Climate Change Scoping Plan Appendices

VOLUME II:
ANALYSIS AND DOCUMENTATION

a framework for change

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Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Prepared by
the California Air Resources Board
for the State of California

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* This appendix is not included because the BEAR model was not run for the Recommendation in the Scoping Plan. For results from the BEAR model, see the Economic Analysis Supplement to the Draft Scoping Plan

Climate Change Scoping Plan Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Appendix G
Economic Analysis

EXECUTIVE SUMMARY

The California Air Resources Board (ARB) is the lead agency charged with implementation of AB 32, the Global Warming Solutions Act of 2006, which requires a statewide reduction of greenhouse gas emissions to 1990 levels by 2020. As the lead agency, ARB is required to develop and approve a Scoping Plan by January 1, 2009, that proposes a comprehensive set of actions designed to achieve the reductions.

The Scoping Plan (Plan) sets out ARB's Recommendation for reducing California's greenhouse gas emissions. Key elements of the Recommendation include the expansion and strengthening of energy efficiency programs, achieving a statewide renewable energy mix of 33 percent, development of a California cap-and-trade program that links with other Western Climate Initiative partner programs, and the implementation of both new and existing state laws and policies geared toward reducing greenhouse gas emissions from the transportation sector.

As required by AB 32, we conducted an economic analysis of the Plan. This analysis is a thorough assessment of the economic impact of the recommended greenhouse gas emission reduction measures on California consistent with the plan's broad programmatic framework of measures and approaches. It shows that implementing the recommended measures will have an overall positive impact on economic growth in California. We will analyze individual strategies and measures in more detail as they are further developed during the measure development and adoption process.

Choosing a Cleaner Path

The Plan outlines an approach that will position California for a more secure, sustainable future where we invest heavily in energy efficiency and clean technologies. This economic analysis indicates that implementation of this forward-looking approach creates more jobs and saves individual households more money than if we stood by and pursued an unacceptable course of doing nothing at all to address our unbridled reliance on fossil fuels.

Continued economic growth is perhaps the clearest indicator of the fundamental health of California's economy. Under a business-as-usual case (i.e., without putting into effect any of the recommended measures to reduce global warming emissions), economic growth is expected to total 43 percent between now and 2020, culminating in a Gross State Product of almost $2.6 trillion. The analysis we have conducted indicates that if California implements the comprehensive greenhouse gas reduction strategy recommended in the Plan not only will the economy grow by a similar amount as we move toward 2020, but it will grow at a

slightly higher rate. Increased economic growth is anticipated primarily because the investments motivated by several measures, such as the expansion and strengthening of existing energy efficiency programs and implementation of new and existing policies to reduce emissions from the transportation sector, result in substantial energy savings that more than pay back the cost of the investments at expected future energy prices. These results support the conclusion that the decision California made in 2006 to reduce its greenhouse gas emissions was not just a good environmental choice, it also will help sustain growth and enable the state to reap the full range of economic benefits that come with a transition to a more sustainable future.

Overall Impact on the Economy

Our analysis relied upon the Environmental Dynamic Revenue Assessment Model (E-DRAM), a macroeconomic model that characterizes the flow of production, consumption, investment, and saving throughout the California economy in response to specified policies. ARB has previously used E-DRAM to assess the economic impacts of its regulations.

Macroeconomic models such as E-DRAM are best suited to analyzing the economy-wide impact of a set of recommended policy measures by taking into account their interaction and the shifting of economic activity across sectors. Such tools and related cost-estimation methods, however, tend to understate the benefits afforded by market-based policies because they cannot accurately model some important cost-saving features of market-based compliance mechanisms, such as those included in California's clean car standards (AB 1493, Chapter 200, Statutes of 2002, Pavley), those anticipated as part of the low carbon fuel standard, and in particular, a cap-and-trade program. This is largely the result of the inability of macroeconomic models to predict how firms might invest in cost-effective energy efficient technologies at individual facilities that will result in reduced greenhouse gas emissions and reduced energy-related expenditures. As a result of this limitation, our economic analysis likely understates the extent of the positive impact on the California economy from the full complement of measures in the Recommendation.

With these caveats in mind, our modeling shows that implementation of the Recommendation in the Plan will benefit California's economy above and beyond the business-as-usual projections, in 2020, by:

- Increasing production activity by $33 billion
- Increasing overall Gross State Product by $7 billion
- Increasing overall personal income by $16 billion
- Increasing per capita income by $200
- Increasing jobs by more than 100,000

Sector Specific Impacts

In addition to assessing the overall economic impacts of the Plan, we also evaluated the impacts that implementing the Recommendation would have on households, employment, businesses including small business, jobs, and green technology. Overall economic impacts for each of these sectors are consistent with the other findings and are projected to be small,

and for the most part positive, keeping in mind that the models tend to underestimate the benefits to the economy as a result of market mechanisms.

Business Sectors

Compared to the business-as-usual case the implementation of the Recommendations minimally alters current growth projections for most business sectors, and in fact enhances their growth in most cases. A potential decrease in output and employment is, however, projected for the utility and to a lesser extent for the retail sectors. The primary reason for these projections is that consumers are expected to purchase a decreasing amount of electric power, natural gas, and gasoline – considered by the model to be a retail 'product' – as a result of the implementation of efficiency measures contained in the Plan. While increased spending on efficiency and renewable energy is expected to increase employment overall, many of the resulting jobs will not appear in the utility sector.

Low-Income Households

AB 32 recognizes the importance of ensuring that efforts to reduce greenhouse gases do not produce disproportionate impacts on low-income communities. To assess the impacts on low-income households, we analyzed how implementation of the Recommendation in the Plan would affect per capita income, household expenditures, and jobs. With the Plan in effect the average income per capita changed very little for all income groups compared to the business-as-usual scenario. Further, our analysis indicates increased job opportunities for lower skilled workers (approximately 50,000 additional low-wage jobs in 2020) and lower overall household expenditures driven by greater energy efficiency. As a result, the analysis concludes that the overall impacts of the Recommendation will be positive for low-income households in California.

Small Business

AB 32 also recognizes the key role that small businesses play in California's economy. To assess the impacts that implementation of the Scoping Plan would have on small businesses in the state, we analyzed how changes in energy expenditures would affect the competitiveness and profitability of small business. To establish those impacts, we drew upon a recent study that demonstrates that implementing a set of policies similar to those recommended in the Plan would decrease the average electricity bill by 5 percent in 2020. Our analysis indicates that small businesses will experience a slight net economic benefit as a result of lower energy expenditures along with a similar rise in the national competitiveness level of California businesses measured according to the percentage of revenue expended on electricity.

Green Technology Leadership

The development of green technologies and a workforce trained to design, develop and deploy them will be key to the success of California's efforts to reduce greenhouse gas emissions. Our state is already benefitting from the influx of investment capital in green technology. In the second quarter of 2008, California dominated the world investment in

clean technology venture capital, receiving $800 million of the global total of $2 billion. This places us well ahead of any other state, even though other states, such as Massachusetts and Florida, are now undertaking similar efforts to capture clean technology investment. Taking charge of our state's energy destiny provides California with a key opportunity to create and maintain a steady stream of 21st century jobs, and to continue our lead ahead of other forward-looking states.

The Cost of Inaction

This economic analysis deals only with the economic impacts of the implementation of the Recommendation in the Plan. It does not address other potential costs to California that will directly result from inaction under the business-as-usual case. Doing nothing places California at economic risk from a variety of perspectives. We will continue to be at the mercy of foreign imports of petroleum and the vagaries of the international oil market. We could lose our competitive edge as the nation's technology leader and magnet for venture capital in the field of clean energy technology. And, by doing nothing, California will fail to do its part to help prevent the most severe impacts of climate change, such as reduced snowpack and disruption of water supplies, rising sea level and escalated coastal erosion, increased pollution in our cities, longer and more severe heat waves, and increased wildfire danger. It is important to keep the potential costs of adapting to such impacts in mind as a background and context for the measures and approaches analyzed here.

Peer Review and Next Steps

As part of our effort to develop the most complete picture possible of the economic impacts of state greenhouse gas emission reduction policies, the Economic Analysis of the Draft Scoping Plan was submitted to an independent panel for peer review. In addition to the formal peer review, the economic analysis and related ongoing work also was reviewed by the Climate Action Team.

Conclusion

The Scoping Plan Recommendation contains a robust and effective mix of approaches and takes advantage of the strengths each approach offers. It calls for the deployment of efficient technologies and strategies which will both reduce emissions and save consumers money. Performance standards with market mechanisms will further allow regulated businesses to meet those standards in the most efficient and profitable manner. A multi-sector cap-and-trade program will provide a strong financial incentive for both producers and consumers to search out and pursue the most cost-effective emissions reduction opportunities in ways that will achieve additional savings not fully captured within the model.

The economic impact to the state is not the only consideration when choosing which path to pursue; there are other aspects and benefits to consider. In this regard, the Recommendation offers not only financial savings predicted within the model, but also assures that meaningful emission reductions will occur in *each* sector of the California economy. It creates a policy framework to maximize participation and benefits at every level of government including state, regional and local. The cap-and trade program provides further environmental and leadership benefits, including placing an absolute emission limit on capped sectors, expanding coverage of the program through the Western Climate Initiative, providing a

model for future federal programs, and creating larger markets for California's clean technology industries.

While an important part of the process of developing the Plan, the results of the economic analysis will inform, but not wholly decide the full range of measures and approaches that will constitute the Plan adopted by the Air Resources Board. Once the final Scoping Plan has been adopted, ARB will conduct further economic modeling for each of the measures pursued to inform the best design of those measures. The analysis presented here, therefore, represents the beginning, not the end, of what will be an ongoing evaluation of the best ways to achieve the goals of the overall program.

California has all of the ingredients to emerge as the vanguard of 21st century economies that are built upon clean, efficient and renewable energy sources. The state has a track record of successful and transformative innovation, a strong commitment to both public and private investment in new technologies, and a history of demonstrated success in designing environmental policies that also help to foster economic growth. The results of the economic analysis clearly show that California can achieve the goals of Global Warming Solutions Act and maintain and enhance its economic and environmental leadership.

1. INTRODUCTION

California strengthened its commitment to address and respond to climate change when Governor Schwarzenegger signed Assembly Bill 32, the Global Warming Solutions Act of 2006 (Núñez, Chapter 488, Statutes of 2006). As the lead agency for implementing AB 32, the Air Resources Board (ARB) is developing a Scoping Plan that will lay out a comprehensive set of actions designed to reduce greenhouse gas emissions in California, improve our environment, reduce our dependence on oil, diversify our energy sources, save energy, and enhance public health while creating new jobs and driving growth in California's economy.

The California Air Resources Board released the Scoping Plan on October 15, 2008. The Plan provides a Recommendation that includes a mix of strategies that combine market mechanisms, regulations, voluntary measures, fees, and other policies and programs to reduce greenhouse gas emissions. Key elements of California's Recommendation for reducing California's greenhouse gas emission levels to 1990 levels by 2020 include:

- Expanding and strengthening existing energy efficiency programs as well as building and appliance standards;
- Achieving a statewide renewables energy mix of 33 percent;
- Developing a California cap-and-trade program that links with other Western Climate Initiative partner programs to create a regional market system;
- Establishing targets for transportation-related greenhouse gas emissions for regions throughout California and pursuing policies and incentives to achieve those targets;
- Adopting and implementing measures pursuant to existing State laws and policies, including California's clean car standards, goods movement measures, and the Low Carbon Fuel Standard; and
- Creating targeted fees, including a public goods charge on water use, fees on high global warming potential gases, and a fee to fund the administrative costs of the State's long-term commitment to AB 32 implementation.

Virtually every sector of California's economy will play a role in reducing greenhouse gas emissions. Implementation of the Scoping Plan will require our state's industrial, commercial and consumer sectors to invest in new, more efficient technologies and it will put California at the forefront of forward-looking economies that will be driven by clean, safe and secure energy sources.

This Appendix summarizes our evaluation of the economic costs and benefits associated with the measures set out in the Recommendation of the Scoping Plan. As is further discussed below, available models and related cost estimation methods tend to underestimate the important cost-saving features inherent to market-based policies such as the proposed cap-and-trade program and the market-based compliance mechanisms included in the clean car standards and the low carbon fuel standard. As a result, we have had to adapt the available

tools to approximate the Recommendation, with the result that the likely costs of achieving the targeted reductions are likely to be overstated.

Next Steps

We are requesting comments on this Appendix along with comments on the Plan itself. Staff will provide an update to the Board meeting, as needed, to respond to comments received on the economic analysis of the Scoping Plan. The economic impact of the proposal will be one of a number of factors that the Board will weigh when it considers adoption of the Plan at its December hearing.

Even after Board approval, the measures in the Scoping Plan will undergo additional development and refinement. The measures in the Scoping Plan must be adopted through the normal regulatory or other formal processes, with the necessary analysis and public input. Most of the measures included in the Scoping Plan do not yet have fully developed implementation details, so the information currently available regarding their costs and savings is necessarily preliminary. Further economic analysis will be conducted when ARB and other agencies move to adopt regulations or programs to implement the measures.

Structure of the Analysis

The evaluation summarized here relied primarily on a macroeconomic model of California, using current estimates of the costs and savings of the various measures being analyzed. In addition to considering the macroeconomic impacts of the Recommendation on California, other impacts are considered, including: preliminary evaluation of the potential effects on low-income households, other households, and businesses, particularly small businesses.

The following subsection summarizes the model we used to perform the analysis. Section 2 presents the results both from a macroeconomic perspective and in relation to certain sectors including households and small businesses. Section 3 presents an analysis of the "Greentech" sector and the role it will play in California's greenhouse gas reduction efforts. Section 4 describes the peer review procedure that the economic analysis will undergo. Section 5 summarizes our overall findings and outlines the path forward.

1.1 Summary of Models

This section outlines the modeling approach employed and the model used. (A summary of the costs and savings of the measures that were modeled and a full description of the model and are included in Appendices G-I and G-II; additional documentation of the calculation of the cost and savings estimates are included in Appendix I.) In large part, the results of any macroeconomic analysis are driven by the input assumptions; our cost and savings estimates that constitute many of these inputs are based on the best information available to staff. As with all elements of this analysis, we welcome stakeholder comment on these estimates. In addition to the models and modeling analysis described in this supplement, we will also review any stakeholder analyses of the Scoping Plan policies. We believe that obtaining results from additional models and methodologies will help to further inform the assessment of potential impacts of the Scoping Plan policies on California's economy.

Macroeconomic Modeling

The primary economic analysis was conducted using the Environmental Dynamic Revenue Assessment Model (E-DRAM). This is a 'general equilibrium macroeconomic model' of the California economy, meaning that it calculates changes in the prices of goods and services and factors of production in the economy in such a way that the total quantity demanded and supplied is kept in balance – in equilibrium. As a result, it is possible to track the flow of money from one sector to another when a specific policy is set in place. E-DRAM was originally developed for use by the California Department of Finance and was subsequently refined to assess the impacts of environmental regulations.[1] ARB has used E-DRAM for several years for a variety of economic assessments, including evaluation of the potential economic impacts on California associated with the State Implementation Plan for the Clean Air Act and the greenhouse gas motor vehicle regulations developed in response to AB 1493. E-DRAM was also used for the macroeconomic analysis of the Climate Action Team (CAT) report.[2] More background on E-DRAM and a full description of the modeling results can be found in Appendix G-II.

Professor David Roland-Holst, of UC Berkeley, also ran the Berkeley Energy and Resources Model (BEAR) to analyze the preliminary recommendation included in the Draft Scoping Plan. The results of this analysis were included in Appendix III of the Economic Analysis Supplement that was released in September 2008. Because of the short time between release of the supplement and of this appendix and the similarity of the results from E-DRAM and BEAR in the supplement, Professor Roland-Holst did not provide an additional evaluation of the Recommendation in the Plan.

E-DRAM is a macroeconomic model that characterizes the flow of production, consumption, investments and savings throughout the economy in response to policies. In order to model the measures being evaluated, the estimated costs and savings must be mapped to the applicable sectors in the model. This is an important step because the relationship that sectors have with one another describes how dollars flow throughout the economy. The relationships on how dollars flow throughout the economy are defined in a Social Accounting Matrix discussed further in the appendices.

The input assumptions for E-DRAM were based on cost and savings assumptions for the individual measures in the Scoping Plan developed by staff from the ARB and other state agencies. The costs and savings of each measure were analyzed using a standard ARB methodology to consider costs, savings, and cost-effectiveness of its proposed regulations for the past three decades. (Additional information on these estimates is provided in Appendix G-I and in Appendix I.)

The modeling results are highly sensitive to the input assumptions. As previously mentioned, the measure-by-measure cost estimates represent the best information currently available to the ARB. The level of detail on the costs and saving for the different measures

[1] The Department of Finance itself does not generate long-term economic projections for the entire California economy; however, its demographic forecasts are used as inputs to E-DRAM.
[2] Climate Action Team Economics Subgroup, "Updated Macroeconomic Analysis of climate Strategies Presented in the March 2006 Climate Action Team Report – Final Report," October 2007. http://climatechange.ca.gov/climate_action_team/index.html

included in the Scoping Plan vary widely. Some of the measures are in the later stages of regulatory development, and as a result, costs and savings estimates were readily available. For other measures that have yet to undergo the full regulatory process, costs and savings were specifically estimated for the Scoping Plan.

Energy Sector Modeling

ARB has also been working with a third model, ENERGY 2020, developed by System Solutions Incorporated (SSI). In response to a competitive solicitation, ICF International and its subcontractor, SSI, were selected to support a more detailed analysis of the economic impact of energy-related measures using the ENERGY 2020 model. This modeling analysis would have provided another perspective to supplement the E-DRAM results.

However, at this time no results are available from ENERGY 2020 because the model has not yet been fully calibrated. The calibration effort consists of harmonizing the ENERGY 2020 model with a business-as-usual case consistent with California-specific projections for emissions as well as demand for energy sources (e.g., gasoline). The calibration effort has required several more months of work than anticipated and, as indicated, is still underway. ARB has also been working with the contractor to incorporate detailed California-specific measure descriptions into the model. Although the methodology to integrate ENERGY 2020 and E-DRAM has been developed (i.e., mapping ENERGY 2020 outputs to E-DRAM inputs so that the models can work together), the calibration of investment and fuel expenditures has not been completed. Thus, ENERGY 2020 was not used in the analysis of the Scoping Plan, but is expected to help inform the subsequent regulatory phase of the program. ARB continues to work with ICF International and its subcontractor, SSI, to further refine and calibrate the ENERGY 2020 model and prepare it for evaluation of future regulations and policy designs.

1.2 Challenges in Modeling Market-Based Approaches

The primary insight to be gained from our macroeconomic modeling is the combined net beneficial impact of the set of recommended policies and measures embodied in the Recommendation on the California economy, taking into account their interaction and the shifting of economic activity across sectors. For the reasons outlined below, however, such models understate the benefits associated with market-based polices, and thus also likely understate the full range of the beneficial impacts.

1.2.1 Limitations of Available Models

Macroeconomic models such as E-DRAM are well suited to analyzing the economy-wide impact of a set of recommended policy measures, taking into account their interaction and the shifting of economic activity across sectors. As noted above, E-DRAM has been used in this fashion for a variety of past economic assessments.

Such models face several challenges in attempting to model market-based policies. First, the macroeconomic tools do not have the ability to predict how firms might invest in cost-effective energy efficient technologies that will result in reduced greenhouse gas emissions and reduced energy-related expenditures. Such cost-saving investments can only be reflected if they are specified in advance as inputs to the

model. This can be done for specific investments and measures for which the costs and savings have been estimated.

But available models do not have a mechanism to properly determine the nature or costs of "unspecified reductions" that are anticipated due to the broad flexibility allowed by a cap-and-trade program. By their very nature, such reductions cannot be attributed in advance to any specific measures or even source type. In order to produce additional unspecified reductions, the models simulate a more costly alternative. They adjust each sector's output and resulting emissions by adjusting prices of products so that they reflect the cost of GHG emissions (based upon calculated allowance prices) until the required emissions reductions are achieved. Consequently, emissions reductions in the model occur in response to reduced demand induced by increased prices. This provides an inaccurate picture that overestimates the costs of how a cap-and-trade program would operate in practice, since it fails to account for new investment that could increase efficiency and produce emissions reductions either at a net savings or lower cost.

In addition, the macroeconomic models operate at the sector level and, therefore, do not have the ability to capture the heterogeneity of facility-level emission reduction opportunities, that is, the full range of options for reducing greenhouse gas emissions available at individual facilities throughout the state. One of the primary advantages of market-based policies is that they take advantage of this heterogeneity—both in terms of variety of existing options and range of ability to innovate—to minimize costs.

Such savings have been documented by empirical studies. As was noted by the Market Advisory Committee, "This potential for cost savings is not simply a theoretical proposition. Studies indicate substantial cost savings from existing cap-and-trade programs. The two major studies of cost savings for the SO2 program[3] are in general agreement that savings under the trading program amounted to 43–55 percent of expected compliance costs under an alternative regulatory program that imposed a uniform emission standard. Carlson et al. cite savings of over 65 percent compared to a policy that might have forced post-combustion controls (scrubbers) to achieve the same level of emissions."[4] However, the models and related cost estimation methodologies treat all facilities within a sector as similar and therefore do not capture the cost reducing benefits of market-based policies that these studies have demonstrated.

Moreover, the models do not fully capture how individual consumers can and will take steps to pursue lower cost options. This is being observed today as consumers change driving habits and make greater use of public transit, carpooling and biking in response to gasoline price increases. In addition, over time, market-based approaches

[3] Carlson, C., Burtraw, D., Cropper, M. & Palmer K.L. (2000). Sulfur Dioxide Control by Electric Utilities: What are the Gains from Trade? The Journal of Political Economy, 108(6), 1292-1326; Ellerman, A. D. (2003). Lessons from Phase 2 Compliance with the U.S. Acid Rain Program. Working Paper 03-009. Cambridge: MA: Massachusetts Institute of Technology Center for Energy and Environmental Policy Research.

[4] Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California, Recommendations of the Market Advisory Committee to the California Air Resources Board, June 30, 2007, p. 7.

provide an incentive to find innovative ways to reduce emissions beyond the level necessitated by an individual firm under a performance standard. Again, available models do not capture how such innovation can reduce cost.

Other modeling tools can provide a more detailed look at the cost reduction options available to facilities. For example, ENERGY 2020 and similar models allow for an investment in improved energy efficiency as a way to achieve emission reductions. These models also treat all facilities in a sector the same with the exception of the utility sector, which in some models is represented at the individual power plant level. In general they face the same inability to capture market-oriented cost savings resulting from facility-level decisions.

1.2.2 Approach Used to Address Limitations

The Recommendation in the Scoping Plan incorporates a regulatory-based cap-and-trade program that links with the Western Climate Initiative, as well as a number of sector-based regulatory measures, many of which make extensive use of market mechanisms. Our assessment of the economic impact of the Recommendation is subject to the limitations of the models noted above with a resultant underestimation of benefits.

Given those limitations, we have approximated the operation of the cap-and-trade program as well as possible with the available modeling tools. For example, to capture how facilities might make technology changes to reduce emissions, the costs and savings of known efficiency measures were identified so that the cost per ton for reductions from those measures could be compared to carbon prices under a cap-and-trade program as modeled by E-DRAM. As a proxy for the types of actions that facilities would take in a cap-and-trade program, it is then assumed that facilities will choose to implement measures that cost less than the anticipated carbon price, to the extent they have been identified.

This approach provides a conservative approximation of how a portion of the reductions will be achieved by facilities covered by the cap-and-trade program. This technique partially addresses the model's lack of an internal mechanism to identify efficiency measures, but cannot fully eliminate it. Further, the model does not allow for the impact of innovation on cost reduction, and does not reflect the variety of emission reduction opportunities at the individual facility level.

Keeping these limitations in mind, our estimate of the economic impact of the Recommendation will understate the benefits of the market-based policies—including the cap-and-trade program—and therefore will understate the positive impact of the Recommendation on the California economy. We nevertheless believe that the estimate provides useful information for evaluating the Recommendation and is a reasonable application of the model.

1.2.3 Valid Comparison of Approaches Not Possible

The limitations of the available modeling tools noted above prevent a comparison between market-based approaches and alternative strategies, such as one that relies

only on direct regulation. It is worth noting that, to our knowledge, no previous work has made such a comparison in any rigorous way that incorporates the costs and savings of specific reduction measures. Other studies have either only modeled variations on one approach – typically one that includes market-based measures – or have used a broad-brush surrogate for a regulatory approach, such as uniform percentage reductions employed at the sector level, rather than incorporating the detailed cost and savings information from individual measures.

It is important to understand, as well as possible, the potential impacts of the various options available, and we devoted considerable time and effort to analyze alternatives to the Recommendation. We have ultimately concluded that tools are not available to make a valid comparison of one approach to the others, in great part because of the inability of the model to capture the benefits of the market mechanism measures. While results of analysis of alternative approaches were included in the appendices to the Economic Analysis Supplement to the Draft Scoping Plan, the analysis presented here focuses solely on the Recommendation in the Scoping Plan.

1.3 Western Climate Initiative Modeling Activity

The Scoping Plan recommends that California develop a cap-and-trade program that links to the broader regional market being developed by the Western Climate Initiative (WCI). In order to examine the economic impacts of WCI program design options, WCI Partner jurisdictions contracted with ICF International and SSI to perform economic analyses using ENERGY 2020, a multi-region, multi-sector energy model. The WCI work, as is appropriate for a multi-state analysis, is analyzing broad greenhouse gas reduction policies applied uniformly across the region rather than incorporating state by state specific implementation details. The WCI economic modeling results are reporting in full in Appendix D and they are discussed in the Background Report on the Design Recommendations for the WCI Regional Cap-and-Trade Program, also included in
Appendix D.

To help inform the program design process, the WCI analysis examined the implications of key design decisions, including: program scope; allowance banking; and the use of offsets. Due to time and resource constraints, the modeling was limited to the eight WCI Partner jurisdictions in the Western Electric Coordinating Council (WECC) area, thereby excluding from the analysis three Canadian provinces, Manitoba, Quebec, and Ontario. Future analyses are planned that will integrate these provinces so that a full assessment of the WCI Partner jurisdictions can be performed.

The WCI website (http://www.westernclimateinitiative.org/Economic_Analysis.cfm) contains an overview of the modeling and analysis. The main inputs to ENERGY 2020 are presented in the Assumptions Book for ENERGY 2020, which is being updated as the analysis proceeds, and is also posted on the WCI website. The inputs include:

- Historical energy consumption data by sector;
- Forecasts of fuel prices through 2020;
- Population forecasts by state and province through 2020; and,
- Forecast of economic growth by sector, and by state and province through 2020.

The WCI partners' analysis incorporated a set of policy assumptions into the reference case against which the cap-and-trade programs would be evaluated. These policy assumptions include:

- Energy efficiency, fuel standards, and automobile fuel efficiency (CAFE) standards from the Energy Independence and Security Act; and,
- Existing renewable portfolio standards adopted in the WECC states and provinces.

Additionally, the reference case incorporates assumptions regarding the availability and cost of various electric generating technologies and emission control technologies, including fossil fuel-fired generation (oil, gas, and coal) and wind, solar, biomass and geothermal generation.

The WCI modeling work is not directly comparable to the ARB results reported here. The WCI analysis relies on a more aggregated set of GHG emission reduction measures rather than the specific individual policies recommended in the Scoping Plan; it uses somewhat different assumptions regarding the "business-as-usual" case, and it models the entire WECC rather than California. Nevertheless, the results of the WCI modeling provide useful insight into the economic impact of greenhouse gas emission reduction policies.

Consistent with the conclusions of the ARB evaluation, overall, the WCI analysis found that the WCI Partner jurisdictions can meet the regional goal of reducing emissions to 15 percent below 2005 levels by 2020 (equivalent to the AB 32 2020 target) with small overall savings due to reduced energy expenditures exceeding the direct costs of GHG emission reductions. The savings are focused primarily in the residential and commercial sectors, where energy efficiency programs and vehicle standards are expected to have their most significant impacts. Energy-intensive industrial sectors are estimated to have small net costs overall (less than 0.5 percent of output).

The WCI analysis does not examine the potential macroeconomic impacts of the costs and savings estimated with ENERGY 2020. The WCI Partner jurisdictions are planning to continue the analysis so that macroeconomic impacts, such as income, employment, and output, can be assessed. Once completed, the macroeconomic impacts can be compared to previous studies of cap-and-trade programs considered in the United State and Canada.

2. SUMMARY OF MACROECONOMIC ANALYSIS RESULTS

To evaluate the economic impacts of the Scoping Plan, we compare estimated economic activity under a business-as usual (BAU) case to the results obtained when the policies in the Recommendation are implemented. The BAU case and the Recommendation are briefly described below and discussed in greater detail later in this section. The estimated costs and savings used as model inputs for individual measures are outlined in Appendix G-I. Additional detail for all of the individual measures contained in the Scoping Plan can be found in Appendix C of the Plan, and more detail on the calculation of the costs and savings for the measures is included in Appendix I of the Plan. All monetary estimates are in 2007 dollars.

Under the business-as-usual (BAU) case described below, Gross State Product (GSP) in California is projected to increase from $1.8 trillion in 2007 to around $2.6 trillion in 2020. The results of our economic analysis indicate that the Recommendation in the Scoping Plan will have an overall positive, net economic benefit for the state. Positive impacts are anticipated primarily because the investments motivated by several measures result in substantial energy savings that more than pay back the cost of the investments at expected future energy prices.

Business-as-Usual (BAU) Reference Case

The business-as-usual case is a representation of what the state of the California economy would be in the year 2020, assuming that none of the measures included in the Scoping Plan are implemented. While a number of the measures in the plan will be implemented as the result of existing federal or state policies and do not require additional regulatory action resulting from the implementation of AB 32, we do not include them in the BAU case to ensure that the economic impacts of all of the measures in the Scoping Plan are fully assessed.

The BAU case is not generated by the E-DRAM or BEAR models. Rather, the BAU case is constructed using several forecasts from other sources. Additional information about these sources can be found in Appendix G-II. Aspects of the BAU case are subject to uncertainty, for example to the possibility that future energy prices could deviate from those that are included in the BAU case. No sensitivity analysis is presented in this document, but ARB is exploring appropriate methods to incorporate sensitivity analysis in future work.

Recommendation

The Recommendation in the Scoping Plan includes measures related to energy efficiency, alternative fuels and high global warming potential gases, and a regulatory-based cap-and-trade program that together reduce emissions by 174 $MMTCO_2E$. The key measures providing the reductions include:

- Expanding and strengthening existing energy efficiency programs as well as building and appliance standards;
- Achieving a statewide renewables energy mix of 33 percent;
- Developing a California cap-and-trade program that links with other Western Climate Initiative partner programs to create a regional market system;
- Establishing targets for transportation-related greenhouse gas emissions for regions throughout California and pursuing policies and incentives to achieve those targets;
- Adopting and implementing measures pursuant to existing State laws and policies, including California's clean car standards, goods movement measures, and the Low Carbon Fuel Standard; and
- Creating targeted fees, including a public goods charge on water use, fees on high global warming potential gases, and a fee to fund the administrative costs of the State's long-term commitment to AB 32 implementation.

2.1 Impact of the Scoping Plan on California's Economy

Table G-1 summarizes the modeling results. Several economic indicators are shown for 2007 and for the 2020 model results from the business-as-usual (BAU) case and the Recommendation. Though the model results include other metrics, Gross State Product, personal income, and employment have historically been determined to be most useful for evaluating the macroeconomic impacts of policies and economic well-being. Under the BAU case, Gross State Product increases by $775 billion between 2007 and 2020, personal income grows by 2.8 percent per year from $1.5 trillion in 2007 to $2.1 trillion in 2020, and employment grows by 0.9 percent per year from 16.4 million jobs in 2007 to 18.4 million jobs in 2020.

As noted above, macroeconomic models will understate the benefits of market-based policies, including the cap-and-trade program. Consequently, our estimate of the economic impact of the Recommendation understates the positive impact on the California economy. Nonetheless, using the current best estimates of the costs and savings of the measures, the models demonstrate that the Recommendation has a positive effect on Gross State Product, personal income, and employment. For example, Gross State Product and personal income are projected to increase slightly more than they would in the BAU case, by about 0.3 and 0.8 percent, respectively, and employment is also projected to experience an increase of 0.6 percent. The modeling results indicate that California can meet the ambitious AB 32 target while maintaining and enhancing economic growth.

Table G-1: Summary of Economic Impact Modeling of the Scoping Plan Using E-DRAM

Economic Indicator	2007	Business-as-Usual[1]	Recommendation[2]
Real Output ($Billion)	2,535	3,597	3,630
Gross State Product ($Billion)	1,811	2,586	2,593
Personal Income ($Billion)	1,464	2,093	2,109
Income Per Capita ($Thousand)	38.6	47.56	47.76
Employment (Million Jobs)	16.41	18.41	18.53
Emissions ($MMTCO_2E$)	500[3]	596	421
Carbon Prices (Dollars)	-	-	10.00

[1] Business-as-usual is a forecast of the California economy in 2020 without implementation of any of the measures recommended in the Scoping Plan.
[2] Includes all measures in the Recommendation in the Scoping Plan, plus additional emission reduction options expected to be undertaken because they are estimated to have a cost-per-ton lower than the market price, as a proxy for reductions from the cap-and-trade program
[3] Approximate value. ARB is in currently estimating GHG emissions for 2007.

The economic impacts of the Scoping Plan are expressed as changes from a business-as-usual estimate of California's economic growth. As noted, the BAU case assumes that none of the measures included in the Scoping Plan are implemented. As Table G-2 below indicates, in the BAU case Gross State Product is projected to grow by about 2.7 percent annually to a value of nearly $2.6 trillion by 2020. Personal income is projected to grow by approximately 2.8 percent annually and job growth is also expected to continue as we move toward 2020.

Table G-2: Business-as-usual Case for California Economy

Economic Indicator	2007	2020	Change	Average Annual Growth (%)
Real CA Output ($Billions)	2,535	3,597	1,062	2.7%
Gross State Product ($Billions)	1,811	2,586	775	2.8%
California Personal Income ($Billions)	1,464	2,093	628	2.8%
Income Per Capita ($1000)	38.6	47.6	9	1.6%
Employment (Millions)	16.41	18.41	2	0.9%
Emissions ($MMTCO_2E$)	500[(1)]	596	96[(1)]	1.4[(1)]

[1] Approximate value. ARB is currently estimating the GHG emissions for 2007.

Table G-3 shows how implementation of the Recommendation would affect California's economy relative to a business-as-usual growth trajectory between now and 2020. As indicated in the table, the effects on output, personal income and employment are small but positive. Total output, which represents production activity in the state, increases by 0.9 percent over BAU. This translates into an increase of approximately $33 billion in 2020,

which is a relatively minor increase when evaluated in the context of a $3.6 trillion economy, but still positive nonetheless. Also represented in Table G-3 are the impacts of the Recommendation on Gross State Product, personal income, income per capita, and employment. In each case, the modeling shows a similar positive, but small, impact.

Table G-3: E-DRAM Estimates of Economic Impacts of the Scoping Plan Recommendation

Economic Indicator	BAU Case	Preliminary Recommendation	Change	% Change
Real Output ($Billions)	3,597	3,630	33	0.9%
Gross State Product ($Billions)	2,586	2,593	7	0.3%
Personal Income ($Billions)	2,093	2,109	16	0.8%
Income Per Capita ($1000)	47.56	47.76	0.2	0.4%
Employment (Millions)	18.41	18.53	0.12	0.7%
Emissions ($MMTCO_2E$)	596	422	174	-29%
Carbon Price (Dollars)	NA	10.00	NA	NA

The positive impacts are largely attributable to savings that result from reductions in expenditures on energy. These savings translate into increased consumer spending on goods and services other than energy. Many of the measures entail more efficient use of energy in the economy, with savings that exceed their costs. In this way, investment in energy efficiency results in money pumped back into local economies. Table G-4 summarizes the energy savings that are projected from implementation of the Recommendation in the Scoping Plan. These savings are estimated to exceed $28 billion annually by 2020.

Table G-4: Fuels and Electricity Saved in 2020 from Implementation of Recommendation [needs additional vmt savings of T-3]

	Gasoline	Diesel	Electricity	Natural Gas
Use Avoided[1]	4,600 million gallons	670 million gallons	74,000 GWh	3,400 million therms
Value of Avoided Fuel Use (Million $2007)	$17,000	$2,500	$6,400[2]	$2,700
Percent Reduction from BAU	25%	17%	22%[3]	29%[4]

[1] These estimates are based on reduced use of these fuels due to increased efficiencies, reduced vehicle miles traveled, etc. Changes to the fuel mix, such as those called for under the RPS or LCFS, are not included here. These estimates are not the same as the estimates of reduced fuel combustion used in the public health analysis.
[2] Based on estimated avoided cost based on average base-load electricity, including generation, transmission and distribution.
[3] This is as a percentage of BAU total California electricity consumption in 2020.
[4] This does not include natural gas used for electricity generation.

All told, the specified reduction measures in the Scoping Plan's Recommendation (not including additional unspecified reductions from cap and trade) are expected to reduce emissions of approximately 174 $MMTCO_2E$ at a net savings of about $15.4 billion, providing a positive stimulus to the economy.

When modeling the Recommendation, the model should reflect the fact that facilities will pursue emission reduction options that have a cost per ton that is lower than the market price. In the absence of complete information on what those options might be, we included in the model runs the technical options that were identified as part of the additional measures under consideration in the Draft Scoping Plan that cost less than the carbon price (other than feebates, because of the regulatory structure that would be necessary to implement that measure). The carbon price is an output of E-DRAM. The model was initially run with just the Recommended measures. The resulting carbon price was used to select additional low-cost measures to serve as a proxy for reductions resulting from the cap-and-trade program. Thus, this approach provides a rough approximation of how a portion of the reductions from the market approach would be achieved. This produces, however, an incomplete list of choices since the model does not have the capability to adequately reflect the full set of options that are available to covered sectors under cap and trade. This approach resulted in measures that provided an additional 19 $MMTCO_2E$ in reductions included in the model run of the Recommendation. Reductions for the remaining 14 $MMTCO_2E$ were then modeled using an approach that represented pricing mechanisms that moderated consumer demand. Appendix G-I provides a complete list of the measures included in this modeling run.

As a result, the modeling results presented for the cap-and-trade program of the Recommendation reflect a carbon price of $10 per ton. It is important to note that the $10 per-ton figure does not reflect the average cost of reductions; rather, it is the *maximum* price at which reductions to achieve the cap are pursued based on the market program. We will continue to evaluate these results and anticipate that modeling efforts currently underway in the Western Climate Initiative will provide useful additional information.

2.2 Impact on Specific Business Sectors

In addition to evaluating the projected statewide macroeconomic impacts of implementation of the Scoping Plan, we also modeled how implementation will affect specific sectors. E-DRAM is capable of generating information at a general level of detail that describes how specific sectors of the California economy will be affected. Additional discussion regarding how E-DRAM models sector specific impacts and the various types of industries that comprise each sector can be found in Appendices G-II and G-IV.

As indicated in Table G-5, the effects of the plan are not uniform across sectors. Implementation of the Recommendation in the Scoping Plan would have the strongest positive impact on output and employment for the agriculture, forestry and fishing sector; the finance, insurance and real estate sector; and the mining sector. Similar to the statewide economic impacts projected by the model, these results also indicate that impacts due to implementation of the plan, compared to the business-as-usual case, are still positive, and alter the current growth projections for most sectors by only very small amounts.

Table G-5 also shows that for several sectors a decrease in output and employment is projected. In the utility sector, the modeling indicates that implementation of the Recommendation would significantly reduce the need for additional power generation and natural gas consumption which subsequently reduces the growth in output for this sector. This results in a reduction from business-as-usual for both economic output and employment of approximately 17 and 15 percent, respectively, in 2020. The primary reason for these

projections is the implementation of efficiency measures and programs for both consumers and producers as described in the Scoping Plan. While increasing spending on efficiency and renewable energy is expected to increase employment, many of the resulting jobs will not appear in the utility sector.

The retail trade sector, which is projected to grow by nearly 50 percent in both the business-as-usual and the Recommendation case, is also projected to experience a slight net decline in output relative to business-as-usual. Since gasoline is considered a consumer retail purchase under this model, the reduced growth is mostly due to the decrease of approximately $19 billion in retail transportation fuel purchases, which is largely offset by the $14 billion increase in spending at other retail enterprises.

Table G-5: **E-DRAM Estimates of Sector Specific Economic Impacts of the Recommendation**

	Output ($Billions)				Employment (thousands)			
Sector	**2007**	**BAU**	**Rec**	**Percent Change from BAU**	**2007**	**BAU**	**Rec**	**Percent Change from BAU**
Agriculture, Forestry and Fishing	76	109	113	3.9%	398	449	464	3.5%
Mining	27	29	31	7.2%	26	26	26	1.3%
Utilities	51	72	60	-16.7%	60	67	57	-14.7%
Construction	114	164	166	1.7%	825	929	934	0.5%
Manufacturing	673	943	948	0.5%	1,821	2,046	2,057	0.5%
Wholesale Trade	120	171	173	1.0%	703	791	793	0.1%
Retail Trade	207	296	291	-1.6%	1,688	1,901	1,916	0.8%
Transportation and Warehousing	76	109	111	1.9%	447	503	510	1.2%
Information	164	235	238	1.1%	398	448	450	0.4%
Finance, Insurance and Real Estate	391	559	572	2.3%	911	1,026	1,046	2.0%
Services	636	910	927	1.9%	5,975	6,729	6,773	0.7%
Government	-	-	-	-	3,100	3,491	3,502	0.3%
Total	**2,535**	**3,597**	**3,630**	**0.8%**	**16,352**	**18,405**	**18,528**	0.6%

2.3 Household Impacts

Our analysis also included an evaluation of how households in California would be affected by the implementation of AB 32, particularly low- and middle-income households. The results indicate that both low- and middle-income households will realize savings on the order of a few hundred dollars per year in 2020, compared to the business-as-usual case, primarily as a result of increased energy efficiencies.

2.3.1 Low-Income Households

Based on current U.S. Department of Health and Human Services poverty guidelines, we evaluated the projected impacts of the plan on households with earnings at or below both 100 and 200 percent of the poverty guidelines. For the typical household of three members, an income of $17,600 corresponds to 100 percent of the poverty level and an income of $35,200 corresponds to 200 percent of the poverty level.[5] For all households, including those with incomes at 100 percent and 200 percent of the poverty level, implementation of the Recommendation produces a slight increase in household income relative to the business-as-usual case.

At the same time, the analysis projects a small increase in the number of jobs available for lower-income workers[6] relative to business-as-usual as a result of implementing the plan.

For example, implementation of the Recommendation produces approximately 50,000 more such jobs in 2020 than there would otherwise be. The largest employment gains come in the retail, food service, agriculture, and health care fields. A decline in such jobs is projected in the retail gasoline sector due to the overall projected decrease in output from this sector. This decline is more than offset by the increases experienced in other areas, and the vast majority of workers displaced in the retail gasoline sector would not likely require any additional training or experience to transition into a new field of employment.

