefore increase in the long term.

16 Refurbishment and renovation

Since buildings have a long lifetime of 50 – 100 years or more there will be need for major renovation and improvement in the lifetime of buildings. Refurbishments or improvements are necessary, because some parts of the buildings will need replacing, such as roofs, boilers, windows, variation systems, air condition etc. Change or refurbishment is also necessary because constructions, equipment or the organisation of the building becomes inadequate.

Typically these major refurbishment projects will take place at least 2 or 3 times over the life time of the building. For residential buildings this will typically occur every 30 – 40 years because of change in lifestyle and reduced functionality of the building parts and of heating and cooling systems. For commercial buildings these renovations may happen more often because the functions of commercial buildings change faster. By these major renovations or refurbishment of buildings, energy efficiency is in particular feasible and higher energy efficiency can be obtained.

Improvement of energy efficiency becomes more cost effective by refurbishment, because there is only need to pay for the additional efficiency costs, for instance if windows are replaced it is only necessary to pay the extra costs for efficient windows while the whole price of the windows, the installation, and the removal of the old windows have to be paid

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[148] CEPHEUS project on Cost Effective Passive Houses as European Standard.

[149] Energy Technology Policy Perspective, Scenarios & Strategies to 2050.

[150] WEO, World Energy Outlook 2006, IEA 2007.

[151] The development of efficiency in buildings in India and China will be studied further in the coming issue of the WEO.

[152] EJ is Exa Joule equivalent to 10^{18} Joule or 277 billion KWh.

by exchange alone for energy efficiency. Some building parts might be open and it is easy to fit extra insulation for instance in roofs constructions. Costs for scaffolding or establishment of a building site may be paid by the general renovation but might also be used for energy efficiency improvement projects.

Some works can only be done by renovation because the constructions are renewed or opened. This could for instance be floors, which are exchanged and therefore can be insulated or efficiency improved in other ways.

All in all efficiency projects by refurbishment will often lead to better feasibility of the projects, and will also lead to enlarged potentials because of lower better costs for efficiency. Timing for these projects is essential as it is necessary that they are carried out while these works go on. The day after the renovation or the refurbishment project is ended is too late and the next refurbishment or renovation maybe in 30 – 40 years.

The major barriers mentioned for new buildings above will to a large extent also influence projects by refurbishment. Major renovations and refurbishment projects are therefore often carried out without concern for energy consumption and possible efficiency projects.

Efficiency policies and initiatives are required to increase energy efficiency by renovation or refurbishment. Demands for efficiency should therefore be included in the building regulations in the form of building codes or special energy efficiency standards.

16.1 Potentials for efficiency by refurbishment

Different IEA scenarios show substantial potentials for improvement of energy efficiency in existing buildings. In these scenarios costs effective energy efficiency improvements in buildings play a major role in the reduction of the energy consumption. Many regional studies support these findings since the all identify major energy saving potentials in buildings.

A study made by ECOFYS on Mitigation of CO_2 Emission from the Buildings Stock[153] supported by EURIMA and EUROACE shows that 55 % of the energy reduction and CO_2 emissions from buildings in the 15 old European Union members can on average be saved alone through increased efficiency in the building shell.

A specific study was made for the additional member states from the last extensions of the union. The study carried out by ECOFYS[154] for new member states show larger savings giving potential savings for residential buildings of 67 - 80 per cent for the new regions on average for single family houses and 55 - 69 per cent for multifamily houses.

These two studies for the European Union calculated the economic least cost optimum for a 30 years lifetime and only measures, which are feasible for the owners are included in the estimates. Only savings which can be obtained through improvements of the buildings envelope are included.[155]. Further savings can be obtained through improvements of heating, cooling and ventilation systems, through energy supplies such as heat pumps and renewable energy sources such as solar collectors or photo voltage, which are integrated in the buildings.

[153] ECOFYS supported by EURIMA and EUROACE, Mitigation of CO2, Emissions from the Building Stock, Beyond the EU Directive on the Energy Performance of Buildings and Cost-Effective Climate Protection in the EU Building Stock.

[154] ECOFYS supported by EURIMA. Cost-Effective Climate Protection in the Building Stock of the New EU member States. All report can be found on www.eurima.org

[155] Measures are highly feasible for the building owners and money will be retuned up to 7 times over lifetime. EURIMA Energy savings in a nutshell, 2004 and Ecofys study on Sensitive Analysis of Cost Effective Climate Protection of the EU Building Stock., June 2006, to estimate the impact of high oil prices for energy efficiency.