Another important factor to consider when analyzing the impact of the Scoping Plan on households is how it will affect household expenditures. As indicated in Table G-6, analysis based on the modeling projections estimates a savings (i.e., reduced expenditures) of around $400 per household in 2020 for low-income households under both federal poverty guideline definitions. These savings are driven primarily by the implementation of the clean car standards and energy efficiency measures in the Scoping Plan that over time are projected to outweigh potential increases in electricity and natural gas prices that may occur. As the measures in the Scoping Plan are implemented, we will work to ensure that the program is structured so that low income households can fully participate in and benefit from the full range of energy efficiency measures. Additional information regarding the data in Table G-6 can be found in Appendix G-IV.

[5] Source: Federal Register, Vol. 73, No. 15, January 23, 2008, pp. 3971-3972.

[6] Low-income jobs are defined as those with a median hourly wage below $15 per hour (2007 dollars) based on wage data and staffing pattern projections from the California Employment Development Department. The shares of low-wage occupations for each industry are then applied to the corresponding E-DRAM sector employment projections.

Table G-6: Impact of Implementation of Scoping Plan on Total Estimated Household Savings in 2020 (2007 $)

	Income at 100% of Poverty Guideline	Income at 200% of Poverty Guideline	Middle Income[1]	High Income[2]	All Households[3]
Recommendation	$400	$400	$500	$500	$500
Share of Total Expenditures	2%	2%	1%	1%	1%

[1] All households between 200 percent and 400 percent of the poverty guidelines.
[2] All households above 400 percent of the poverty guidelines.
[3] Average of households of all income levels.

The modeling indicates that implementation of the Scoping Plan is likely to result in small savings for most Californians, with little difference across income levels. Largely due to increased efficiencies, low-income households are projected to be slightly better off from an economic perspective in 2020 as a result of implementing AB 32.

2.3.2 Middle-Income Households

In addition to looking at how low-income households would be affected, we also analyzed what the projected impacts of the plan would be for a middle-income California household. For purposes of our analysis we define "middle-income" households as those earning between 200 percent and 400 percent of the federal poverty guidelines. For the average-size household in California, this equates to an annual income between $35,000 and $70,000.

As previously discussed, the analysis indicates that implementation of the plan produces a small increase in per capita income across all income levels, including middle-income households relative to the business-as-usual case. In terms of how jobs[7] for middle-income households would be impacted, the analysis indicates a slight overall increase of nearly 40,000 in 2020.

As shown in Table G-6, the analysis projects a net-savings in annual household expenditures of about $500 in 2020 for middle-income households. These savings are driven by the emergence of greater energy efficiencies that will be implemented as a result of the plan.

The results of our analysis show that implementation of the Scoping Plan will have a small, but overall positive, impact on middle-income California households. These findings are consistent with the projected impacts of the plan on low-income households and with the economy-wide modeling results as well.

[7] Hourly wage between $15 and $30 per hour, (2007 dollars), based on wage data and staffing pattern projections from the California Employment Development Department.

2.4 Small Business Impacts

Small businesses in general will not be directly affected by the measures recommended in the Scoping Plan. Any impacts will primarily come in the form of changes in the costs of goods and services that they procure, and in particular, changes in energy expenditures. Therefore, in this analysis we focus on how implementation of the Recommendation would affect the percentage of revenue small businesses spend on energy, and how this could impact their profitability and overall economic competitiveness. Additional detail regarding the methodology we used is in Appendix G-V.

Recent analysis from Energy and Environmental Economics, Inc.[8] (E3) forecasts that a package of greenhouse gas emission reduction measures similar to those contained in the Scoping Plan would deliver a 5 percent decrease in electricity expenditures for the average California electricity customer relative to business-as-usual in 2020. Changes to individual entities will deviate from the average and the E3 analysis does not predict how these savings will be distributed among customers. This projection is based on the assumption that increases in electricity prices will be more than offset by the continued expansion of energy efficiency measures and that more efficient technologies will be developed and implemented.[9] We also make a conservative assumption that expenditures on natural gas remain the same, balancing the projected 18 percent decrease in natural gas consumption in California with the model's projected natural gas price increase of 7.9 percent.

Based on this assessment, our analysis indicates that implementation of the Recommendation in the Scoping Plan will likely have minor but positive impacts on small businesses in the state. These benefits are attributable primarily to the measures in the plan that will deliver significantly greater energy and fuel efficiencies. Even when higher per-unit energy prices are taken into account, these efficiencies will decrease overall energy expenditures for small businesses. Additionally, as previously described, the California economy is projected to experience robust economic growth between now and 2020 as AB 32 is implemented. Small businesses will experience many of the benefits associated with this growth in the form of more jobs, greater production activity, and rising personal income.

The projected decrease in electricity expenditures is especially important for small businesses since they typically spend more on energy as a percentage of revenue compared to larger enterprises. For example, firms with a single employee spend approximately 3.3 percent of each sales dollar on electricity while businesses with between 10 and 49 employees spend around 1.2 percent. As a result, smaller businesses are likely to experience a greater relative benefit from decreased energy expenditures relative to their larger counterparts.

From the broader economic perspective, these changes will make California more competitive as a location for small business, moving it from 7th highest to 19th among all

[8] Based on their GHG calculator, CPUC/CEC GHG Docket (CPUC Rulemaking.06.04.009, CEC Docket 07-OIIP-01), available at http://www.ethree.com/cpuc_ghg_model.html.

[9] The E3 analysis focuses on direct programmatic measures and does not include the incremental price impact of the cap and trade program, which will depend upon allowance price, allocation strategy, the capped sector industry response and other program design decisions.

states in terms of the percentage of revenue that businesses expend on electricity.[10] As was noted above for low-income households, care must be taken to ensure that the program is structured to allow small businesses to participate in and benefit from the energy efficiency measures.

[10] Although our natural gas data is less specific, we expect a similar scenario where increased prices are typically offset by greater efficiencies for most small businesses.

3. GREEN TECHNOLOGY LEADERSHIP

The development of green technologies and a trained workforce equipped to design, develop and deploy them will be key to the success of California's long-term efforts to combat global warming. This section outlines a variety of ways in which the state's greenhouse gas emission reduction policies will support and foster green technology.

3.1 Green Technology Attracts Capital

Bold, long-range environmental policies help drive innovation and investment in emission-reducing products and services in part by attracting private capital. Typically, the private sector under-invests in research and development for products that yield public benefits. When environmental policy is properly designed and sufficiently robust to support a market for such products, private capital is attracted to green technology development as it is to any strategic growth opportunity.

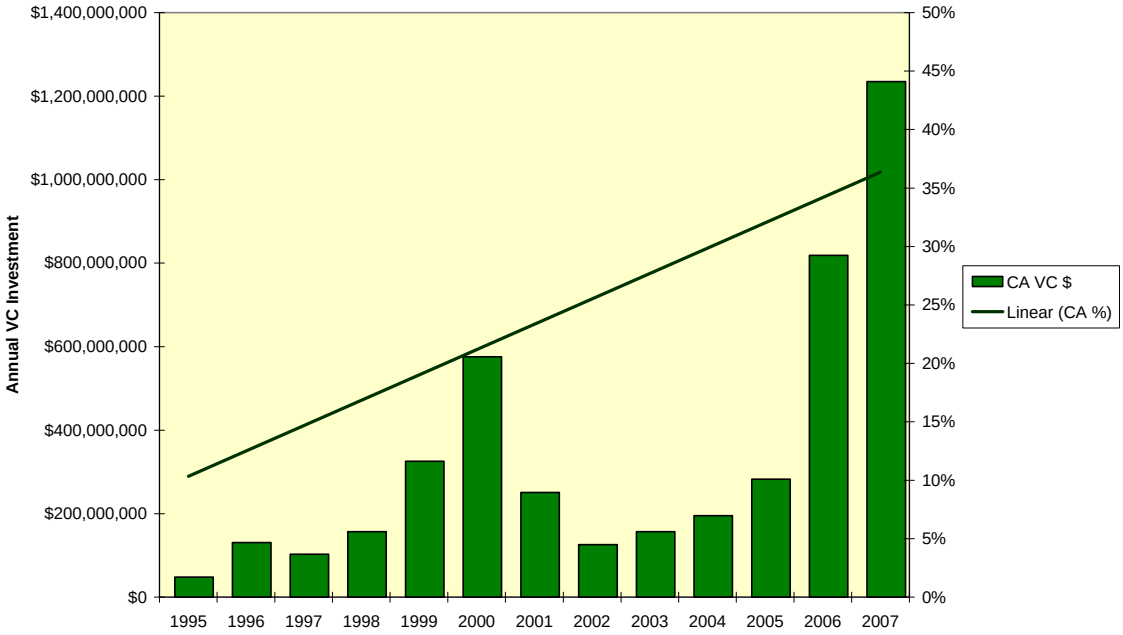
In addition to well-designed environmental policy, other factors are also important in attracting private resources to invest in technological innovation. These include the presence of adequate innovation infrastructure in the form of established centers of research and development, a physical and cultural environment that attracts the most innovative human resources, and a large-scale local market for innovative products. Where all of these other factors are present – as they are in California – state policies can have an extremely important positive impact.

California's leadership in environmental and energy efficiency policy has helped attract an increasing share of venture capital investment in green technologies. According to statistics from PricewaterhouseCoopers and the National Venture Capital Association, California's share of U.S. venture capital investment in innovative energy technologies increased dramatically from 1995 to 2007 (see Figure G-3 below).[11] The same period saw a stream of pioneering environmental policy initiatives, including energy efficiency codes for buildings and appliances, a renewable portfolio standard for energy, climate change emission standards for light duty automobiles and, most recently, AB 32. Flows of venture capital into California are escalating as a direct result of the focus on greenhouse gas reduction. According to Cleantech Network, LLC, an industry group that tracks clean technology financial trends, California captured the largest single portion of global venture capital investment ($800 million out a total of $2 billion dollars) during the second quarter of 2008.[12]

[11] Based on historical trend data for the 'Industrial/Energy' industry for California and the United States from the PricewaterhouseCoopers MoneyTree Report. https://www.pwcmoneytree.com/MTPublic/ns/nav.jsp?page=historical (accessed October 12, 2008).
[12] "Cleantech Venture Investment Reaches Record of $2 Billion in 2Q08", Cleantech Network, LLC, July 08, 2008.

Figure G-3

California's Growing Share of Venture Capital Investment in Energy Innovation, 1995-2007 (current $, % share)



Source: Based on historical trend data for the 'Industrial/Energy' industry for California and the United States from the PricewaterhouseCoopers MoneyTree Report. https://www.pwcmoneytree.com/MTPublic/ns/nav.jsp?page=historical (accessed October 12, 2008)

A survey of clean technology investors by Global Insight and the National Venture Capital Association found that public policy influences where venture capitalists invest;[13] and investments in green technology solutions produce jobs at a higher rate than investments in comparable conventional technologies.[14] Venture Capitalists estimate that each $100 million in venture capital funding helps create 2,700 jobs, $500 million in annual revenues for two decades, and many indirect jobs.[15]

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[13] Clean Tech Entrepreneurs & Cleantech Venture Network LLC. *Creating Cleantech Clusters: 2006 Update*. May 2006. p.43 http://www.e2.org/ext/doc/2006%20National%20Cleantech%20FORMATTED%20FINAL.pdf (accessed October 12, 2008)

[14] Report of the Renewable and Appropriate Energy Laboratory. *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* Energy and Resources Group/Goldman School of Public Policy at University of California, Berkeley. April 13, 2004. http://rael.berkeley.edu/old-site/renewables.jobs.2006.pdf (accessed October 12, 2008)

[15] Report prepared for the National Venture Capital Association. *Venture Impact 2004: Venture Capital Benefits to the U.S. Economy*. Prepared by: Global Insight. June 2004. http://www.globalinsight.com/publicDownload/genericContent/07-20-04_fullstudy.pdf (accessed October 12, 2008)

Access to capital controlled by institutional investors is also enhanced by policies that encourage early adoption of green technologies. When California-based corporations use green technologies to reduce their exposure to climate change risk, institutional investors reward them by facilitating their access to capital. The Investor Network on Climate Risk – including institutional investors with more than $8 trillion of assets under management – endorsed an action plan in 2008 that calls for:

- Requiring asset managers to consider climate risks and opportunities when investing;
- Investing in companies that develop and deploy clean technologies; and,
- Expanding climate risk scrutiny by investors and analysts.[16]

Additional capital for green technologies helps drive increased employment, both indirectly, as energy savings are plowed back into other sectors of the economy; and directly, as new green products are successfully commercialized.

3.2 Green Job Creation

The increasing emphasis on making a transition toward safer and more secure energy sources has spurred a steady rise in demand for energy efficiency and renewable energy products and services. Mainstream capital markets have started to actively seek out and embrace green business opportunities. Now an accepted investment category in capital markets, green technology portfolios routinely outperform broader market indices such as the Standard & Poor's 500 and the Dow Jones Industrial Average.[17] Alternative energy is no longer an alternative investment.

McKinsey & Company projects average annual returns of 17 percent on global investments in energy productivity, and sizes the global investment opportunity at $170 billion annually through 2020.[18] Meanwhile, global investment in energy efficiency and renewable energy has grown from $33 billion to more than $148 billion in the last four years. Beyond 2020, green technologies are expected to attract investment of more than $600 billion annually.[19] In short, green technology is now a *bona fide* global growth industry.

Today, green technology businesses directly employ at least 43,000 Californians, primarily in energy efficiency and energy generation, according to a 2008 study from the California Economic Strategy Panel. Green jobs are concentrated in manufacturing (41 percent), and professional, scientific and technical services (28 percent), with median annual earnings of

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[16] The Investor Network on Climate Risk. *Final Report, 2008 Investor Summit on Climate Risk*. February 14, 2008. http://www.ceres.org//Document.Doc?id=331 (accessed October 12, 2008)

[17] "Cleantech Venture Capital: How Public Policy Has Stimulated Private Investment" James Stack, UC Berkeley Goldman School of Public Policy , E2 Environmental Entrepreneurs, and Cleantech Venture Network, LLC, May 2007, pages.8-9

[18] McKinsey Global Institute. *The Case for Investing in Energy Productivity*. McKinsey & Company. February, 2008. p.8 http://www.mckinsey.com/mgi/reports/pdfs/Investing_Energy_Productivity/Investing_Energy_Productivity.pdf (accessed October 12, 2008)

[19] United Nations Environment Programme-New Energy Finance Ltd. *Global Trends in Sustainable Energy Investment 2008: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency* 2008. p.12 ISBN: 978-92-807-2939-9 http://www.unep.fr/energy/act/fin/sefi/Global_Trends_____2008.pdf (accessed October 12, 2008)

$35,725 and $56,754, respectively.[20] By 2030, under a moderate growth scenario, green businesses nationwide are expected to generate revenues of $2.4 trillion, (2006 dollars), and employ 21 million Americans.[21]

3.3 Energy Efficiency Jobs

As a leader in green technology development and use, California has already realized substantial economic benefits from the adoption of energy efficiency policies. State energy efficiency measures have saved enough energy over the past 30 years to avoid construction of 24 500-megawatt power plants. Today, California's per capita electricity consumption is 40 percent below the national average, and the carbon intensity of California's economy is among the lowest in the nation.[22]

Household consumption accounts for over 70 percent of Gross State Product, and household energy savings are a key driver of both employment and economic growth. As energy-efficient households shift spending from the capital intensive supply chain of the energy industry to the more labor-intensive supply chains of other products and services, more new jobs are created. As a result, net employment impacts of energy efficiency for California are strongly positive.

Building and appliance efficiency standards have saved California households more than $56 billion in electricity and natural gas costs since 1978, and increased the growth of Gross State Product by 3 percent ($31 billion) over the same period. California's Title 24 building standards are expected to produce another $23 billion in household energy savings by 2013, while California's appliance standards are projected to deliver another $25 billion in energy savings through 2020.[23]

3.4 Renewable Energy Jobs

Renewable energy—solar, wind, biomass, geothermal—will also bring new employment opportunities to Californians while spurring economic growth. Compared to other states, California enjoys significant advantages for renewable energy development. These include: concentrated innovation resources; a large potential customer base; key natural resources such as reliable insolation and wind; and supportive regulatory programs, including the California Renewable Portfolio Standard, the Million Solar Roofs Initiative, the California Global Warming Solutions Act of 2006, and the Solar Water Heating and Efficiency Act of 2007.

Other researchers have estimated that under a national scenario with 15 percent renewables penetration by 2020, California will experience a net gain in direct employment of 140,000

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[20] California Economic Strategy Panel with Collaborative Economics. *Clean Technology and the Green Economy*. March 2008. p.14-15 http://www.labor.ca.gov/panel/pdf/DRAFT_Green_Economy_031708.pdf (accessed October 12, 2008)

[21] The American Solar Energy Society. *Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century.* 2007. p.39 ISBN 978-0-89553-307-3 http://www.ases.org/images/stories/ASES-JobsReport-Final.pdf (accessed October 12, 2008)

[22] California Energy Commission. *2007 Integrated Energy Policy Report*. Document No. CEC-100-2007-008-CMF. 2007. p. 3 http://www.energy.ca.gov/2007publications/CEC-100-2007-008/CEC-100-2007-008-CMF.PDF (accessed October 12, 2008)

[23] Ibid.

jobs by 2020.[24] Because investments in green technologies produce jobs at a higher rate than investments in conventional technologies, jobs losses that occur in traditional fossil fuel industries will be more than compensated for by gains in the clean energy sector.

Furthermore, if California's renewable energy suppliers field products that are sufficiently competitive to penetrate the export market, employment and earnings dividends for the state will also increase. California renewable energy industries servicing the export market can generate up to 16 times more employment than those that only manufacture for domestic consumption, according to a study by the Research and Policy Center of Environment California.[25]

[24] Tellus Institute and MRG Associates. *Clean Energy: Jobs for America's Future.* As cited in: Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate? Energy and Resources Group/Goldman School of Public Policy at University of California, Berkeley. April 13, 2004. http://rael.berkeley.edu/old-site/renewables.jobs.2006.pdf (accessed October 12, 2008)

[25] Environment California Research and Policy Center. *Renewable Energy and Jobs. Employment Impacts of Developing Markets for Renewables in California*. July 2003. As cited in: Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate? Energy and Resources Group/Goldman School of Public Policy at University of California, Berkeley. April 13, 2004. http://rael.berkeley.edu/old-site/renewables.jobs.2006.pdf (accessed October 12, 2008)

4. PEER REVIEW OF THE SCOPING PLAN ECONOMIC ANALYSIS

ARB believes that this economic analysis will benefit from an independent peer review and has taken steps, through an established independent process conducted by the California Environmental Protection Agency (Cal/EPA), to establish a peer review panel. Submission of the economic analysis for peer review can strengthen the economic assessment as well as the findings presented in the Scoping Plan. The purpose of the review is for the peer reviewers to make a determination as to whether the economic analysis is based upon sound scientific knowledge, methods, and practices. In short, the purpose of the peer review is to ensure that the scientific underpinnings of the economic analysis are based on the best science. In an effort to establish the peer review panel, Cal/EPA requested the University of California, Berkeley to initiate the process of selecting experts to review the economic analysis presented in this document. The panel will remain anonymous to the ARB and only be identified after submitting its comments.

The Economic Analysis Supplement to the Draft Scoping Plan was provided to the peer reviewers through the University of California, Berkeley. The reviewers were selected by the Berkley Institute of the Environment based on their professional experience, having distinguished themselves as experts in the field of economics with a particular focus in areas including economic modeling, market mechanisms and the economics of climate change mitigation. As part of its review the panel completed the following:

- Assess the theoretical basis of the models;
- Assess the appropriateness of the models to support the evaluation of the policy scenarios to reduce emissions of GHGs;
- Assess the key data sets (e.g., energy consumption forecasts) upon which one or more of the models rely;
- Examine the assumptions for their validity and practicality;
- Assess the key variables to which the model is most sensitive and a qualitative assessment of how alternative assumptions could impact the results;
- Assess the economic analysis of the Scoping Plan including the associated inputs and assumptions;
- Comment on the reasonableness of the models' results as well as their interpretation as presented in the analysis;
- Comment on additional analyses that ARB should consider incorporating during the implementation of the Scoping Plan; and,
- Comment on additional modeling approaches that others have done/may do in response to the Scoping Plan.

The ARB will consider the results of this peer review when it is provided and will respond as appropriate. In addition to the formal peer review, the economic analysis and related ongoing work will also be reviewed by the Climate Action Team.

5. CONCLUSION

California has boldly accepted the challenge to address climate change by developing a comprehensive program to reduce greenhouse gases. As the economic analysis presented here indicates, the Scoping Plan's Recommendation also presents us with a tremendous economic opportunity. We can implement AB 32 in a way that not only protects, but actually enhances economic growth and creates thousands of new jobs. We can grow our economy while also making it cleaner, more efficient and more secure. Many economic benefits will accompany the implementation of a comprehensive emission reduction strategy as outlined in the Scoping Plan.

Our analysis concludes that:

- California can reach its emission reduction target in a manner that is beneficial to the economy by increasing economic output, jobs and income;
- On average, consumers are expected to be better off because of the savings due to the implementation of increased energy efficiency measures in the Scoping Plan;
- All households, including low-income households, are projected to experience net economic savings due to the implementation of the plan;
- Business impacts of the Scoping Plan are positive. Several measures in the plan encourage, require or promote energy efficiency, which is likely to reduce energy costs for businesses of all sizes over time; and,
- Implementation of the plan will drive California-based technologies to the forefront of the growing global market in green technology, providing jobs and income to many Californians.

The Plan recommends an effective mix of approaches for reducing greenhouse gases and takes advantage of the strengths of each. It calls for the deployment of efficient technologies and strategies which will both reduce emissions and save consumers money. Performance standards with market mechanisms will further allow regulated businesses to meet those standards in the most efficient and profitable manner. A multi-sector cap-and-trade program will provide a strong financial incentive for both producers and consumers to search out and pursue the most cost-effective emissions reduction opportunities in ways that will achieve additional savings not fully captured within the model.

These positive economic impacts to the state are not the only consideration when choosing which path to pursue. In addition to the financial savings predicted within the model, the Recommendation also assures meaningful reductions will occur in each sector of the California economy. It creates a policy framework to maximize participation and benefits at every level of government including state, regional and local. The cap-and-trade program provides further environmental and leadership benefits including placing an absolute emission limit on capped sectors, expanding coverage of the program through the Western Climate Initiative, providing a model for future Federal programs and creating larger markets for California's clean technology industries.

Moving forward, ARB will continue to refine its economic analysis of the measures contained within the Scoping Plan as well as review the results of the peer review and other relevant modeling. Once the Scoping Plan has been adopted, ARB will conduct further economic modeling for each of the measures pursued to inform the best design of those measures. This analysis represents the beginning, not the end, of what will be an ongoing evaluation of the best ways to achieve the goals of the program.

California has all of the ingredients to emerge at the vanguard of 21st century economies that are built upon clean, efficient and renewable energy sources. The state has a track record of successful and transformative innovation, a strong commitment to both public and private investment in new technologies, and a history of demonstrated success in designing environmental policies that also help to foster economic growth. The results of the economic analysis clearly show that California can achieve the goals of the Global Warming Solutions Act of 2006 and enhance its economic and environmental leadership.

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Climate Change Scoping Plan Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Appendix G: Economic Analysis
Appendix G-I
Modeling Assumptions for Economic Analysis of the Scoping Plan

Introduction

Appendix G presents the results of the economic analysis of the Recommendation in the Scoping Plan. Staff from ARB and other agencies developed estimates of the costs and savings of those measures. The costs and savings of each measure were analyzed using a standard ARB methodology to consider costs, savings, and cost-effectiveness of its proposed regulations for the past three decades. The methodology is the annualized discounted cost analysis, further explained below.

The annualized discounted cost analysis methodology is well established and accepted, and has been used for the economic assessment of major regulations developed by ARB in recent years. For example, ARB used the methodology to analyze the costs of the Light–Duty Motor Vehicle Greenhouse Gas Standards (AB 1493, Pavley) designed to reduce greenhouse gas emissions. The methodology was also used by the Economic Subcommittee of the Climate Action Team to assess the costs, savings, and cost-effectiveness of its GHG reduction measures.[26] Several other regulatory and planning efforts have used the annualized discounted cost analysis.

The level of detail on the costs and savings for the different measures included in the Scoping Plan vary widely. Because some of the measures are in the later stages of regulatory development, their costs and savings estimates were readily available. For other measures the costs and savings were specifically estimated for the Scoping Plan. Many of these estimates are preliminary, and are likely to change during the regulatory process. For example, the costs and savings for some measures were developed, in part, by drawing from cost per ton information compiled to support related measures proposed or adopted by other organizations.

[26] Climate Action Team Economics Subgroup, "Updated Macroeconomic Analysis of Climate Strategies Presented in the March 2006 Climate Action Team Report – Final Report," October 2007. http://climatechange.ca.gov/climate_action_team/index.html

Cost and Savings Analysis Methodology

Applying a consistent methodology for analyzing the costs of measures is a necessary step to prepare inputs for the E-DRAM model.[27] Specifically, the methodology annualizes all costs and savings to calculate the net cost per ton of emissions reduced for each measure.

Many of the measures have up-front costs for equipment or devices that last many years, thus supporting ongoing emission reductions. The costs need to be spread over the years that the equipment operates. For example, an efficient refrigerator that costs more will provide refrigeration with less electricity and cause lower greenhouse gas emissions for 10 to 15 years. The additional cost of purchase would have to be spread over the life of the refrigerator to correspond with the refrigeration benefits to allow comparison with the savings through reduced energy consumption, which also occur over the lifetime of the refrigerator. The up-front costs for many of the measures were reported as the capital expenditures necessary to implement the measure.

Another cost factored into the analysis is the ongoing cost for operations and maintenance after a measure is implemented. In some cases, this cost may be negative, representing a savings when a measure reduces ongoing costs.

Savings are treated similarly to annualized costs if they occur up-front. However, almost all savings from the measures resulted from reduced energy use or operations and maintenance costs, and were reported as an annual amount.

The following items were included in the cost and savings information on the measures and were used in the economic modeling:

- Up-front or Capital Expenditures: investments in equipment or facilities with lifetimes of more than one year.
- Equipment Life: the period of time the equipment provides its benefits.
- Operations and Maintenance Costs: on-going costs that facilitate realization of the benefits from the installed equipment or devices.
- Energy Costs and Savings: were reported in energy units for each year and were valued using a consistent energy price forecast.
- Non-Energy Savings: reported for each year.
- Constant 2007 Dollars: used for all valuations.

[27] E-DRAM is described in more detail in Appendix G-II.

The analysis of costs and savings involved four steps. The first step is to annualize the up-front or capital expenditures using the following formulas:

$$\text{Annualized Cost of Capital} = \text{Capital Expenditures} \times \text{Capital Recovery Factor}$$

$$\text{Capital Recovery Factor} = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where i is the discount rate (5%) and n is the life of the capital.

The capital expenditures developed for the proposed measures were multiplied by a capital recovery factor to give the annualized cost of capital. The capital recovery factor requires selecting a discount rate and equipment lifetime. A uniform real discount rate of five percent was used for all measures, and the equipment lifetime was estimated for each measure. The primary rationale for using a real discount rate of five percent is that it is equivalent to rate of return on an inflation-adjusted 10-year treasury security, (about 2 percent in the past five years)[28] , plus the California Environmental Protection Agency recommended 3 percent risk premium.[29] The five percent real discount rate has been used for several recent ARB regulations. Additionally, the five percent is the average of what the US Office of Management and Budget recommends (7 percent) and what US Environmental Protection Agency has used historically for regulatory analysis. The result of this first step is a levelized cost that will be incurred for every year the equipment or device operates until the capital expenditure is fully paid. This way, the costs of a measure can be matched with the annual savings and the emission reductions the measure provides.

The second step is to determine the on-going costs. These costs were reported as operating and maintenance costs for most of the measures for each year of the equipment life.

The third step is to calculate the value of the energy savings. Many of the measures reduce gasoline, diesel, natural gas, or electricity usage. The savings for each fuel were valued at the prices forecasted by California Energy Commission. The forecast prices for 2020 are displayed in Table G-I-1.

[28] http://www.federalreserve.gov/releases/h15/data/Annual/H15_TCMII_Y10.txt
[29] Cal/EPA Management Memorandum: Implementation of 1993 Regulatory Reform Legislation.

Table G-I-1: Forecasted Energy Prices Used in Estimating Measure Costs and Savings (2007 $)

Energy Type	Price	Metric
Electricity avoided cost 2020[(1)(2)]	$86.09	Per MWh
Natural gas avoided cost 2020[(2)]	$7.94	Per MMBtu
Gasoline price 2020[(3)]	$3.673	Per gallon
Diesel fuel price 2020[(3)]	$3.685	Per gallon

1 8,760 average price for avoided generation and T&D costs
2 Source: Updated from Climate Action Team (CAT) Report, updated to 2007 dollars
3 Source: California Energy Commission, Table B-3 of *Transportation Energy Forecasts for the 2007 Integrated Energy Policy Report*, September, 2007, CEC-600-2007-009-SF (http://www.energy.ca.gov/2007publications/CEC-600-2007-009/CEC-600-2007-009-SF.PDF).

The last step is to calculate the net cost for each measure. The net cost was the sum of annualized capital costs, operating and maintenance costs, value of energy savings, and other savings. Some measures, particularly the energy efficiency measures, had negative net costs (i.e. a net savings). Others had positive net costs, meaning that the costs exceeded savings. The costs and savings for the Scoping Plan measures are displayed in Tables G-I-2. Table G-I-3 lists the measures that were identified as part of the cap-and-trade implementation adopted by the market forces without regulation. Additional details on the derivation of the cost and savings estimates for each measure are provided in the Appendix I of the Scoping Plan, the Measure Documentation Appendix.

Cost-Effectiveness

AB 32 requires the Board to consider cost-effectiveness of the measures when adopting the Scoping Plan, and defines cost-effectiveness as, "the cost per unit of reduced emissions of greenhouse gases adjusted for its global warming potential." (H&S Code 38505 (d)) This definition specifies using a metric of cost per unit of reductions emissions (e.g. dollars per metric ton CO_2E) by which the Board must express cost-effectiveness, but it does specify what should be included in the cost calculation and does not provide criteria to assess if a regulation is or is not cost-effective. In addition to reducing greenhouse gas emissions, some of the measures will provide co-benefits by reducing emissions of criteria pollutants (e.g., particulate matter, ozone precursors). Therefore, when conducting more detailed analyses as part of the regulatory process, ARB staff plan to account for the value of the co-benefits by reducing the estimated cost of the greenhouse gas emission reduction measures by the average cost of control for the criteria pollutants reduced as a co-benefit. This method is consistent with the approach used in the macroeconomic impact analysis of the Climate Action Team Report. However, this accounting for co-benefits has not been included as part of the analysis conducted for the Scoping Plan.

To achieve the AB 32 2020 emission limit, ARB has estimated that emission reductions from business-as-usual of 174 $MMTCO_2E$ will be needed. The Preliminary Recommendation in the Scoping Plan achieves these reductions through a broad spectrum of measures, including

performance-based regulations and a California cap-and-trade program linked to a western regional market.

Tables G-I-2 and G-I-3 present estimated costs and savings of the recommended greenhouse gas reduction measures as well as other measures under evaluation. The last column in both tables shows the cost-effectiveness (i.e. net annualized cost per ton of CO_2E emissions reduced) of each measure as currently estimated. As previously indicated, many of the measures are in the early stages of development. It is anticipated that as the analysis proceeds and the measures move through the regulatory process the costs for some will change; some will increase while others will decrease.

A number of measures included in the Scoping Plan provide greenhouse gas reduction benefits, but are being pursued for other policy reasons. For example, the ship electrification (T-5) and goods movement measures (T-6) are being pursued to achieve reductions in criteria air pollutants and toxic air contaminant emissions. While the greenhouse gas emission reductions that result will help California achieve the 2020 target, ARB is not attributing the costs or savings that result from these measures to implementation of AB 32. For this reason, these measures, along with the high speed rail measure (T-9), the California solar programs measure (E-4), and the solar hot water heater measure (CR-2) all show zero costs and zero savings in the tables below.

Table G-I-2: Costs, Savings, and Dollars Per Metric Ton of CO_2E Reduced Recommended Greenhouse Gas Reduction Measures

	Measures	Reductions ($MMTCO_2E$ in 2020)	Costs ($Millions)	Savings ($Millions)	Net Cost or Savings Per $MTCO_2E$ ($)
	Transportation				
T-1	Pavley I Light-Duty Vehicle GHG Standards	27.7	1,372	11,381	-361
	Pavley II - Light-Duty Vehicle GHG Standards	4.0	594	1,643	-262
T-2	Low Carbon Fuel Standard	15	11,000	11,000	0
T-3	Local Government Actions and Targets (VMT Reduction)	5	500	2054	-311
T-4	Low Friction Oil	2.8	520	1,150	-225
	Tire Pressure Program	0.55	152	224	-131
	Tire Tread Program (Low resistance)	0.3	0.6	123	-408
	Solar Reflective Automotive Paint and Window Glazing	0.89	360	366	-6
T-5	Ship Electrification at Ports	0.20	0(1)	0(1)	0(1)
T-6	Goods Movement Efficiency Measures	3.5	TBD	TBD	0
T-7	Heavy-Duty Vehicle GHG Emission Reduction (Aerodynamic Efficiency)	6.4(2)	1,616(2)	2,137(2)	-81(2)
T-8	Medium and Heavy-duty Vehicle Hybridization	0.5	93	177	-169
T-9	High Speed Rail	1	0(1)	0(1)	0(1)
	Subtotal	***67.8***			
	Building and Appliance Energy Efficiency and Conservation				
E-1	Electricity Reduction Program 32,000 GWH reduced	15.2	3,402	5,065	-109
	Utility Energy Efficiency Programs				
	Building and Appliance Standards				
	Additional Efficiency and Conservation				
E-2	Increase Combined Heat and Power Use by 30,000 GWh	6.7	362	1,673	-190
CR-1	Natural Gas Reduction Programs (800 Million Therms saved)	4.3	963	1,433	-109
	Utility Energy Efficiency Programs				
	Building and Appliance Standards				
	Additional Efficiency and Conservation				
	Subtotal	***26.4***			

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Table G-I-2 (cont.): Costs, Savings, and Dollars Per Metric Ton of CO_2E Reduced
Recommended Greenhouse Gas Reduction Measures

	Measures	Reductions ($MMTCO_2E$ in 2020)	Costs ($Millions)	Savings ($Millions)	Net Cost or Savings Per $MTCO_2E$ ($)
	Renewable Energy				
E-3	RPS (33%)	21.3	3,672	1,889	133
E-4	California Solar Programs (3000 MW Installation)	2.1	0(1)	0(1)	0(1)
CR-2	Solar Water Heaters (AB 1470 goal)	0.14	0(1)	0(1)	0(1)
	High GWP Measures				
H-1	MVACS: Reduction of Refrigerant from Non-Professional Servicing	0.26	3	0	11.5
H-2	SF6 Limits in Non-Utility and Non-Semiconductor Applications	0.30	0.22	0.14	0.3
H-3	High GWP Reduction in Semiconductor Manufacturing	0.15	2.6	0	17
H-4	Limit High GWP Use in Consumer Products	0.25	0.06	0	0.2
H-5	High GWP Reductions from Mobile Sources	3.3	20.86	0	6.32
H-6	Specifications for Commercial and Industrial Refrigeration	4.0	1.24	0.66	0.1
	Foam Recovery and Destruction Program	0.30	9.0	0	30
	SF6 Leak Reduction and Recycling in Electrical Applications	0.10	0.3	0.4	-0.1
	Alternative Suppressants in Fire Protection Systems	0.10	1.96	0.2	18
	Gas Management for Stationary Sources--Tracking/Recovery/Deposit Programs	6.30	1.02	3.6	-0.4
	Residential Refrigeration Early Retirement Program	0.10	18.9	24.79	-58.9
H-7	Mitigation Fee on High GWP Gases	5	100	0	20

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Table G-I-2 (cont.): Costs, Savings, and Dollars Per Metric Ton of CO_2E Reduced
Recommended Greenhouse Gas Reduction Measures

	Measures	Reductions ($MMTCO_2E$ in 2020)	Costs ($Millions)	Savings ($Millions)	Net Cost or Savings Per $MTCO_2E$ ($)
	Industrial				
I-1	Energy Efficiency and Co-Benefits Audits	TBD	TBD	TBD	TBD
I-2	Oil and Gas Extraction GHG Emission Reduction	0.2	0.4	4	-18.5
I-3	GHG Leak Reduction from Oil and Gas Transmission	0.9	0.5	18	-19
I-4	Refinery Flare Recovery Process Improvements	0.33	6.7	46.1	-120
I-5	Removal of Methane Exemption from Existing Refinery Regulations	0.014	3.3	2.7	40.9
	Others				
RW-1	Landfill Methane Capture	1.0	52	0	52
A-1	Methane Capture at Large Dairies[3]	1.0	156	0	156
F-1	Sustainable Forest Target	5.0	50	0	10
W-1	Water Use Efficiency[4]	1.4	-	-	
W-2	Water Recycling[4]	0.3	-	-	
W-3	Pumping and Treatment Efficiency[4]	2.0	-	-	
W-4	Reuse Urban Runoff[4]	0.2	-	-	
W-5	Increase Renewable Energy Production[†]	0.9	-	-	
	Recommended Measures Totals	***140***	***$24,878***	***$40,417***	

Notes for Table I-2:

1 These measures are being pursued to achieve other policy goals, including renewable energy development and air quality/public health goals, so their costs and savings have not been attributed to implementation of AB 32.

2 The costs for this measure include the full equipment cost and savings to California firms realized nationwide. The California only GHG emissions reduction is 0.93 $MMTCO_2E$.

3 Because the emission reductions from this measure are not required, they are not counted in the total.

4 GHG reductions from the water sector may already be incorporated into the 2020 forecast. Therefore, they are not currently counted toward the 2020 goal. ARB will work with the appropriate agencies to determine whether these reductions are additional.

5 Subtotal is for Landfill Methane Capture and Sustainable Forest Target measures only.

Table G-I-3: Costs, Savings, and Dollars Per Metric Ton of CO_2E Reduced Measures Included in The Cap-and-Trade

Measures	Reduction ($MMTCO_2E$)	Costs ($Millions)	Savings ($Millions)	Net Cost or Savings Per $MTCO_2E$ ($)
Transportation				
Incentives to Reduce VMT[1]	*2*	*200*	*821*	*-310*
Electricity				
Energy Efficiency (8000 additional to 32,000 GWh Reduced Demand) [1]	*3.8*	*1,276*	*1,226*	*2.5*
Natural Gas				
Energy Efficiency (200 million Therms Reduced) [1]	*1.1*	*369*	*367*	*2.5*
Industrial				
Carbon Intensity Standard for Calif. Cement Manufacturers[1]	*1.9*	*19.4*	*22.8*	*-1.8*
Carbon Intensity Standard for Concrete Batch Plants[1]	*3.1*	*0*	*0*	*0*
Waste Reduction in Concrete Use[1]	*1.2*	*55*	*83*	*-23.5*
Refinery Energy Efficiency Process Improvement[1]	*3.4*	*64.5*	*415*	*-103*
Oil and Gas Extraction GHG Emission Reduction[1]	*1.8*	*107*	*274*	*-93*
GHG Leak Reduction from Oil and Gas Transmission[1]	*0.1*	*15*	*16*	*-15*
Industrial Boiler Efficiency[1]	*1.0*	*22.9*	*150*	*-127*
Stationary Internal Combustion Engine Electrification[1]	*0.3*	*17.9*	*25*	*-24*
Total	***19.7***	***$2,146***	***$3,070***	

Note for Table I-3:

1 Measures in italics are low-cost measures that were included in the economic modeling of the Proposed Recommendation, as discussed in Appendix G. They include the measures under evaluation in the Draft Scoping Plan with a cost per ton of reduction less than the carbon price produced by E-DRAM. They are intended as a proxy for the types of reductions that would be made under a cap-and-trade program.

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Climate Change Scoping Plan Pursuant to AB 32
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Appendix G: Economic Analysis
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Environmental Dynamic Revenue Assessment Model's Sources And Methods

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Climate Change Scoping Plan Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Appendix G: Economic Analysis
Appendix G-II
Environmental Dynamic Revenue Assessment Model's Sources and Methods

1. INTRODUCTION

This Appendix describes the economic analysis and modeling results of the measures set out in the Recommendation of the Scoping Plan. The description of the results is followed by documentation for the Environmental Dynamic Revenue Analysis Model (E-DRAM), the model used for the economic assessment.

Macroeconomic models such as E-DRAM are well suited for analyzing the economy-wide impact of a set of recommended policy measures that either impose costs, provide savings, or both, taking into account their interaction and the shifting of economic activity across sectors. E-DRAM has been used in this fashion for a variety of past economic assessments.

Such models, however, face several challenges in attempting to model market-based policies that provide incentives to discover the least cost options for reducing emission including investments in improving technology. First of all, the macroeconomic tools do not have the ability to predict how firms might invest in cost-effective energy efficient technologies that will result in reduced greenhouse gas emissions and reduced energy-related expenditures. In E-DRAM, such cost-saving investments can only be reflected if they are specified in advance as exogenous inputs to the model, rather than the model endogenously determining the type and level of investment. This can be done for specific measures for which the costs and savings have been estimated. It can also be estimated for some portion of the reductions required from a cap-and-trade program where there is knowledge that sources under the cap have the ability to reduce emissions from well-defined, relatively low-cost investments in their own facilities that end up costing less than purchasing the reductions from the market.

An important characteristic of a market-based approach is the ability to reveal low-cost emission reduction opportunities as a result of market incentives. Because of the broad flexibility allowed by cap and trade, available models do not have a mechanism to properly determine the nature or costs of such "unspecified reductions" needed to meet the cap. By their very nature such reductions cannot be attributed in advance to any specific measures or even source type. To produce additional unspecified reductions the models simulate such reduction by reducing economic output. This type of model is unable to account for the possibility of new investment in some sectors that could increase their energy efficiency and reduce emissions either at a net savings or lower cost than reducing demand through price increases. Instead, these models adjust prices of products so that they reflect the cost of GHG emissions (based upon calculated allowance prices), resulting in reductions in sector production and resulting sector emissions until the required emissions reductions are

achieved. Consequently, emission reductions in the model occur in response to reduced demand induced by increased prices. For this reason, these models provide an inaccurate and overly costly picture of how a cap-and-trade system would operate in practice.

In addition, the macroeconomic models operate at the sector level and therefore do not have the ability to capture the heterogeneity of facility-level emission reduction opportunities. One of the primary advantages of market-based approaches is that they take advantage of this heterogeneity to minimize costs. Such savings have been documented by empirical studies. As was noted by the Market Advisory Committee, "This potential for cost savings is not simply a theoretical proposition. Studies indicate substantial cost savings from existing cap-and-trade programs. The two major studies of cost savings for the SO_2 program[30] are in general agreement that savings under the trading program amounted to 43–55 percent of expected compliance costs under an alternative regulatory program that imposed a uniform emission standard. Carlson et al. cite savings of over 65 percent compared to a policy that might have forced post-combustion controls (scrubbers) to achieve the same level of emissions."[31]

The marginal cost of achieving reductions varies significantly among facilities, firms, and regions depending on a host of site, firm, or location-specific factors. Market-based approaches enable the reductions to come from those facilities that can achieve them at lower cost than the market price. However, the models treat all facilities within a sector as similar and therefore cannot account for cost structure differences and as such cannot capture cost reduction opportunities.

Moreover, the models do not fully capture how individual consumers can and will take steps to pursue lower cost options. This is being observed today as consumers change driving habits and make greater use of public transit, carpooling and biking in response to gasoline price increases. In addition, over time market-based approaches provide an incentive to find innovative ways to reduce emissions beyond the level necessitated at an individual firm under a performance standard. Again, available models do not capture how such innovation can reduce cost.

Our E-DRAM modeling of the Recommendation attempted to remedy these limitations by searching for measures that are likely to meet the market test of being lower than the carbon price established by the market participants. That is, we have approximated the operation of the cap-and-trade program as well as available modeling tools allow. To capture how facilities might make technology changes to reduce emissions, the costs and savings of known efficiency measures were identified so that the cost per ton for reductions from those measures could be compared to allowance prices under a cap-and-trade system. It is then assumed that facilities will choose to implement measures that cost less than the anticipated

[30] Carlson, C., Burtraw, D., Cropper, M. & Palmer K.L. (2000). Sulfur Dioxide Control by Electric Utilities: What are the Gains from Trade? The Journal of Political Economy, 108(6), 1292-1326. ; Ellerman, A. D. (2003). Lessons rom Phase 2 Compliance with the U.S. Acid Rain Program. Working Paper 03-009. Cambridge: MA: Massachusetts Institute of Technology Center for Energy and Environmental Policy Research.
[31] Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California, Recommendations of the Market Advisory Committee to the California Air Resources Board, June 30, 2007 p. 7

allowance price to the extent they have been identified. This follows the market rule of selecting low cost options. Therefore, the analysis of the Recommendation includes measures that cost less per ton of GHG emissions reduced than the simulated cap-and-trade market price of carbon. These measures had a net cost that falls below the market price as solved by the model through an iterative process were used as inputs (i.e., because they represent a lower cost path than the market price the measures would be expected to occur).

This approach provides a conservative approximation of how a portion of the reductions will be achieved by industry. This technique partially addresses the model's lack of an internal mechanism to identify efficiency measures, but does not eliminate it. It does not allow for innovation, nor does it address the limitations noted above regarding cost minimization decisions made at the facility level.

Keeping these limitations in mind, our estimate of the economic impact of the Recommendation will understate the benefits of market-based approaches including the cap-and-trade program and therefore will understate the positive impact of the Recommendation on the California economy. We nevertheless believe that the estimate provides useful information and is a reasonable application of the model.

2. MODELING RESULTS

E-DRAM was used to analyze the Recommendation from the Scoping Plan. The input assumptions for this analysis included cost and savings information for specified measures from the Scoping Plan that result in emission reductions of approximately 160 million metric tons of CO_2E ($MMTCO_2E$). These reductions include 140 $MMTCO_2E$ from the specified measures in the Recommendation, plus an additional 20 $MMTCO_2E$ that result from low cost measures expected to be pursued under a cap-and-trade program that were included among the other measures under evaluation in the Scoping Plan. The remaining 14 million tons needed to achieve the 174 $MMTCO_2E$ of emission reductions included in the Recommendation are achieved through the simulation of the cap-and-trade program as described below.

The analysis used the greenhouse gas emission reduction measures presented in the Scoping Plan to characterize the costs, savings and emission reductions. More detailed descriptions of the measures were included in Appendix C to the Scoping Plan. Additional information on the cost and savings estimates used in this modeling effort is presented in Appendix G-I, and additional information on the calculation of the costs and savings used in the economic analysis is presented in Appendix I.

The cap-and-trade component of the Recommendation is simulated by increasing the price of electricity, natural gas, and transportation fuels to reflect the carbon content of those fuels. As discussed earlier, this provides a conservative estimate of the benefits of a cap-and-trade approach. All allowance or fee revenues remain in the state and are allocated back to consumers. Per the previous discussion, this approach was used to identify the carbon price necessary to result in reduction of 14 $MMTCO_2E$ in 2020. The subsequent section provides further detail on the approach that was used to model the Recommendation.

No additional cost minimizing methods, such as offsets, emission allowance banking or borrowing, are included in the analysis.

2.1 Business-as-usual Base Case

The economic impacts of the Scoping Plan are expressed as changes from a business-as-usual estimate of California's economic growth. As noted, the business-as-usual (BAU) case assumes that none of the measures included in the Scoping Plan are implemented. As Table G-II-1 below indicates, for the BAU case, Gross State Product is projected to grow by about 2.8 percent annually to a value of nearly $2.6 trillion by 2020. Personal income is projected to grow by approximately 2.8 percent annually and job growth is also expected to continue as we move toward 2020.

Table G-II-1: Business-as-usual Case for California Economy

Economic Indicator	2007	2020	Change	Average Annual Growth (%)
Real Output ($Billions)	2,535	3,597	1,062	2.7%
Gross State Product ($Billions)	1,811	2,586	775	2.8%
California Personal Income ($Billions)	1,464	2,093	628	2.8%
Income Per Capita ($1000)	38.6	47.6	9	1.6%
Employment (Millions)	16.41	18.41	2	0.9%
Emissions ($MMTCO_2E$)	500[1]	596	96	1.4%[1]

[1] Approximate value. The ARB is in process of estimating the GHG emissions for 2007.

2.2 Macro-Economic Effects of the Recommendation

Table G-II-2 shows how implementation of the Recommendation would impact California's economy relative to a business-as-usual growth trajectory between now and 2020. The effects on output, personal income and employment are small but positive. Total output, which represents production activity in the state, increases by 0.9 percent over BAU. This translates into an increase of approximately $33 billion in 2020, which is a relatively minor increase when evaluated in the context of a $3.6 trillion economy. Also represented in Table II-2 are the impacts of the Recommendation on Gross State Product, personal income, income per capita, and employment. In each case, the modeling shows a small but positive impact.

Table G-II-2: Economic Impacts of the Scoping Plan Recommendation

Economic Indicator	BAU Case	Recommendation	Change from BAU	Percent Change from BAU
Real Output ($Billions)	3,597	3,630	33	0.9%
Gross State Product ($Billions)	2,586	2,593	7	0.3%
Personal Income ($Billions)	2,093	2,109	16	0.8%
Income Per Capita ($1000)	47.56	47.76	0.21	0.4%
Employment (Millions)	18.41	18.53	0.12	0.7%
Emissions ($MMTCO_2E$)	596	421	175	-29%
Carbon Price (Dollars)	NA	10.00	NA	NA

The positive impacts are largely attributable to savings that result from reductions in expenditures on energy. These savings translate into increased consumer spending on goods and services other than energy. Many of the measures entail more efficient use of energy in the economy, with savings that exceed their costs. All told, the specified reduction measures in the Scoping Plan's Recommendation (not including additional unspecified reductions from cap-and-trade) are expected to reduce emissions of approximately 160 $MMTCO_2E$ in 2020 at a net savings of about $15.4 billion, which provides a positive stimulus to the economy.

When modeling the Recommendation, the model should reflect the fact that facilities will pursue emission reduction options that have a cost per ton that is lower than the market price. In the absence of complete information on what those options might be, we included in the model runs the technical options that have been identified as part of the additional measures that cost less than the market allowance price. This is an incomplete list, and the model does not have the capability to adequately reflect the full set of options that are available to covered sectors under cap and trade. Thus, this approach provides a rough approximation of how a portion of the reductions from the market approach would be achieved. This approach resulted in measures that provided an additional 20 $MMTCO_2E$ in reductions being included in the model run of the Recommendation, with only the final 14 $MMTCO_2E$ of reductions achieved by pricing mechanisms within the model itself that moderated consumer demand. Appendix G-I provides a complete list of the measures included in this modeling run.

The modeling results presented for the cap-and-trade component of the Recommendation reflect a carbon price of $10 per ton of $MTCO_2E$. It is important to note that the $10 per ton figure does not reflect the cost of the program; rather it is the maximum price at which reductions to achieve the cap is pursued. We will continue to evaluate these results and anticipate that modeling efforts currently underway in the Western Climate Initiative will also provide useful additional information. We also encourage any interested stakeholders to conduct their own analyses and share their results.

As discussed in the Scoping Plan, a properly designed offset program can play a valuable role within a cap-and-trade program. Offsets offer the opportunity to achieve reductions from sectors outside of the cap, often at costs lower than reductions from within the cap. This can be a key driver in moderating allowance prices, particularly in the early years of a program. Offsets also provide incentives for entities to develop and implement innovative strategies to reduce emissions outside of the capped sectors, which can have additional economic and environmental benefits.

As previously discussed, the estimated allowance price for a cap-and-trade program was $10 per ton. As such, when we ran the E-DRAM with offsets only assumed to be available at $20 per ton, there was no demand. Nevertheless, we believe that a limited availability of high quality offsets is advisable in light of the uncertainty associated with program implementation. As we work on further analysis related to the allowance price in a cap-and-trade program design, we will continue to evaluate the economic impact of offsets as well.

2.3 Sector-Level Effects of the Recommendation

The E-DRAM provides a detailed picture of the California economy that includes 120 distinct industrial sectors. For the industrial sectoring, a grouping of firms all of which make similar, though by no means identical, products is referred to as a sector. The model's input dataset is an explicit representation of the inter-sector flows of value within the California economy in 2003. The sectoral linkages established in this dataset determine how policy effects are transmitted through the economy. Sectors are affected directly by a specific policy and indirectly through sector linkages.

A model such as E-DRAM is most useful for characterizing economic impacts at the state level. It can also be informative at the sector level with the understanding that some sectoral details that may be important in characterizing how producers will respond to a policy change may not be fully reflected in the model. For example, the industrial sectors, as represented in the model, produce a single good utilizing the same production technology that is sold at a single price. Issues that may be particularly important to individual sectors will likely have to be more thoroughly assessed using other methods as individual regulations targeting the sector are developed.

With an individual measure, understanding which sectors are affected and why is straightforward. However, given the number of measures in the Recommendation presented in the Scoping Plan, breaking out exactly how and why a specific sector is affected can be challenging. Many of the individual measures affect prices in opposite directions. For example, an efficiency measure causes less energy to be purchased, which would have the effect of reducing the price of energy. A carbon price would do the opposite by raising the price of energy. However, when the measures are run together, as is the case for the analysis presented in this supplement, the effect on energy prices of an efficiency measure and a cap-and-trade measure would depend on which measure produces the stronger effect.

Finally, with 120 industrial sectors, the volume of information produced can make interpretation of results difficult. Results are therefore aggregated by industry type corresponding to the 2-digit North American Industry Classification System (NAICS). Aggregation of related sectors is a useful approach for gaining insights into the "big picture" impacts of the policies. Further detail for each of the aggregated sectors is discussed in the remainder of this document.

Tables G-II-3 and G-II-4 present the change in Average Weighted Prices, Real Output and Employment for the sector aggregations for the Recommendation. The values reported in the tables for Real Output and Employment are simply summations of Output and Employment for the individual sectors. Price changes are weighted based on the individual sectors' share of output in the aggregate sector so that the price change is reflective of the price change that occurs in the larger sectors.

All changes are discussed in relation to the business-as-usual case, so when it is stated that a sectors grows, it means that it grows in excess of the BAU growth.[32] A brief discussion of aggregated sectors within the model follows.

[32] All individual sectors grow in the business-as-usual case with the exception of the Petroleum and Natural Gas Extraction sector, which declines by assumption.

Table G-II-3: E-DRAM 2020 Business-as-usual Prices, Output and Employment

Sector	Prices*	Output (Billions 2007 $)	Employment (Thousands)
Agriculture, Forestry and Fishing	1.0	109	449
Mining	1.0	29	26
Utilities	1.0	72	67
Construction	1.0	164	929
Manufacturing	1.0	943	2,046
Wholesale Trade	1.0	171	791
Retail Trade	1.0	296	1,901
Transportation and Warehousing	1.0	109	503
Information	1.0	235	448
Finance, Insurance and Real Estate	1.0	559	1,026
Services	1.0	910	6,729
Government	-	-	3,491
Total	**-**	**3,597**	**18,405**

* All prices are normalized to 1.0 in the Business as Usual case.

Table II-4: E-DRAM 2020 Estimates the Changes in Prices, Output and employment for the Recommendation

Sector	Prices	Output (Billions 2007$)	Employment (Thousands)
Agriculture, Forestry and Fishing	1.0	113	464
Mining	1.0	31	26
Utilities	1.1	60	57
Construction	1.0	166	934
Manufacturing	1.0	948	2,057
Wholesale Trade	1.0	173	793
Retail Trade	1.0	291	1,916
Transportation and Warehousing	1.0	111	510
Information	1.0	238	450
Finance, Insurance and Real Estate	1.0	572	1,046
Services	1.0	927	6,773
Government	-	-	3,502
Total	**-**	**3,630**	**18,528**
	Percent change from BAU		
Agriculture, Forestry and Fishing	0.0	3.9	3.5
Mining	0.9	7.2	1.3
Utilities	8.8	-16.7	-14.7
Construction	0.1	1.7	0.5
Manufacturing	0.2	0.5	0.5
Wholesale Trade	-0.6	1.0	0.1
Retail Trade	-0.3	-1.6	0.8
Transportation and Warehousing	-0.5	1.9	1.2
Information	-0.3	1.1	0.4
Finance, Insurance and Real Estate	-0.2	2.3	2.0
Services	-0.4	1.9	0.7
Government	-	-	0.3
Total	**-**	**0.9**	**0.7**

2.3.1 Agriculture, Forestry and Fishing (NAICS Code 11)

The Agriculture, Forestry and Fishing sector comprises establishments primarily engaged in growing crops, raising animals, harvesting timber, and harvesting fish and other animals from a farm, ranch, or their natural habitats. The Agriculture, Forestry and Fishing sector is comprised of four individual E-DRAM sectors.

Overall, prices in the Agriculture, Forestry and Fishing sector remain unchanged from the BAU case. Output and employment both increase by more than 3 percent from the BAU case. Much of the overall sector growth can be attributed to increased producer energy efficiency and an increase in the demand for agricultural output as

feedstock for the production of ethanol. Output and employment in all of the individual sectors in this grouping grow.

2.3.2 Mining (NAICS Code 21)

The Mining, Quarrying, and Oil and Gas Extraction sector comprises establishments that extract naturally occurring mineral solids, such as coal and ores; liquid minerals, such as crude petroleum; and gases, such as natural gas. The term mining is used in the broad sense to include quarrying, well operations, beneficiating (e.g., crushing, screening, washing, and flotation), and other preparation customarily performed at the mine site, or as a part of mining activity. The Mining sector is comprised of two individual E-DRAM sectors.

Overall, prices in the Mining sector decrease slightly, while output increases by 7.2 percent and employment increases by 1.3 percent. The Petroleum and Natural Gas Extraction sector accounts for all of the growth in the Mining sector. The reason for the increased growth in the Petroleum and Natural Gas Extraction sector is directly related to the Oil and Gas Extraction Emission Reduction measure that is estimated to provide savings that greatly exceed the costs of implementation (i.e., net savings of about $56 million). Output and employment decreases in the other mining sector primarily because of the increased price of electricity.

2.3.3 Utilities (NAICS Code 22)

The Utilities sector comprises establishments engaged in the provision of the following utility services: electric power, natural gas, steam supply, water supply, and sewage removal. Within this sector, the specific activities associated with the utility services provided vary by utility: electric power includes generation, transmission, and distribution; natural gas includes distribution; steam supply includes provision and/or distribution; water supply includes treatment and distribution; and sewage removal includes collection, treatment, and disposal of waste through sewer systems and sewage treatment facilities. The Utilities sector is comprised of three individual E-DRAM sectors.

Prices in the Utilities sector increase, with the price of electricity increasing by 11 percent and the price of natural gas increasing by almost 9 percent. Output and employment in the Utilities sector decrease by 16.7 percent and 14.7 percent respectively. The negative output and employment effects in the Utilities sector result from consumers purchasing less electric power and natural gas because of implementing the energy efficiency measures and because of higher prices. Decreases in the demand for electricity and natural gas translates into decreases in employment for the Electrical Power Generation and Distribution (-32 percent) and Natural Gas Distribution sectors (-7 percent). Most utility sector jobs are linked to the delivery of power and maintaining the system and not in the actual running of power plants. In addition, many jobs resulting from increased investment in renewable resources and energy efficiency will appear in other sectors, such as construction. So it is likely that the number of jobs in this sector will remain relatively unchanged even though the model estimates a decreased number of jobs.

However, it should be noted that the Utility sector is relatively small in terms of overall employment.

2.3.4 Construction (NAICS Code 23)

The construction sector comprises establishments primarily engaged in the construction of buildings or engineering projects (e.g., highways and utility systems). Establishments primarily engaged in the preparation of sites for new construction and establishments primarily engaged in subdividing land for sale as building sites also are included in this sector. The Construction sector is comprised of five individual E-DRAM sectors.

Prices in the Construction sector remain virtually unchanged, increasing by 0.1 percent. Output and employment in the Construction sector increase slightly: 1.7 percent for output and 0.5 percent for employment. Increases in output for the Residential, Nonresidential and Other Construction sectors, however, offsets reductions in Street and Bridge (-0.3 percent) and Utility Infrastructure Construction (-11 percent). The growth in output is potentially the result of the residential and commercial building efficiency strategies increasing the demand for new and retrofit construction. Reduced demand for electricity and natural gas reduces the need for new Utility Infrastructure construction which translates into less employment for this sector (-12 percent).

2.3.5 Manufacturing (NAICS Codes 31-33)

The Manufacturing sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. The Manufacturing sector is comprised of 42 individual E-DRAM sectors.

Prices in the Manufacturing sector increase by 0.2 percent. Output and employment in the Manufacturing sector increase slightly: 0.5 percent for both output and employment. Most of the individual sectors grow with the exception of Oil Refineries, Apparel Manufacturing, Automobile Manufacturing and Other Vehicle Manufacturing. The negative effect on Oil Refineries (-27 percent) is a direct response to the transportation and fuel policies that explicitly state that less transportation fuel will be purchased in California. However, we believe that virtually all of the change in output in the refinery sector will be the result of reduced imports of refined gasoline and not the result of reduced in-state production. Therefore, it is unlikely that the projected number of jobs would be reduced significantly from the business-as-usual case. Additionally, it should be noted that the Refining sector is relatively small in terms of overall state employment.

The effects on the remaining sectors are less straightforward. The Apparel Manufacturing, Automobile Manufacturing and Other Vehicle Manufacturing sectors are all sectors where a large share of the California demand is met by imported products. Any increase in the California price will further increase the demand for imported products at the expense of California production. In the Apparel sector,

demand for apparel increases as expenditures shift away from energy to other goods. The increased demand for apparel increases the California price relative to the import price which causes output to decrease by 15 percent and employment to decrease from 16 percent.

A similar pattern is exhibited in the Automobile Manufacturing and Other Vehicle Manufacturing sectors. Increases in the price of vehicles that result from the motor vehicle measures increases the demand for imported vehicles at the expense of domestically produced vehicles which causes output and employment to decrease. In the Automobile Manufacturing sector output decreases by 2.5 percent and employment decreases by 3.4 percent, while in the Other Vehicle Manufacturing sector output decrease by 4.6 percent and employment decreases by 6 percent.

2.3.6 Wholesale Trade (NAICS Codes 42)

The Wholesale Trade sector comprises establishments engaged in wholesaling merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. The merchandise described in this sector includes the outputs of agriculture, mining, manufacturing, and certain information industries, such as publishing. The wholesaling process is an intermediate step in the distribution of merchandise. The Wholesale Trade sector is comprised of five individual E-DRAM sectors.

Prices in the Wholesale Trade sector decrease by 0.6 percent. Output increases slightly (1.0 percent) while employment is unchanged. Sector growth can likely be attributed to increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

2.3.7 Retail Trade (NAICS Codes 44-45)

The Retail Trade sector comprises establishments engaged in retailing merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. The retailing process is the final step in the distribution of merchandise; retailers are, therefore, organized to sell merchandise in small quantities to the general public. The Retail Trade sector is comprised of 12 individual E--DRAM sectors.

Prices in the Retail Trade sector decrease by 0.3 percent. Output decreases by 1.6 percent, while employment increases by 0.8 percent. However, most of the individual sectors grow with the exception of the Retail Gasoline sector. The large negative effect on the Retail Gasoline sector (-18 percent) is the result of reduced purchases of transportation fuel that occur because of the transportation and fuel measures.

Growth in the other sectors can likely be attributed increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

2.3.8 Transportation and Warehousing (NAICS Codes 48-49)

The Transportation and Warehousing sector includes industries providing transportation of passengers and cargo, warehousing and storage for goods, scenic and sightseeing transportation, and support activities related to modes of transportation. Establishments in these industries use transportation equipment or transportation related facilities as a productive asset. The type of equipment depends on the mode of transportation. The modes of transportation are air, rail, water, road, and pipeline. The Transportation and Warehousing sector is comprised of eight individual E-DRAM sectors.

Prices in the Transportation and Warehousing sector decrease slightly (0.5 percent). Output and employment increase by 1.9 and 1.2 percent respectively. No individual sectors are adversely affected. Sector growth can be attributed to increased vehicle efficiency which reduces the price of providing transportation related services and the decreased price of transportation fuels.

2.3.9 Information (NAICS Code 51)

The Information sector comprises establishments engaged in the following processes: (a) producing and distributing information and cultural products, (b) providing the means to transmit or distribute these products as well as data or communications, and (c) processing data. The Information sector is the aggregation of four individual E-DRAM sectors.

Prices in the Information sector decrease by 0.3 percent. Output (1.1 percent) and employment (0.4 percent) both increase. No individual sectors are adversely affected. Sector growth can likely be attributed to increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

2.3.10 Finance, Insurance and Real Estate (NAICS Codes 52-53)

The Finance and Insurance sector comprises establishments primarily engaged in financial transactions (transactions involving the creation, liquidation, or change in ownership of financial assets) and/or in facilitating financial transactions. The Real Estate and Rental and Leasing sector comprises establishments primarily engaged in renting, leasing, or otherwise allowing the use of tangible or intangible assets, and establishments providing related services. The Finance, Insurance and Real Estate sector is comprised of five individual E-DRAM sectors.

Prices in the Finance, Insurance and Real Estate sector decrease by 0.2 percent. Output and employment increase by 2.3 percent and 2.0 percent respectively. No individual sectors are adversely affected. Sector growth can likely be attributed to increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

2.3.11 Services (NAICS Codes 54-81)

The service sector comprises establishments primarily engaged in the provision of services to their customers. These include Professional, Scientific, and Technical Services, Management Services, Administrative Services, Educational Services, Health Services, Arts, Entertainment, and Recreation, Accommodation and Food Services and Other Services. All service sectors are aggregated in a single sector. The Service sector is comprised of 29 individual E-DRAM sectors.

Prices in the Service sector decrease by 0.4 percent. Output (1.9 percent) and employment (0.7 percent) both increase. Most individual sectors respond positively to the Scoping Plan measures except for Amusement Parks and Hospitals. The reason for the negative result in these two sectors is potentially the response to higher electricity prices since purchases from the Electrical Power Generation and Distribution make up a large share of these sectors' operating expenses. Growth in the other sectors can likely be attributed increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

3. OVERVIEW OF THE ENVIRONMENTAL-DYNAMIC REVENUE ANALYSIS MODEL

Computable General Equilibrium (CGE)[33] models represent explicitly the utility and profit maximizing behavior of households and firms and estimate how policy impacts affect agents both directly and indirectly. The models are "computable" because numeric solutions are found using computers rather than solved for algebraically. They are "general" in the sense that all markets and all income flows in the economy are accounted for. They reflect "equilibrium" insofar as prices adjust to equilibrate the demand for and supply of goods, services, and factors of production (labor and capital) of the model.

The specific model described here is a modified version of the Environmental-Dynamic Revenue Analysis Model (E-DRAM). The E-DRAM was built for the California Air Resources Board (ARB) by researchers at the University of California at Berkeley. The E-DRAM evolved from the Dynamic Revenue Analysis Model (DRAM), which was developed jointly by the California Department of Finance (DOF) and Berkeley researchers to perform dynamic revenue analyses of proposed legislation as mandated by Senate Bill 1837 in 1994. Much of the description of E-DRAM is closely adapted from Berck, Golan, and Smith (1996), which, henceforth, will be referred to as the DRAM Report.[34] The model has been updated to a 2003 base year.

The remainder of this Appendix is a non-technical description of E-DRAM.

3.1 Description of E-DRAM

The E-DRAM describes the relationship among California producers, California households, California governments, and the rest of the world. Rather than tracking each individual producer, household, or government agency in the economy, however, E-DRAM combines similar agents into single sectors. Constructing a sectoring scheme, the first step of model construction, is discussed immediately below; this discussion is followed by a description of the key agents in the economy—producers and consumers.

3.1.1 Aggregation and Data Sources

The E-DRAM, like all other empirical economic models, treats aggregates rather than individual agents. Aggregation is done both to provide focus for the analysis and constrain the number of variables in the model. Constructing an aggregation (or sectoring) scheme is critical in the development of a CGE model because it determines the flows that the model will be able to trace explicitly. For the E-DRAM model, the California economy has been divided into 186 distinct sectors: 120 industrial sectors, 2 factor sectors (labor and capital), 9 consumer good sectors, 8 household sectors, 1 investment sector, 45 government sectors, and 1 sector

[33] For E-DRAM's sources and methods discussed in this Appendix, an unpublished paper by Professor Peter Berck is liberally quoted.
[34] The DRAM Report is available at www.dof.ca.gov/HTML/FS_DATA/dyna-rev/dynrev.htm.

representing the rest of the world. The complete details of the sectoring are given in Chapter II of the DRAM Report.

For industrial sectoring purposes, all California firms making similar products are aggregated together. The agriculture sector, for example, contains all California firms producing agricultural products. The output value of that sector is the value of all output produced by California agricultural producers. A sector's labor demand is the sum of labor used by all firms in the sector. Along with agriculture, there are 119 other producer aggregates in the model. These aggregates generally represent the major industrial and commercial sectors of the California economy, though a few are tailored to capture sectors of particular regulatory interest. For instance, production of internal-combustion engines and consumer chemicals are each delineated as distinct sectors, as requested by ARB.[35]

Data for the industrial sectors originate from the U.S. Department of Commerce's Bureau of Economic Analysis and are based on the Census of Business—a detailed survey of U.S. companies conducted every five years. The survey contains information about intermediate purchases, factor (labor, capital, land, and entrepreneurship) payments, and taxes. Although quite extensive, the survey only allows inference about groups of firms at the national level. The disaggregation of national data to a California level is accomplished using a combination of state-level employment data and estimates from California Department of Finance.

Like firms, households are also aggregated. California households are divided into categories based upon their income. The model includes eight such categories, each one corresponding to a California Personal-income Tax marginal tax rate (0, 1, 2, 4, 6, 8, 9.3, and a high-income 9.3 percent). Thus, the income from all households in the 1 percent bracket is added together and becomes the income for the "1 percent" household sector. Similarly, all expenditure on agricultural goods by the 1 percent households is added and becomes the expenditure of the 1 percent household sector on agricultural goods. Total household expenditure on agricultural goods is the sum of expenditures by all eight household sectors. Household income data come from the California Franchise Tax Board Personal-income Tax "sanitized" sample. Data on consumption by income class are derived from national survey data.

The government sectors in E-DRAM are organized so that both government revenue flows and expenditure flows are traced explicitly. The E-DRAM includes 45 government sectors: 7 federal, 27 state, and 11 local. Government sector data are culled from published federal, state, and local government reports.

[35] The alcohol, tobacco, and horse-racing sector, distinct in DRAM, has been folded into the foods sector in the latest version of E-DRAM.

3.1.2 Producers and Households

Fundamental to the California economy and, hence, E-DRAM, are the relationships between the two principal types of economic agents—producers and households.

Producers are aggregated into industrial sectors. For example, the output of all of California's agricultural firms is modeled as coming from a single entity—the agriculture sector. Each sector takes the price that it receives for its output and the prices that it pays for its inputs (capital and labor, called "factors of production," and other inputs, called "intermediate goods") as given. The model assumes perfect competition which means that producer purchase decisions have no effect on input prices. Each producer is assumed to choose inputs and output to maximize profits. Inputs are labor, capital, and intermediate goods (outputs of other firms). Thus, the producer's supply of output is a function of its product price and the prices of inputs. More information on producers is provided in Chapter IV of the DRAM Report.

Households make two types of decisions: they buy goods and services and they sell labor and capital. Households are assumed to make these decisions in the way that maximizes their well-being (called "utility" in the economics literature). Like firms, consumer purchases have no effect on product prices. In addition to their labor income, households receive dividends and interest from their stocks and bonds and other ownership interests in capital.

Households' supply of labor, as a function of the wage rate, is called the "labor-supply function." A more detailed description of the supply of labor is given in Chapter VII of the DRAM Report.

Households' demand for goods or services, as a function of prices, is simply called the "demand function." A more detailed description of the demand for goods and services is given in Chapter III of the DRAM Report as well as in Berck, Hess, and Smith, 1997. The latter report explains how the distribution of household spending across the 120 industrial sectors via the nine consumer goods sectors is based on analysis of U.S. Bureau of Labor Statistics' Consumer Expenditure Survey data.

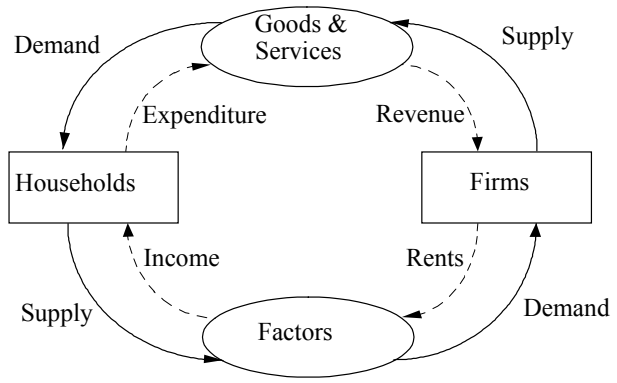
3.1.3 Equilibrium

So far, two types of agents have been described: firms and households. It remains to be explained how these agents relate. Agents relate through two types of markets: factor markets and goods-and-services markets. Firms sell goods and services to households in the goods-and-services markets. Households sell labor and capital services to firms in the factor markets. There is a price in each of these markets. There is a price for the output of each of the 120 industrial sectors. There is a price for labor, called the "wage," and a price for capital, called the "rental rate." Equilibrium in the market means that the quantity supplied is equal to the quantity demanded. Equilibrium in the factor markets for labor and capital and in the markets for goods and services defines a simple general equilibrium. That is, there are 122 prices (the wage, the rental rate, and one for each of the 120 goods made by the 120 sectors) and these 122 prices have the property that they equate quantities supplied and demanded in all 122 markets.

These relationships are shown in more detail in Figure II-1, called a "circular-flow diagram." The outer set of flows, shown as solid lines, are the flows of "real" items, goods, services, labor, and capital. The inner flows, shown as broken lines, are monetary flows. Thus, firms supply goods and services to the goods-and-services market in return for revenues that they receive from the goods-and-services markets. Firms demand capital and labor from the factor markets and in return pay wages and rents to the factor markets.

Households, the other type of agent in a simple model, buy goods and services from the goods-and-services markets. Households sell capital and labor on the factor markets and receive income in exchange.

Figure II-1: The Basic Circular-Flow Diagram



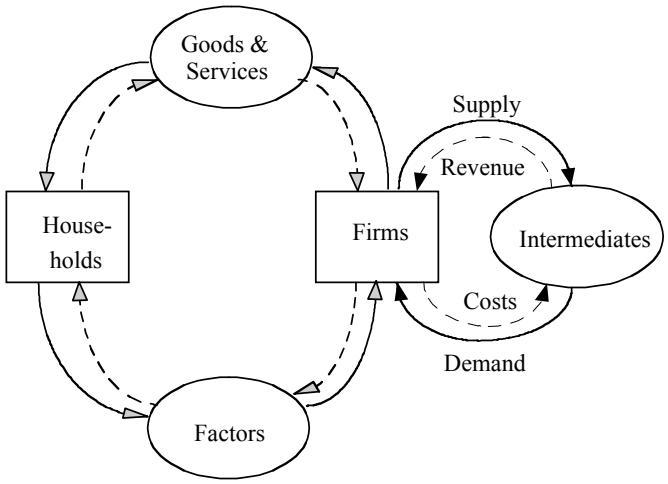
Source: Berck, Golan, and Smith, 1996.

3.1.4 Intermediate Goods

The economy of California is far more complex than that shown in Figure II-1. There are not only final goods-and-services markets but also intermediate-goods markets in

which firms sell to firms. A typical example of a market for intermediate goods would be fertilizer sold to agricultural firms. A final output of the chemical industry is fertilizer, which is an intermediate good in the agricultural industry. This type of market interaction is demonstrated in Figure II-2. Here, part of the output of a chemical firm (chemical industry in the example) is not sold to households but rather to another firm. The expense of buying the input is a cost of production. Chapter IV of the DRAM Report contains the model specification for these types of transactions, which are based upon a national input-output table.

Figure II-2: The Circular-Flow Diagram with Intermediate Goods

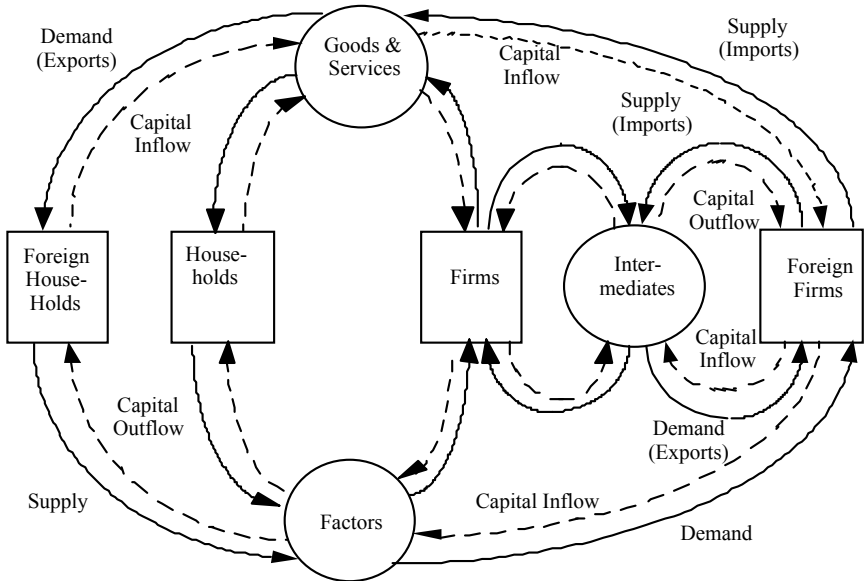


Source: Berck, Golan, and Smith, 1996.

3.1.5 Rest of the World

California is an open economy, which means that it trades goods, services, labor, and capital with neighboring states and countries. In this model, all agents outside California are modeled in one group called "Rest of World." No distinction is made between the rest of the United States and foreign countries. California interacts with two types of agents: foreign consumers and foreign producers. Taking the producers first, Figure II-3 shows that the producers sell goods on the (final) goods-and-services markets and on the intermediate markets, i.e., they sell goods to both households and firms. The model takes these goods as being imperfect substitutes for the goods made in California. Agricultural products from outside of California (e.g., feed grains, bananas) are taken as being close to, but not identical to, California-grown products (e.g., avocados, fresh chicken). The degree to which foreign and domestic goods substitute for each other is very important, and the evidence is described in Chapter V of the DRAM Report. Foreign households buy California goods and services on the goods-and-services markets. They and foreign firms both can supply capital and labor to the California economy, and domestic migration patterns are described in Chapter VIII.

Figure II-3: The Circular-Flow Diagram with Intermediate Goods and Trade

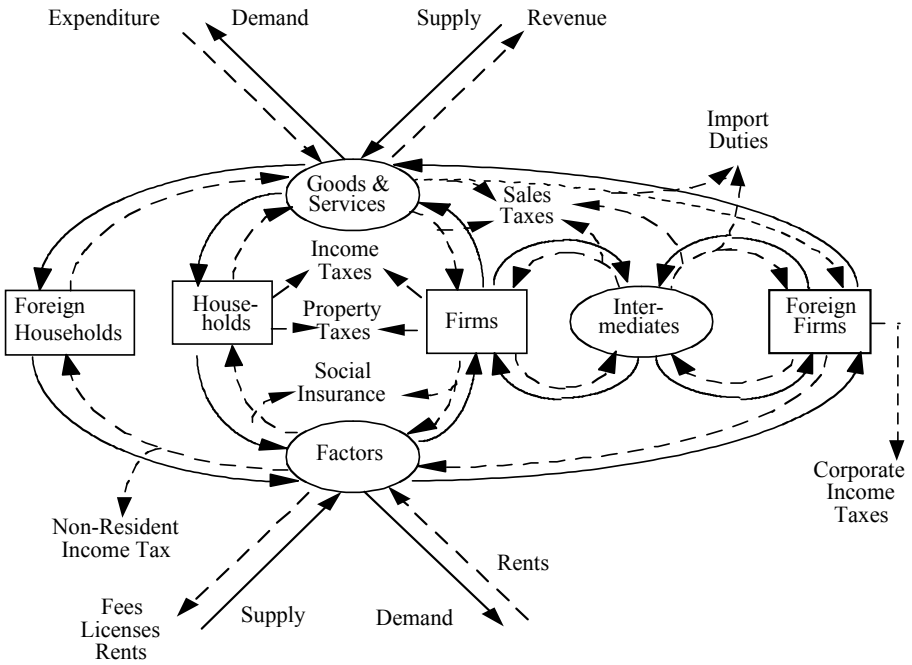


Source: Berck, Golan, and Smith, 1996.

3.1.6 Government

Finally, government is considered. Combining the taxing and spending effects of the three levels of government (federal, state, and local) gives the additional flows in Figure II-4. Beginning at the top, the figure shows that government buys goods and services and gives up expenditure. It supplies goods and services for which it may or may not receive revenue. Government also supplies factors of production, such as roads and education. Government also makes transfers to households, which are not shown in the diagram. The middle section of the diagram shows the myriad of ways in which government raises revenue through taxation. Chapter II of the DRAM Report includes a detailed description of the government activities in the model.

Figure II-4: The Complete Circular-Flow Diagram



Source: Berck, Golan, and Smith, 1996.

3.1.7 Data Organization: The Social Accounting Matrix

The first step in constructing a CGE model is to organize the data. The traditional approach to data organization for a CGE model is to construct a Social Accounting Matrix (SAM). A SAM is a square matrix consisting of a row and column for each sector of the economy. Each entry in the matrix identifies an exchange of goods and services purchased by one sector from another sector (or itself). The entries along a row in the SAM show each payment received by that particular row sector from each column sector. Summing across the row gives total payments made to that row sector by all column sectors. The entries down a column in the SAM show the expenditures made by that particular column sector to all row sectors. Summing down a column

gives total expenditures by that column sector to all row sectors. For accounting purposes, a SAM must "balance," i.e., each row sum and corresponding column sum must be equal. This balancing ensures that no money "leaks" out of the economy, i.e., that all money received by firms (row sum) is spent by them (column sum).

3.1.8 Other Considerations and Model Building

Computable General Equilibrium models are not forecasting models; they are calibrated to reproduce a base year. In the case of E-DRAM, the model is constructed to exactly reproduce the economic conditions of calendar year 2003. Of course, there are forecasting models. However, such models typically do not have the level of detail needed to examine dynamic policy effects. Given the paucity of California-specific data, it seems a better compromise to use a forecasting model, such as the one maintained by DOF, to set a base case and then use a policy model, such as DRAM, to analyze deviations from that case.

The E-DRAM model incorporates two assumptions that require some comment. It assumes competitive behavior in all private sectors. This is a good first approximation, particularly at the level of a sector. The alternative, market power, may well be present, but the degree of non-competitive pricing is not likely to be significant in aggregated sectors. The second assumption is that involuntary unemployment is constant. This assumption is unlikely to be strictly true. The model has voluntary unemployment, which are agents deciding to work less when the wage is lower. This assumption is common to all equilibrium models. Technical issues of model closure are described in Chapter IX of the DRAM Report.

Once the major agents in the economy have been identified and the relationship between these agents has been specified, the model can be built. In E-DRAM, the algebraic representation of the relationships between the agents in the California economy is achieved with the General Algebraic Modeling System (GAMS). The model currently has 1,100+ equations, exclusive of definitions and of the code to read in and organize the data. All of the model's equations and GAMS code are detailed in Chapter X of the DRAM Report.

3.1.9 Further Documentation

Fuller description of common features shared by E-DRAM and DRAM is available in the report cited above. The primary contents of that report, the presentation of which mirrors the sequence of tasks involved in building DRAM, are as follows. In Chapter II of the DRAM Report, the major agents in the economy are identified and aggregated into sectors. These aggregates are constructed to focus the model on the major industries, taxpayers, and government agencies in the California economy. Data sources are also identified.

Chapters III through VIII of the DRAM Report review the literatures, functional forms, and elasticities relevant to the six primary behavioral equations that link all the various sectors of the model and drive its results. Chapter III of the DRAM Report reviews the literature on the economic behavior of households with respect to

consumption and savings decisions. The literature on the production decisions of firms is examined in Chapter IV of the DRAM Report. Chapter V of the DRAM Report summarizes the literature on international and interregional trade. Investment theory is discussed in Chapter VI of the DRAM Report. Chapter VII of the DRAM Report covers the literature on regional labor-supply response to taxation and economic growth, while the literature on migration and economic growth is examined in Chapter VIII of the DRAM Report.

After establishing the sectoring scheme, data sources, and behavioral equations for the model, all that remains before the actual model can be built is a description of the model-closure rules. Closure rules concern the mathematics of insuring that a solution exists to the 1,100+ equations of the model. Model closure is developed in Chapter IX of the DRAM Report.

Chapter X of the DRAM Report describes the mathematical and corresponding GAMS notation for each equation in DRAM. It is a technical description of the complete California DRAM.[36] Chapter XI of the DRAM Report presents some sensitivity analyses.

Appendices follow Chapter XI of the DRAM Report. They include the original literature search by Dr. Berck and Mr. Dabalen in the summer of 1995, explanations of notational methods used, lists of parameter and variable names used in the mathematical and software input files, and printed copies of the input files themselves.