Further studies have been carried out in individual member states in the EU[156]. They show similar potentials for savings, which exceed 50 % for the individual country.

Similar studies from US show that the energy consumption in the existing building stock can be reduced with up to 50 % alone through improved insulation.

16.2 Conclusion on potentials in refurbishment of existing buildings

The potentials for energy efficiency in existing buildings are calculated with the figures from WEO and combined with the findings in this study.

It is estimated that the total feasible potential for energy savings by renovation and refurbishment in most OECD countries will be around 50 % of the actual consumption. In transition economies this potential will be even larger, because of lower energy standard of the existing buildings. In fast developing countries outside OECD the feasible potentials is estimated to be larger too, but the savings in these countries will be reduced by an increase in the comfort levels both for cooling and heating.

Not all buildings will be renovated before 2030 since a full renovation cycles will take around 30 – 40 years, and a policy to demand improvement of efficiency by refurbishment would not be fully effective. The possible saving potential for these measures should therefore be estimated to be around 15 – 25 % of the consumption in the existing buildings.[157]

Based on the WEO 2006 and the values for 2004 this will result in possible savings on 15 – 40 EJ (15000 – 40000 PJ) or 950 Mtoe in 2030 alone if strong measures are taken for improvement of energy efficiency by refurbishment and major renovation.

17 Conclusion potentials

The potential for energy efficiency in buildings is very large both in new and in existing buildings. Over time the energy efficiency in buildings can be reduced by more than 50 % alone with measures, which are feasible already today.

Buildings have a long lifetime and it is possible and feasible to halve the consumption over a long period, but there is a need for taking action today. There is a special need to reduce consumption in new buildings and by renovation, improvement or refurbishment existing buildings, as energy efficiency in buildings is especially feasible by these actions.

Because buildings are renovated after 30 – 40 years, some existing buildings will not yet have been refurbished in 2030 and the potential to cost-effectively raise buildings' efficiency before 2030 is smaller than the total potential. The potential for energy efficiency in 2030 is therefore estimated to 30-50 EJ (30000 – 50000 PJ) per year in 2030 or 700 – 1200 Mtoe by initiatives addressing new buildings and improvements by refurbishment and major renovation.[158]

These cost efficient potentials will continue increase also after 2030 because there will still be need for improvements by refurbishment and because new buildings will continue to be

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[156] For instance estimates Danish Energy Authority a saving potential on heating on 48 %. Technical report for action plan. EDF estimates that France could reduce heat consumption with 55 % trough feasible improvements by renovation and that a best possible technology would be able to reduce consumption by 70 %. D.Osso, H.Bouia, P.Mandrou, MH.Laurent, paper for ECEEE 2007 (European Council for Energy efficient Economy).

[157] Further work and studies for existing buildings will go on in the continuation of the work on Gleneagles Plan of Action. The results will be published in an end use assessment of buildings in 2008.

[158] The potentials named in this study are larger than the estimates used in the WEO 2006 alternative policy scenario, but smaller than the potentials documented in Energy Technology Perspectives.

constructed. Similar will the limits for feasible improvements continue to increase because of new technologies, improved solutions and cost reductions.

To obtain these large potentials there is a need to take actions right now and to set up a package of policies and initiatives to improve the efficiency in buildings. These policies have to address al major barriers and there is need to set emphasis on both highly efficient buildings as for increasing the efficiency in the least effective new buildings as to set up strategies for development and demonstration.[159]

A package of recommendation is set up for these policies.

18 Recommendations

To realise the large potential for energy conservation in new and existing buildings, governments must surmount the barriers to energy efficiency in the building sector. Policies and measures to improve buildings' efficiency include:

All governments, states or regions should set, enforce and regularly update requirements for energy efficiency in new buildings. These requirements can appear independently or within building codes. Requirements for efficiency should be based on least costs over 30 years.

Energy efficiency in new buildings is a very efficient way to obtain savings, but many barriers work against energy efficiency. Building codes is a way to ensure and increase the energy efficiency in the vast majority of new buildings and can ensure a certain minimum standard in the buildings. Standards can be set either in building codes or as a specific standard for efficiency and they can be set on a national or a federal state level.