The updating to the 2003 base year is documented at http://are.berkeley.edu/~peter/Research/DRAM03B/OverviewIII_1018.doc.

The most recent updating is documented at http://are.berkeley.edu/~peter/Research/2003_sam_and_edram.htm.

Particularly, see "Construction of SAM" for technical details and spread sheet models. See SAM120 for the basic models. See "Predicting Future Years" for an explanation of how the future SAMs were calibrated to data on employment, income, and the like.

[36] See Berck, Hess, and Smith (1997) for revisions to the consumer demand portion of the model. Modification of equations from DRAM to E-DRAM are discussed in Berck and Hess (2000). Changes introduce parameters that facilitate running policy scenarios as some combination of price, intermediate good, and/or investment changes.

3.2 Sector Base Data Modification

E-DRAM's original industrial accounts are national accounts scaled to the state level using California employment data. These accounts do not give the same values as the Energy Information Administration does for California energy usage and production. We have used the Energy Information Administration data for these accounts in preference to the estimates derived from the industrial accounts.

3.2.1 Extrapolation from 2003 to 2020

The E-DRAM is not a forecasting model but, rather, a model constructed to exactly reproduce the economic conditions of calendar year 2003. To answer questions concerning the impacts of emission reduction strategies far into the future, E-DRAM must be augmented to reflect future conditions. To "rebase" E-DRAM, i.e., move from a model of the 2003 economy to model of the economy in 2020, E-DRAM's input data must be modified to reflect economic conditions in those "out years." The following process leaves the basic structure of economic relationships intact while scaling up 2003 monetary and employment data using state personal income (SPI), population, and industry-specific forecasts.

The transformation of the 2003 SAM into the 2020 SAM was based on the projected changes to personal income, population, and energy. The sources for these projections were as follows:

Personal-income growth.
The California Personal-income Growth data and California Consumer Price Index data are taken from the DOF. The annual percentage change of both is taken, and then the real growth percentage is determined by taking the differences of the percentage changes. This is done for years 2004-2020.

Working population growth (ages 18-64).
The California working population forecast through 2050 is from the DOF.

Refinery growth.
The factors assume a 0.5 percent growth rate in the refining and gas-producing sectors.

Oil and gas extraction growth.
The growth rates are based on the assumption that the gas and oil extraction sector of California will halve its production by 2020 (starting 2003). This is equivalent to a 4 percent fall in output each year and continues after 2020 at the same rate.

Natural gas per dollar efficiency.
The natural gas per unit of Gross State Product is calculated from the University of California, Davis, Advanced Energy Pathways baseline demand scenario reports.

Electricity per dollar efficiency.
The electricity per unit of Gross State Product is calculated from the University of California, Davis, Advanced Energy Pathways baseline demand scenario reports.

Fuel per dollar efficiency.
The California Energy Commission estimates of total fuel use (gas and diesel) for future years are used to calculate the per unit of Gross State Product usage of fuel.

The basic method of projection is first to increase the size of all values in the SAM by the projected increase in personal income and then to increase or reduce the rows and columns pertaining to the specific energy sectors by their intensities. The result of this exercise is that California in the future is predicted to have the same basic industrial structure as it does today, except that the named sectors generally grow more slowly than the economy as a whole. As a result, California is predicted to be more energy efficient over time.

3.2.2 Adjusting for Technological Change

As described in Berck and Hess (2000), the original E-DRAM allows for changes in production technology. Each industrial sector in E-DRAM is implicitly characterized by a production function that relates output to factor (capital and labor) and intermediate inputs. Technological change is modeled by altering the relationships of input mix per unit of output as follows. Industry J's demand for intermediates from industry I's per unit of output is governed by production parameters AD(I,J), which are input-output coefficients calculated from primary data contained in the SAM. These coefficients can be altered via technology multiplier parameters REG1(I,J). Changing REG1(I, industry J label) from its default setting of unity to 0.9, for example, simulates a technological change enabling one unit of industrial good J to be produced using only 90 percent of the intermediate inputs (from all 120 industries) previously required. Specifying AD(industry I label, industry J label) = 0.9, in contrast, simulates a technological change enabling one unit of good J to be produced using 90 percent of the intermediate inputs previously required from industry I (with inputs from the 119 other industries unchanged).

Similarly, there are expenditure pattern multipliers for government spending. For state spending, REG18(I,G) increases the expenditure from government G to sector I while decreasing the expenditure to all other sectors so as to keep the total expenditure constant.

3.3 Conclusion

This model overview summarizes the essence of the E-DRAM for the California economy. As stated earlier, E-DRAM describes the relationship among California producers, California households, California governments, and the rest of the world. The E-DRAM, like all other empirical economic models, treats aggregates rather than individual agents. For this it combines similar agents into single sectors. In the E-DRAM model, the California economy has been divided into 186 distinct sectors.

To answer questions concerning the impacts of emission reduction strategies far into the future, the model uses specific growth factors to model future years. To "rebase" E-DRAM, i.e., move from a model of the 2003 economy to model of the economy in 2020, E-DRAM's input data must be modified to reflect economic conditions in those "out years." This process leaves the basic structure of economic relationships intact while scaling up. Overall, the measures and changes in expenditure patterns are captured in the E-DRAM model as changes in technology and changes in government and personal expenditure patterns.

Attachment 1. Sectors Used for the E-DRAM Model

SECTOR DESCRIPTION
Agriculture, Forestry and Fishing
Agriculture
Cattle
Dairy
Forestry
Mining
Petroleum and Natural Gas Extraction
Mining
Utilities
Electrical Power Generation and Distribution
Natural Gas Distribution
Water Distribution and Sewage Treatment
Construction
Residential Construction
Nonresidential Construction
Street and Bridge Construction
Utility Infrastructure Construction
Other Construction-related Industry
Manufacturing
Food Manufacturing
Food Processing
Other Food Related Industry
Beverage and Tobacco Products
Textile and Leather Manufacturing
Apparel Manufacturing
Wood Products Manufacturing
Pulp and Paper Mills
Paper Products Manufacturing
Printing
Oil Refineries
Industrial Gas
Chemical and Drugs Manufacture
Basic Chemical Manufacture
Soaps and Detergents Manufacture
Other Chemical Products Manufacture
Plastics Manufacture
Glass Products Manufacture
Cement
Concrete

SECTOR DESCRIPTION
China and Clay Products
Primary Metals
Aluminum
Metal Fabrication
Machinery Manufacture
Refrigeration and Air Conditioning
Computer Manufacture
Communications Equipment Manufacture
Electronic Components Manufacture
Electronic Instruments Manufacture
Electronic Recording Media Manufacture
Electrical Equipment Manufacture
Automobile Manufacturing
Other Vehicle Manufacture
Motor Vehicle Body Manufacture
Motor Vehicle Parts Manufacture
Ship Building and Repair
Other Vehicle Manufacture
Aerospace Manufacture
Furniture
Laboratory and Dental Equipment
Miscellaneous Manufacturing
Wholesale Trade
Vehicle Services
Wholesale Durable Goods
Wholesale Non Durable Goods
Wholesale Gas
Wholesale Trade
Transportation and Warehousing
Transportation
Air Transportation
Railroad Transportation
Waterway Transportation
Truck Transportation
Public Transportation
Other Transportation
Vehicle Transportation
Retail Trade
Retail Vehicles and Parts

SECTOR DESCRIPTION
Retail Furniture
Retail Electronics and Appliances
Retail Building Materials
Retail Food and Beverage
Retail Health and Personal Care
Retail Gasoline Stations
Retail Clothing and Accessories
Retail Sporting Goods, Books, Music
Retail General Merchandise
Retail Miscellaneous
Retail Nonstore
Information
Motion Picture Industry
Other Broadcasting and Recording Industry
Telecommunications
Internet and Information Services
Finance, Insurance and Real Estate
Financial Securities
Insurance
Banking
Real Estate
Other Financial
Services
Legal Services
Accounting
Architecture
Design
Computer Related Services
Consulting
Research
Advertising
Other Professional Services
Business Services
Temporary Administrative Services
Security Services
Building Maintenance
Other Administrative Services
Waste Management
Landfills
Education
Medical Services
Hospitals

SECTOR DESCRIPTION
Nursing
Day Care
Recreation and Entertainment
Amusement Parks
Hotels
Full Service Restaurants
Fast Food
Caters and Mobile Food Services
Drinking Establishments
Personal Services
Labor and Capital Factors
FACTOR FACTOR LABOR
FACTOR FACTOR ALL OTHER FACTORS COMBINED AS CAPITAL
Commodity
COMMODITY FOOD AND BEVERAGE
COMMODITY SHELTER
COMMODITY FUEL AND UTILITIES
COMMODITY HOUSEHOLD FURNISHING AND OPERATION
COMMODITY APPAREL AND ITS UPKEEP
COMMODITY TRANSPORTATION
COMMODITY MEDICAL CARE
COMMODITY ENTERTAINMENT
COMMODITY OTHER GOODS AND SERVICES
California Marginal Personal Income Tax Brackets
HOUSEHOLD 0.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 1.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 2.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 4.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 6.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 8.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 9.3 PERCENT MARGINAL CA PIT UNDER 200K
HOUSEHOLD 9.3 PERCENT MARGINAL CA PIT OVER 200K
INVESTMENT
INVESTMENT

SECTOR DESCRIPTION
GOVERNMENT
GOVERNMENT FEDERAL TAX SOCIAL SECURITY
GOVERNMENT FEDERAL TAX PERSONAL INCOME TAX
GOVERNMENT FEDERAL TAX PROFITS
GOVERNMENT FEDERAL TAX DUTY
GOVERNMENT FEDERAL TAX MISCELLANEOUS
GOVERNMENT CALIFORNIA TAX VARIOUS HOUSEHOLD TAXES
GOVERNMENT CALIFORNIA TAX ALCOHOL TAXES
GOVERNMENT CALIFORNIA TAX CIGARETTE TAXES
GOVERNMENT CALIFORNIA TAX HORSE RACING
GOVERNMENT CALIFORNIA TAX ESTATE TAXES
GOVERNMENT CALIFORNIA TAX TRAILER FEES
GOVERNMENT CALIFORNIA TAX MOTOR VEHICLE LICENSE FEES
GOVERNMENT CALIFORNIA TAX DIESEL FUEL TAXES
GOVERNMENT CALIFORNIA TAX MOTOR VEHICLE REGISTRATION FEES
GOVERNMENT CALIFORNIA TAX MISCELLANEOUS
GOVERNMENT CALIFORNIA TAX INSURANCE GROSS PREMIUM TAX
GOVERNMENT CALIFORNIA TAX GASOLINE FUEL TAXES
GOVERNMENT CALIFORNIA TAX SALES AND USE TAXES
GOVERNMENT CALIFORNIA TAX BANK AND CORPORATION TAX
GOVERNMENT CALIFORNIA TAX LABOR TAXES UI AND WORKERS COMP
GOVERNMENT CALIFORNIA TAX PERSONAL INCOME TAX
GOVERNMENT CALIFORNIA TAX REGULATORY LICENSES AND FEES
GOVERNMENT CALIFORNIA TAX SERVICES TO THE PUBLIC
GOVERNMENT CALIFORNIA TAX USE OF PROPERTY AND MONEY

SECTOR DESCRIPTION
GOVERNMENT CALIFORNIA GENERAL FUND
GOVERNMENT LOCAL TAX PROPERTY
GOVERNMENT LOCAL TAX SALES AND USE
GOVERNMENT LOCAL TAX MISCELLANEOUS ON FIRMS
GOVERNMENT LOCAL TAX MISCELLANEOUS ON HOUSEHOLDS
GOVERNMENT LOCAL TAX MISCELLANEOUS ON FIRMS AND HOUSEHOLDS
GOVERNMENT FEDERAL SPENDING DEFENSE
GOVERNMENT FEDERAL SPENDING NON DEFENSE
GOVERNMENT CALIFORNIA SPENDING TRANSPORTATION
GOVERNMENT CALIFORNIA SPENDING CORRECTIONS
GOVERNMENT CALIFORNIA SPENDING K TO 14 EDUCATION
GOVERNMENT CALIFORNIA SPENDING UNIVERSITIES
GOVERNMENT CALIFORNIA SPENDING WELFARE
GOVERNMENT CALIFORNIA SPENDING HEALTH
GOVERNMENT CALIFORNIA SPENDING OTHER
GOVERNMENT LOCAL SPENDING TRANSPORTATION
GOVERNMENT LOCAL SPENDING CORRECTIONS
GOVERNMENT LOCAL SPENDING K TO 14 EDUCATION
GOVERNMENT LOCAL SPENDING WELFARE
GOVERNMENT LOCAL SPENDING HEALTH
GOVERNMENT LOCAL SPENDING OTHER
REST OF WORLD /
REST OF WORLD /

Climate Change Scoping Plan Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Appendix G: Economic Analysis
Appendix G-III
Economic Analysis of California Climate Policy Initiatives Using the Berkeley Energy and Resources (BEAR) Model

This appendix is not included because the BEAR model was not run for the Recommendation in the Scoping Plan. For results from the BEAR model, see the Economic Analysis Supplement to the Draft Scoping Plan.

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Climate Change Scoping Plan Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Appendix G: Economic Analysis
Appendix G-IV
Calculation of Household Savings by Income Group

1. INTRODUCTION

This appendix provides additional background on the calculation of the potential effects of the Recommendation from the Scoping Plan on households as discussed in Section 2.3 of Appendix G. To evaluate these effects, we first determined consumer expenditures on major goods and services as a function of income levels and household size. Then, we adjusted those expenditures based on the non-energy price changes reflected in the E-DRAM modeling of the Recommendation. Finally, we factored in additional savings from energy efficiency improvements for the residential and transportation sectors, including the Pavley regulation (Light-Duty Vehicle GHG Standards). The results from these calculations indicate a net annual savings of $400 to $500 per household for the various income categories – two percent or less of total household expenditures – due to implementation of the Recommendation.

2. CALCULATION OF HOUSEHOLD SAVINGS BY INCOME GROUP

To assess the impacts of projected price changes, we used household expenditure data from the Bureau of Labor Statistics' Consumer Expenditure Survey (2005-2006)[37] to obtain budget shares devoted to major consumer categories for different income groups. The budget shares for low- and higher-income households are shown in Table G-IV-1.

Because the precise effects of the Recommendation on non-energy household consumption are unclear, we assume that it remains constant as a conservative starting point. This assumption allows current expenditures to serve as a proxy for consumption levels. Constant consumption implies that households are not adjusting their purchasing in response to price changes. Combining the consumer expenditure patterns with E-DRAM's projected price changes for each non-energy category[38] yields an estimate of total change in household expenditures for these major goods and services.

[37] The survey is weighted for the entire nation and not for specific state-level analysis.
[38] In some cases, several E-DRAM industrial sectors are aggregated to form a single expenditure category, e.g. food comprises both food consumed at home and away from home.

Table IV-1: Budget Shares for Major Expenditure Categories by Income Group in 2005-2006

Expenditure Category	Percent of Household Budget Spent for Each Household Income Level			
	100% Poverty	200% Poverty	Middle Income(1)	High Income(2)
Housing	22%	21%	18%	18%
Food	17%	15%	14%	12%
Healthcare	6%	7%	6%	5%
Gasoline and motor oil	5%	5%	5%	4%
Apparel and services	5%	5%	4%	4%
Electricity	4%	4%	3%	2%
Entertainment	4%	4%	5%	5%
Vehicle maintenance, repair, insurance	3%	3%	3%	3%
Education	3%	2%	2%	2%
Natural Gas	2%	1%	1%	1%
Water	1%	1%	1%	1%
Other (e.g. taxes, social security payments, vehicle purchases, charitable donations, personal care products/services, etc.)	27%	31%	38%	44%

Source: Bureau of Labor Statistics, Consumer Expenditure Survey, Two-Year Cross Tabs 2005-2006

1 All households between 200% and 400% of the poverty guidelines. Note that "$70,000 or more" is the highest income bracket reported in the Consumer Expenditure Survey. For households of four or more, 400% of the poverty guidelines exceeds $70,000. In these cases, half of the households were assumed to be uniformly distributed between $70,000 and the average income reported for this bracket and household size category to distinguish between middle and high income households.

2 All households above 400% of the poverty guidelines. See previous footnote as well.

As shown in Table G-IV-2, for most major expenditure categories, such as gasoline, food, apparel, and healthcare, E-DRAM projects essentially no change in price (less than one percent and generally a price decrease). However, for the Recommendation, electricity and natural gas prices are projected to increase eleven and eight percent, respectively.[39] With the exception of electricity and natural gas expenditures, applying these price changes to current expenditure patterns yields the change in total expenditures resulting from price effects alone (i.e., no changes in consumption levels due to improved efficiency or demand response). The treatment of electricity and natural gas expenditures is described below. Overall, the price

[39] E3's analysis shows a slightly larger increase in average statewide rates of 14 percent, however also shows a net decrease in overall statewide bills.

effects alone would not significantly change household expenditures in these categories across all household groups, assuming that households do not change consumption in response to new prices.

Table G-IV-2. E-DRAM Projected Price Changes in 2020 for Select Sectors

Category	Preliminary Recommendation
Owned dwellings	0.0%
Rented dwellings	0.0%
Food at home	-0.1%
Food away from home	-0.7%
Healthcare	-0.6%
Gasoline and motor oil	0.1%
Apparel and services	-0.6%
Electricity	11.3%(1)
Entertainment	-0.5%
Vehicle maintenance and repair	-0.3%
Vehicle insurance	-0.2%
Education	-0.4%
Natural Gas	7.9%(2)
Water	-0.1%

Shaded rows indicate increasing prices; Unshaded rows show decreasing prices

1 Although E-DRAM projects a price increase for electricity, E3's analysis estimates an overall 5% decrease in electricity bills. The change in bills is more representative of changes in household expenditures. Thus, for this analysis -5% is used for the change in the electricity sector.

2 Although E-DRAM projects a price increase for natural gas, the analysis conservatively balances this increase with the estimated 29 percent overall decline in natural gas use in California by assuming no change in natural gas bills.

For the electricity sector, many measures in the Scoping Plan are expected to improve end-use electricity efficiency and reduce consumption levels. Total bills will vary depending on the type of customer (e.g. commercial or residential), customer usage patterns, opportunity for reductions in usage from energy efficiency and/or change in practices, and the rate structure of the electricity provider. Because utility rates are adjusted to collect total utility costs over time, though, a forecast of total utility costs can serve as a proxy for the electricity bills of all customers in the State. Based on projections by Energy and Environmental Economics, Inc.'s (E3) GHG Spreadsheet Calculator for the Joint CEC/CPUC Proceeding on AB 32 (CPUC Rulemaking 06.04.009, CEC Docket 07-OIIP-01), total utility costs for all customers statewide are expected to be approximately five percent lower than the base case

in 2020.[40] Their finding is that the utility savings attributed to energy efficiency and CHP more than make up for the additional costs in the electricity sector. However, as previously discussed, changes to individual entities will deviate from the average and the E3 analysis does not predict how these savings will be distributed among customers. For purposes of this analysis, we assume a household's total electricity bill decreases by five percent on average, which is more representative of the changes to a household's expenditures than just the change in electricity price.

For natural gas, E-DRAM projects a price increase of eight percent. We have estimated that the measures in the Recommendation will result in an overall 29 percent decrease in natural gas consumption in California. As a conservative estimate that balances the projected price increase with the estimated decline in natural gas consumption, we have assumed no change in natural gas bills for the purposes of this analysis.

In addition, the Pavley regulation (Light-Duty Vehicle GHG Standards) is likely to further enhance the savings to households. The cumulative savings to the household will largely depend on when households are able to purchase either a new or used Pavley vehicle. Based on the economic evaluation conducted during the Pavley rulemaking process, low-income households could expect to save about 100 gallons of gasoline each year by driving a Pavley-compliant vehicle. Using the projected gas prices of $3.67 per gallon in 2020 (in terms of 2007 dollars), low-income households would save about $360 in fuel alone in 2020 relative to business-as-usual. Factoring in the additional annualized cost of about $50 for a used Pavley-compliant vehicle (LT2) yields net savings of approximately $300 per year. For higher income households purchasing new vehicles and traveling more miles, the net savings total roughly $400 per year. The findings from this analysis would change if based on different assumptions for fuel prices and/or vehicle costs. For example, to the extent that fuel prices are higher the savings would be greater.

The household savings presented in Table G-IV-3 were calculated as follows:

- Multiply the average household expenditures for each major category and income group by the price changes projected by E-DRAM for the Recommendation. For the electricity category, replace electricity price changes with -5 percent to reflect the average reduction in electricity bills as estimated by E3. For the natural gas category, replace the natural gas price change with a zero percent change to reflect the balance between increased prices and decreased use of natural gas.
- Sum the changes for all of the categories.
- Add the net Pavley savings to the total change under the Recommendation. For low-income households, net savings from Pavley equal $300; for higher income households (greater than 200% of the federal poverty guidelines), net savings total $400. No distinction was made between middle or high income households in vehicle type purchase or annual vehicle miles traveled.
- Final estimates are rounded to one significant digit.

[40] The E3 analysis focuses on direct programmatic measures and does not include the incremental price impact of the cap and trade program, which will depend upon allowance price, allocation strategy, the capped sector industry response, and other program design decisions.

Table G-IV-3: Total Estimated Household Savings by Income Group in 2020 (2007 $) Due to Implementation of the Recommendation

	100% Poverty	200% Poverty	Middle Income[a]	High Income[b]	All Households[c]
Total Savings	$400	$400	$500	$500	$500
Share of Total Expenditures	2%	2%	1%	1%	1%

[a] All households between 200% and 400% of the poverty guidelines.
[b] All households above 400% of the poverty guidelines.
[c] Average of households of all income levels.

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Climate Change Scoping Plan Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Appendix G: Economic Analysis
Appendix G-V
Impacts on Businesses

1. INTRODUCTION

This appendix provides additional background on the calculation of the potential effects of the Recommendation from the Scoping Plan on business, particularly small business. Section 38560(e) of the California Global Warming Solutions Act of 2006 (AB 32) requires the Air Resources Board to consider the potential for adverse effects on small businesses when developing its Scoping Plan. The Recommendation in the Plan promotes energy efficiency through better management of energy resources and the use of more energy efficient technologies, which is expected to more than offset likely increases in the unit price of energy. On balance, the Recommendation is expected to reduce electricity expenditures for average California customers by 5 percent in 2020 relative to business-as-usual according to a recent analysis by Energy and Environmental Economics, Inc. (E3).[41] Based on estimates of reduced natural gas use in California, similar declines in average natural gas bills are also likely. We estimate that total natural gas use in California will decrease by 29 percent, which would more than offset the approximately 9 percent increase in natural gas prices estimated by E-DRAM. Because both the projected decrease in natural gas use and the price increase are aggregate figures for all of the California economy, this analysis conservatively uses an estimate of no change in natural gas bills. Natural gas market complexity, vast differences in business energy consumption characteristics, combined with a lack of adequate data prevent a more detailed analysis of such savings. Further, the transportation measures in the Plan will bring about significant savings to businesses that rely heavily on transportation fuels for their business. However, for the analysis presented here, there is not sufficient data to represent the benefits to business due to reduced consumption of transportation fuels resulting from measures in the Plan.

[41] Recent analysis from Energy and Environmental Economics, Inc. [based on their GHG Calculator, CPUC/CEC GHG Docket (CPUC Rulemaking.06.04.009, CEC Docket 07-OIIP-01), available at http://www.ethree.com/cpuc_ghg_model.html] forecasts that a package of greenhouse gas reduction measures similar to the Recommendation in the Proposed Scoping Plan would deliver a 5 percent decrease in electricity expenditures relative to business-as-usual in 2020. This change is being used as a proxy for the bill impacts for the average California electricity customer. Changes to individual entities will deviate from the average and the E3 analysis does not predict how these savings will be distributed among customers. The E3 analysis focuses on direct programmatic measures and does not include the incremental price impact of the cap and trade program, which will depend upon allowance price, allocation strategy, the capped sector industry response, and other program design decisions.

The analysis presented in this section provides a financial assessment of the impacts of the Recommendation on California businesses. The assessment resulted in the following findings.

- Businesses in general are expected to experience no significant change in total energy costs.
- Small businesses in almost every industry spend a greater percentage of revenue on energy than large businesses.
- As a result of implementing the Recommendation, California business ranking in terms of electricity expenditures per dollar of sales would change from 7th highest to the 19th highest in the nation, considerably improving California business competitive position vis-à-vis out-of-state businesses.
- Large businesses are likely to be more responsive to the changes required by the Scoping Plan than small businesses because of their greater ability to invest in energy efficient technologies to achieve energy savings, thus underscoring the need to explore options for assisting small business during the implementation of the plan.

2. DATASETS

Under a contract to ARB, Dun and Bradstreet (D&B) created a statistical data model that estimates the portion of revenue that businesses spend on electricity and natural gas bills. The model is based on all of D&B marketing files of approximately 17 million businesses nationwide including over 2.1 million from California. The annual spending on electricity was calculated for affected businesses as follows:

- D&B collected monthly electrical bills data for approximately 628,000 businesses from 18 electrical utility providers nationwide, including two California utilities from April 2007 to March 2008.
- Annual spending on electricity was calculated for these businesses by summing up monthly bills.
- Of the 628,000 businesses nationwide for which D&B collected electricity bill data, D&B had revenue data for 210,000 businesses.
- Revenue data were available for a greater number of large businesses in the sample. Thus, the sample distribution was adjusted to represent the true universe distribution of the D&B database of 17 million businesses.
- Analysis of the data was provided based on a number of characteristics such SIC (Standard Industrial Classification) Code, business size.

The D&B data on natural gas spending were not as extensive as its data on electricity spending. However, D&B provided data on natural gas spending for several industries at the national level. These data, along with electricity spending data, were used to form a complete picture of the impact that energy price changes may have on small business due to implementation of the Recommendation in the Plan.

3. METHODOLOGY

The Scoping Plan measures are expected to change the energy costs for most businesses in California. The change in energy spending by California businesses may alter their profitability, thus the need for the analysis. Since profitability data were not available for businesses in the D&B database, the change in energy spending as a percentage of revenue was used as a proxy for the change in business before-tax profitability, though this method does not account for changes in economic output from implementing the Recommendation. Estimating the change in energy spending by businesses provides a snapshot analysis of the likely impact that energy costs may have on businesses in California.

The calculations were based on the following assumptions:

1) D&B national data were used to calculate business electricity and natural gas spending as a percentage of revenue;
2) Based on expert opinions, the average electricity bill for all California customers is expected to decline by about 5 percent relative to business-as-usual, which was assumed to represent the average bill impact for California businesses;
3) Expenditures for natural gas are assumed to remain the same as a conservative assumption, based on the projected 29 percent decrease in natural gas consumption in California and E-DRAM's projected natural gas price increase of approximately 9 percent;
4) Data on natural gas spending were only available for industries nationwide. Spending on natural gas for a typical California firm in each industry is expected to be similar to a typical national firm in that industry.

4. BUSINESS COMPETITIVENESS

California ranked 7th in the nation based on the percentage of revenue a business, on the average, spends on the electricity (Table G-V-1). California businesses are currently spending less than 3 percent of their revenues on electricity. As stated above, the average electricity bill for businesses is expected to decline by 5 percent in 2020 as a result of the Scoping Plan relative to business-as-usual. A 5 percent decline in the electricity spending for business would favorably push back California's ranking from 7th highest to 19th highest in the nation, considerably improving California's competitive position compared to other states.

Table G-V-1. Spending on Electricity as a Percentage of Revenue by State

State	Business No.	Before Regulation		After Regulation	
		%Spending	Ranking	%Spending	Ranking
Georgia	595,952	3.26	1	3.26	1
Louisiana	226,355	3.26	2	3.26	2
Arizona	300,690	3.24	3	3.24	3
Wisconsin	289,720	3.10	4	3.10	4
Alaska	39,518	3.05	5	3.05	5
Montana	307,026	3.00	6	3.00	6
California	**2,152,141**	**2.94**	**7**	**2.79**	**19**
Maine	73,452	2.90	8	2.90	7
West Virginia	70,068	2.90	9	2.90	8
Washington DC	47,506	2.90	10	2.90	9
Wyoming	38,782	2.90	11	2.90	10
Vermont	43,492	2.89	12	2.89	11
South Dakota	53,703	2.88	13	2.88	12
Indiana	104,859	2.87	14	2.87	13
New Mexico	96,922	2.86	15	2.86	14
Montana	71,842	2.84	16	2.84	15
Delaware	45,393	2.84	17	2.84	16
Hawaii	61,410	2.83	18	2.83	17
North Dakota	44,066	2.81	19	2.81	18
Arkansas	142,205	2.79	20	2.79	20

Table G-V-2 displays the percentage of the revenues spent on electricity for the top 20 California industries compared to the same industries nationwide. For most industries, California businesses spend slightly more on electricity than similar businesses nationwide. However, the majority of the listed business categories are those that serve local markets such as trailer parks and camps, hotels, barbershops, coin-operated laundries, etc. Out-of-state businesses cannot serve these local markets. As a result, California businesses are unlikely to experience a competitive pressure from out-of-state businesses to lower the prices of their products; therefore, they experience increased profitability if their electricity costs decline.

Table G-V-2. List of 20 Industries with Highest Percentage of Revenue Spending on Electricity

SIC	Industry Description	CA Average %	US Average %
8641	Civic and Social Associations	8.6	7.6
7032	Sporting and Recreational Camps	8.2	7.7
7033	Trailer Parks and Campsites	8.2	8.2
7021	Rooming and Boarding Houses	7.4	6.8
7219	Laundry and Garment Services, NEC	6.9	6.5
7041	Membership-basis Organization Hotels	6.9	6.4
7241	Baber Shops	6.9	6.3
5461	Retail Bakeries	6.9	6.1
8231	Libraries	6.8	5.8
6719	Holding Companies, NEC	6.6	6.1
5813	Drinking Places	6.4	6.0
7011	Hotels and Motels	6.4	6.1
7215	Coin-operated Laundries and Cleaning	6.2	5.5
7231	Beauty Shops	6.2	5.8
7217	Carpet and Upholstery Cleaning	6.1	5.5
5441	Candy, Nut, and Confectionery Stores	6.0	5.5
4941	Water Supply	6.0	5.8
0259	Poultry and Egg, NEC	5.9	6.4
8351	Child Day Care Services	5.9	5.4
8361	Residential Care	5.8	5.2

Note: NEC: Not elsewhere classified.

Table G-V-3 provides cumulative spending on both electricity and natural gas for the listed industries. As shown, total electricity and natural gas expenditures as a percentage of revenue for the twenty highest affected industries in California varies from a high of 22.2 percent to a low of 7.8 percent.

Table G-V-3. List of Top 20 Industries California with Highest Percent of Revenue Spending on Energy Without the Scoping Plan

SIC	Industry Description	%Spending on Electricity	%Spending on Natural Gas	%Spending Total
7215	Coin-operated Laundries and Cleaning	6.2	16.0	22.2
7219	Laundry and Garment Services, NEC	6.9	8.4	15.3
8641	Civic and Social Associations	8.6	5.8	14.4
7021	Rooming and Boarding Houses	7.4	6.9	14.3
7041	Membership-basis Organization Hotels	6.9	6.8	13.7
7033	Trailer Parks and Campsites	8.2	5.1	13.3
7241	Baber Shops	6.9	5.0	11.9
6719	Holding Companies, NEC	6.6	5.2	11.8
7011	Hotels and Motels	6.4	4.9	11.3
7032	Sporting and Recreational Camps	8.2	2.8	11.0
8351	Child Day Care Services	5.9	4.4	10.3
5461	Retail Bakeries	6.9	3.2	10.1
8231	Libraries	6.8	3.3	10.1
5813	Drinking Places	6.4	3.6	10.0
7231	Beauty Shops	6.2	3.7	9.9
7217	Carpet and Upholstery Cleaning	6.1	1.9	8.9
8361	Residential Care	5.8	3.1	8.9
4941	Water Supply	6.0	2.7	8.7
5441	Candy, Nut, and Confectionery Stores	6.0	1.8	7.8
0259	Poultry and Egg, NEC	6.0	n.a.	n.a.

Notes: NEC: Not elsewhere classified
n.a.: not available.

Assuming that the Recommendation in the Plan decreases electricity expenditures in California by 5 percent and leaves natural gas expenditures unchanged, the average percent of revenue spent on energy by California firms in Table G-V-3 will decrease by 0.3 percent for the coin-operated laundries and cleaning businesses (high end users), and also decline by 0.3 percent for Candy, Nut, and Confectionery businesses (the low end users). Table G-V-4 recreates the 20 top high users of combined electricity and natural gas in Table G-V-3 after the expenditure effects are reflected. Most businesses experience no significant change in their energy expenditures.

Table G-V-4. List of Top 20 Industries California with Highest Percent of Revenue Spending on Energy With the Scoping Plan

SIC	Industry Description	%Spending on Electricity	%Spending on Natural Gas	%Spending Total
7215	Coin-operated Laundries and Cleaning	5.9	16.0	21.9
7219	Laundry and Garment Services, NEC	6.6	8.4	15.0
8641	Civic and Social Associations	8.2	5.8	14.0
7021	Rooming and Boarding Houses	7.0	6.9	13.9
7041	Membership-basis Organization Hotels	6.6	6.8	13.4
7033	Trailer Parks and Campsites	7.8	5.1	12.9
7241	Baber Shops	6.6	5.0	11.6
6719	Holding Companies, NEC	6.3	5.2	11.5
7011	Hotels and Motels	6.1	4.9	11.0
7032	Sporting and Recreational Camps	7.8	2.8	10.6
8351	Child Day Care Services	5.6	4.4	10.0
5461	Retail Bakeries	6.6	3.2	9.8
8231	Libraries	6.5	3.3	9.8
5813	Drinking Places	6.1	3.6	9.7
7231	Beauty Shops	5.9	3.7	9.6
7217	Carpet and Upholstery Cleaning	5.8	1.9	7.7
8361	Residential Care	5.5	3.1	8.6
4941	Water Supply	5.7	2.7	8.4
5441	Candy, Nut, and Confectionery Stores	5.7	1.8	7.5
0259	Poultry and Egg, NEC	5.7	n.a.	n.a.

Notes: NEC: Not elsewhere classified
n.a.: not available.

5. SMALL BUSINESS IMPACT

As stated, the D&B data on natural gas spending were not as extensive as its data on electricity spending. The following analysis, thus, could only be performed based on

business electricity spending in the United States. Classifications of business expenditures on electricity by employee size show that small businesses tend to spend a larger share of their business expenditures on electricity than larger businesses. Thus, a reduction in electricity expenditures is expected to benefit small businesses relatively more than large businesses.

The smaller a business is, the larger its share of spending on electricity. As shown in Figure G-V-1, small businesses with a single employee spend 3.3 percent of each sales dollar on electricity, while businesses with 500 or more employees spend only 0.30 percent. This represents 11 times greater spending on electricity as a percentage of revenue for small businesses than for large businesses. A 5 percent reduction in electricity expenditures would reduce small business spending on electricity from 3.3 percent to 3.1 percent of each sales dollar while reducing large business spending from 0.30 to 0.29 percent of each sales dollar.

Figure G-V-1. Percent of Revenue Spending on Electricity by Business Employee Size

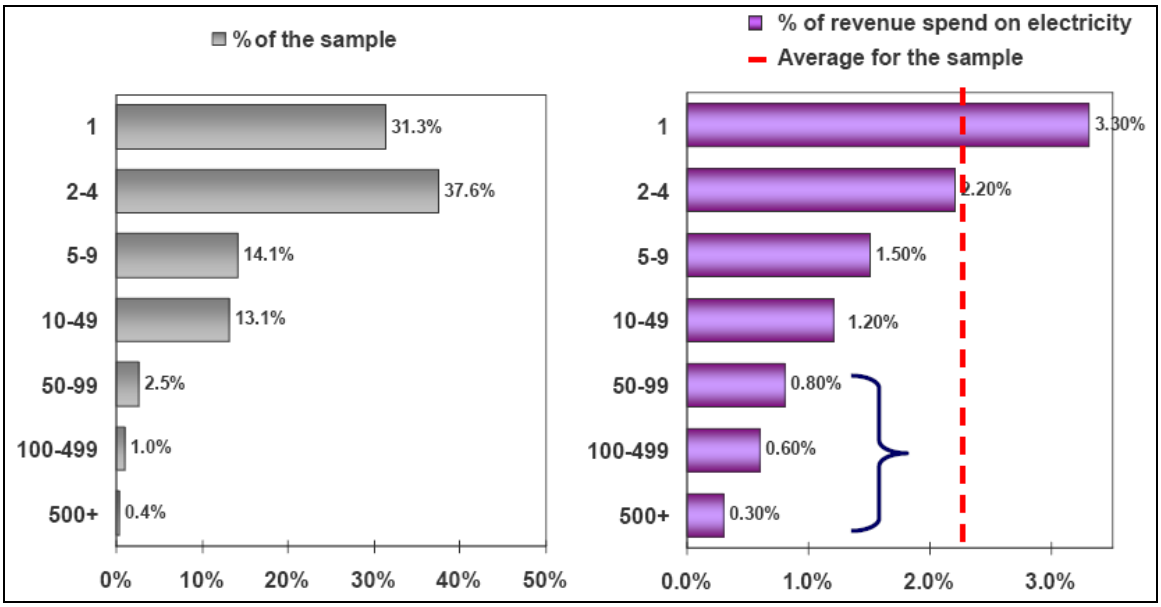
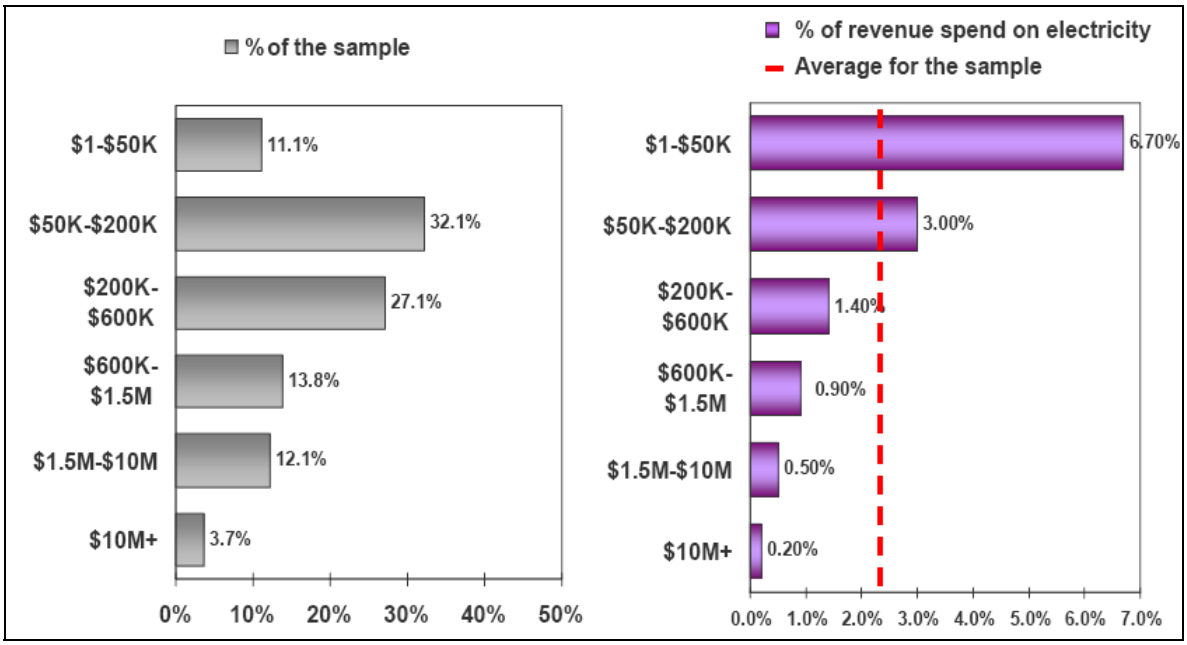


Figure G-V-2 shows that the U.S. businesses with smaller sales spend much higher percentages on electricity than larger businesses. Small businesses earning less than $50,000 in sales spend 34 times more on electricity as a percentage of revenue than large businesses with $10 million or more in sales. A five percent reduction in electricity expenditures would reduce small business spending on electricity from 6.7 percent to 6.4 percent of each sales dollar while reducing large business spending on electricity from 0.20 percent to 0.19 percent of each sales dollar. Generally, the smaller a business is, the larger the benefit it receives from a reduction in energy expenditures.

Businesses in general are expected to experience no significant change in energy costs although businesses that currently spend more on natural gas per dollar of sales will experience slight increase in their total energy costs.

Figure G-V-2. Percent of Revenue Spending on Electricity by Business Revenue



6. CONCLUSIONS

On average, businesses in California are expected to experience a slight decrease in energy expenditures. Further, any savings from the transportation measures in the Scoping Plan, which are not reflected in this analysis, would yield further benefits.

A reduction in electricity bills will dramatically improve California business competitive position in the nation, moving it from 7th highest to the 19th highest in the nation in terms of electricity expenditures per sales dollar. However, we expect large businesses, especially in the short run, to be more responsive to the changes required by the Scoping Plan than small businesses because of their greater ability to invest in energy efficient technologies to achieve energy savings. These results are consistent with the results of the macroeconomic analysis presented in Appendix G, which shows the overall energy cost savings would stimulate increased economic activity, resulting in increased output and personal income.

Appendix H: Public Health Analysis

Statewide Public Health and Environmental Benefits of Scoping Plan Measures

Regional Assessment of Air Quality-Related Public Health Benefits of Scoping Plan: South Coast Air Basin

Community Level Assessment of Air Quality-Related Public Health Benefits of Proposed Scoping Plan: Wilmington Example

Overview of Regulatory Programs for Criteria and Toxic Air Pollutants in California

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INTRODUCTION

AB 32, the Global Warming Solutions Act of 2006, requires ARB to evaluate the environmental and public health impacts of the Scoping Plan. The analysis of this plan is focused primarily on the quantification of air quality-related public health benefits at statewide, regional, and local scales that would result from implementation of the proposal. Climate change from greenhouse gas pollutants emitted in another state or country have the same potential to damage our public health and the environment as do climate change pollutants emitted within California, and California is only a small part of the overall solution. However, many of the measures aimed at reducing global warming pollutants also provide co-benefits to public health and California's natural resources.

California's actions to reduce greenhouse gas emissions will help transition the State to new technologies, improved efficiencies, and land use patterns also necessary to meet air quality standards and other public health goals. California's challenging public health issues associated with air pollution are already the focus of comprehensive regulatory and incentive programs. These programs are reducing smog forming pollutants and toxic diesel particulate matter at a rapid pace. However, to meet increasingly stringent air quality standards and air toxics reduction goals, transformative changes are needed in the 2020 timeframe and beyond. Implementation of AB 32, will provide additional support to existing State efforts devoted to protecting and improving public health.

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Statewide Public Health and Environmental Benefits of Scoping Plan Measures

1. AB 32 REQUIREMENTS

The Global Warming Solutions Act of 2006 (AB 32) requires the California Air Resources Board (ARB or Board) to evaluate the economic, public health and environmental benefits of the Scoping Plan. ARB must also evaluate the potential for localized effects before implementing market-based compliance programs. This document discusses public health and environmental impacts. Economic impacts are discussed in a separate document.

Addressing climate change effects expands the way we view how our actions affect our environment and our health. In California, there are a number of State agencies dedicated to protecting and restoring the state's environment and improving public health. ARB, through the implementation of the Climate Change Scoping Plan and Appendices, December 2008 (collectively "Scoping Plan"), will meet California's greenhouse gas reduction target in ways that help the State meet other public health and environmental goals. Any adverse environmental impacts will be assessed and mitigated as required by the California Environmental Quality Act (CEQA). The necessary CEQA documents for the Scoping Plan are included as Appendix J.

For the purposes of the Scoping Plan, ARB investigated the recommended measures' potential direct and indirect physical effects on the environment: air quality, water quality and supply, land resources, and biological resources. ARB then used these evaluations to examine the Scoping Plan's potential effects on public health, primarily through changes to air quality, and the potential for localized effects. For the purposes of evaluating implementation of the Scoping Plan, we first established and examined a "business as usual" scenario for absent the Scoping Plan measures. The "business as usual" scenario includes implementation of existing ARB policies and plans such as the Diesel Risk Reduction Plan, the Goods Movement Emission Reduction Plan and the State Implementation Plan for criteria pollutants. ARB then examined each measure to evaluate potential changes the Scoping Plan might cause.

The Scoping Plan describes the framework of the proposed recommendation and Appendix C describes each measure, by sector, in detail. These documents were relied upon and are not necessarily repeated within this evaluation. Measures are described as needed to discuss the related environmental or public health effect.

2. 2020 CONDITIONS WITHOUT AB 32 SCOPING PLAN – BASELINE FOR EVALUATION

There are two main drivers of the 2020 Business As Usual ("BAU" or "No Project") scenario: population growth and current laws and regulations. Population growth in California will result in 2020 conditions with more vehicle miles driven, more fuel used, greater electricity consumption, more consumer products, more goods movement, and greater water demand. Laws and regulations already in place or in process will continue to maintain and even improve our environmental resources, even with population growth.

The following describes the BAU scenario, which is used as a baseline for the evaluation of each proposed or evaluated measure. Descriptions of the 2020 BAU forecasts for the major sectors of the inventory are given below with key assumptions staff used to estimate these future emissions.

Transportation

Petroleum-based fuels supply 96 percent of California's transportation needs and will continue provide a substantial portion into the future. GHG emissions in 2020 from the transportation sector as a whole are expected to increase from current levels to 225.4 million metric tons of carbon dioxide equivalents ($MMTCO_2E$). This forecasted increase is dominated by increases in emissions from on-road transportation, i.e., passenger cars and heavy-duty trucks. To forecast on-road transportation emissions, ARB staff used 2007 fuel sales data obtained from the California Board of Equalization and estimated 2020 emissions based on the growth in projected vehicle miles traveled (VMT) derived from the 2007 Emissions Factor Model (EMFAC2007). This BAU forecast assumes no change in vehicle fleet mix over time. The BAU forecast also assumes no reductions in VMT or airplane traffic due to the High Speed Rail (HSR), although the HSR has completed all of its environmental evaluations (SCH #2001042045) and could proceed independent of AB 32 implementation.

Goods movement activities in California are projected to increase up to 250 percent between 2006 and 2020, as the United States increases its exports and imports in the globalized economy. This increase translates to more ship and truck trips in and around ports, and more truck activity between and at rail yards and distribution centers. Rail trips will probably not increase, as improvements in locomotive efficiencies accommodate larger hauls. Some of this growth may require new infrastructure to relieve traffic congestion and improve efficiencies, such as port and highway expansions. ARB adopted and is implementing a Goods Movement Emission Reduction Plan to reduce emissions from goods movement activities and address regional ozone and particulate matter standards, as well as impacts on already adversely-impacted communities, which can be located near ports, rail yards, and distribution centers.

The 2007 Integrated Energy Policy Report indicates that by 2020, at current trends, more than 44 million Californians will consume more than 24 billion gallons of gasoline and diesel fuel each year. Such increased consumption would require major investments in petroleum refinery and delivery infrastructure expansions. Assembly Bill 1007 (Pavley, 2005) directed the California Energy Resources and Conservation Commission (CEC) and ARB to develop a plan to increase the use of alternative fuels in California, effectively reducing California's demand on

refineries. California's refineries also supply other western states, which are currently expected to increase their demands for gasoline and diesel into the future due to population growth. Fuel diversity has also been identified as a major policy objective in the CEC's *2003 Integrated Energy Policy Report*[3] and the Governor's BioEnergy Executive Order S-06-06 and Bioenergy Action Plan[4].

California's population is continuing to grow at 1.2 percent per year. If the measures in the Scoping Plan are not implemented, land use patterns and decision making will likely continue to foster leap frog development and urban sprawl, which directly relates to a continued increase in VMT, further degradation of air quality, and an increase in detrimental health effects. Most of the gains made by introducing cleaner vehicles and fuels will be eroded unless more efficient methods of urban and community planning, transit choices, and public safety measures are implemented.

Electricity and Natural Gas

Under a business as usual scenario, population growth in California will affect electricity demand in two ways: the number of residents will increase the overall demand for electricity and natural gas, and the location of those residents, primarily in the state's inland areas, will change the pattern of energy use. Trends toward larger homes and increases in electronic equipment will also increase demand. Historically, California's appliance and building efficiency standards were able to hold our per capita electricity and natural gas demands steady, but under a business as usual scenario these programs will not be able to continue this trend through 2020 and new capacity would be needed.[42] As demands increase, older, less efficient and dirtier power plants would be expected to operate more frequently.

The pattern of energy use is important, because the electrical system is sized to accommodate peak demands. The base of the state's electrical demand is a minimum amount of energy demanded by the state all the time. The peak demand is the difference between this base and the maximum amount of energy needed, usually during periods of extreme weather. Power plants that provide base energy are the most cost-effective, because they are run fairly constantly. "Peaker" power plants, on the other hand, can be run as little as 4 hours a day on a few very hot summer days, and the low duration of operation tends to result in higher co-pollutant emissions than their base counterparts on a per MW basis. Power plants are typically dispatched starting with the most efficient sources, which are generally also those with lowest emissions. Under BAU conditions, many new power plants will need to be built in California to accommodate load growth and to replace the existing fleet of aging power plants that have low efficiencies and relatively high co-pollutant emissions. There are also several coastal plants that could be closed in response to proposed environmental requirements for their once-through cooling systems.[43]

Power plants are typically located close to power recipients, suggesting that new power plants would most likely follow population growth in the state. Repowering old plants or constructing new plants in the South Coast, where the state's greatest demand is located, has been identified as particularly problematic due to the region's air quality constraints.

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[42] CEC, "2007 Integrated Energy Policy Report", CEC-100-2007-008-CMF.
[43] State Water Resources Control Board, proposed *Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling*, March 2008.

Along with reliable power plants, important components of a reliable electricity system are distribution, transmission, and availability of fuel supplies. Like power plants, distribution systems are aging, and require substantial infrastructure investments to ensure their continued reliability. The construction of new transmission lines is needed to increase the state's renewable electricity sources to meet the existing regulatory goals of 20 percent. If these goals are not met, the price of electricity could increase as utilities incur financial penalties. These issues have all been identified in the 2007 Integrated Energy Policy Report (2007 IEPR) as high priorities for the state in the near term.

A third challenge is from the effects of climate change such as increasing frequency and magnitude of extreme weather events. This could drastically affect the duration and magnitude of peak demands, increasing reliance on aging power plants. During the summer months, California also imports energy generated by hydropower from the Northwest to meet peak demand. Decreasing snowpack within California and throughout the west is likely to reduce the availability of this clean and relatively inexpensive hydropower source, further exacerbating the problem. In addition, a large number of power plants in California are located along the coast. The potential for sea level rise associated with climate change could impact the operation of those plants.

The 2020 business-as-usual greenhouse gas emissions forecast for the electric power sector is 139.2 $MMTCO_2E$. These emissions are the result of in-state power generation plus specified and unspecified imported power. BAU forecasted emissions assume that all growth in electricity demand by 2020 will be met by either unspecified imports or in-state natural gas-fired power plants.

The 2020 BAU forecast for emissions from specified sources of imported electricity (i.e., power received from specific out-of-state power plants) is assumed to decrease resulting from the closure of one coal-fired power plant (Mojave) previously supplying imported electricity. The demand previously served by the closed plant was replaced by in-state natural-gas generation. Based on outputs from the California Energy Commission's (CEC) electricity demand models, in-state electricity generation and specified imports would not meet the State's full electricity demand in 2020. The remaining demand is assumed to be met by unspecified imported electricity (i.e., power received from a mix of power generating sources outside the State).

The Emissions Performance Standard, (EPS) was established by SB 1368 (Perata, Chapter 598, Statutes of 2006), and will effectively reduce emissions from imported, coal-generated electricity. Regulations adopted pursuant to SB 1368 set by the CPUC for investor-owned utilities and by the CEC for publicly-owned utilities prevent all California utilities from entering into long-term contracts that fail to meet an emissions performance standard. As existing agreements expire, coal-intensive electric utilities will see reduced emissions that minimize their need for allowances under cap and trade. Such utilities will need to plan to replace coal-generated electricity with energy efficiency, renewables and less carbon-intensive resources. ARB does not consider the EPS in the forecasted 2020 emissions. This allows the Scoping Plan reductions from increasing renewable power generation to be counted against with the BAU forecasted 2020 emissions without double-counting the reductions.

Electricity and Natural Gas in Residential and Commercial Properties

The Commercial and Residential sector is expected to contribute 46.7 $MMTCO_2E$ or about eight percent of the total statewide greenhouse gas emissions in 2020. Forecasted BAU emissions from the Commercial sector include combustion emissions from natural gas and other fuels (e.g., diesel) used by office buildings and small businesses. Residential emissions result primarily from natural gas combustion used for space heating and for hot water heaters. Growth in emissions from the Commercial and Residential sector is due primarily to the expected increase in population and assumed increased use of natural gas. Emissions from the use of other fuels, such as diesel fuel, are assumed to remain relatively constant over time.

Population growth in California will continue to increase electricity demand. The extent of the increase depends on natural gas used and the location of the users.. Trends towards larger homes and increases in electronic equipment will also increase demand.

According to the Attorney General's website, during 2007 and 2008, an unprecedented number of communities across the state implemented environmentally sensitive, or "green" building requirements in order to increase energy efficiency and decrease greenhouse gas emissions and other environmental impacts within their jurisdictions. In the first half of 2008 alone, nearly a dozen mandatory green building ordinances have taken effect, requiring private developers to utilize and document green building practices used throughout the construction and life of the project. Other California cities, like San Francisco, San Leandro, Santa Rosa, Hayward and Los Altos Hills are currently developing ordinances for enactment in the near future. The experience of these cities has shown that bold, ambitious action to reduce carbon emissions is possible. These efforts have taken place without the Green Building measures being adopted as part of the Scoping Plan, and ARB applauds all the jurisdictions that are moving forward with adopting green building ordinances.

Water

California's water system is stressed today, and will likely be more so in 2020. The California Water Plan Update 2005 presents three potential scenarios for conditions in 2030. All three scenarios indicate a growing demand for water and increasing stresses on a complicated system. The Colorado, Delta, and Klamath water supply systems are experiencing serious conflicts among ecosystem, agricultural, and urban needs, and many infrastructure solutions under discussion today will likely not be in place by 2020.

All sectors will be affected by the changing dynamic in the amounts of water stored in the state's snowpack. Balancing the water needs of the state, the expected increase in water demand for energy production and industrial uses, consumption by an increasing population, increase in demand to grow crops all balanced with maintaining water quality and healthy ecosystems, will become more complex, challenging and expensive.

Water is intricately linked with energy and the state is already experiencing the need to conserve both water and electricity. In California, hydropower provides about 15 percent of the total electricity[44] while approximately 19 percent of the state's electrical demand comes from transporting, treating and using water. California's economy is built upon both reliable and affordable fuels and water. If the State does not implement the water measures identified in this

[44] http://www.energyquest.ca.gov/story/chapter12.html

Plan, the already over-allocated water system will face additional water shortages. Without actions to improve water supplies, water shortages could get worse at a rate of approximately two to three percent per year. This rate is likely to be much higher, given the likely impacts that global warming will have on the State's water system. These measures are needed, at a minimum, to meet increasing demand from a growing population.

Industry

The Industry Sector as defined in the Scoping Plan includes refineries, oil and gas facilities, cement and glass manufacturing, and industrial facilities that employ boilers or general combustion engines. The business-as-usual assumptions for refineries are discussed in the transportation section above. Activity in oil fields in southern California and gas fields in northern California are driven by price and availability, and could therefore expand in the future if current price trends continue. Off-shore drilling would most likely hold steady, due to the limited yield and potential for severe environmental impacts. While the demand for cement will grow with population growth, most of the demand is likely to be met through out of state production while the current rate of in-state production holds steady. Overall manufacturing is expected to slightly decline, while the commercial sector increases. Manufacturing will likely remain concentrated in the South Coast and Bay Area, with agricultural and food processing concentrated in the San Joaquin Valley.

Emissions for this sector are forecasted to grow to 100.5 $MMTCO_2E$ by 2020, an increase of approximately five percent from the average emissions level of 2002-2004. BAU-forecasted emissions for this sector are variable, but overall are not expected to grow substantially. Most of the growth from this sector comes from the fuel use and process emissions of three industries: cement plants, oil and gas production, and refining. Emissions from the combustion of natural gas are expected to grow for some industries (e.g., cement plants) and decline for others (e.g., food processors). These assumptions of growth and decline in natural gas demand are based on outputs from energy demand modeling conducted by CEC staff for the 2007 IEPR.

Recycling and Waste Management

Currently, California disposes of an estimated 42 million tons of waste in landfills each year, of which an estimated 30 percent is compostable organic materials, 22 percent is construction and demolition debris, and 21 percent is paper.[45] Fifty-four percent of California's waste is diverted from landfills and recycled or repurposed. Most of the remainder of California's waste is sent to landfills in the state. In the future, the need for new landfills will be determined by both population growth and by how well the State implements its waste management goals. The California Integrated Waste Management Board (CIWMB) has a strategic goal of becoming a Zero Waste State. One supporting goal is to halve the volume of organics going to landfills by 2020. These goals will require the development of new facilities to recycle and repurpose waste, but will also reduce the need for new landfill capacity.

Forests

The Forest sector is unique to California's GHG inventory because it combines both positive and negative emissions into a current sink of approximately -5 $MMTCO_2E$ (2002-2004 average). This net number is negative because the gross emission rate from fires, decomposition,

[45] From the California Integrated Waste Management Board website: http://www.ciwmb.ca.gov/Climate/ Organics/ default.htm.

harvesting, land conversion, and waste is less than the atmospheric uptake of carbon from forest growth. In addition to being a GHG sink, forests also provide multiple ecological benefits like habitat, structure, and nutrient cycling, as well as a suite of other human benefits or services such as water storage, soil stability, air and water quality, wood products, and recreation. The BAU inventory shows that forest sector emissions are increasing while forest growth is remaining the same. Two factors addressed in the Scoping Plan which affect forest sector emissions are land conversion and the incidence of wildfires. If this trend continues, emissions will equal uptake by about 2020 meaning that the inventory will increase to zero and this sink will be lost.

As seen in summer 2008, wildfires can significantly impact air quality and threaten public safety. Wildfires in water supply watersheds can also impact drinking water quality for years after they occur. Population growth will increase pressure to develop forest lands and development in close vicinity of forests can further increase risk. Global warming is also likely to increase risks associated with the Forest sector through changes to weather patterns which can impact forests both directly and indirectly, by creating hospitable conditions for pests and catastrophic fires.

High Global Warming Potential (High-GWP) Gases

Consumer demand, vehicle use patterns, and increased electrical demand due to population growth will increase the amount of high-GWP gases released to the atmosphere. The rates of increase vary by type of activity.

The forecasted BAU 2020 emissions of high-GWP gases are 46.9 MMTCO_2E. High-GWP gases, including sulfur hexafluoride (SF_6) from electric utility applications, substitutes for ozone depleting substances (ODS) (primarily hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)), and other high-GWP gases used in semiconductor manufacturing and other industrial processes are combined under one sector for purposes of the Scoping Plan. The forecast of business-as-usual emissions of high-GWP gases is derived from the United States Environmental Protection Agency (U.S. EPA) Vintaging Model, which outputs predicted annual consumption and emissions of all high-GWP gases based on end-use equipment, the amount of gas required for manufacture and maintenance, and disposal emissions. Emissions of HFCs and PFCs as ODS substitutes occur from their use in refrigeration and air conditioning systems, among other commercial and industrial applications. The high business-as-usual forecasted emissions in 2020 comes about as ODS's are rapidly replaced by substitutes, as more ODS's are phased out. In addition, ARB assumes that the effect of an expansion of the electrical transmission system infrastructure, combined with the technical improvements to the equipment in the system, will result in no net change in SF_6 emissions in 2020.

Agriculture

The agriculture sector includes emissions from livestock; i.e. digestive processes and manure management; combustion of liquid and gaseous fuels used for irrigation and crop production; emissions from fertilizer use and application of other soil additives; and emissions from agricultural residue burning. By 2020 there is significant potential for continued conversion of farmlands to urban, commercial or industrial development or other uses. The California Department of Food and Agriculture is currently developing a strategic plan for the future of agriculture in California.

Agricultural residue burning and livestock emissions were forecast using ARB's criteria pollutant forecasting approach. Forecasted emissions from the combustion of natural gas were

estimated using outputs from the 2007 IEPR developed by CEC. Other agriculture-related emissions were either held constant or extrapolated using historical trends to obtain a 2020 BAU estimate. BAU emissions from the agriculture sector are forecasted to increase about seven percent from current levels to 29.8 $MMTCO_2E$ in 2020, due exclusively to the assumed increase in livestock population.

In spite of current measures to preserve farmlands and open space, through Williamson Act contracts, State land purchase, and general plan land zoning, population increases will continue to pressure the conversion of farmlands to urban, commercial and industrial development.

3. POTENTIAL ENVIRONMENTAL BENEFITS OF CLIMATE CHANGE SCOPING PLAN

A. AIR RESOURCES

ARB and local air quality management districts (AQMD) and air pollution control districts (APCD) have a long tradition of successfully regulating stationary sources, vehicles, fuels, and consumer products to improve California's air quality. California's weather and topography combine to trap air pollutants that commonly result in poor air quality. Twenty counties in California fail to meet the health-based State ambient quality standard for ozone (smog) and eleven counties fail to meet the health standards for fine particulate matter. In addition, some California communities experience disproportionate impacts from poor air quality due to the proximity to a concentration of pollution sources. California's numerous air quality plans, programs, and regulations collectively provide the mechanisms to continually improve air quality.

Climate change can lead to changes in weather patterns that can influence the frequency of meteorological conditions conducive to the development of high pollutant concentrations. High temperatures, sunlight, and stable air masses tend to occur simultaneously and increase the formation of ozone and secondary organic carbon particles. Weather conditions associated with warmer temperatures increase smog. Thus, climate change effects are expected to exacerbate air quality problems in the future. This evaluation does not attempt to quantify the effects of climate change in 2020 nor evaluate Scoping Plan implementation in this context.

For the purposes of this section, criteria pollutant and toxic air contaminant emissions will often be referred to as "co-pollutants" since the focus of the Scoping Plan is greenhouse gas emissions. This section focuses on the potential impacts on co-pollutant emissions since the recommended measures are designed to reduce greenhouse gases.

Criteria Pollutants

Both the California and federal governments have adopted health-based standards for the criteria pollutants, which include ozone, particulate matter (PM10, PM2.5), carbon monoxide (CO), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2).

Ozone, a colorless gas that is odorless at ambient levels, is the chief component of urban smog. Ozone is not directly emitted as a pollutant, but is formed in the atmosphere when hydrocarbon and NOx precursor emissions react in the presence of sunlight. Meteorology plays a major role in ozone formation. Generally, low wind speeds or stagnant air, coupled with warm temperatures and cloudless skies provide the optimum conditions for ozone formation. As a result, summer is generally the peak ozone season. Because of the reaction time involved, peak ozone concentrations often occur far downwind of the precursor emissions. Therefore, ozone is a regional pollutant that often impacts a large area. Inhalation of ozone can lead to inflammation and irritation of the tissues lining the body's airways, which can cause spasm and contraction, reducing the amount of air that can be inhaled. Ozone in sufficient doses can also increase the

permeability of lung cells, making them more susceptible to damage from environmental toxins and infection. Ozone exposure is associated with an increase in hospital admissions and emergency room visits, particularly for lung problems such as asthma and chronic obstructive pulmonary disease. The elderly, children, adolescents, and adults who exercise or work outdoors are most susceptible to adverse impacts from ozone exposure.

Particulate matter (PM) is a mixture of substances that includes elements such as carbon and metals; compounds such as nitrates, sulfates, and organic compounds; and complex mixtures such as diesel exhaust and soil. These substances may occur as solid particles or liquid droplets. Some particles are emitted directly into the atmosphere. Others, referred to as secondary particles, result from gases that are transformed into particles through physical and chemical processes in the atmosphere. Exposure to PM aggravates a number of respiratory illnesses and may even cause premature death in people with existing heart and lung disease. Both long-term and short-term exposure can have adverse health impacts. Particulate matter less than 2.5 microns in diameter (PM2.5) poses an increased health risk because it can deposit deep in the lung and contains substances that are particularly harmful to human health.

ARB and local air districts have regulated the sources of criteria pollutants – cars, trucks, consumer products and industrial sources – for decades. The State Implementation Plan (SIP) describes California's comprehensive plan for reducing emissions of ozone and fine particle precursors to meet the federal standards for healthful air. Table H-1 summarizes the Scoping Plan measures that are already being pursued as part of the 2007 revision to the SIP (2007 SIP), or that were already underway before the enactment of AB 32.

The 2007 SIP calls for significant reductions in emissions of nitrogen oxides (a precursor to both ozone and fine particles) and direct emissions of fine particles. As seen in Table H-2, the 2007 SIP is expected to reduce emissions of NOx by about 20 percent statewide from "business as usual" levels in 2020, and direct emissions of fine particles by almost 15 percent. Many control measures first identified in the Goods Movement Emission Reduction Plan (GMERP) are also included in the 2007 SIP.

Toxic Air Pollutants

A toxic air contaminant (TAC) is defined as an air pollutant which may cause or contribute to an increase in mortality or serious illness, or which may pose a hazard to human health. TACs are usually present in minute quantities in the ambient air. However, their high toxicity or health risk may pose a threat to public health even at very low concentrations. In general, for TACs, there is no concentration that does not present some risk. In other words, there is no threshold level below which adverse health impacts are not expected to occur. This contrasts with the criteria pollutants for which acceptable levels of exposure can be determined and for which the State and federal governments have set ambient air quality standards.

The majority of the estimated health risk from TACs can be attributed to a relatively small number of compounds, with the highest risk from PM from diesel-fueled engines (diesel PM, or PM2.5 from diesel sources). In addition to diesel PM, benzene and 1,3-butadiene are also significant contributors to overall ambient public health risk in California. The other seven TACs posing the greatest ambient risk are acetaldehyde, carbon tetrachloride, hexavalent

chromium, *para*-dichlorobenzene, formaldehyde, methylene chloride, and perchloroethylene. Over the past ten years, ARB programs have reduced TAC emissions in the state by 50 percent.[46]

[46] http://www.arb.ca.gov/toxics/brochure.pdf

Table H-1: Scoping Plan Measures Included in 2007 SIP

Measure	In 2007 SIP	Not in 2007 SIP but underway before AB 32	Early Action Measure or New in DSP
California Cap-and-Trade Program Linked to Western Climate Initiative			X
Pavley I and Pavley II-Light-Duty Vehicle GHG Standards	X		X
Vehicle Efficiency Measures			X
Low Carbon Fuel Standard			X
Ship Electrification at Ports	X		
Goods Movement Efficiency Measures	X		X
Heavy Duty Vehicle GHG Emission Reduction – Aerodynamic Efficiency			X
Medium and Heavy-Duty Vehicle Hybridization			X
Regional Transportation-Related GHG Targets			X
High Speed Rail		X	
Energy Efficiency (Electricity)			X
Energy Efficiency (Natural Gas)			X
Solar Water Heating		X	
Million Solar Roofs		X	
Increase Combined Heat and Power			X
Renewables Portfolio Standard		X	X
Water Use Efficiency		X	
Water Recycling		X	
Water System Energy Efficiency			X
Reuse Urban Runoff			X
Increase Renewable Energy Production (from Water Sector)			X
Public Goods Charge (for Water)			X
Energy Efficiency and Co-Benefits Audits for Large Industrial Sources			X
Industry Sector Measures			X
Landfill Methane Control			X
Additional Reductions in Landfill Methane: Increase the Efficiency of Landfill Methane Capture			X
High Recycling/Zero Waste		X	
Sustainable Forest Target			X
High- GWP Measures			X
Methane Capture at Large Dairies		X	

Table H-2: Statewide Emission Reductions from Proposed New 2007 SIP Measures in 2020
(tons per day)

	Baseline Emissions	Reductions from 2007 SIP Measures	Emissions with 2007 SIP
NOx	2254	441	1813
PM2.5	247	34	213

Today, particulate matter from diesel represents 70 percent of the known risk from air toxics in California. The Diesel Risk Reduction Plan sets a goal of reducing the risk from diesel particulate matter 85 percent by 2020. ARB has adopted 24 airborne toxic control measures to control TAC emissions from mobile and stationary sources for both diesel and for the other TACs.

Evaluation Process

For measures that have already been adopted as regulations or have been analyzed in broader plans, the pertinent environmental analysis is summarized in this section. For other proposed measures, existing evaluations of similar activities were identified and explored to identify the types of potential impacts associated with the measure. ARB also developed statewide emission factors to establish a correlation between avoided combustion of fuels or production of electricity and emissions of NOx and PM2.5.

1. CALIFORNIA CAP-AND-TRADE PROGRAM LINKED TO WESTERN CLIMATE INITIATIVE

A cap-and-trade program would establish an enforceable limit (or cap) on total emissions for sources covered by the program. In the Scoping Plan, ARB recommends a cap-and-trade program under which emissions in 2020 from covered sources in the cap-and-trade program, plus expected emissions from uncapped (non cap-and-trade) sources, would be no greater than what was emitted in the aggregate in 1990. A key component of a cap-and-trade program is an allowance, which is a permit to emit greenhouse gases. As fewer allowances are issued over time, the cap declines. This proposed measure would cover about 85 percent of California's greenhouse gas emissions in 2020.

Under the recommendation, capped sectors would include electricity, transportation fuels, natural gas, and large industrial sources. The recommendation calls for a cap-and-trade program that would begin in 2012 with emissions declining through 2020. The total amount of greenhouse gas emissions from industrial sources and electricity generation would be capped beginning in 2012, and decline over time through 2020. Greenhouse gas emissions from commercial and residential fuel use (e.g., natural gas and propane) and transportation fuels would be capped after 2012, but no later than 2020.

The program would allow the limited use of surplus reductions from non-capped sources that are additional to reductions required by AB 32. These surplus reductions are called offsets. If permitted, offsets would be subject to stringent criteria and verification procedures to ensure their enforceability and consistency with AB 32 requirements.

Under the proposed measure, emissions and energy use from most of the sectors covered by a cap-and-trade program would also be governed by other regulatory measures and enforceable

policies, including performance standards, efficiency programs, and direct regulations. All measures that otherwise apply to capped sectors would contribute to achieving the cap by reducing their need to obtain allowances.

In the proposed cap-and-trade program, allowances would be allocated in an amount equal to the total emissions allowed in a compliance period. Each compliance period would run for a specific time period, such as one or three years. At the end of each such period, covered firms in the program would be required to surrender allowances equal to their total emissions for the compliance period. Allowances that are held by a covered source could be banked for future use if they are not needed to meet its compliance obligation. Alternatively, an unused allowance could be re-sold (traded) if the firm emits less than the number of allowances it holds.

This allowance value would reflect the average cost of reducing emissions; in other words, a firm would only go into the market to buy an allowance if the market value of the allowance is less than reducing emissions on site; alternatively, if a firm believes that selling its allowance in the market is worth more than banking the permit for future use, it would probably trade the allowance to another source at the current market price.

Failure of a facility to surrender sufficient allowances to cover its emissions would result in significant penalties. To maintain the environmental integrity of the system, non-compliance penalties would include purchasing and surrendering allowances at least equal to the facility's excess emissions.

ARB expects that the proposed cap and trade measure would provide air quality benefits. Because most greenhouse gas emission sources also emit criteria and toxic air pollutants, the proposed measure would generally result in overall air quality improvement. The recommended cap and trade program as well as other related measures applicable to capped sources would be designed to ensure that program implementation is consistent with State air quality plans and related statutory requirements.

Some individuals have expressed concerns about the potential for localized environmental impacts as a result of the trading component of the cap and trade program. This concern arises from the possibility that under a cap and trade program, a source of greenhouse gas emissions that impacts a community adversely impacted by criteria pollutants or TACs would not be required to reduce emissions. While the cap and trade program would not provide an incentive for a facility to increase emissions relative to BAU, it does allow a facility the option of obtaining allowances or offsets instead of reducing greenhouse gas emissions at their facility. While greenhouse gas emissions have no direct public health impacts, the processes involved in manufacturing and electricity generation from capped sources also emit criteria pollutants and toxic air contaminants. These pollutants can pose direct and adverse health effects on exposed populations.

California air pollution regulatory programs at the federal, state, and local level address individual source emissions from a regional and localized perspective. ARB evaluated the potential impacts of the recommendation on an example community – Wilmington – and found that the Scoping Plan would improve public health. The assessment is described in the Community Air-Quality Related Public Health Assessment in this Appendix. However, recognizing that this is only one example, if the Board chooses to pursue a cap-and-trade

program, during the regulatory development phase, staff will evaluate the program design to ensure that the program meets AB 32 requirements related to protection of public health as well as ARB's policies and actions for environmental justice (December 2001).[47] Local agencies, such as air pollution districts and planning commissions, could also impose more stringent requirements for sources of criteria pollutants and air toxics to address potential cumulative impacts.

2. TRANSPORTATION

Regulatory Background

The transportation sector includes personal transportation vehicles (like cars and trucks) as well as vehicles that transport goods (such as heavy trucks, ships, planes and trains). The transportation sector does not include off-road sources like bulldozers and forklifts, which are included in the industrial sector emissions inventory. Farm equipment, like tractors, is included in the agricultural sector emissions inventory. Emissions from recreational off-road equipment like all-terrain vehicles and recreational boats are relatively small, and their emissions are counted in the industrial sector. In 2006, on-road mobile sources[48] emitted the most NOx and ROG (ozone precursors) statewide. Exhaust emissions from mobile sources contributed only a very small portion of directly emitted PM2.5 emissions, but were a major source of the ROG and NOx that contribute to the secondary formation of PM2.5. ARB's control programs will continue to focus on meeting more stringent ozone and PM standards as well as reducing the risk associated with diesel particulate.

ARB has a long history of regulating passenger vehicles and other transportation sources to reduce emissions of criteria and toxic air pollutants. ARB has many regulatory programs in place to reduce criteria and toxic pollutant emissions – and in some cases GHG emissions – from transportation sources including:

The **Low-Emission Vehicle Program** (LEV and LEV II) has set standards to reduce emissions of NOx, ROG, non-methane organic gases (NMOG) and PM from passenger vehicles, light-duty trucks, and medium-duty vehicles. Pavley regulations to control tailpipe CO_2 and other associated GHG emissions are complementary to the LEV II program and both programs are implemented through the Low Emission Vehicle Regulations and Test Procedures.

The State's **Smog Check Program** ensures that passenger vehicle emission control systems are properly maintained throughout their useful life.

ARB's fuel programs require the use of gasoline and diesel fuel that burn more cleanly, reducing emissions of criteria and toxic air contaminants from the transportation sector, as well as off-road and stationary engines that use gasoline and diesel fuel. As the next phase of these fuel regulations, ARB is currently pursuing a low-carbon fuel standard that will reduce the carbon intensity of transportation fuel by at least 10 percent by 2020. The Board is scheduled to consider this regulation in 2009. Health and Safety Code §43830.8 requires that any new fuel undergo an environmental assessment of the fuel's potential impact on air,

[47] http://www.arb.ca.gov/ch/programs/ej/ejpolicies.pdf.
[48] 2008 Emissions Almanac.

water, soil, and as waste. The assessment must be peer reviewed, and any impacts minimized or mitigated.

The **Zero-Emission Vehicle Regulation** (ZEV), first adopted in 1990 and most recently modified in 2008, requires manufacturers to offer for sale in California an increasing number of hybrid, partial-zero, and zero emitting vehicles. Although the regulation focuses most directly on criteria pollutants, the emerging technologies encouraged by the regulation, such as battery electric, fuel cell and hybrid electric vehicles, also offer significant GHG benefits. Fuel cell, hydrogen, and electric vehicles are considered "zero emission vehicles" because they have either no exhaust or only water vapor. As a direct result of the ZEV program, over 750,000 Californians are currently driving vehicles that that receive partial-zero emission credit, conventional vehicles that achieve the most stringent emission tailpipe standards, zero evaporative emissions, and come with extended warranties. On March 27, 2008 ARB directed staff to look at incorporating climate change considerations into the program.

A complementary effort by the State is the **California Hydrogen Highway Network**, which is a public-private partnership to build the infrastructure for hydrogen vehicles and to add hydrogen vehicles into public transportation fleets. The current goal of this program is to have at least 50 hydrogen stations in the state and 2,000 hydrogen-powered vehicles by 2010, followed by a second and third phase of implementation. The program examines the well-to-wheel emissions of various hydrogen sources, and has adopted goals of a 30 percent reduction in greenhouse gas emissions; the use of at least 20 percent new renewable energy resources to produce the hydrogen; and no increase in toxic or smog-forming emissions relative to comparable gasoline vehicles.

The **Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles** (October 2000) calls for all new diesel-fueled vehicles and engines to use state-of-the-art catalyzed diesel particulate filters and very low-sulfur diesel fuel, and proposes retrofitting existing vehicles and engines where feasible. The plan sets a goal of reducing the 2000 risk from diesel PM from diesel-fueled engines and vehicles by 85 percent in 2020. To implement this Plan, ARB has adopted regulations to reduce toxic diesel risk from a wide range of in-use engines including those used in trash trucks, buses, public fleet vehicles, stationary engines, cargo handling equipment, transportation refrigeration units, and off-road equipment. ARB is scheduled to consider regulations to reduce diesel particulate emissions from in-use on-road trucks in 2008.

The **Emissions Reduction Plan for Goods Movement and Ports** (GMERP 2006) sets a goal of reducing the 2000 risk from diesel PM from goods movement and ports 85 percent by 2020. In order to accomplish this goal, the Plan identifies a number of measures to reduce diesel PM emissions from ships, harbor craft, off-road construction equipment, trucks, and rail. This Plan includes Ship Electrification at Ports, Ocean-Going Vessel Speed Reduction, and Port Drayage Truck regulations. ARB has already adopted a number of regulations to implement the GMERP including regulations on cargo handling equipment, drayage trucks, commercial harbor craft, and ocean-going ships.

(T-1) Pavley I and II-Light-Duty Vehicle GHG Standards 31.7 $MMTCO_2E$
Feebates - In-lieu of Pavley Regulations 31.7 $MMTCO_2E$

The Pavley I and II standards require reductions in tailpipe GHG emissions from passenger vehicles. The Pavley I regulations could affect the overall mix of fuels used by vehicles in 2020, by increasing the number of alternative fuel vehicles or low-emission vehicles. In the Initial Statement of Reasons for the regulation, ARB estimated criteria pollutant emission reductions of approximately 1.4 tons per day (TPD) NOx and 4.6 TPD ROG in 2020 due to reduced petroleum shipping, storage and distribution.[49]

The Pavley II measure is not yet defined well enough to quantify the potential to reduce air emissions; however it is also expected to reduce NOx, ROG, and PM2.5 emissions. Assuming Pavley II reductions are similar to Pavley I (reduced upstream emissions) they would reduce 0.2 TPD NOx, 0.7 TPD PM2.5, and 0.7 TPD ROG.

If the Pavley standards cannot be implemented they would be replaced by a Feebate program to achieve GHG reductions. The Feebate program would financially incent the transition from high-GHG emitting vehicles to low-GHG emitting vehicles by imposing a fee on the former and offering a rebate on the latter. Air emission effects from this measure will largely depend on the success of the incentive and the types of vehicles included. Under this measure, fuel would be more efficiently used and less fuel would be combusted statewide (essentially similar to an increase in average miles per gallon). Avoided fuel combustion would reduce NOx, PM2.5, and ROG.

(T-4) Vehicle Efficiency Measures 4.5 $MMTCO_2E$

Under this measure, tire inflation, tire tread programs and solar-reflective paints on vehicles are proposed to increase vehicle engine efficiency or reduce air conditioning use. This measure is estimated to reduce gasoline use by 507 million gallons in 2020, which could potentially result in the reduction of 0.8 TPD PM2.5 through avoided combustion. Since future engines would have to meet NOx standards, this measure would not result in new NOx emission reductions from the tailpipe. Similar to measure T-1, reductions of 0.2 TPD NOx and 0.8 TPD ROG could be achieved through upstream reductions in the transportation and refining of fuels.

Co-pollutant emissions from solar-reflective automotive paint and window glazing manufacturing and application are anticipated to be similar to existing paints and glazes, so there would be no change in associated emissions.

(T-2) Low Carbon Fuel Standard 15 $MMTCO_2E$

The Low Carbon Fuel Standard (LCFS) is currently undergoing regulatory development in parallel with the AB 32 Scoping Plan. The goal of LCFS is to reduce the carbon intensity – the amount of greenhouse gas emissions associated with the life cycle of the fuel – by 10 percent by 2020. It is anticipated that there will be a variety of options fuel producers can pursue to meet this standard, which makes the environmental impact of the LCFS a difficult measure to examine in the context of the Scoping Plan. A reduction in carbon intensity does not directly relate to a specific change in criteria pollutants or in fuel combustion. The LCFS regulatory proposal will contain a more detailed analysis of these fuel paths, their life-cycle GHG emissions and environmental impacts, and potential combinations of use for compliance. This section

[49] Final Statement of Reasons, Pavley I Regulations.

highlights the potential sources and types of air emissions associated with identified lower-carbon fuel types that may be pursued in the implementation of the LCFS. One goal of the LCFS is to maintain or reduce criteria pollutant or TAC emissions. Although ARB expects the LCFS will reduce criteria pollutants, to be conservative in this analysis we have assumed no change in criteria pollutants. The regulation will more fully document and quantify potential air resource impacts or benefits.

Low carbon fuels that may be used to comply with the LCFS include low carbon ethanol (sugarcane, switchgrass, waste residues, etc.), electricity, hydrogen, natural gas, and renewable biodiesel (from soybean, animal fat, recycled cooking oil, etc.). Potential fuel sources will be discussed in this evaluation, and potential fuel end uses (e.g. vehicles, energy plants) are discussed under relevant measures in other sectors.

The goal of the LCFS measure is to reduce the full life-cycle carbon content of transportation fuel, which will reduce net GHG emissions. Another goal of the LCFS is to maintain or reduce criteria pollutant emissions evaluated over the lifecycle of the fuel stock.

"**Biofuels**" is a general term used to describe various fuels produced from renewable sources. These include alcohol fuels, such as ethanol, various types of biodiesel and other fuels. Biofuels can be produced from food crops (e.g., sugarcane, corn, etc.), non-food crops (switchgrass, algae, etc.), vegetable oils (often used cooking oil), or other waste residues (often called biomass and include agricultural residues, municipal waste, forest trimmings, etc.). Biomass waste residue is expected to play a large role in the future due to its expected low-carbon intensity. Biofuels can be used to produce blends of conventional fuels (e.g. gasoline and ethanol or biodiesel and diesel) or can be used as essentially 100 percent biofuels. In addition, some processes are designed to produce biofuels that can be used to directly replace conventional fuels.

The air emissions associated with each of these sources can vary considerably. Some factors that affect the air emissions are described below.

- **Recycling of waste materials** to produce biofuels does not typically create a new emission source, and is environmentally preferable to traditional disposal. There are emissions associated with truck trips for collecting these materials, but they most likely do not result in a net increase in co-pollutant or greenhouse gas emissions as they would replace disposal-related truck trips.

- **Food crop production** for biofuels may create new emission sources for acquiring the feedstock. This would not occur if there is merely a redirection of existing food production to fuel production. Land use conversion is discussed in the Land Resources section of this evaluation. Critical factors in determining air emissions include where the feedstock is produced (which will impact both the resources needed for production, as well as rail and other transportation-related emissions), whether the biofuel crop is replacing another type of crop (and the difference in air emissions associated with the two crops), and whether the crop is competing with food crops for land. Crop production requires the use of off-road equipment, application of fertilizer and pesticides, and irrigation water. Air emissions from fertilizers and pesticides as well as run-off into streams, rivers and lakes result from traditional agricultural practices. Each of the biofuel production approaches mentioned above has associated air emissions. There are NOx, volatile organic compounds (VOCs),

and PM emissions associated with agriculture, as well as emissions associated with truck trips to transport raw materials to intermediate processing facilities.

- **Non-food crop production** for biofuel production (energy crops) uses plants that are less resource-intensive (requiring less fertilizer and water consumption), and thus have lower associated air pollutant emissions. The associated truck trip emissions would be expected to be similar to truck trip emissions from food crop production.

- **Algae** are a relatively newly identified source of biofuels and not yet fully studied. Early research shows that algae grow faster, contain significantly more energy per mass than other identified crop types, do not require the use of crop or valuable habitat lands, do not necessarily require fresh water (brackish and some wastewater can be used), and can consume waste CO_2 from refineries or power plants.

There are numerous current and proposed biofuel plants within California: Figure H-1 displays the mixture of biodiesel and ethanol facilities, while Figure H-2 displays the feedstocks these facilities are using or propose to use.