Buildings codes should reflect the least cost over time and not just the incremental costs for the buildings. Since the technology and the economy changes fast there is a need for regularly update of the standards.

Best practice and demonstration buildings such as Passive Houses and Zero Energy Buildings should be encouraged and supported to help these buildings penetrate the market. National target should beset to ensure that these buildings will really present at the market for new buildings in 2020.

Passive Houses (buildings that use so little energy that no heating or cooling system is needed) are in many areas a feasible alternative to traditional buildings, but many barriers work against these buildings. They need support to penetrate the market and become a real option for the general market. Zero energy buildings (buildings that use no energy over a year) are becoming more and more economic cost effective, but are still a more expensive solution than traditional buildings also seen over time. Support, demonstration projects, research and development is needed to mature this option and to bring these buildings in the market.

Passive Houses and Zero Energy Buildings should be the target for future buildings codes. A path should be set up to reach this target no later than 2030.

On the longer term only passive houses and zero energy buildings will be a sustainable solution. Passive houses or even Zero Energy Buildings should be set as a target for future building codes or energy efficiency standards to send a message to the market and to ensure the development of good solutions.

Financial restrains for new buildings preventing energy efficiency should be removed to ensure that buildings can be cost optimized over 30 years.

[159] Future IEA analysis of energy efficiency in existing buildings will offer further recommendations.

Financial barriers and maximum loans can be a barrier for increased efficiency. Information activities should be targeted on the increase of the understanding of energy efficiency and the cost benefits by these institutions.

Energy demands should be set by major renovation and refurbishment of all buildings, no matter the size, type of use or ownership of these buildings.

Energy efficiency by major renovation and refurbishment is a feasible possibility to increase the energy efficiency of existing buildings substantially. Building codes or standards for energy efficiency in buildings should include demands for energy efficiency of the whole buildings by major renovation or refurbishment and the codes should include efficiency demands for the individual components on installations by replacement.

Energy efficiency for buildings should be made visible in the market place to give building owners a real choice. This could be by certification, labelling or other declaration of energy consumption.

There is too little emphasis on energy efficiency by the purchase of buildings although the energy costs can be a substantial part of the costs in the new building. Efficiency of buildings and life costs are difficult to understand for the ordinary buyer. Efficiency of new buildings and especially the efficiency of buildings, which are better than the minimum energy efficiency requirements in the building regulation should be increased for instance by stars, by labelling schemes or by certification of buildings. These schemes should be reliable and need to be controlled by governments or other public authorities.

Governments should lead by example and make new governmental buildings optimized for life costs over a 30 years time or for the whole life time of the building.

New public buildings and in particular buildings owned by the state should show a good example for the citizens and the companies. In particular public buildings should therefore be built based on a life time approach making these buildings a least as energy efficient and cost effective as possible over lifetime. Public building could even be used for demonstration to facilitate the development of even more efficient buildings. Governments should be the first to build to passive house standards or to construct zero energy or zero carbon buildings.

Governments should set up a package of initiative to address the barriers for energy efficiency in both new and existing buildings including the mentioned recommendations above.

Since there are many barriers that work against energy efficient buildings both for new and for existing buildings, there is a need for different initiatives to remove these barriers. Governments should study the efficiency in buildings and determine the most important barriers, which work against efficiency in buildings, and then set up a package of policies to remove the most important of these barriers as well for new buildings as for existing buildings.

Special outreach activities should be taken for the fast developing countries such as China and India where most of the world's new buildings are constructed.

Most of the new buildings are constructed in the fast developing countries and especially in China and India. The largest potentials for savings in new buildings are therefore in these regions. At the same time new supply systems are needed in these countries, which make energy savings in buildings even more feasible from a national economy. Special activities should be taken to ensure that buildings in the fast developing countries are as efficient as possible and that new technologies, Passive Houses and Zero Carbon Buildings are introduced.

Further R&D (Research and Development) should be undertaken in buildings including R&D in development and intelligent design of highly energy efficient buildings.

Although the energy potentials are huge in with measures which already exist and are feasible even today, then this potential could be increased further by research and development. If the potentials for zero energy or even plus energy houses can be unlocked, the total potential in the building sector will increase substantial over the longer term.

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