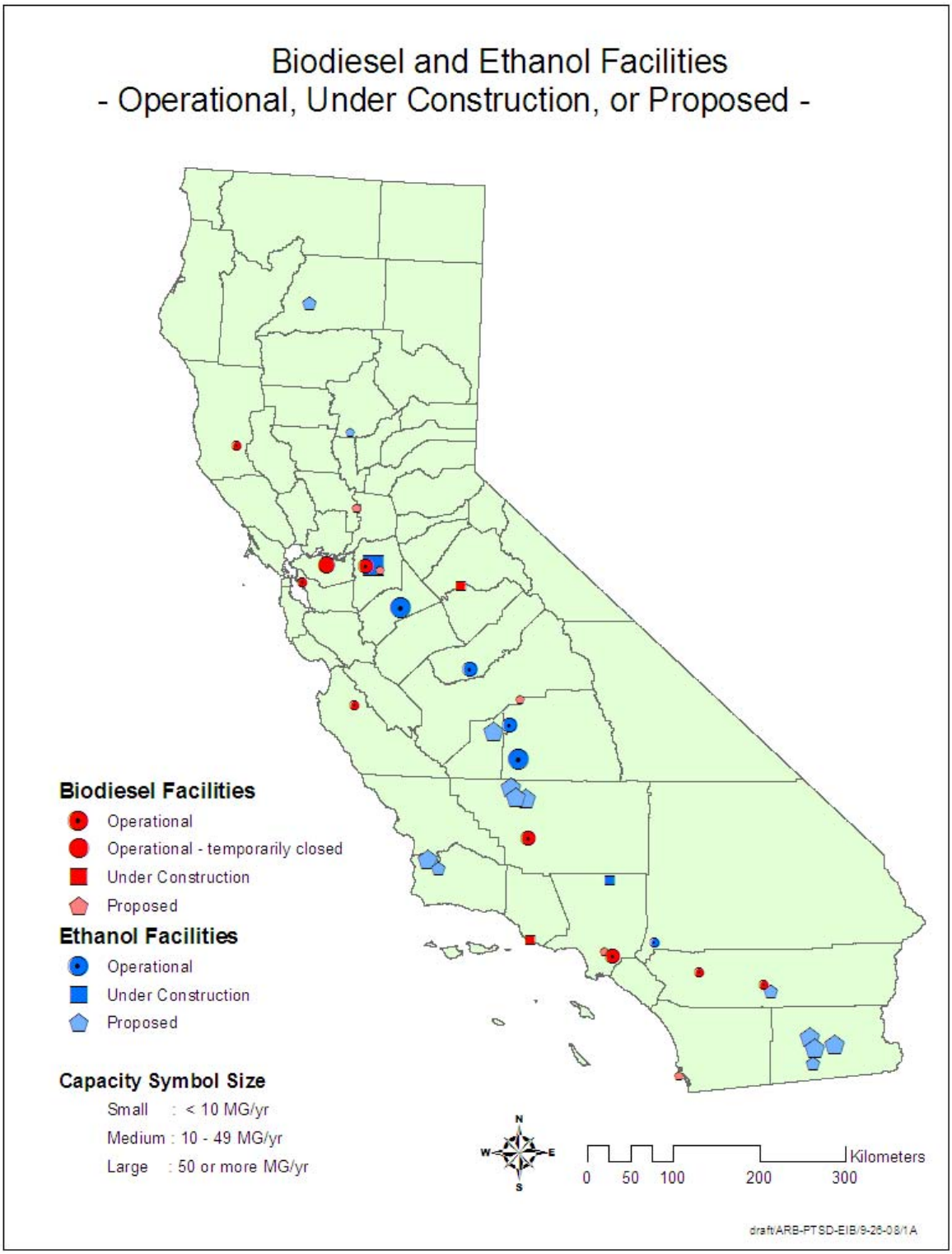
Note that projections of fuel production will likely change since the use of biofuels (biodiesel and ethanol) will be partially driven by recent federal legislation[50] directing fuel producers to increase their use of renewable fuels and mandating amounts of advanced biofuels, including those derived from cellulosic and biomass resources.

Biodiesel: ARB estimates that 675 million gallons (MG) of biodiesel could be needed per year to meet the 2020 LCFS demand. In addition to the 72 MG per year[51] already built or planned, California could produce between 125 to 500 MG per year of biodiesel from waste oils and fats and 100 to 200 MG per year of biodiesel from soybean oil.[52, 53] Regulatory measures could require maximizing the use of waste materials for biodiesel production. Rather than dictate which specific fuels should be used, the LCFS will release life cycle carbon intensity values for all available fuels. Fuel suppliers will use that information to decide how best to meet regulatory carbon limits. Waste materials would be expected to have lower carbon intensity than virgin materials. Several biodiesel plants are already under construction or planned for construction in California, using waste oils, waste grease, animal fats and some soybean oil. Additional demand could be met through construction of plants using other feedstocks, such as soybean oil, and through importation of biodiesel from outside the state.

Biodiesel production plants tend to be located close to their feedstocks and secondarily close to rail yards or freeways for distribution to retail sites. Methane emissions are associated with the biodiesel production process, which can be reduced by an estimated 90 percent through a condensation/recovery process. Other emissions are related to the energy source and demand of

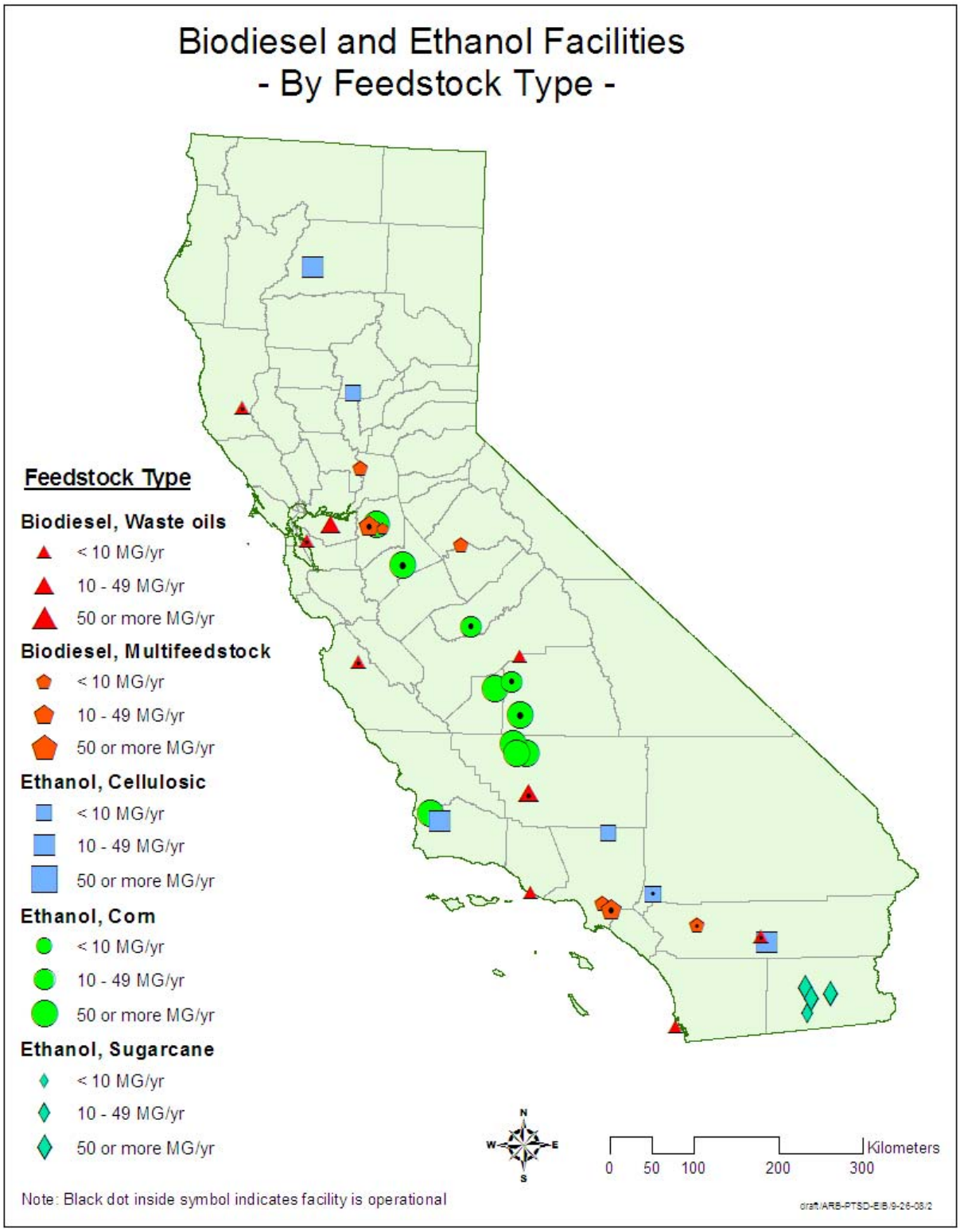
[50] The Federal Energy Independence and Security Act of 2007.
[51] Estimate based on CEC Staff Report in review (Yowell, 2007) and on the Crimson Renewable Energy Plant under development in Bakersfield (30 MG).
[52] Presentation at ARB Workshop, May 9, 2008.
[53] *Compliance Pathways for Meeting the Low Carbon Fuel Standard in California. Part I. Biofuel Supply Curves,* Nathan Parker et.al.; Western Governors' Association Report, *Transportation Fuels for the Future. Biofuels: Part II*, January 8, 2008.

Figure H-1: Location and Size of Known and Proposed Biodiesel and Ethanol Facilities[54]



[54] Based on ARB staff research.

Figure H-2: Feedstocks of Known and Proposed Biodiesel and Ethanol Facilities[55]



[55] Based on ARB staff research.

the plant. Production of biodiesel locally to meet California's projected needs could result in a net reduction in emissions associated with the truck and rail traffic generated by importing biodiesel from the Midwest.

Ethanol: The CEC estimates that by 2020, California will have a demand for 1.6 billion gallons of ethanol per year,[56] and that this demand will continue to grow beyond 2020. ARB estimates that California could meet this demand through production of up to 1 billion gallons per year of ethanol from waste products (municipal solid waste, forest residue, agricultural residues), and 600 million gallons per year of ethanol from corn.[57] As an example, this demand could be met through approximately 50 production plants, each producing around 50 MG per year.

Ethanol facilities tend to be located near rail or truck terminals. Siting may also consider proximity to the feedstocks or the users of ethanol co-products. For example, one of the largest ethanol production facilities currently permitted in California is located in a rural agricultural area close to users of their distilled grain by-product. The facility does not employ co-generation, so it burns natural gas to produce the steam needed to produce ethanol, and purchases electricity from the utility. The steam production is the primary source of NOx emissions, the largest sources of PM10 are associated with grain handling, and the largest sources of VOC emissions are associated with the fermentation, distillation, storage, and loading of the ethanol produced. Because VOC emissions from this facility triggered offset requirements, emissions above the trigger level of 20,000 lbs/yr were mitigated by procuring VOC emissions offsets. Emissions of NOx, CO, PM10, and SOx did not trigger offset requirements. Emission control technologies employed by this facility include ultra-low NOx burners on steam boilers, baghouses for PM control, and wet scrubbers to control VOC emissions. This 40 MG per year facility, as permitted, could emit up to 0.02 TPD of NOx, 0.07 TPD CO, 0.05 TPD VOC, 0.04 TPD PM10 and 0.005 TPD SOx.

The LCFS regulation will consider the impacts of the life cycle of each fuel path. For ethanol air pollutant emissions, this would also include indirect emissions associated with the transportation of the product and feedstock by truck and/or rail.

Hydrogen: Depending upon how it is produced, hydrogen can be a low carbon fuel. As a transportation fuel, hydrogen can be used in either modified internal combustion engines or in fuel cells. Unlike the burning of carbon-based fuels which produces CO_2, CO, NOx, VOC and PM and other potentially toxic compounds, combusting hydrogen produces heat, water, and some oxides of nitrogen. Hydrogen-fueled fuel cell vehicles only produce heat and water vapor.

Like other fuels, hydrogen must be examined over the entire process chain, including the energy needed to produce the fuel as well to compress or cool the hydrogen for storage. Potential hydrogen production methods include electrolysis of water, steam reformation of natural gas, biomass gasification and coal gasification. Today, the two most common ways to produce hydrogen are steam reformation of natural gas and electrolysis of water. Hydrogen produced using electricity generated from renewable resources and used to power fuel cell vehicles results in extremely low air emissions. Senate Bill 1505 (2006) directs ARB to develop environmental

[56] California Energy Commission estimate, presented at May 9, 2008 ARB Workshop: *Compliance Pathways for Meeting the Low Carbon Fuel Standard in California, Part I. Biofuel Supply Curves*.
[57] Ibid.

regulations for the production of hydrogen for transportation use, a process that started in late 2007.

Electricity: Increasing the number of electric vehicles and plug-in hybrids would substantially lower the carbon-intensity of transportation fuels. The co-pollutant emissions associated with electricity as a transportation fuel are expected to be the same as the co-pollutant emissions associated with electricity overall and are discussed in the Energy section. Off-peak loads would increase significantly as grid-rechargeable electric vehicle penetration increases. This increased load would produce some increase in GHGs and co-pollutants from base load power plants. Little to no increase in ozone would occur, since the increased load would occur between the late evening and the early morning. All such increases in emissions would be more than offset, however, by the displacement of internal combustion vehicles.

(T-5) Ship Electrification at Ports 0.2 MMTCO_2E
(T-6) Goods Movement Efficiency Measures 3.5 MMTCO_2E

The goods movement efficiency measures propose to reduce GHG emissions. The recommended goods movement measures in the Scoping Plan include regulations identified through the Goods Movement Action Plan and GMERP, as well as new measures for additional GHG emission reductions.

The GMERP prioritized implementation of air emission reductions based on health risk assessments, which identified how each port source category contributed to risk. The already adopted Goods Movement Sector regulations will reduce criteria and toxic air pollutants. For instance, ARB recently passed a series of regulations to reduce emissions of diesel PM, SOx, and NOx from ocean-going vessels, cargo handling equipment, transport refrigeration units, port drayage trucks, and commercial harbor craft. Also, new engine standards have been adopted by U.S. EPA for U.S. ships, off-road equipment, on-road trucks, harbor craft and locomotives. As these fleets turn over, we expect to see emissions reductions in criteria pollutant emissions and in some cases GHG emissions, as the vehicles and equipment become more fuel efficient.

California has also taken steps to reduce emissions from locomotives, entering into a Memorandum of Understanding (MOU) in 2005 with Union Pacific Railroad Company and BNSF Railway Company to reduce diesel PM. The MOU identifies actions including: reducing motor idling, accelerating the use of low sulfur diesel, reducing visible emissions, and conducting Health Risk Assessments for rail yards. Combined, these measures are expected to continue to reduce criteria and toxic air pollutant emissions from goods movement sources in the future, improving air quality and public health both in localized areas near goods movement sources and regionally.

The following section describes existing efforts to reduce emissions from goods movement activities as contained in the GMERP, as well as a new measure to improve the efficiency, and lower the GHG emissions, of goods movement activities in California.

Ship Electrification at Ports (Measure T-5): The GMERP establishes a goal of utilizing shore power for 20 percent of the ship visits to California ports by 2010, 60 percent of visits by 2015, and 80 percent of visits by 2020. ARB has already adopted a regulation to require ship electrification at ports and another is under development to further reduce at-berth emissions. Ships include container ships, passenger ships, refrigerated cargo ships, bulk ships, tankers, and

vehicle carriers. Over 2000 ocean-going vessels call at major California ports like the Ports of Los Angeles, Long Beach, Oakland, San Diego, San Francisco, and Hueneme each year. By 2020, hotelling of these ships are projected to emit 37 TPD NOx and 0.67 TPD PM without regulations; ship electrification will reduce these emissions by 9.6 TPD NOx and 0.6 TPD PM2.5. Although the Ship Electrification regulation was adopted primarily to reduce emissions of air toxics, it also provides GHG emissions reductions and is a discrete early action under AB 32.

Ocean-going Vessel Speed Reduction: The ocean-going vessel speed reduction (VSR) measure builds upon a voluntary program at the Ports of Los Angeles and Long Beach. This existing voluntary program contributes to implementation of the 1994 Ozone State Implementation Plan to reduce NOx in the South Coast Air Basin. Preliminary estimates from the Port of Los Angeles indicate this measure can reduce emissions from this source by 37 percent for NOx (3 TPD), 49 percent for SOx (2 TPD), and 49 percent for diesel PM (0.3 TPD). ARB will be assessing the results of the program to evaluate potential application to other areas and to estimate the statewide potential for reductions in emissions of NOx, SOx, diesel PM, and CO_2.

Clean (Green) Ships: Under this measure, a variety of strategies and technologies will be investigated to reduce fuel consumption and associated CO_2 emissions from ships. In part, it is expected that reductions of NOx will occur based on the penetration rates of Selective Catalytic Reduction technologies on new and existing ships.

Port Drayage Trucks: The adopted Port Drayage Truck Regulation[58] is expected to reduce NOx, PM10 and CO_2, by either accelerating the fleet's turnover to higher standard trucks or retrofitting existing trucks. Drayage trucks are on-road, diesel-fueled, heavy-duty trucks that transport containers, bulk, and break-bulk goods to and from the ports and intermodal rail yards and many other locations. ARB estimates that there are approximately 100,000 drayage trucks statewide, of which approximately 20,000 frequently service the ports and rail yards. This segment of the drayage fleet consists largely of independent owner/operators and ARB estimates that approximately 80 percent of such drayage trucks are operator owned. ARB estimates that drayage trucks emit an estimated 2.3 TPD diesel PM and 48 TPD NOx while moving goods to and from California's ports and intermodal rail yards.[59] Under the regulation adopted in 2007, regulatory compliance has two phases. By 2009, all pre-1994 truck engines must be retired or replaced with 1994 or newer engines. In addition, all 1994-2003 model year engines must achieve an 85 percent PM emission reduction through the use of an ARB-approved level 3 verified diesel emission control strategy. ARB estimates a statewide diesel PM emissions reduction of approximately 2.0 TPD PM2.5. In the second phase, drayage trucks would need to comply with the 2007 heavy-duty diesel-fueled on-road emission standards by 2014, which would reduce NOx emissions by approximately 33 TPD.

Commercial Harbor Craft: This measure would develop best management practices and outreach to encourage regular maintenance, vessel speed reduction, and other operational and maintenance practices to improve efficiency of commercial harbor craft. Air emission

[58] Regulation to Control Emissions from In-Use On-Road Diesel –Fueled Heavy Duty Drayage Trucks, adopted December 7, 2007.
[59] Drayage Truck Fact Sheet, http://www.arb.ca.gov/msprog/onroad/porttruck/drayagetruckfactsheet.pdf.

reductions have not been quantified.

Cargo Handling Equipment: Reducing the idling times of diesel-powered equipment could potentially reduce associated criteria pollutants. A future study of idling occurrences and emissions will determine the potential for air emission reductions.

Transport Refrigeration Units: Transport Refrigeration Units (TRUs) are refrigeration systems powered by diesel internal combustion engines designed to refrigerate or heat perishable products that are transported in various containers, including semi-trailers, truck vans, shipping containers, and rail cars. ARB adopted an Airborne Toxic Control Measure (ATCM) regulation to reduce emissions from in-use TRUs in 2004. ARB is now evaluating the feasibility of regulations to further reduce air toxic emissions from TRUs on trucks, shipping containers, and railcars by eliminating extended cold storage practice at distribution facilities, grocery stores, and other facilities where TRUs operate. This measure could reduce diesel fuel use by approximately 1.7 MG per year starting in 2011, reducing PM2.5 emissions by 0.1 TPD in 2020.

Rail: Other than addressing rail through the Goods Movement Efficiency Measures, the Scoping Plan does not recommend any specific measures for rail. Rail does play a critical role in goods movement, and reducing emissions from locomotives is a focus of ARB's efforts to improve public health in California. As fuel prices increase, increased demand for transport may be met through rail more than trucks, because rail can be up to four times more fuel efficient than trucks. ARB has worked with the federal government and railroads to reduce the criteria pollutants and air toxics associated with locomotives through fuel regulations, idling reduction requirements, increased fuel efficiency and pollutant control technologies. There are no direct effects from rail due to the Scoping Plan.

Goods Movement Efficiency Improvements: The GMERP and Goods Movement Action Plan identify the opportunity to improve the efficiency of goods movement activities, including more efficient engines and vehicles and through tracking and better scheduling of activities. The proposed measure in the Scoping Plan would identify and implement strategies to improve goods movement efficiency within the four key goods movement corridors in California in excess of the measures already contained in the GMERP. The measure would take advantage of available low carbon technologies and operational improvements to improve efficiency at the equipment/vehicle level, at goods movement facilities such as ports and intermodal railyards, and within the goods movement network within each trade corridor. Because in most cases, improvements in efficiency would result in decreased fossil fuel usage, air emission reductions are expected. If these measures reduce GHGs by 3.5 $MMTCO_2E$ through fuel efficiency and through some electrification of internal combustion engines, the emission reductions that could occur within California are approximately 16.9 TPD of NOx and 0.6 TPD PM2.5.[60]

[60] This estimate was made using an emission factor for heavy-duty vehicles (conservative for the goods movement inventory categories) and assuming 50 percent of emission reductions occur outside of California land boundaries.

(T-7) Heavy Duty Vehicle GHG Emission Reduction – Aerodynamic Efficiency 0.93 MMTCO_2E

This measure recommends improving the aerodynamic efficiency of heavy-duty trucks to reduce GHG emissions, an efficiency that is estimated to reduce NOx emissions by 1.5 TPD.

(T-8) Medium and Heavy-Duty Vehicle Hybridization 0.5 MMTCO_2E

This measure recommends hybridization of medium and heavy-duty trucks that make frequent stops and starts, reducing diesel combustion by 500,000 gallons per day and reducing tailpipe criteria pollutants by 4.07 TPD NOx and 0.17 TPD PM2.5.

(T-3) Regional Transportation-Related Greenhouse Gas Targets 5 MMTCO_2E

Under this measure, ARB would work with metropolitan planning organizations (MPOs) to establish passenger vehicle GHG emission reduction targets (regional targets). It is important to achieve significant greenhouse gas reductions from changed land use patterns and improved transportation to help achieve the goals of AB 32. The specific air quality impacts of particular land use and transportation strategies applied to implement this measure would be evaluated under existing applicable regulatory structures as they are triggered, including CEQA. Generally, however, this measure would result in vehicle use reduction, which has the potential to improve air quality. If VMT were reduced four percent statewide by 2020 (approximately corresponding to reductions of 5 MMT CO_2E), associated criteria pollutants are estimated to decrease by 8.7 TPD of NOx, 12.9 TPD of ROG and 1.4 TPD of PM2.5.

(T-9) High Speed Rail 1 MMTCO_2E

The Scoping Plan supports the implementation of a high speed rail system. The recommended High Speed Rail (HSR) program has undergone environmental review under CEQA and National Environment Policy Act (NEPA) (http://www.cahighspeedrail.ca.gov/). ARB reviewed this documentation for its air emissions analysis. The programmatic Environmental Impact Report/Environmental Impact Statement (EIR/EIS) examined the potential impacts of HSR on existing air quality. Regional pollutant burdens were calculated for each alternative, considering highway VMT, number of plane operations, number of train movements, and electrical power requirements for the recommended HSR system. Localized air quality impacts were also evaluated. In 2020, the air emission reductions based on the avoided fuel consumption of 18.7 million annual passenger trips in light duty vehicles would be 1.1 TPD NOx and 0.2 TPD PM2.5. If HSR uses natural gas-based electricity, it would increase emissions by 0.2 TPD NOx and 0.1 TPD PM2.5. HSR has informed ARB that it may seek renewable power supplies, which would eliminate the emissions associated with its electrical demand.

Summary of Co-Pollutant Emissions

Table H-3 presents the estimated co-pollutant benefits from the recommended measures in the Transportation sector. Recommended Pavley (T-1) and Goods Movement measures (T-5 and T-6) have been quantified within existing regulations and within the SIP, and are therefore included in the BAU scenario, and separated appropriately.

Table H-3: Estimated Statewide Co-Pollutant Emission Changes from Transportation Sector Measures in Scoping Plan
(tons per day in 2020)

Measure	Included in 2007 SIP or GMERP		Additional to 2007 SIP and GMERP	
	NOx	PM 2.5	NOx	PM 2.5
(T-1) Pavley I and II – Light-Duty Vehicle GHG Standards	-0.2	-0.5	-1.4	-0.6
(T-4) Vehicle Efficiency Measures			-0.2	-0.8
(T-2) Low Carbon Fuel Standard			0	0
(T-5) Ship Electrification at Ports	-9.6	-0.6		
(T-6) Goods Movement Efficiency Measures			-16.9	-0.6
Ocean Going Vessel Speed Reduction	-18.9	-1.6		
Clean (Green) Ships	-74	-0.8		
Port Drayage Trucks	-33	-2.0		
Commercial Harbor Craft	--	--	--	--
Cargo Handling Equipment	--	--	--	--
Transport Refrigeration Unit		-0.1		
(T-7) Heavy Duty Vehicle GHG Emission Reduction – Aerodynamic Efficiency			-1.5	-0
(T-8) Medium and Heavy-Duty Vehicle Hybridization			-4.1	-0.2
(T-3) Regional Transportation-Related GHG Targets			-8.7	-1.4
(T-9) High Speed Rail[a]			-0.9	0.
Transportation Sector Total: [b]	**-135.7**	**-5.6**	**-33.7**	**-3.5**

[a] High Speed Rail emission reductions were not included in the public health analysis, due to difficulty in proportioning among air basins.
[b] Numbers may not add up as presented due to rounding.

3. ELECTRICITY AND NATURAL GAS

Regulatory Background

The air emissions of all stationary sources in California are regulated. For power plants or energy facilities, the **CEC Certification process** serves as an equivalent to the otherwise required state and local permitting requirements. The CEC has authority to certify (permit) the construction and operation of thermal electric power plants 50 megawatts or larger and all related facilities. The site certification process provides a review and analysis of all aspects of a proposed project, including public health and environmental impacts, safety, efficiency, and reliability, equivalent to the CEQA process. The process is also a public process. Smaller facilities with no potentially significant environmental impacts can apply for an exemption process, similar to a mitigated negative declaration approach under CEQA.

The CEC works with power plant proponents and local APCDs or AQMDs to complete a functionally equivalent permitting process. CEC prepares the necessary evaluation in a "Preliminary Staff Assessment", working with the local AQMD to ensure it provides the

information needed for the AQMD to approve the project. The final site certification from the CEC serves as its air quality permit, compliant with New Source Review requirements,[61] and including monitoring, reporting, and inspection requirements.

(E-1) Energy Efficiency (Electricity) 15.2 $MMTCO_2E$
(CR-1) Energy Efficiency (Natural Gas) 4.3 $MMTCO_2E$

Activities recommended under these measures would affect air quality by reducing the overall demand for electrical generation and the overall combustion of natural gas in California's residential and commercial sectors. California's appliance standards improve the operation and efficiency of refrigerators, freezers, air conditioners, and other appliances. All of the technologies utilized to implement the recommended energy efficiency standards are considered "off the shelf" in that they are readily available in the marketplace.

Efficiency and conservation measures that reduce peak demand are the most likely to reduce air emissions, as aging, less efficient plants are more likely to be operated when demand is high.

Measure E-1 recommends reducing electricity demand by 32,000 gigawatt-hours (GWh). Translating these reductions into the avoided operation (or possibly construction) electrical grid natural gas power plants,[62] ARB estimates that Measure E-1 would reduce statewide NOx by 7.0 TPD and statewide PM2.5 by 4.0 TPD in 2020.

Measure CR-1 recommends reducing residential and commercial natural gas combustion for heating by 800 million therms. The avoided air emissions associated with Measure CR-1 are 10.4 TPD of NOx statewide and 0.8 TPD of PM2.5 statewide in 2020, assuming emissions from residential and commercial natural gas units are similar in 2020 to today's emission rates.[63]

(CR-2) Solar Water Heating 0.1 $MMTCO_2E$

This measure recommends an alternative, zero-emission way to heat residential water that works with traditional water heating to replace a portion of the natural gas that would normally be burned. The recommended measure would replace an estimated 26 million therms of residential natural gas use each year. The avoided air emissions associated with the recommended measure is 0.3 TPD of NOx and 0.03 TPD of PM2.5 statewide in 2020.

(E-4) Million Solar Roofs 2.1 $MMTCO_2E$

This measure is an existing program that predates AB 32 and the Scoping Plan. Translating the recommended measure's avoided electricity into the avoided operation (or possibly construction) of electrical grid natural gas power plants,[64] equates to 1.0 TPD of NOx and 0.6 TPD of PM2.5 statewide in 2020.

[61] New Source Review requirements are discussed in greater detail in the Regulatory Framework for Stationary Sources at the end of this Appendix.
[62] Co-pollutant emission factors for electric grid natural gas power plants were developed using the state inventory of these sources projected out to 2020 with existing district control measures.
[63] Co-pollutant emission factors for commercial and residential natural gas combustion were developed using recent (1997 and 2000) methodologies and inventories of these sources with existing district control measures.
[64] Co-pollutant emission factors for electric grid natural gas power plants were developed using the state inventory of these sources projected out to 2020 with existing district control measures.

(E-2) Increase Combined Heat and Power 6.7 MMTCO$_2$E

Combustion-based power plants do not convert all of their available energy into electricity and typically lose more than half of the energy as excess heat. At the same time, there are many industrial facilities that require both electricity and heat which currently purchase electricity from the grid and burn natural gas in industrial boilers to generate thermal energy (heat). Combined heat and power (CHP) systems generate both electricity and thermal energy on site. When the systems are optimally sized to either meet the heat load of the industrial facility or provide the maximum amount of electricity that the facility could use during peak demand, excess electricity is produced that could be distributed to other electricity users. Combined heat and power is a more efficient use of the energy contained in fuel, and can also reduce the need to develop new or expand existing power plants.

Combined heat and power systems would be developed to improve energy efficiency in situations that also result in net reductions of GHG and co-pollutant emissions. While existing AQMD/APCD regulations on CHP systems and industrial boilers limit co-pollutant emissions, they do not necessarily evaluate the net change in emissions between CHP systems and the grid electricity they replace. Installation of CHP systems has the potential to affect local air emissions and should be examined for this potential at a project level.

Nearly all CHP systems are currently regulated by AQMDs and APCDs. A combined heat and power system can be fueled with natural gas or with renewable fuels. Co-pollutant emissions may vary by fuel type, similar to the discussion under measure E-2. ARB estimates that increasing the use of combined heat and power systems by 4,000 MW has the potential to reduce statewide natural gas combustion by 2.1 billion therms.[65] Assuming that on-site boiler use is reduced when cost-effective CHP systems are installed and that CHP systems are optimized for thermal load, the net change in co-pollutants due to the shift from industrial boiler to CHPs would be reductions of 2.0 TPD of NOx and 0.7 TPD of VOCs and increases of 0.6 TPD PM2.5 and 0.1 TPD SOx.

Using CHP systems to displace grid electricity also reduces co-pollutant emissions. Translating these reductions into the avoided operation (or possible construction) of electrical grid natural gas power plants, they would equate to 6.5 TPD of NOx and 3.7 TPD of PM2.5 statewide in 2020.

(E-3) Renewables Portfolio Standard 21.3 MMTCO$_2$E

This recommended measure would increase the overall percentage of renewable energy sources such as wind, solar, biomass and geothermal, of each utility's energy sources. Currently, California's energy profile includes 12 percent renewable sources. This requirement could be met through any potential mixture of renewable energy sources, and will most likely be driven by a number of factors, including the availability of renewable sources within the geographic region of each utility. For these reasons the benefits and impacts of each renewable resources are evaluated relative to electrical grid natural gas power plants, and are not individually quantified for potential air emissions.

There are air quality impacts associated with the construction of facilities to harness renewable resources– primarily from fugitive dust and diesel particulates from operation of construction

[65] For reference, a *therm* is equal to 100,000 British thermal units (*BTUs).*

equipment. These are assumed to be similar in nature to the construction-related emissions from natural gas-powered power plants, although the location and size of facilities can affect the magnitude and duration of these impacts. These impacts could be significant but would be temporary and would also most likely employ best management practices to minimize dust. ARB's implementation of the Diesel Risk Reduction Plan began reducing diesel particulates from construction equipment in 2002.

The remainder of this section focuses on the operation and maintenance of renewable resource facilities.

Wind energy is harnessed through large turbines. Wind power operation does not have any associated air emissions.

There are two major types of **solar** energy. The first concentrates the heat in sunlight using mirrors or lenses. This concentrated heat can be converted to electricity in a process similar to that used in a power plant. The second uses photovoltaic (PV) panels. When sunlight hits the PV cells, it is converted directly to electricity. Solar power does not have any associated air emissions from its operation.

Biomass energy is harnessed through the combustion of organic waste materials, residuals or agricultural products. Air emissions from biomass sources depend on the fuel type. These are also indirect emissions associated with the production, transportation, and/or disposal of the fuel source. Indirect emissions (from trucks and/or rail) are discussed in the Transportation section above (Measure T-2). The life cycle of biomass includes the sequestration of carbon within the biomass and the avoided carbon emissions from alternative methods of disposal. The trade-offs between energy production and the alternative methods of disposal are the primary source of potential environmental benefits.

Biomass (forest or agricultural residuals) or **municipal solid waste** (MSW) may be pre-processed and then combusted to produce steam to generate electricity. Biomass combustion must be controlled to limit emissions of NOx, particulate matter and carbon monoxide, as biomass combustion generates 17 times the amount of NOx and 27 times the amount of PM as electrical grid natural gas power plants (per MWh).[66] MSW combustion must also be controlled to limit emissions of NOx, particulate matter and carbon monoxide, as MSW combustion generates 24 times the amount of NOx and 5 times the amount of PM as electrical grid natural gas power plants (per megawatt-hour (MWh)). In some areas of the state, agricultural residuals are burned in open fires as a means of disposal. If the residuals used in a biomass plant would otherwise have been disposed of in open fires, burning the residuals in a biomass plant would reduce the air emissions while also producing electricity. All of these emissions can be minimized with modern control technologies or through good plant design.

The **anaerobic digestion** of human, animal, or wet organic wastes produces a gas of 50 to 80 percent methane. This "biogas" can be combusted to produce electricity. Anaerobic digesters must also be controlled to limit emissions of NOx, particulate matter and carbon monoxide, as digester gas-based electricity generation generates 22 times the amount of NOx and 9 times the

[66] Estimates are based on renewable power generation emission factors developed from ARB surveys and emission inventories in 2000-2001, conducted during the California electricity crisis.

amount of PM as electrical grid natural gas power plants (per MWh). All of these emissions can be minimized with modern control technologies or through good plant design.

Combustion of **landfill gases** (mostly methane) to produce electricity puts methane to use that would otherwise be flared to control the methane emissions. Combustion is also used to reduce the toxic air contaminants associated with some landfills. Combustion of landfill gases must be controlled to limit emissions of NOx, particulate matter and carbon monoxide, as its combustion generates 27 times the amount of NOx and 7 times the amount of PM as electrical grid natural gas power plants (per MWh). All of these emissions can be minimized with modern control technologies or through good plant design.

Geothermal energy harnesses naturally occurring geothermal formations, using the steam to produce electricity and returning spent brine to the geothermal resource. Emissions associated with geothermal sources can include hydrogen sulfide, arsenic, mercury, radon 22, and ammonia. The cooling towers at geothermal power plants can emit particulate matter. All of these emissions can be minimized with modern control technologies or through good plant design.

Hydroelectric power uses the potential energy of water to turn turbines that generate electricity. Small hydropower projects that capture the energy of water (100 kilowatts to 30 MW) without requiring a new or increased appropriation or diversion of water are considered a renewable resource under current California law. These types of projects would take advantage of constructed waterways, such as aqueducts, canals, pipelines and ditches. These types of projects do not have associated air emissions.

If natural gas-powered power plants were substituted entirely with zero-emission renewable sources through the RPS, air emissions would be reduced by 3.6 TPD NOx and 2.1 TOD PM2.5 for an increase in renewable sources from 2006 levels to 20 percent, and by 6.2 TPD NOx and 3.6 TPD PM2.5 for an increase in renewable sources from 20 to 33 percent.

The addition of significant new renewable resources may also alter the needed transmission infrastructure as renewable facilities are constructed to maximize resource capture at sites with optimal wind, solar, and geothermal resources. ARB has not evaluated the air quality impacts of changes or additions to transmission infrastructure, but notes that there is an ongoing process to examine this issue for several western states and provinces – the Renewable Energy Transmission Initiative (RETI). RETI is also prioritizing the addition of specific renewable projects to optimize the efficiency and minimize the environmental impact of new transmission infrastructure. There are no long-term air emissions associated with transmission lines, but there are short-term co-pollutant emissions associated with construction that can be minimized through best practices and project design.

Summary of Co-Pollutant Emissions

Table H-4 presents the estimated co-pollutant benefits from the recommended measures in the Electricity and Natural Gas Sector.

Table H-4: Estimated Statewide Co-Pollutant Emission Changes from Electricity and Natural Gas Sector Measures in Scoping Plan
(tons per day in 2020)

Measure	NOx	PM 2.5	ROG	CO	SOx
(E-1) Energy Efficiency (Electricity)	-7.0	-4.0	-1.0	-14.2	-0.6
(CR-1) Energy Efficiency (Natural Gas)	-10.4	-0.8	-0.6	-4.9	-0.1
(CR-2) Solar Hot Water	-0.3	-0.03	-0.02	-0.2	0
(E-4) Million Solar Roofs	-1.0	-0.6	-0.1	-2.0	-0.1
(E-2) Increase Combined Heat and Power (change from boiler to CHP) [a]	-2.0	+0.6	-0.7	-12.7	+0.1
(E-2) Increase Combined Heat and Power (avoided grid electricity) [a]	-6.4	-4.3	-0.9	-13.2	-0.6
(E-3) Renewables Portfolio Standard	-9.8	-5.6	-1.4	-19.9	-0.8
Electricity and Natural Gas Sector Total [b]	**-36.8**	**-14.3**	**-4.6**	**-67**	**-2.1**

[a]Combined Heat and Power emission changes were not included in the public health analysis, due to uncertainty in where they would occur.
[b]Numbers may not add up as presented due to rounding.

4. WATER

Regulatory Background

The operation and maintenance of water facilities and related infrastructure do not generally have significant direct air emissions. Significant emissions are indirect and the result of the electricity and natural gas use related to water. Construction activities would have temporary impacts on air resources, and are regulated by local AQMDs and APCDs, while construction equipment is regulated by ARB.

(W-1) Water Use Efficiency 1.4 MMTCO$_2$E

This measure identifies the potential for statewide water use efficiency improvement through implementation of individual i.e. per capita voluntary water conservation goals. Increasing statewide, total water demand can be met through individual end use efficiency improvements (appliances and fixtures that use less water than existing appliances and fixtures) and through individual water conservation (changes to behavior and practices). Water demand is expected to grow under the BAU scenario, but it is not clear precisely what the net change in water demand will be in 2020. Measure E-1 estimates energy efficiencies including benefits of water use efficiency. Best management practices and high efficiency appliances and fixtures such as water heaters, washing machines, faucets, shower heads, toilets, and irrigation systems reduce individual water demand. Significant air emissions associated with water use are indirect and result from the embedded energy required to move, treat, use, and dispose of or reuse that water.

This measure generates 1.76 (1.8) million acre-feet (MAF) of urban water supply to meet approximately two-thirds of the expected 2020 BAU growth in demand. Currently, the municipal and industrial use of water accounts for about 20% (8.8 MAF) of the State's total 44 MAF annual demand and is expected to increase by about 30% from 2005 through 2020. Agricultural water use accounts for the other 80% or about 35 MAF. While the water and associated emission reductions generated by this measure are assumed under baseline/BAU (BAU) i.e. they are not additional, were it not for this measure the states energy use would

increase by an estimated 5,150 GWh (approximately 16 percent of E-1). Translating this energy use into avoided use of CCNGTs yields a reduction of 1.16 TPD NOx, 0.29 TPD PM2.5, 0.12 TPD ROG, and 0.05 TPD SOx.

(W-2) Water Recycling 0.3 MMTCO$_2$E

This measure proposes to increase water supply reliability to meet increasing demand by increasing water recycling in locations where the energy associated with recycling is less than the energy associated with transporting and treating water. While the water and associated emission reductions generated by this measure are also assumed under BAU i.e. not additional, avoiding the need to import new water supplies by recycling water nevertheless avoids the increased emissions that would otherwise be the case. Recycled water is used primarily for landscaping and industrial processes. Again, the only air emissions are those from the energy use associated with the water. The avoided emissions from using 0.5 MAF of recycled water per year instead of importing new supply is estimated as 1,250 GWh (approximately 4 percent of E-1). Translating this savings into avoided use of CCNGTs yields a reduction of 0.28 TPD NOx, 0.07 TPD PM2.5, 0.03 TPD ROG, and 0.01 TPD SOx.

(W-3) Water System Energy Efficiency 2.0 MMTCO$_2$E

This measure proposes to reduce the amount of energy used to transport, treat and deliver water. Reductions in air emissions are directly relative to reductions in energy use. A target of 20% efficiency improvement yields 4,400 GWh electricity savings (approximately 14 percent of E-1). Translating this savings into avoided use of CCNGTs yields a reduction of 0.99 TPD NOx, 0.24 TPD PM2.5, 0.10 TPD ROG, and 0.04 TPD SOx. Measure E-1 includes these energy savings and associated criteria pollutant reductions.

(W-4) Reuse Urban Runoff 0.2 MMTCO$_2$E

This measure proposes to increase local surface and groundwater supplies by adopting stormwater management strategies, such as Low Impact Development (LID). LID increases infiltration in urban areas increasing regional stormwater capture and storage. Constructing neighborhood facilities to capture and reuse dry weather flows also increases local supply. These water supplies (270,000 - 333,000 acre-feet) can be used to avoid the need for new imported water supplies with higher energy-intensity. While the water and associated emission reductions generated by this measure are also assumed under BAU i.e. not additional, avoiding the need to import new water supplies by reusing runoff avoids increased emissions that would otherwise be the case. The amount of energy savings obtained through this measure relative to new imported supply is estimated as 632 - 781 GWh (1 - 2 percent of E-1). Translating this savings into avoided use of CCNGTs yields a reduction of 0.14 – 0.18 TPD NOx, 0.02 TPD PM2.5, and 0.01 TPD ROG.

There are air quality impacts associated with the construction of these types of structures - primarily from fugitive dust and diesel particulates from operation of construction equipment. These impacts could be significant but would be temporary and would also most likely employ best management practices to minimize dust. ARB's implementation of the Diesel Risk Reduction Plan includes reducing diesel particulates from construction equipment operation by 2020.

(W-5) Increase Renewable Energy Production 0.9 MMTCO$_2$E

This measure proposes to develop renewable energy projects on lands associated with California's state and local water infrastructure. The air emissions associated with these types of projects are evaluated in measure E-3. The amount of renewable energy obtained through this measure is estimated as 2,100 GWh (approximately 4 percent of E-3). Translating this savings into avoided use of CCNGTs yields a reduction of 0.46 TPD NOx, 0.11 TPD PM2.5, 0.05 TPD ROG and 0.02 TPD SOx. Measure E-3 includes these energy savings and associated GHG emission reductions and criteria pollutant reductions

(W-6) Public Goods Charge for Water TBD MMTCO$_2$E

This measure proposes to impose a monetary charge on water use and to use resulting funds to reduce the GHG emissions from water-related energy use, as described in measures W-1 through W-5. Measures W-1 through W-5 are evaluated separately.

Summary of Co-Pollutant Emissions

Table 4 presents the co-pollutant benefit estimations for the proposed Water Sector regulations. These benefits are assumed under BAU or accounted for in the Electricity and Natural Gas sector.

Summary of Co-Pollutant Emissions

Table H-5 presents the estimated co-pollutant benefits from the recommended measures in the Water Sector. Many of these benefits are assumed to occur under the BAU scenario or they are accounted for in the Electricity and Natural Gas sector estimates.

Table H-5: Estimated Statewide Co-Pollutant Emission Changes from Water Sector Measures in Scoping Plan
(tons per day 2020)

Measures[a]	NOx	PM 2.5	ROG	CO	SOx
(W-1) Water Use Efficiency	-1.1	-0.7	-0.2	-2.3	-0.10
(W-2) Water Recycling	-0.3	-0.2	-0.04	-0.6	-0.02
(W-3) Water System Energy Efficiency	-1.0	-0.6	-0.1	-2.0	-0.08
(W-4) Reuse Urban Runoff	-0.1	-0.1	-0.02	-0.2	-0.01
(W-5) Increase Renewable Energy Production	-0.4	-0.3	-0.1	-0.9	-0.04
(W-6) Public Goods Charge for Water	--	--	--	--	--
Water Sector Total [b]	**-3.0**	**-1.7**	**-0.4**	**-6.0**	**-0.3**

[a] Greenhouse gas reductions from the Water sector are not currently counted toward the 2020 goal. ARB anticipates that a portion of these reductions will be additional to identified reductions in the Electricity sector and is working with the appropriate agencies to refine the electricity/water emissions inventory.

[b] Numbers may not add up as presented due to rounding.

5. INDUSTRY

Regulatory Background

The air emissions of all stationary sources in California are regulated. Before a facility can be constructed, it must obtain permits to emit air pollutants, use water resources, and to develop land. Applicable air quality regulations are described in the last section of this Appendix.

(I-1) Energy Efficiency and Co-Benefits Audits for Large Industrial Sources TBD $MMTCO_2E$

This recommended measure would require large stationary sources of GHG emissions to conduct an audit to determine whether cost-effective GHG reductions that also provide needed co-pollutant emission reductions are available. Based on the results of these audits, ARB will consider rule revisions or permit conditions to ensure the best combination of pollution reduction. This recommended measure is designed to balance GHG and co-pollutant reductions. The co-pollutant benefits of this measure will depend on the results of the audits so are unknown at this time. The GHG measures for industrial sources (described below) provide some indication of the possible control measure, and some indication of the potential magnitude of co-pollutant reductions from large industrial sources.

(I-2) Oil and Gas Extraction GHG Emission Reduction 0.2 $MMTCO_2E$

This measure would address fugitive methane emissions from the oil and gas extraction process, including both on and off-shore sources. Approximately 5 percent of the oil and gas extraction-related GHG emissions come from fugitive sources. Net criteria pollutant emission reductions are estimated to be 0.3 TPD VOC.

(I-3) GHG Leak Reduction from Oil and Gas Transmission 0.9 $MMTCO_2E$

This measure would address fugitive emissions from the transmission and distribution of natural gas throughout California. This transmission involves approximately 12,000 miles of pipeline. Transmission-related emissions come primarily from fugitive sources and consist primarily of methane. Net criteria pollutant emissions reductions from controlling fugitive sources are estimated to be 1.3 TPD VOC.

(I-4) Refinery Flare Recovery Process Improvements 0.33 $MMTCO_2E$

This measure would require oil refineries to increase the gas-recovery capacity of their flare systems to capture these gases before combustion in the flares and reroute them into various refinery processes. Staff is also evaluating tying into the flare system remote pressure-relief devices that currently discharge to the atmosphere. Finally, this measure assumes best management practices regarding planned shutdowns and flare activity. Staff estimates that flare emissions would be halved by this measure.

Using natural gas as a surrogate for flared gases, this measure could reduce NOx by 0.8 TPD and PM2.5 by 0.02 TPD. ARB is establishing a technical working group to explore the potential GHG and other air emission reductions that can be achieved through improving process efficiencies.

(I-5) Removal of Methane Exemption from Existing Refinery Regulations

0.01 $MMTCO_2E$

This measure would remove the existing fugitive methane exemption from regulations applicable to equipment and sources within refineries. Storage tanks, wastewater treatment facilities, and process losses (leaks) are all sources of fugitive methane emissions. Practices employed to implement this measure, including improved inspection and repair, could also reduce VOC emissions.

Summary of Co-Pollutant Emissions

Table H-6 presents the estimated co-pollutant benefits from the recommended measures in the Industry Sector. Changes in co-pollutant emissions could not be estimated for all measures due to the specificity of the measures or lack of underlying data. Emission reductions that could not be estimated are not included in the table.

Table H-6: Estimated Statewide Co-Pollutant Emission Changes from Industry Sector Measures in the Scoping Plan
(tons per day in 2020)

Measure	NOx	PM2.5	CO	SOx	VOC
(I-2) Oil and Gas Extraction GHG Emission Reduction	0	0	0	0	-0.3
(I-3) GHG Leak Reduction from Oil and Gas Transmission [a]	0		0		-1.3
(I-4) Refinery Flare Recovery Process Improvements	-0.8	-0.02			
Quantified Industry Sector Total	**-0.8**	**-0.02**	**0**	**0**	**-1.6**

[a] Changes in co-pollutant emissions could not be estimated for all measures due to the specificity of the measures or lack of underlying data. Emission reductions that could not be estimated are not included in the table.

6. RECYCLING AND WASTE MANAGEMENT

Regulatory Background

Air emissions from the construction and operation of Municipal Solid Waste (MSW) landfills and combustors, material recovery facilities (MRFs) and composting facilities are regulated to support maintenance and attainment of **National Ambient Air Quality Standards (NAAQS).** The last section of this Appendix more fully describes these regulations. The State, through the CIWMB, ARB, and State Water Resources Control Board (SWRCB), has been working to reduce the environmental impacts of solid waste management for many decades. Local governments have the primary responsibility for managing solid waste. The **CIWMB** requires the development of regional **Integrated Waste Management Plans (IWMPs)** by local agencies.

IWMPs and some projects identified within IWMPs will have to comply with the **California Environmental Quality Act (CEQA)**. CEQA requires proposed plans and facilities to analyze and describe the potential for environmental impacts, identify ways to reduce adverse impacts and offer alternatives to the project, and to disclose this information to the public. This process examines projects for localized impacts and proposes measures to mitigate significant impacts.

Much of the environmental protections around solid waste management are implemented at a local government level. State waste management programs are primarily carried out through **local solid waste enforcement agencies (LEAs)**. LEAs have the primary responsibility for ensuring the correct operation and closure of solid waste facilities in the state. They also have responsibilities for guaranteeing the proper storage and transportation of solid wastes.

(RW-1) Landfill Methane Control Measure 1.0 MMTCO$_2$E
(RW-2) Additional Reductions in Landfill Methane: Increase the Efficiency of Landfill Methane Capture TBD MMTCO$_2$E

Landfills are managed to protect human health and the environment. Although landfills are regulated to minimize decomposition of wastes in landfills, some anaerobic decomposition of organic wastes creates byproducts of gaseous methane and carbon dioxide, plus trace gas constituents. Methane and carbon dioxide are both GHGs, with methane being 21-22 times more potent than carbon dioxide. Large landfills typically have gas collection and control systems to collect and destroy (by flaring or using an energy recovery device) the methane emissions and TACs and are required to meet fugitive surface emission standards. Some smaller landfills do not currently collect or control methane emissions; however, if the landfill is properly capped, the amount of unintended emissions could be significantly reduced. Measure RW- 1 will require the installation of gas collection and control systems at smaller and other uncontrolled landfills that are currently not required to install emission controls. The measures also establish statewide standards for the gas collection and control system, including methane destruction efficiency requirements and landfill methane surface emission standards, for all landfills where systems are required. The collection and control of landfill gas may increase the amount of flared gases, and subsequently might also increase NOx and CO emissions but may decrease TACs like benzene or vinyl chloride. Measure RW-2 proposes to develop best management practices and standards to minimize fugitive methane emissions.

(RW-3) High Recycling/Zero Waste 9 MMTCO$_2$E

Commercial Recycling recommends developing voluntary commercial recycling goals. Commercial facilities generate over half of the State's solid waste, and much of it is recyclable. Commercial recycling of materials potentially avoids or reduces emissions associated with full production cycles and landfills. Full production cycles may occur outside of the state.

Increasing Production and Markets for Compost could double the amount of organic material diverted from landfills by creating compost instead. The use of compost can reduce water demands of vegetation, reduce the amount of chemical pesticides used for weed control, and reduce chemical fertilizer applications. VOCs and NOx can be byproducts of the compost manufacturing process and are a function of the compost feedstock, the amount of mechanical mixing, and the emission controls on mechanical equipment. Diesel related emissions may also be associated with the equipment used at compost facility operations; however, the same amount of diesel related emissions may also occur in the processing and application of chemical fertilizers. A comparison of emissions will need to occur in order to more fully assess benefits or impacts. VOCs are precursors to ozone generation: both ozone precursors and diesel emissions are currently regulated by ARB and local air districts. ARB and local air districts seek to reduce emissions in order to achieve the goals of the 2007 SIP to meet the national ozone and PM2.5 standards. This measure would also reduce landfill gas (by diverting materials from landfills) and potentially reduce chemical fertilizer emissions, but could potentially generate VOCs. ARB

and CIWMB have established a working group to guide research into VOC and GHG production during composting.[67]

The **anaerobic digestion** of human, animal, or wet organic wastes produces a gas of 50 to 80 percent methane. This "biogas" can be combusted to produce electricity. Combustion of digester gases must also be controlled to limit emissions of NOx, particulate matter and carbon monoxide, as anaerobic digestion generates 22 times the amount of NOx and 9 times the amount of PM as natural gas-powered power plants (per MWh). All of these emissions can be minimized with modern control technologies or through good plant design.

Extended Producer Responsibility proposes to incorporate the costs of treatment and disposal into the total cost of a product. This should result in environmentally preferable products, as manufacturers seek to reduce overall product costs by minimizing treatment and disposal costs. **Environmentally Preferable Purchasing** would encourage the purchase of environmentally preferable products, products which use less energy, water, virgin materials and hazardous chemicals to produce. These measures intent is to reduce environmental impacts of product manufacturing. Because of the broad spectrum of products, and the geographical extent of extraction and manufacturing, it is not possible to specifically describe potential benefits to air quality in California, although some of these benefits would be the reduced demand for landfilling.

7. FORESTS

Regulatory Background

The 33 million acres of California's forests, forest type, species composition, ownership and management are very diverse. Approximately 45 percent of these acres are privately owned with about 52 percent under federal ownership, and 3 percent is owned by the State or local governments. Management of forests is strongly influenced by land ownership goals. With respect to air emissions: forests remove carbon as they grow; but emissions of criteria pollutants from fires can negatively affect air quality. Several sources of air emissions associated with forest activities are already regulated by the State:

> **Off-road equipment** used for operation and maintenance activities in forests is regulated by ARB to reduce criteria pollutant emissions. Timber harvesting and forest management activities that could have temporary impacts on air resources are regulated by local AQMDs and APCDs.
>
> The **California Board of Forestry and Fire Protection** (BoF) is authorized to provide direction for fuels management to reduce the risk of wildfires. Wildfires are a natural and necessary element of the forest lifecycle, but fires, especially catastrophic ones can have significant air quality impacts.

(F-1) Sustainable Forest Target 5 MMTCO$_2$E

BoF has very broad authority, including a role as a forest practice regulation entity, a role in setting the policy and the structure for fire protection in California, and also the responsibility to represent the State in federal forestry issues. This measure recommends establishing and

[67] http://www.arb.ca.gov/cc/compost/compost.htm

implementing a target to sustain current levels of net carbon sequestration in the Forest sector with actions such as reforesting areas lost to wildfires and improving forest management to reduce the risk of catastrophic wildfires in the state. One of the main co-benefits of this measure is reduced emissions of criteria pollutants from large fires which can significantly impair air quality. Emissions from additional operation and maintenance activities to reduce the risk of catastrophic fires and to increase afforestation and reforestation will be minimized by existing off-road equipment regulations. Air emissions were not quantified because the measure is still under development. The benefits and impacts of this measure will be further evaluated as specific details are developed.

8. HIGH GWP

Regulatory Background

Chemicals, refrigerants and consumer products are regulated at both federal and state levels. At the federal level:

> Toxicity levels, exposure rates, release data and disposal information for a wide range of **chemicals** are gathered and disseminated by U.S. EPA. U.S. EPA works with industry to implement chemical uses that will diminish the damage caused to the environment and human life and to establish protocols for spills and other accidents.[68]
>
> At a federal level, **refrigerants** identified as ozone depleting substances are regulated by U.S. EPA as a result of the 1990 Clean Air Act Amendments. U.S. EPA regulates the sale, servicing and recovery operations involving ozone depleting substances used as refrigerants. Mobile sources are regulated in coordination with the National Institute for Automotive Service Excellence and the Mobile Air Conditioning Society. The Society of Automotive Engineers industry sets standards for technical specifications related to motor vehicle air conditioning system (MVAC) servicing issues. U.S. EPA also sets appliance standards.
>
> **Workplace safety protection** from exposure to refrigerants and chemicals is regulated by the Occupational Safety and Health Administration with safety limits established by the National Institute of Occupational Safety and Health.

At the state level:

> ARB regulates **mobile sources**, including refrigerant systems and servicing. Local air districts regulate **stationary sources.** ARB also has authority to adopt regulatory requirements for chemically formulated **consumer products**. The focus of ARB's consumer product regulations is the reduction of VOCs and ozone depleting substances.
>
> The Office of Environmental Health and Hazard Assessment evaluates the risks posed by hazardous substances (**chemicals**) and sets appropriate standards to protect human health and the environment.

[68] http://www.epa.gov/ebtpages/pollchemicals.html

(H-1) Motor Vehicle Air Conditioning Systems: Reduction of Refrigerant Emissions from Non-Professional Servicing 0.26 $MMTCO_2E$

The primary purpose of this Discrete Early Action is to reduce the emissions of the high global warming potential (GWP) gas HFC-134a, a potent GHG with a GWP of 1,300, from activities associated with do-it-yourself (DIY) charging. HFC-134a is not regulated as an ozone precursor, a contributor to particulate matter, or as a toxic air contaminant. Leakage of HFC-134a from motor vehicle refrigerant systems is not associated with criteria pollutants or TACs; therefore, this measure is not anticipated to affect air resources.

(H-2) SF_6 Limits in Non-Utility and Non-Semiconductor Applications 0.3 $MMTCO_2E$

This Discrete Early Action measure will consider a potential ban on the use of sulfur hexafluoride (SF_6) where technologically feasible and cost-effective alternatives are available, as well as a performance standard for other uses. The main uses of SF_6 in California that are not directly related to utilities or semiconductor manufacturing include: magnesium casting, tracer gas use (including fume hood testing), and medical uses (ultrasounds, eye surgery). Alternative gases are being pursued for magnesium die-casting and tracer gas uses. Medical use emissions appear to be very low, and are proposed to be exempt from SF_6 bans due to low emissions, high costs, and lower effectiveness of alternatives. Neither SF_6 nor its replacement gases are criteria pollutants or TACs; therefore, this measure is not expected to affect air resources.

(H-3) High GWP Reduction in Semiconductor Manufacturing 0.15 $MMTCO_2E$

This measure recommends requiring manufacturers to use process optimization, alternative chemistries, and abatement technologies in combination or separately to reduce high GWP emissions from semiconductor manufacturing. This measure considers an existing U.S. EPA voluntary program. There are currently no known replacements for the high GWP gases used in this industry, so efforts have focused on using additional abatement equipment and developing processes to reduce their use of high GWP gases. Individual fabricators would determine the optimal methods of compliance. There are no anticipated effects on criteria pollutants or TACs.

(H-4) Limit High GWP Use in Consumer Products 0.25 $MMTCO_2E$

At its June 2008 Board Hearing, ARB approved amendments to the Consumer Products Regulation that will attain approximately a 0.23 $MMTCO_2E$ per year reduction from Pressurized Gas Dusters (2020 reductions). In the 2009-2010 timeframe, staff will evaluate other GHG reduction opportunities from Consumer Products and may propose more regulations to attain additional reductions. Consumer Products are also regulated to reduce VOC and TAC emissions. Additional regulations would include analysis to limit the replacement of high GWPs with lower GWPs that could contribute to the formation of ground level ozone.

(H-5) High GWP Reductions from Mobile Sources 3.3 $MMTCO_2E$

The **Low GWP Refrigerants for New Motor Vehicle Air Conditioning Systems** measure recommends requiring low GWP refrigerants with overall improved lifecycle climate performance for new MVAC systems, with initial emphasis on systems used for heavy-duty and off-road vehicle application, followed by requirement for light-duty vehicles. The employment of low GWP refrigerants is not expected to affect air emissions.

The **Air Conditioner Refrigerant Leak Test during Vehicle Smog Check** measure recommends reducing the number of in-use MVACs that leak excessively by identifying them through the existing Smog Check program and requiring their subsequent repair. This measure

would prevent the ongoing "leak-recharge-leak" cycle associated with the use of small cans of refrigerant by do-it-yourselfers to systems that need repair but are not fixed. Leakage of HFC-134a from motor vehicle refrigerant systems is not associated with any regulated air contaminants; therefore, this measure is not anticipated to affect air resources.

The **Refrigerant Recovery from Decommissioned Refrigerated Shipping Containers** measure recommends recovering refrigerant remaining in the decommissioned containers' cooling systems, reducing leakage from these containers, and ensuring proper disposal as they approach their end-of-life. Leakage of these types of refrigerants is not associated with any regulated air contaminants; therefore, this measure is not anticipated to affect air resources.

The **Enforcement of Federal Ban on Refrigerant Release during Servicing or Dismantling of Motor Vehicle Air Conditioning Systems** measure recommends improving compliance with existing regulations prohibiting the venting of certain types of refrigerant, including HFCs, to the atmosphere when MVAC equipment is serviced or dismantled.[69] Venting is avoided by recovering refrigerants with specialized equipment before dismantling or servicing. The recovered refrigerant can be re-used or transferred to re-processors approved by U.S. EPA for proper disposal. Leakage of HFC-134a from motor vehicle refrigerant systems is not associated with any criteria pollutants or TACs; therefore, this measure is not anticipated to affect air resources.

(H-6) High GWP Reductions from Stationary Sources 10.9 MMTCO$_2$E

Two measures are proposed in the **High GWP Stationary Equipment Refrigerant Management Program.** The **Refrigerant Tracking/Reporting/Repair/Deposit Program** measure recommends requiring commercial and public facilities with large stationary air conditioning and refrigeration equipment to minimize emissions of high GWP refrigerants through reporting, leak repair, improved servicing, and end-of-life control. The **Specifications for Commercial and Industrial Refrigeration Systems** measure proposes new specifications for commercial and industrial refrigeration systems to both reduce emissions of high GWP refrigerant and to increase energy efficiency of the units. There are no criteria pollutants or TACs associated with commercial and industrial refrigeration systems; therefore, this measure is not anticipated to affect air resources.

Insulation foam that is diverted to landfills emits high GWP gases into the atmosphere.[70] The **Foam Recovery and Destruction Program** measure recommends minimizing these emissions to as close to zero as possible by diverting waste foam away from landfills and destroying the foam at high temperatures, or by capturing the high-GWP GHGs within the foam and destroying the foam gas. There is a potential for criteria pollutants and toxic emissions if the recovered foams are combusted at high efficiency treatment facilities. This would be further evaluated during regulation development.

[69] Existing federal regulation (40 CFR 82.154) bans the release to the atmosphere of high GWP refrigerants at the end-of-life or during equipment servicing.
[70] USEPA, U.S. High GWP Emissions 1990-2010: Inventories, Projections and Opportunities for Reductions, EPA 000-F-97-000, June 2001.

Gas-insulated circuit breakers and gas-insulated substations are sources of fugitive SF_6 emissions in California electricity systems, and older equipment generally produces more fugitive emissions than newer equipment. Particle accelerators emit SF_6 from equipment similar to that found in electricity systems and use SF_6 as a quenching medium. The **SF_6 Leak Reduction and Recycling in Electrical Applications** measure recommends reducing emissions of SF_6 within the electric utility sector and at particle accelerators by requiring the use of best achievable control technology for the detection and repair of leaks, and the recycling of SF_6. Additionally, particle accelerator industry representatives are considering the use of possible substitute mediums. Neither SF_6 nor its replacement gases are criteria pollutants or TACs; therefore, this measure is not expected to affect air resources.

The **Alternative Suppressants in Fire Protection Systems** measure recommends evaluating the use of alternative suppressants in total flooding (fixed) and streaming (portable) fire suppression systems. Neither existing nor alternative suppressants are criteria pollutants or TACs; therefore, this measure is not expected to affect air resources.

The **Residential Refrigeration Early Retirement Program** measure recommends partnering with existing voluntary programs to retire inefficient residential refrigeration appliances such as refrigerators and freezers. Appliance early retirement includes the recovery of high-GWP refrigerants and blowing agents for reclamation or destruction to avoid GHG emissions. There are no criteria pollutants or TACs associated with these refrigeration systems.

(H-7) Mitigation Fee on High GWP Gases 5 $MMTCO_2E$

This measure recommends attaching a fee to the use of high GWP gases. This measure would support the goal of reducing high-GWP gas emissions and therefore have similar effects as Measures H-1 through H-6. No reductions of criteria pollutants or TACs are expected.

9. AGRICULTURE

Regulatory Background

Anaerobic digesters are regulated as stationary sources. Applicable air quality regulations are described in the last section of this Appendix.

(A-1) Methane Capture at Large Dairies 1.0 $MMTCO_2E$

This is a voluntary measure. Methane from dairy manure can be captured through the installation and use of anaerobic digesters. The anaerobic digestion of animal wastes produces a gas of 50 to 80 percent methane. This “biogas” produced by the digester can be used as an alternative to natural gas in combustion, power production, or as a transportation fuel. Digester gas-based electricity generates 22 times the amount of NOx and 9 times the amount of PM as electrical grid natural gas power plants (per MWh). Controls can reduce the amount of NOx in exhaust gases, but the types and sizes of engines typically used in conjunction with a dairy digester may not be available, cost effective or able to meet local air district NOx requirements. Using “biogas” as a transportation fuel could replace diesel combustion in farm-related equipment and truck trips.

10. SUMMARY

From a statewide perspective, the recommended measures of the Scoping Plan will generally benefit air resources in California. The majority of this benefit will come through reduced and

avoided combustion of gasoline, diesel, and natural gas. Higher polluting fuels, like diesel, will transition to lower polluting and non-polluting fuels, while increased efficiencies and implemented transportation targets work to reduce the overall demand for these fuels at the same time that population within the state is increasing. Implementation of the Cap and Trade regulation should further reduce criteria pollutants and TACs. Table H-7 summarizes the estimated NOx and PM2.5 reductions that are used to estimate public health benefits later in this Appendix.

Table H-7: NOx and PM2.5 Statewide Reductions from Recommended Scoping Plan Measures used in Public Health Evaluation
(tons per day)

Measure	NOx	PM2.5
Light-Duty Vehicle • Pavley I and Pavley II GHG Standards • Vehicle Efficiency Measures	1.6	1.4
Goods Movement Efficiency Measures	16.9	0.6
Medium and Heavy-Duty Vehicle GHG Emission Reduction • Aerodynamic Efficiency • Hybridization	5.6	0.2
Regional Transportation-Related GHG Targets	8.7	1.4
Energy Efficiency (Electricity)	7.0	4.0
Energy Efficiency (Natural Gas)	10.4	0.8
Solar Water Heating	0.3	0.03
Million Solar Roofs	1.0	0.6
Renewables Portfolio Standard	9.8	5.6
Total	**61**	**15**

There is a potential for these improvements to occur unevenly throughout the state, although it will be difficult to assess how much of this is due specifically to AB 32 implementation. There are also some potential pathways under consideration (such as biomass to energy or ethanol production) which may have higher associated criteria pollutants or TACs than other potential pathways. The geographical diversity of actual criteria pollutant and TAC reductions will depend on further regulation development and implementation pathways. The ARB regulatory process, as well as AQMD and APCD regulations, existing environmental regulations, and regional air quality plans would partially prevent and publicly disclose potentials for local increases in criteria pollutants and TACs.

B. LAND RESOURCES

California is the third largest state in the United States, encompassing almost 100 million acres of land and 5 million acres of water areas. The federal government holds approximately 23 million acres and manages them as federal parks, forests, and conservation areas. The federal government also holds and manages mineral and resource rights on an additional 45 million acres. The State holds 1.5 million acres of land as parks, forests, and conservation areas. Approximately 27 million acres are in agricultural production (27 percent of total state acreage) and 3.9 million acres are urbanized. There are 56 cities with populations over 100,000, including four of the country's 25 largest cities: Los Angeles, San Diego, San Jose, and San Francisco.

Regulatory Background

Open spaces and agricultural resources are special categories of land resources where there are concerns about impacts and conversions. Land resources in California are currently protected through:

The **California Land Conservation Act of 1965**, known as the Williamson Act, enables local governments to enter into contracts with private landowners to restrict properties to agricultural and open space activities.

CEQA requires proponents of proposed projects to describe the potential for environmental impacts, including impacts to Williamson Act contracts and to established land uses, through a public process. CEQA also requires General Plans to describe the potential for environmental impacts through a public process.

Local Agency Formation Commissions in each county adopt spheres of influence for each city within the county, and make determinations on changes to those boundaries. Their decisions can influence air quality in the way in which they allow additional development to occur.

Evaluation Context

ARB examined the potential effects of the recommended measures in the Scoping Plan on land resources in California. Potential impacts that extend outside of the state are identified, but the potential effects on land resources out of state were not evaluated.

Evaluation Process

Where possible, existing studies, environmental documentation, and regulatory documentation for measures were reviewed for pertinent information. Documentation and studies for existing activities were used to estimate expansion of those types of activities. Where no information was available, ARB consulted experts at state agencies, including at ARB and Climate Action Team agencies. More detailed information about the recommended regulations and the measures under evaluation is provided in Appendix C of the Scoping Plan, as well as in the previous section evaluating air resources.

1. CALIFORNIA CAP-AND-TRADE PROGRAM LINKED TO WESTERN CLIMATE INITIATIVE

Land use considerations are determined by local governments and no land use or planning requirements would be mandated or altered by this recommended measure. Instead, the recommended measure would require capped entities that have already received permits to operate consistent with existing land easements and ordinances to comply with AB 32 requirements and the cap and trade regulation. Offset projects would have to comply with existing land use regulations as well as AB 32 requirements.

2. TRANSPORTATION

(T-1) Pavley I and Pavley II-Light-Duty Vehicle GHG Standards 31.7 $MMTCO_2E$
Feebates - In-lieu of Pavley Regulations 31.7 $MMTCO_2E$
(T-4) Vehicle Efficiency Measures 4.5 $MMTCO_2E$

There are no anticipated changes to land use as a result of these measures, as they are not projected to affect the total number of vehicles in the state.

(T-2) Low Carbon Fuel Standard 15 $MMTCO_2E$

Although the Low Carbon Fuel Standard is still in the regulatory development process, there are likely to be a variety of ways in which the final regulatory requirements can be met. There are potential land resource issues associated with the biofuels pathways, particularly those related to the potential for biofuel crops to replace food crops. The impacts associated with renewable energy to generate hydrogen or electricity for vehicles is evaluated in the electricity and natural gas section.

Biofuel Raw Materials – Waste Materials: The conversion of waste materials to fuels would reduce the need for landfill space in the state.

Biodiesel – Soy: The majority of soybeans needed to fill the anticipated 2020 demand for soy-based biodiesel is projected to be produced out-of-state. Midwestern states and Texas are currently the largest growers of soybeans, and out-of-state biodiesel plants using soybeans tend to be located close to production fields. California could meet future biodiesel demands either through importing soybeans and other raw materials or through importing finished biodiesel. Potential land resource issues related to the use of soybeans to produce fuel include the conversion of undeveloped/natural habitats to agriculture and the conversion of food-based agriculture lands to fuel-based agriculture lands. These issues will be further evaluated as part of the LCFS regulatory development process.

Biodiesel Production Facilities: Biodiesel production facilities are usually sited based on access to feedstock and the market for the finished product. Production facilities processing out-of-state feedstocks need to be accessible to truck and rail routes. Facilities processing recycled waste tend to be located closer to the sources of that waste – restaurants and industrial facilities. Facilities sited in industrial-zoned areas will already be compatible with existing land use designations since biodiesel production falls into the industrial category. Potential land use impacts could occur if non-compatible areas are rezoned to accommodate the siting of new production facilities. Preliminary analysis for the LCFS estimates a projected maximum demand for biodiesel in California by 2020 that could require the equivalent of almost 30 new 25 million gallon-capacity biodiesel production facilities.

Ethanol – Corn: Food-to-fuel crop conversion acreage estimates are currently under development as part of the LCFS regulatory process. Potential land resource issues related to the use of corn to produce fuel include the conversion of undeveloped/natural habitats to agriculture and the conversion of food-based agriculture lands to fuel-based agriculture lands. These issues will be further evaluated in the LCFS regulatory development.

Ethanol – Cellulosic: Less is known about the potential land use issues with cellulosic agriculture, which may be heartier than food crops and thus can be cultivated in locations where food cannot be economically cultivated. Most cellulosic feedstocks will consist of woody waste materials (corn stover and other crop residues, waste wood chips, and municipal solid waste) which would derive from existing land uses. The only potential land resource issues related to the use of cellulosic materials to produce fuel would occur where (and if) undeveloped/natural habitats or food-based agriculture lands are converted to fuel-based agriculture lands. These issues will be further evaluated in the LCFS regulatory development.

Ethanol Production Facilities: Ethanol production facilities typically need access to sources of feedstock, users of their waste products, and to the market for this finished product. Facilities sited in industrial-zoned areas generally will not cause as many land use concerns as siting in undeveloped areas. Potential land use impacts could occur if non-compatible areas are rezoned to accommodate siting of new ethanol production facilities. The preliminary analysis for the LCFS proposal estimates a maximum projected need for ethanol in California by 2020 that could require the equivalent of over 50 new 50 million gallon-capacity plants.

Hydrogen: Land use issues related to renewably-produced hydrogen resources are discussed in the Electricity and Natural Gas Section. Hydrogen production stations are typically constructed in developed, populated areas and within zoning that allows for a production station. Stations that use natural gas or on-site solar power as the energy source for production would probably not raise land resource issues if located in developed areas.

(T-5) Ship Electrification at Ports 0.2 $MMTCO_2E$

(T-6) Goods Movement Efficiency Measures 3.5 $MMTCO_2E$

Ports and highway infrastructure may continue to expand to meet the increasing demand for goods movement. No new ports or rail yards are currently anticipated and existing rail yards are not expected to expand.[71] ARB does not anticipate that implementation of the Scoping Plan will affect port infrastructure activities beyond the business as usual scenario. ARB will develop strategies for improving the efficiency of goods movement, with the goal of improving air quality. The majority of the measures expected to be included in these strategies will essentially recommend physical or operational and maintenance changes to vehicles and equipment, but not change the future numbers of vehicles and equipment. In general, these measures are not expected to effect changes in land uses. Some measures recommend replacing diesel engines with grid electricity, which would increase the demand for electricity. If construction of new facilities or repowering of existing facilities is required to meet this increased demand, these measures could collectively impact land resources. The impacts of new facilities are described in the Electricity and Natural Gas sector evaluation.

[71] Goods Movement Action Plan.

(T-7) Heavy Duty Vehicle GHG Emission Reduction – Aerodynamic Efficiency 0.9 MMTCO$_2$E

(T-8) Medium and Heavy-Duty Vehicle Hybridization 0.5 MMTCO$_2$E

There are no anticipated changes to land use as a result of this measure, as this measure would not affect the total number of vehicles in the state.

(T-3) Regional Transportation-Related Greenhouse Gas Targets 5 MMTCO$_2$E

Under this measure ARB would work with MPOs to establish passenger vehicle greenhouse gas emission reduction targets (regional targets) for 2020 and 2035. The specific land resource impacts of particular land use and transportation strategies applied to implement this measure would be evaluated under existing applicable regulatory structures as they are triggered, including CEQA. Generally, this measure encourages more compact development patterns that have the potential to reduce future impacts on current natural resource and agricultural lands.

(T-9) High Speed Rail 1 MMTCO$_2$E

The Scoping Plan supports the implementation of a high speed rail system. The recommended HSR program has undergone environmental review under CEQA and NEPA. ARB reviewed this documentation for its land use analysis. The programmatic EIR/EIS examined the impacts of the HSR on land resources, land planning, agricultural lands, and environmental justice. The analysis finds the recommended HSR would be compatible with local and regional plans that support rail systems and transit-oriented development, as well as improved inter-modal connectivity with existing local and commuter transit systems. As new transportation corridors would be developed with the HSR, there is the potential for localized land use impacts and property right impacts. The programmatic EIR/EIS identifies additional land use incompatibilities and significant impacts on agricultural lands at regional levels. Mitigation strategies and design practices are proposed to compensate these impacts. For example, the California High Speed Rail Authority has established policies regarding the use of smart growth and transit oriented development strategies for station areas to help to avoid secondary growth impacts on agricultural lands.

3. ELECTRICITY AND NATURAL GAS

Regulatory Background

The air emissions of all stationary sources in California are regulated. For power plants or energy facilities, the **CEC Certification process** serves as an equivalent to the otherwise required state and local permitting requirements. The CEC has authority to certify (permit) the construction and operation of thermal electric power plants 50 megawatts or larger and all related facilities. The site certification process provides a review and analysis of all aspects of a proposed project, including public health and environmental impacts, safety, efficiency, and reliability, equivalent to the CEQA process. The process is also a public process. Smaller facilities with no potentially significant environmental impacts can apply for an exemption process, similar to a mitigated negative declaration approach under CEQA.

The CEC works with local governments to ensure a functionally equivalent permitting process. CEC prepare the necessary evaluation in a “Preliminary Staff Assessment”, working with the local government to ensure it provides the information needed for the local government to approve the project. The final site certification serves as the local permit to construct.

(E-1) Energy Efficiency (Electricity) 15.2 $MMTCO_2E$
(CR-1) Energy Efficiency (Natural Gas) 4.3 $MMTCO_2E$

There are no expected direct land use impacts from these recommended measures. Avoided demand for electricity would potentially result in a reduction of the number of power plants constructed in the future. A conventional natural gas plants uses approximately 1 acre per 9.6 MW; solar fields (the most land intensive source of electrical power) would require 5 to 10 acres per MW. Avoiding 32,000 GWh of electrical demand could avoid development of 520 to 46,600 acres. This avoided land use type could be developed land, agricultural lands, or natural habitat.

(CR-2) Solar Water Heating 0.1 $MMTCO_2E$

There are no expected direct land use impacts from these recommended and under evaluation measures. Avoided demand for natural gas for home and commercial water heating would slightly reduce the impacts around the world from development of natural gas and production of liquefied petroleum natural gas.

(E-4) Million Solar Roofs 2.1 $MMTCO_2E$

Avoided demand for electricity could potentially result in a reduction of the number of power plants constructed in the future. A conventional natural gas plants uses approximately 1 acre per 9.6 MW; solar fields (the most land intensive source of electrical power) would require 5 to 10 acres per MW. Avoiding 3,000 MW of electrical demand could avoid development of 312 to 30,000 acres. This avoided land use type could be developed land, agricultural lands, or natural habitat.

(E-2) Increase Combined Heat and Power 6.7 $MMTCO_2E$

Combined heat and power systems would be installed within existing facility boundaries, typically located in already disturbed, industrial areas. Generally, these projects are not expected to impact land resources.

The increased efficiency of combined heat and power systems would lead to avoided demand for electricity, potentially resulting in a reduction of the number of power plants constructed in the future. A conventional natural gas power plant uses approximately 1 acre per 9.6 MW; a solar field (the most land intensive source of electrical power) requires 5 to 10 acres per MW. Avoiding 4,000 MW of electrical demand could avoid development of 416 to 40,000 acres. This avoided land use type could be developed land, agricultural lands, or natural habitat. Avoided demand for natural gas could slightly reduce the impacts around the world from development of natural gas and production of liquefied petroleum natural gas.

(E-3) Renewables Portfolio Standard 21.3 $MMTCO_2E$

This recommended measure would increase the overall percentage of renewable energy sources such as wind, solar, biomass and geothermal, of each utility's energy sources. This requirement could be met through any potential mixture of renewable energy sources, and will most likely be driven by a number of factors, including the availability of renewable sources within the geographic region of each utility. For these reasons the benefits and impacts of each renewable resources are evaluated relative to natural gas, and are not individually quantified for potential air emissions. Land resource impacts are best evaluated at the project-level, as the quality of the land resource being impacted is more important than the quantity. Project-level evaluations are currently evaluated within the CEC certification process.

Wind farms are generally located on undeveloped lands, but have a relatively small land footprint. Modern wind turbines are more powerful and require fewer turbines per acre than older generation wind turbines.

Solar thermal fields use 8 acres of land per MW on average[72] and are generally proposed in undeveloped lands in unshaded areas. The mirrors and lenses at solar thermal facilities require periodic washing, so unvegetated soils are treated to reduce erosion, but they remain porous.

There are no current large-scale **solar photovoltaic** plants operating in California, although there are several proposed. Photovoltaic plants use more land per MW than solar thermal plants, and about 80 times the acreage of a combined-cycle natural gas plant per MW. The 2007 Environmental Performance Report states that current technological advances may reduce the land footprint by up to 50 percent.

There is a current example of potential land impacts from large scale collective development of wind and solar power. The Bureau of Land Management has received applications to develop 66,200 MW of renewable energy on the lands they manage in the California desert, which could encompass up to 1.16 million acres, some of which is important biological habitat and difficult to offset in high volumes.

The land resource effects of **biomass** sources depend on the fuel type.

- The use of biomass (forest or agricultural residuals) or municipal solid waste (MSW) requires a physical plant, similar in land use patterns to natural gas power plants but generally located close to the source materials (such as landfills) to reduce transportation costs. Land use impacts associated with these facilities are highly dependent on their location. Use of waste materials precludes the need to destroy or landfill them in other manners, reducing future land resource impacts. These materials do not require additional lands for production, and the collection of the waste usually complements the operational needs of forest and agricultural practices. **Municipal solid waste** may contain hazardous materials, which could result in solid and gaseous hazardous by-products. Air emissions and ash can be treated to reduce this hazard.
- The **anaerobic digestion** of human, animal, or wet organic wastes reduces the physical amount of waste and improves the quality of the waste for disposal, requiring less land for disposal.
- Combustion of **landfill gases** occur within existing landfill facility footprints and therefore have no additional effects on land resources.

Geothermal-fueled power plants use less land than fossil-fuel power plants, but have to be located near their source, which can be undeveloped land or native habitat.

Small hydropower projects take advantage of existing disturbed environments (man made channels, aqueducts, pipelines, etc.) and therefore have a minimal impact on land resources.

[72] 2007 Environmental Performance Report. California Energy Commission. 2007.

New transmission infrastructure may be required to fully develop renewable sources. New transmissions lines may require more land resources than for natural gas power plants of similar capacity. We do not anticipate significant land resource impacts at a statewide level, since the maximum amount of difference would be around 488,850 acres.

4. WATER

Regulatory Background

Water infrastructure includes reservoirs, dams, canals, aqueducts, pipelines, pumping stations, and water treatment plants. Before a facility can be constructed, it must obtain permits to emit air pollutants, use water resources, and to develop land. Regarding land resources, new water infrastructure must comply with:

The California Environmental Quality Act requires proposed industrial facilities to analyze and describe the potential for environmental impacts, identify ways to reduce adverse impacts and offer alternatives to the project, and to disclose this information to the public. Water infrastructure is typically constructed by a local, regional, or state government agency and work with other local, regional, or state government agencies to determine who will serves as the lead or responsible agency for a CEQA document. Local, Regional, and State government agencies also both establish guidance for CEQA analyses and review documents for consistency with established plans and regulations. This process examines projects for localized impacts and proposes measures to mitigate significant impacts.

Land Use/Zoning Laws determine where industrial sources can be constructed and operated. New stationary sources have to obtain a local permit determining compliance with the **General Plan** and authorizing construction. If the proposed location is not within an approved land use area, the facility will have to undergo a public process to obtain a zone change, variance, or conditional use permit, dependent on the compatibility of the facility with the location. Land use permits require environmental review. There are also local building codes in effect that require local construction permits.

(W-1) Water Use Efficiency 1.4 $MMTCO_2E$

This measure identifies the potential for statewide water use efficiency improvement through implementation of individual i.e. per capita voluntary water conservation goals. The portion of energy efficiency savings obtained through water use efficiency while assumed under BAU and not additional is estimated as 5,150 GWh (approximately 16 percent of E-1) could be saved relative to increasing imports (not assumed under BAU). Avoiding 4,928 MW of electrical demand could avoid development of 513 to 49,280 acres. This avoided land use type could be developed land, agricultural lands, or natural habitat. These energy savings and associated land resource benefits are assumed under BAU.

(W-2) Water Recycling 0.3 $MMTCO_2E$

This measure proposes to increase water supply reliability to meet increasing demand by recycling water in locations where the energy associated with recycling is less than the energy associated with transporting and treating additional imported water. Recycled water is used primarily for landscaping and industrial processes. Recycling water also produces waste products (the solids removed from wastewaters) and some of these waste products are processed to create “biosolids” which are used as soil conditioners or fertilizers in agricultural and landscaping applications. There are public concerns over the health impacts of exposure to

biosolids and they are regulated by multiple levels of government. In some California locations, certain applications of biosolids are banned.[73] Increasing water recycling increases the amount of biosolids produce that then require disposal.

The portion of energy efficiency savings obtained through water recycling while assumed under BAU and not additional is estimated as 1,250 GWh (approximately 4 percent of E-1). Avoiding 1,196 MW of electrical demand could avoid development of 124 to 11,960 acres. This avoided land use type could be developed land, agricultural lands, or natural habitat. These energy savings and associated land resource benefits are assumed under BAU.

(W-3) Water System Energy Efficiency 2.0 MMTCO$_2$E

This measure proposes to reduce the magnitude and intensity of energy use associated with transport, treatment and delivery of water. Benefits or impacts to land resources are relative to reductions in energy use, but could also occur with physical changes to or additions of water infrastructure. Surface storage facilities would be the most land intensive feature of water infrastructure.

This measure proposes a target of 4,400 GWh electricity savings (approximately 14 percent of E-1). Avoiding 4,211 MW of electrical demand could avoid development of 439 to 42,110 acres. The avoided land use type could be developed land, agricultural lands, or natural habitat. Measure E-1 includes these energy savings and associated land resource effects.

(W-4) Reuse Urban Runoff 0.2 MMTCO$_2$E

This measure proposes to increase local surface and groundwater supplies by adopting stormwater management strategies, such as Low Impact Development (LID). LID increases infiltration in urban areas increasing regional stormwater capture and storage. Constructing neighborhood facilities to capture and reuse dry weather flows also increases local supply. These water supplies (270,000 - 333,000 acre-feet) can be used to avoid the need for new imported water supplies with higher energy-intensity. While the water and associated emission reductions generated by this measure are assumed under BAU i.e. not additional, avoiding the need to import new water supplies by reusing runoff avoids increased emissions that would otherwise be the case. The impacts of this measure on land resources will vary by type of action. Employment of Low Impact Development concepts could require variances to existing storm water management schemes. Constructing new facilities could require the conversion of land resources, which would be best evaluated on a project-level basis and through existing land use regulations and plans.

The portion of energy efficiency savings obtained through urban runoff reuse is estimated as 632 - 781 GWh (1 - 2 percent of E-1). Avoiding 605 – 747 MW of electrical demand could avoid development of 63 to 74,700 acres. This avoided land use type could be developed land, agricultural lands, or natural habitat. The water and associated energy savings generated by this measure are assumed under BAU i.e. not additional.

[73] From information compiled on the California Integrated Waste Management Board website.

(W-5) Increase Renewable Energy Production 0.9 MMTCO$_2$E

This measure proposes to develop renewable energy projects on lands associated with California's state and local water infrastructure. The potential land impacts associated with these types of projects are evaluated in measure E-3.

The amount of renewable energy from this measure is estimated as 2,100 GWh (approximately 4 percent of E-3). Avoiding 2,010 MW of electrical demand could avoid development of 209 to 20,100 acres. This avoided land use type could be developed land, agricultural lands, or natural habitat. Measure E-3 includes these energy savings and associated land resource effects

(W-6) Public Goods Charge for Water TBD MMTCO$_2$E

This measure proposes to impose a monetary charge on water use and use resulting funds to reduce the GHG emissions from water-related energy use, as described in measures W-1 through W-5. Measures W-1 through W-5 are evaluated separately.

5. INDUSTRY

Regulatory Background

Before a facility can be constructed, it must obtain permits to emit air pollutants, use water resources, and to develop land. Regarding land resources, the stationary source must comply with:

> **CEQA** requires proposed industrial facilities to analyze and describe the potential for environmental impacts, identify ways to reduce adverse impacts and offer alternatives to the project, and to disclose this information to the public. A Local, Regional, or State government agency serves as the lead or responsible agency for a CEQA document. Local, Regional, and State government agencies also both establish guidance for CEQA analyses and review documents for consistency with established plans and regulations. This process examines projects for localized impacts and proposes measures to mitigate significant impacts.
>
> **Land Use/Zoning Laws** determine where industrial sources can be constructed and operated. New stationary sources have to obtain a local permit determining compliance with the **General Plan** and authorizing construction. If the proposed location is not within an approved land use area, the facility will have to undergo a public process to obtain a zone change, variance, or conditional use permit, dependent on the compatibility of the facility with the location. Land use permits require environmental review. There are also local building codes in effect that require local construction permits.

(I-1) Energy Efficiency and Co-Benefits Audits for Large Industrial Sources TBD MMTCO$_2$E

This recommended measure focuses on improving efficiency at large industrial sources. It is anticipated that most efficiency improvements would take place on-site at existing industrial facilities, and would therefore not affect land resources.

(I-2) Oil and Gas Extraction GHG Emission Reduction 0.2 MMTCO$_2$E
(I-3) GHG Leak Reduction from Oil and Gas Transmission 0.9 MMTCO$_2$E

There are no anticipated changes to land use as a result of these measures.

(I-4) Refinery Flare Recovery Process Improvement 0.33 $MMTCO_2E$

(I-5) Removal of Methane Exemption from Existing Refinery Regulations

0.01 $MMTCO_2E$

There are no anticipated changes to land use as a result of these measures, as all changes would occur on land that is already developed.

6. RECYCLING AND WASTE MANAGEMENT

Regulatory Background

Before a facility can be constructed, it must obtain permits to emit air pollutants, use water resources, and to develop land. Applicable regulations are described in the Industry Sector.

(RW-1) Landfill Methane Control Measure 1.0 $MMTCO_2E$

(RW-2) Additional Reductions in Landfill Methane: Increase the Efficiency of Landfill Methane Capture TBD $MMTCO_2E$

There are minimal anticipated changes to land use as a result of this measure, as they would either physically impact already disrupted land resources (retrofit existing landfills with gas collection systems), slightly change the footprint of planned disruptions to land resources (requiring new landfills to include gas collection systems), or improve the efficiency of existing gas collection systems.

(RW-3) High Recycling/Zero Waste 9 $MMTCO_2E$

Commercial Recycling recommends developing voluntary commercial recycling goals. Benefits to land resources are related to avoiding new landfills and to avoiding production of raw materials.

Increasing Production and Markets for Compost recommends halving the amount of organic material diverted to landfills by creating compost instead. This would require development of new facilities or expansion of existing facilities that produce compost. Siting can be difficult for these facilities because of the nature of their operations and their associated dust and odors. Some facilities are sited at a landfill site, which minimizes their potential individual impact. Land use impacts would be similar to siting of other facilities, and would be best evaluated on a project-level basis.

The **anaerobic digestion** of human, animal, or wet organic wastes reduces the physical amount of waste and improves the quality of the waste for disposal, requiring less land for disposal. Minimal land is required for construction of anaerobic digestion facilities.

Extended Producer Responsibility proposes to incorporate the costs of treatment and disposal into the total cost of a product. This should result in environmentally preferable products, as manufacturers seek to reduce overall product costs by minimizing treatment and disposal costs. **Environmentally Preferable Purchasing** would encourage the purchase of environmentally preferable products, products which use less energy, water, virgin materials and hazardous chemicals to produce. These measures intent is to reduce environmental impacts of product manufacturing. Because of the broad spectrum of products, and the geographical extent of extraction and manufacturing, it is not possible to specifically describe potential benefits to land

resources in California, although some of these benefits would be the reduced demand for landfills and reduced demand for virgin materials.

7. FORESTS

(F-1) Sustainable Forest Target 5 $MMTCO_2E$

This measure recommends establishing and implementing a target to sustain current levels of net carbon sequestration in the State's forests through maintenance of forest inventory and growth rates, reforesting areas lost to wildfires, and improving forest management to reduce the risk of wildfires in the state. Forestation provides many benefits to land resources, reducing the potential for topsoil erosion and landslides, and improving soil quality over deforested areas. Forests also provide valuable habitat, open space, and recreation areas which increase the quality of life for residents. The Sustainable Forest Target (F-1) would be implemented by the **California Board of Forestry and Fire Protection**, working with ARB**.** The Resources Agency and its departments will also have an important role to play in implementing this measure. Activities expected to occur to implement this measure must be evaluated in a functionally equivalent process to **CEQA**, which will ensure that potential impacts to land resources are examined.

8. HIGH GWP

Regulatory Background

Facilities that use refrigerants or make products containing refrigerants are regulated the same as the Industry sector. Waste products are regulated as described in the Recycling and Waste Management sector.

(H-1) Motor Vehicle Air Conditioning Systems: Reduction of Refrigerant Emissions from Non-Professional Servicing 0.26 $MMTCO_2E$

The primary purpose of this Discrete Early Action is to reduce the emissions of the high GWP gas HFC-134a from activities associated with DIY charging. It is not expected to affect land resources as it is not expected to affect the number of vehicles or of professional service shops.

(H-2) SF_6 Limits in Non-Utility and Non-Semiconductor Applications 0.3 $MMTCO_2E$

This Discrete Early Action measure will consider a potential ban on the use of SF_6 where technologically feasible and cost-effective alternatives are available, as well as a performance standard for other uses. The use of replacement gases is not expected to result in the need for new facilities or in the change of existing facilities; therefore, there are no land resource effects.

(H-3) High GWP Reduction in Semiconductor Manufacturing 0.15 $MMTCO_2E$

This measure recommends requiring manufacturers to use process optimization, alternative chemistries, and abatement technologies in combination or separately to reduce high GWP emissions from semiconductor manufacturing. These changes would occur on existing fabricator sites and would not affect land resources.

(H-4) Limit High GWP Use in Consumer Products 0.25 $MMTCO_2E$

The objective of this measure is to reduce the use of compounds in consumer products with high GWP when alternatives are available. These changes would occur on existing manufacturing sites and would not affect land resources.

(H-5) High GWP Reductions from Mobile Sources 3.3 $MMTCO_2E$

All of these measures recommend reducing leaks from refrigerant uses in stationary applications. These changes would not affect land resources because they would occur within existing commercial sites.

(H-6) High GWP Reductions from Stationary Sources 10.9 $MMTCO_2E$

Two measures are proposed as the **High GWP Stationary Equipment Refrigerant Management Program.** The **Refrigerant Tracking/Reporting/Repair/Deposit Program** measure recommends requiring commercial and public facilities with large stationary air conditioning and refrigeration equipment to minimize emissions of high GWP refrigerants through reporting, leak repair, improved servicing, and end-of-life control. The **Specifications for Commercial and Industrial Refrigeration Systems** measure proposes new specifications for commercial and industrial refrigeration systems to both reduce emissions of high GWP refrigerant and to increase energy efficiency of the units. These changes would occur on existing commercial and industrial sites and would not affect land resources.

Insulation foam that is diverted to landfills emits high GWP gases into the atmosphere. The **Foam Recovery and Destruction Program** measure recommends minimizing these emissions to as close to zero as possible by diverting waste foam away from landfills and destroying the foam at high temperatures, or by capturing the high-GWP GHGs within the foam and destroying the foam gas. This program would utilize existing facilities and would therefore not affect land resources.

The **SF_6 Leak Reduction and Recycling in Electrical Applications** measure recommends reducing emissions of SF_6 within the electric utility sector and at particle accelerators by requiring the use of best achievable control technology for the detection and repair of leaks, and the recycling of SF_6. Additionally, particle accelerator industry representatives are considering the use of possible substitute mediums. These changes would occur within existing facilities and would not affect land resources.

The **Alternative Suppressants in Fire Protection Systems** measure recommends evaluating the use of alternative suppressants in total flooding (fixed) and streaming (portable) fire suppression systems. The use of alternative suppressants is expected to have only minor operational impacts at existing commercial and residential sites; therefore, the measure would not affect land resources.

The **Residential Refrigeration Early Retirement Program** measure recommends partnering with existing voluntary programs to retire inefficient residential refrigeration appliances such as refrigerators and freezers. Appliance early retirement includes the recovery of high-GWP refrigerants and blowing agents for reclamation or destruction to avoid GHG emissions. This program would utilize existing facilities and would therefore not affect land resources.

(H-7) Mitigation Fee on High GWP Gases 5 $MMTCO_2E$

This measure recommends attaching a fee to the use of high GWP gases. This measure would support the goals and therefore have similar effects as Measures H-1 through H-6.

9. AGRICULTURE

Regulatory Background

Before a facility can be constructed, it must obtain permits to emit air pollutants, use water resources, and to develop land. Applicable regulations are described in the Industry Sector.

(A-1) Methane Capture at Large Dairies 1.0 $MMTCO_2E$

Methane from dairy manure can be captured through the installation and use of anaerobic digesters. This measure recommends installing anaerobic digesters on new and existing dairies, 89 percent of which are located in the Central Valley. Anaerobic digesters may not be compatible with agricultural land uses or Williamson Act contracts. New digesters would go through environmental review and permitting for compatibility with existing land resources.

10. SUMMARY

Measures recommended by the Scoping Plan interact with land resources in several ways. Regional transportation-related GHG targets and Green Building principles have the potential to reduce the impact of urban development and reduce the potential for conversion of agricultural lands and open spaces. Renewable energy resources have the potential to use more land mass to generate electricity, but some types of renewables have fewer overall environmental impacts than traditional natural gas and coal. New facilities constructed to serve alternative fuel demands will also require land resources. Regulatory development could encourage the appropriate siting of any new facilities within appropriate zoning areas and in compliance with ARB's Land Use Handbook principles.

Locally, new construction or modifications would comply with local land use regulations and permitting obligations. Development of a High Speed Rail line through California should be pursued in a way that minimizes the potential for conversion of existing agricultural lands and that encourages Smart Growth and Green Building principles.

C. WATER RESOURCES

Surface water quality around the state qualifies as impaired under the Clean Water Act. Population trends will add to these stresses by adding demand for water supplies, food supplies, and wastewater services. Development creates impervious surfaces which contribute to flood and water quality problems. Development in flood plains exacerbates flooding and increases the risk of property damage and loss of life.

Regulatory Background

Water resources, both supply and quality, are regulated at both the federal and state levels. Federal Laws and Regulations include:

The **Clean Water Act** (33 U.S.C. §1251 et seq.) serves to protect the nation's surface waters. As part of the Clean Water Act, the federal government develops water quality standards to protect aquatic and human life (including recreational use) which are enforced by the state. The state then identifies surface waters that do not meet standards, prioritize their remedies, and develop mass-based loading programs to improve water quality (§303, Total Maximum Daily Load program). The federal government also certifies that projects will not impair water quality (§404) and requires that waters discharged into surface waters meet prescribed standards (National Pollutant Discharge Elimination Source program).

Section 10 of the **Rivers and Harbors Act** (33 U.S.C. §401 et seq.) protects navigable rivers and harbors, requiring federal permits to make physical changes.

State Laws and Regulations include:

The California Department of Fish and Game Code (§1601–1603 [**Streambed Alteration**]) protects aquatic species by requiring a state permit to physically alter stream or lake beds or banks.

The **Porter-Cologne Water Quality Act** (Water Code §13000 et seq.) authorizes the state to implement the Clean Water Act in California.

Cobey-Alquist Flood Plain Management Act (Water Code §8400 et seq.) authorizes the Board that directs state flood control activities and requires permits for encroachments in known flood plains to minimize flood impacts.

A mix of local governments, special districts, and private companies provide water and wastewater services in California. These service providers have their own process for determining how new demands for water or wastewater services can or should be provided. **Senate Bills 610 and 221 (2001)** require development projects to demonstrate that water is available to reliably support the project.

Evaluation Process

Where possible, existing studies, environmental documentation, and regulatory documentation for measures were reviewed for pertinent information. Documentation and studies for existing activities were used to estimate expansion of those types of activities. Where no information was

available, ARB consulted experts at state agencies, including at ARB and Climate Action Team agencies. More detailed information about the proposed regulations and the measures under evaluation is provided in Appendix C of the Scoping Plan, as well as in the discussion of the potential impact on air resources.

1. CALIFORNIA CAP-AND-TRADE PROGRAM LINKED TO WESTERN CLIMATE INITIATIVE

The recommended measure is not expected to have any adverse impacts on water resources. Instead, we expect the declining cap to incentivize utilities to promote local conservation programs to reduce water demand and wastewater discharge. These programs would in turn reduce load demand on public utilities that would otherwise provide electricity for pumping and treatment.

2. TRANSPORTATION

(T-1) Pavley I and Pavley II-Light-Duty Vehicle GHG Standards 31.7 $MMTCO_2E$
Feebates – In-lieu of Pavley Regulations 31.7 $MMTCO_2E$
(T-4) Vehicle Efficiency Measures 4.5 $MMTCO_2E$

At times, the refining, marketing and distribution of gasoline adversely affects water quality due to leaks, spills, and wastewater discharge. Any reduction in fuel use would reduce the opportunity for such occurrences. Consequently, ARB staff projects that the proposed measure would likely have a positive impact on water quality.

(T-2) Low Carbon Fuel Standard 15 $MMTCO_2E$

For this evaluation, ARB compared the potential water resources effects of the LCFS to traditional petroleum fuels. Refinement of crude oil in California consumes 1.5 gallons of water per gallon of gasoline produced.[74] Crude oil is imported from foreign sources (45 percent), Alaska (16 percent), and in-state sources. The two largest uses of water associated with oil production are for drilling and for enhanced recovery. Drilling for crude oil does require water use to form drilling muds, which are used to lift drill cuttings to the surface. These muds contain fine clays, which are often not allowed to be disposed of directly in surface waters, and require treatment prior to disposal. Some crude oils are too heavy to flow, so steam is injected in the vicinity to thin the oil – an enhanced recovery process requiring both water and energy.

The majority of the potential LCFS pathways are evaluated below. The electrification pathway (plug-in electric vehicles) is addressed in the energy section, under the proposed RPS measure.

Biofuels: Water use at biorefineries can vary. Fermentation requires water for hydrolysis, fermentation, and distillation processes, currently around 4 gallons of water consumed per gallon of ethanol produced.[75] Cellulosic feedstocks are broken down with enzyme additions prior to fermentation, generally more water intensive on the whole, but projected to actually consume 2 to 6 gallons of water per gallon of ethanol produced.[76] Biodiesel refining is the least water intensive, consuming around 1 gallon of water per gallon of biodiesel produced.[77] Also, wastewater from biorefineries can contain high levels of biological oxygen demand (BOD)

[74] Pate, R., M.Hightower, C.Cameron, and W.Einfeld,. *Overview of Energy-Water Interdependencies and the Emerging Energy Demands on Water Resource,*. Report SAND 2007-1349C, Los Alamos, NM: Sandia National Laboratories, 2007.
[75] Ibid.
[76] Ibid.
[77] Ibid.

grease and salts. Some facilities in the Midwest have been cited for breaching the limits allowed under the National Pollutant Discharge Elimination System permits the facilities are required to hold.

But the greatest potential impact on water resources by biofuels is the production of feedstock. Agriculture in the United States relies on a mixture of natural rainfall and irrigation, the ratio of which depends on the local climate. Irrigation practices can have a very large effect on the overall water consumption by biofuels. Just as irrigation water demand is highly dependent on location, so is the impact of that water demand. In addition to water demand, the chemicals and fertilizers used on these crops can end up in surface or ground waters, effecting water quality. These issues will be further discussed in the LCFS regulatory development.

The location of these water demands determines their ultimate effect. In the Midwest, where much of the corn and soy beans are grown, historic overdraw of groundwater resources and high organic loading of surface waters would suggest that the additional water demand of biofuel production and increase nitrogen loading of feedstock production could impact existing water resources.

Hydrogen: Hydrogen fuel can be created from water (through electrolysis) or from hydrocarbon sources such as natural gas, methanol, or petroleum products (steam reforming). Steam reformation of natural gas is the most common form of hydrogen production in the United States.[78] Each of these processes uses water: in electrolysis energy is used to break apart water bonds to create hydrogen, in reforming steam is used to break apart hydrocarbon bonds. The consumptive water resource requirements for these processes are not well documented, but given the pressures on California's water supplies, these requirements should be quantified within the LCFS regulatory process or within the siting process for hydrogen production facilities.

(T-5) Ship Electrification at Ports 0.2 MMTCO_2E

(T-6) Goods Movement Efficiency Measures 3.5 MMTCO_2E

At times, the refining, marketing and distribution of diesel and gasoline adversely affects water quality due to leaks, spills, and wastewater discharge. Any reduction in fuel use would reduce the opportunity for such occurrences. Consequently, the recommended goods movement measures that result in reduced fuel consumption would have a positive impact on water quality. Redirected effects due to electrification are addressed in the energy section.

One maintenance practice to be considered in the commercial harbor craft measure is the use of anti-fouling products on the hulls to improve hull smoothness. The active ingredient of a number of anti-fouling products is copper. The copper is slowly leached out of the product and thereby inhibits the growth of species that foul vessel hulls. The potential adverse impacts are associated with the leached copper, particularly in harbors and marinas that are relatively shallow and experience a reduced level of water circulation. The use of anti-fouling products containing copper could negatively impact water quality. ARB staff would promote the use of non-toxic anti-fouling products by vessel owner/operators and educate them about the dangers associated with other products. With non-toxic products, a vessel owner/operator would have to clean the hull more frequently than if they were to use copper-based anti-fouling products. However, non-toxic products do not need to be reapplied as often as copper-based products.

[78] U.S. Department of Energy. http://www1.eere.energy.gov/hydrogenandfuelcells/education/basics_production.html

(T-7) Heavy Duty Vehicle GHG Emission Reduction – Aerodynamic Efficiency 0.93 $MMTCO_2E$

(T-8) Medium and Heavy-Duty Vehicle Hybridization 0.5 $MMTCO_2E$

There are no anticipated changes to land use as a result of measures T-6 and T-8, as these measures would not affect the total number of vehicles in the state or the overall use of fuel. Measure T-7, however, is anticipated to result in 48 million gallons of avoided diesel use. This would have upstream impacts on water quality similar to measures T-1 and T-3.

(T-3) Regional Transportation-Related Greenhouse Gas Targets 5 $MMTCO_2E$

Under this measure ARB would work with MPOs to establish passenger vehicle greenhouse gas emission reduction targets (regional targets) for 2020 and 2035. The specific water resource impacts of particular land use and transportation strategies applied to implement this measure would be evaluated under existing applicable regulatory structures as they are triggered, including CEQA. Generally, this measure encourages more compact development patterns and reduced vehicle use. In so far as compact development patterns reduce traditional large lot development patterns, this measure has the potential to significantly reduce water demand from landscaping, as well as reduce future degradation of surface water quality associated with impervious surfaces. Reductions in vehicle use from this measure could also have water resource benefits similar to measures T-1 and T-3, due to avoided fuel use.

(T-9) High Speed Rail 1 $MMTCO_2E$

The Scoping Plan supports the implementation of a high speed rail system. The recommended HSR program has undergone environmental review under CEQA and NEPA. ARB reviewed this documentation for its water resources analysis. The programmatic EIR/EIS examined the impacts of the High Speed Rail on existing water resources. The impacts are typical of a large-scale infrastructure project, and would have to minimize and mitigate impacts in order to obtain appropriate approvals and permits. Impacts would be less than those associated with an equivalent expansion of highway infrastructure.

3. ELECTRICITY AND NATURAL GAS

Electricity and water are intricately linked in California. Many forms of electricity production require water for steam generation or cooling or use water resources directly as in hydropower and geothermal projects. As water resources are limited in California, technological advances have optimized and minimized water use. Electricity is also used to power the state's water system – transporting water from its source to where it is used, and for heating water for residential, commercial, and industrial uses. The measures recommended in the Scoping Plan for the electricity sector were analyzed for direct and indirect effect on water resources, but electricity savings were not translated into water savings. It is possible that electricity savings will result in water savings, but ARB did not quantify these potential savings.

Regulatory Background

For large energy facilities, the **CEC Certification process** serves as an equivalent to the otherwise required state and local permitting requirements. The CEC has authority to certify (permit) the construction and operation of thermal electric power plants 50 megawatts or larger and all related facilities. The site certification process provides a review and analysis of all aspects of a proposed project, including water supply availability and wastewater impacts, equivalent to the CEQA process. The process is also a public process. Smaller facilities with no

potentially significant environmental impacts can apply for an exemption process, similar to a mitigated negative declaration approach under CEQA.

The CEC works with local governments to ensure a functionally equivalent permitting process. CEC prepare the necessary evaluation in a "Preliminary Staff Assessment", working with the local government to ensure it provides the information needed for the local and state governments to approve the project and either serves as the appropriate permit or basis for the appropriate permit.

SWRCB's "**Water Quality Control Policy on the Use and Disposal of Inland Waters Used for Powerplant Cooling**" (Order No. 75-58) encourages the use of alternative sources of cooling water and/or the use of alternative cooling technology. Alternative sources of cooling water identified in the policy include wastewater, irrigation return flows, and naturally brackish water. The policy also encourages the evaluation of dry or wet/dry cooling technology for those facilities that may require water from the Sacramento-San Joaquin River Delta.

(E-1) Energy Efficiency (Electricity) 15.2 MMTCO$_2$E
(CR-1) Energy Efficiency (Natural Gas0 4.3 MMTCO$_2$E

The California Energy Commission has authority to set efficiency standards for appliances and buildings that include water. Some types of appliance achieve their energy savings partially through reducing the amount of water used, such as washing machines and dishwaters, which are significant contributors to household water demand; some appliances are also used in commercial settings. These types of measures, provided the water-energy linkage continues to hold, are more likely to reduce water use than to increase it.

Water efficiency and conservation can also result in energy efficiency and conservation, lowering the need for energy to heat or cool water, or electricity to move water. Decreases in fossil-fired electricity use could slightly decrease demand for water associated with fossil-fired electricity production. Reductions in water demand can reduce the electricity associated with the transport, treatment and delivery of water.

(CR-2) Solar Water Heating 0.1 MMTCO$_2$E

These measures are expected to have minimal effect on water resources. Although photovoltaic systems require periodic washing, the impact on water resources is expected to be very small.

(E-4) Million Solar Roofs 2.1 MMTCO$_2$E

These measures are expected to have minimal effect on water resources. Although photovoltaic systems require periodic washing, the impact on water resources is expected to be very small. Decreases in fossil-fired electricity use could slightly decrease demand for water associated with fossil-fired electricity production.

(E-2) Increase Combined Heat and Power 6.7 MMTCO$_2$E

The potential impacts on water resources from this recommended measure depends on the technology(ies) deployed. If a combined heat and power system, including its air pollution control technologies, is more efficient than the electricity source it is replacing, water use could decrease. It is not possible to quantify this effect, but ARB recommends that the potential water resource impacts be considered in development of this measure.

(E-3) Renewables Portfolio Standard 21.3 MMTCO$_2$E

This recommended measure would increase the overall percentage of renewable energy sources such as wind, solar, biomass and geothermal, of each utility's energy sources. This requirement could be met through any potential mixture of renewable energy sources, and will most likely be driven by a number of factors, including the availability of renewable sources within the geographic region of each utility. For these reasons the benefits and impacts of each renewable resources are evaluated relative to natural gas, and are not individually quantified for potential air emissions.

Water use for energy production is trending away from freshwater resources and toward recycled water or air cooling processes. Wastewater is also transitioning from surface water disposal towards disposal to municipal wastewater facilities or the elimination of wastewater altogether. For comparison purposes, the 2007 Environmental Performance Report examined water use by plant type and cooling system. Combined-Cycle natural gas plants with re-circulating wet cooling consume 676 to 1,380 gallons per MWh. Dry cooling reduces water use to 50 to 180 gallons per MWh. Peaking plants are generally simple-cycle plants with inlet cooling, and consume 80-600 gallons per MWh. Renewable sources (except hydropower) are generally within or less than the range of combined-cycle natural gas plants with recirculated cooling.

Wind power does not have any associated water use.

Solar thermal plants can be wet or dry cooled. Parabolic trough plants consume 960 to 1,120 gallons per MWh (similar to a wet cooled natural gas plant), while sterling engines consume 4 to 6 gallons per MWh, mostly for mirror washing. Porous surfaces in the project area minimize impacts on surface water storm flows. Solar **photovoltaic** plants require periodic washing but do not require cooling.

Biomass (forest or agricultural residuals) may use water to clean materials prior to combustion. Other water requirements are similar to wet cooled natural gas-fueled plants, 760 to 1,170 gallons per MWh.

The **anaerobic digestion** of human, animal, or wet organic wastes (including wastewaters) may produce a gas with 50 to 80 percent methane (biogas) that can be combusted to produce electricity. Wastewaters are regulated by SWRCB and Regional Water Quality Control Boards to ensure they do not impair surface water or groundwater. Digester projects may need to obtain waste discharge requirements for wastewater discharge if the discharge is not already subject to the permit for a wastewater treatment facility.

Landfill gas (mostly methane) plants using simple-cycle engines consume 80 to 830 gallons per MWh, whereas reciprocating engines consume less than 1 gallon per MWh. Both engines are currently in use, but are both less consumptive than wet cooled natural gas-fueled plants. In the future, use of reciprocating engines should be encouraged to minimize water resource impacts.

Geothermal sources of energy production rely on hot waters and concentrated steams that tend to have high mineral contents. These waters are used to create thermal power and then re-injected into the ground, consuming 8 to 30 gallons per MWh. Geothermal wells are designed to minimize impacts on nearby water resources. Monitoring is usually required to ensure there are no water quality impacts on nearby surface or ground waters.

Small **hydropower** projects are used in locations where water resources are already disturbed. They do not consume additional water resources, impair water quality, or create waste waters.

4. WATER

Regulatory Background

Water infrastructure includes reservoirs, dams, canals, aqueducts, pipelines, pumping stations, and water treatment plants. Before a facility can be constructed, it must obtain permits to emit air pollutants, use water resources, and to develop land. Regarding water resources, new water infrastructure must comply with:

> Water regulated by the state requires a **water right**, which is a lengthy public application process that requires CEQA compliance.
> **CEQA** requires proposed new facilities or significant changes to existing facilities or water operations to analyze and describe the potential for environmental impacts, identify ways to reduce adverse impacts and offer alternatives to the project, and to disclose this information to the public. Water infrastructure is typically constructed by a local, regional, or state government agencies working with other local, regional, or state government agencies to determine who will serve as the lead or responsible agency for a CEQA document. Local, Regional, and State government agencies also both establish guidance for CEQA analyses and review documents for consistency with established plans and regulations. This process examines projects for localized impacts and proposes measures to mitigate significant impacts.

(W-1) Water Use Efficiency 1.4 $MMTCO_2E$

This measure identifies the potential for statewide water use efficiency improvement through implementation of individual i.e. per capita voluntary water conservation goals. Increasing statewide, total water demand can be met through individual end use efficiency improvements (appliances and fixtures that use less water than existing appliances and fixtures) and through individual water conservation (changes to behavior and practices). Water demand is expected to grow under the BAU scenario, but it is not clear precisely what the net change in water demand will be in 2020. Water use efficiency and water conservation will be critical and economical tools for meeting California's diverse water demands in the future. Water conservation can also "harden" water demands, allowing less room for rationing while meeting public health and economic thresholds during extended droughts. Water conservation can also allow for growth of urbanization and development, and the impacts associated with that growth.

(W-2) Water Recycling 0.3 $MMTCO_2E$

This measure proposes to increase water supply reliability to meet increasing demand by recycling water in locations where the energy associated with recycling is less than the energy associated with transporting and treating water. The displacement of 0.37 MAF of new imported water supplies by recycled water supplies would then result in a net energy and water savings. Recycled water is used primarily for landscaping and industrial processes, and is water that would otherwise need to be disposed of, most frequently to a surface water or ocean water. Redirecting this discharge can have positive impacts on receiving water quality.

(W-3) Water System Energy Efficiency 2.0 $MMTCO_2E$

This measure proposes to reduce the amount of energy used to transport, treat and deliver water. ARB expects that this measure will have little to no impact on water resources. Any projects that

have the potential to impact water supply or quality would be subject to CEQA and other permitting requirements.

(W-4) Reuse Urban Runoff 0.2 MMTCO$_2$E

This measure proposes to increase local surface and groundwater supplies by adopting stormwater management strategies, such as Low Impact Development (LID). LID increases infiltration in urban areas increasing regional stormwater capture and storage. Constructing neighborhood facilities to capture and reuse dry weather flows also increases local supply. These water supplies (270,000 - 333,000 acre-feet) can be used to avoid the need for new imported water supplies with higher energy-intensity. These types of actions have the potential to either impact or benefit water resources. Increasing infiltration and capturing dry weather flows can benefit surface waters by reducing diversions, but they can also interrupt the recharge of ground and surface waters. The timing and magnitude of these projects will determine their potential effects on water resources (quantity and quality), and they should be examined and minimized or mitigated on a project by project basis. Recharging ground water basins with urban storm water can also have water quality impacts.

(W-5) Increase Renewable Energy Production 0.9 MMTCO$_2$E

This measure proposes to develop renewable energy projects on lands associated with California's state and local water infrastructure. The potential water impacts associated with these types of projects are evaluated in measure E-3.

(W-6) Public Goods Charge for Water TBD MMTCO$_2$E

This measure proposes to impose a monetary charge on water use and use resulting funds to reduce the GHG emissions from water-related energy use, as described in measures W-1 through W-5. Measures W-1 through W-5 are evaluated separately.

5. INDUSTRY

Regulatory Background

Before a facility can be constructed, it must obtain permits to emit air pollutants, use water resources, and to develop land. For water supply, water quality and wastewater, the stationary source must comply with the following:

> To obtain water service, applications are made to the appropriate local water provider or the SWRCB. Depending on the site location, water supply from groundwater may be obtained through well construction. A permit from a local agency is required for well construction. Water administered by a local agency may be obtained through an application process which may or may not require an environmental review. It may also require the facility to prove it meets a specified degree of water conservation. Water regulated by the state requires a **water right**, which is a lengthy public application process that requires CEQA compliance.
> In general, any person responsible for the discharge of waste that could affect the quality of waters of the state that is not discharged to a community sewer system is required to submit a technical report of the discharge to the appropriate **Regional Water Quality Control Board (RWQCB)**. RWQCBs typically prescribe waste discharge requirements (i.e., a "permit") that reflect the nature of any proposed, existing, or material change to an existing discharge. Prescribed requirements must implement the relevant adopted water quality

control plan (i.e., "Basin Plans"). In some cases, RWQCB may "waive" adoption of waste discharge requirements. Such a waiver can only occur when either a specific discharge or type of discharge is consistent with the applicable water quality control plan and such a waiver is in the public interest.

For discharges to a community sewer system, applications are made to the appropriate local wastewater collection (sewer system) and treatment agency. Local wastewater services may require an engineering analysis to support issuance of a **permit to discharge** into the community sewer system.[79] Wastewater discharges from commercial, institutional, and industrial facilities may also be subject to a local agency's wastewater **Pretreatment Program**, which may require additional onsite pre-treatment of industrial wastewaters. Facilities with **Zero-Discharge Waste** systems may also have to obtain a local permit. Facilities that wish to discharge wastewater directly into surface waters must comply with the **National Pollutant Discharge Elimination System (NPDES)** permits issued by a RWQCB. In general, an NPDES permit prescribes discharge requirements that restrict the magnitude and quality of discharges to avoid degradation of the receiving surface water body as necessary to ensure the protection of beneficial uses of water.

Depending on the scale and nature of water and wastewater associated with a facility, waste discharge requirements may incorporate mitigation measures identified in a **CEQA** analysis. CEQA requires proposed industrial facilities to analyze and describe the potential for environmental impacts, identify ways to reduce adverse impacts and offer alternatives to the project, and to disclose this information to the public. A Local, Regional, or State government agency serves as the lead or responsible agency for a CEQA document. Local, Regional, and State government agencies also both establish guidance for CEQA analyses and review documents for consistency with established plans and regulations. This process examines projects for localized impacts and proposes measures to mitigate significant impacts.

(I-1) Energy Efficiency and Co-Benefits Audits for Large Industrial Sources TBD $MMTCO_2E$

This measure is not anticipated to affect water resources, unless measures are identified and implemented that improve energy efficiency through improving water use efficiency.

(I-2) Oil and Gas Extraction GHG Emission Reduction 0.2 $MMTCO_2E$
(I-3) GHG Leak Reduction from Oil and Gas Transmission 0.9 $MMTCO_2E$

These measures are not anticipated to affect water resources, as they address fugitive air emissions.

(I-4) Refinery Flare Recovery Process Improvements 0.33 $MMTCO_2E$

This measure is not anticipated to affect water resources.

[79] In this case, the municipal wastewater treatment plant is the holder of the state permit to discharge to surface waters.

(I-5) Removal of Methane Exemption from Existing Refinery Regulations 0.01 MMTCO$_2$E

This measure would not affect water resources, as methane is an air emission.

6. RECYCLING AND WASTE MANAGEMENT

Regulatory Background

Before a facility can be constructed, it must obtain permits to emit air pollutants, use water resources, and to develop land. Applicable regulations are described in the Industry Sector.

(RW-1) Landfill Methane Control Measure 1.0 MMTCO$_2$E

Landfills are managed to protect the beneficial uses of the waters of the state. Anaerobic decomposition of organic wastes creates byproducts of gaseous methane and carbon dioxide, plus trace gas constituents. Landfill gas collection systems are partially regulated by the RWQCB, as condensate in collection tanks must be collected and properly disposed of (onsite or through municipal wastewater treatment). In addition, the RWQCB requires monitoring of such systems to ensure the protection of beneficial uses of groundwater. Measure RW-1, also a discrete early action, proposes to require collection and control of methane emissions from uncontrolled MSW landfills without landfill gas collection systems and establish statewide standards for the gas collection and control system, including methane destruction efficiency requirements and landfill methane surface emission standards, for all landfills. While this would increase the amount of condensate generated, existing regulations ensure it would be properly disposed of and would therefore not affect water resources.

(RW-2) Additional Reductions in Landfill Methane: Increase the Efficiency of Landfill Methane Capture TBD MMTCO$_2$E

This measure is not anticipated to affect water resources, as this measure proposes to develop best management practices and standards to minimize fugitive methane emissions.

(RW-3) High Recycling/Zero Waste 9 MMTCO$_2$E

Commercial Recycling recommends developing voluntary commercial recycling goals. Benefits to water resources are related to avoiding new landfills and to avoiding production of raw materials.

Increasing Production and Markets for Compost recommends halving the amount of organic material diverted to landfills by creating compost instead. This would require development of new facilities or expansion of existing facilities that produce compost. Other alternatives for organic material diversion from landfills may have consequences or unknown risks to the environment such as water quality impacts. Landfills provide a specified level of protection for waste, such as leachate collection and removal systems, liners and/or groundwater monitoring networks that can detect releases. Compost facilities can produce a leachate that must be collected and appropriately treated to protect water quality and the environment. RWQCBs can issue conditional waivers in lieu of prescribing waste discharge requirements which described operational ways reduce the potential threat to water quality; otherwise the leachate could be subject to permit conditions to protect water quality.
Application of composted materials to agricultural and urban landscapes may increase water retention within the soil profile thereby reducing the water demands, reducing the demand for California's water supplies and resources.

The **anaerobic digestion** of human, animal, or wet organic wastes (including wastewaters) may produce a gas with 50 to 80 percent methane (biogas) that can be combusted to produce electricity. Wastewaters are regulated by SWRCB and RWQCBs to ensure they do not impair surface water or groundwater. Digester projects may need to obtain waste discharge requirements for wastewater discharge if the discharge is not already subject to the permit for a wastewater treatment facility.

Extended Producer Responsibility proposes to incorporate the costs of treatment and disposal into the total cost of a product. This should effectively result in environmentally preferable products, as manufacturers seek to reduce overall product costs by minimizing treatment and disposal costs. **Environmentally Preferable Purchasing** would encourage the purchase of environmentally preferable products, products which use less energy, water, virgin materials and hazardous chemicals to produce. These measures intent is to reduce environmental impacts of product manufacturing. Because of the broad spectrum of products, and the geographical extent of extraction and manufacturing, it is not possible to specifically describe potential benefits to water resources in California, although some of these benefits would be the reduced demand for landfills and reduced demand for virgin materials.

7. FORESTS

(F-1) Sustainable Forest Target 5 MMTCO$_2$E

This measure recommends establishing and implementing a target to sustain current levels of net carbon sequestration in the Forest sector with actions such as reforesting areas lost to wildfires and improving forest management to reduce the risk of catastrophic wildfires in the state. Deforestation from wildfires or overharvesting can have negative impacts on water quality, particularly by introducing silt and organic carbon into surface waters. Silt and organic carbon can change water chemistry and affect water quality. If the measure includes pesticide applications, it would be further analyzed for impacts to water resources. Forests can serve as "filters" to improve water quality entering groundwater basins and surface waters, and play an important role in the hydrologic cycle, removing contaminants from air before they can enter the water phase. Activities expected to occur to implement this measure must be evaluated in a functionally equivalent process to **CEQA**, which will ensure that potential impacts to land resources are examined.

8. HIGH GWP

Regulatory Background

Facilities that use refrigerants or make products containing refrigerants are regulated the same as the Industry sector. Waste products are regulated as described in the Recycling and Waste Management sector.

(H-1) Motor Vehicle Air Conditioning Systems: Reduction of Refrigerant Emissions from Non-Professional Servicing 0.26 MMTCO$_2$E

The primary purpose of this Discrete Early Action is to reduce the emissions of the high GWP gas HFC-134a from activities associated with DIY charging. It is not expected to affect water resources as leaks do not affect water resources and their reduction will not affect the number or operation of vehicles or professional service shops.

(H-2) SF_6 Limits in Non-Utility and Non-Semiconductor Applications 0.3 $MMTCO_2E$

This Discrete Early Action measure will consider a potential ban on the use of SF_6 where technologically feasible and cost-effective alternatives are available, as well as a performance standard for other uses. The use of SF_6 or its replacement gases do not interact with water resources, and the manufacture of replacement gases is not expected to affect water resources.

(H-3) High GWP Reduction in Semiconductor Manufacturing 0.15 $MMTCO_2E$

This measure recommends requiring manufacturers to use process optimization, alternative chemistries, and abatement technologies in combination or separately to reduce high GWP emissions from semiconductor manufacturing. These changes would occur within existing fabricator processes and would not affect water resources.

(H-4) Limit High GWP Use in Consumer Products 0.25 $MMTCO_2E$

The objective of this measure is to reduce the use of compounds in consumer products with high GWP when alternatives are available. These changes would occur on existing manufacturing sites and would not affect water resources.

(H-5) High GWP Reductions from Mobile Sources 3.3 $MMTCO_2E$

Each of these measures recommends ways to reduce leaks from refrigerant uses in mobile applications. These changes would not affect water resources because liquid refrigerants evaporate quickly at room temperature.

(H-6) High GWP Reductions from Stationary Sources 10.9 $MMTCO_2E$

Each of these measures recommends ways to reduce leaks from refrigerant uses in stationary applications. These changes would not affect water resources because liquid refrigerants evaporate quickly at room temperature.

(H-7) Mitigation Fee on High GWP Gases 5 $MMTCO_2E$

This measure recommends attaching a fee to the use of high GWP gases. This measure would support the goals and therefore have similar effects as Measures H-1 through H-6.

9. AGRICULTURE

Regulatory Background

Before a digester can be constructed, it must obtain permits to emit air pollutants, use water resources, and to develop land. The majority of dairies that are potentially affected by this measure are located in the Central Valley, where they rely on either underlying groundwater or purchased contract water through Irrigation Districts. Dairy wastewater management is regulated by the applicable RWQCB, which will generally require a **Waste Discharge Requirement (WDR)**, dictating how wastewater on the site will be managed. The WDR will require a **CEQA** review.

(A-1) Methane Capture at Large Dairies 1.0 $MMTCO_2E$

Methane from dairy manure can be captured through the installation and use of anaerobic digesters. This measure recommends installing anaerobic digesters on new and existing dairies, 89 percent of which are located in the Central Valley. Anaerobic digestion produces both liquid and solid wastes. Liquid wastes are generally added to existing dairy manure ponds, and

managed to meet the water quality management requirements prescribed by a WDR for the system. WDRs ensure that water resources are not impacted.

10. SUMMARY

Recommended measures within the Scoping Plan would not substantially benefit or impact statewide water resources. Reducing the use of fossil-fuels reduces the use of water in extraction and refining processes, as well as reducing risks of water body contamination during transportation. Smart growth principles encourage reducing development impacts on water resources. Water use efficiency and conservation measures were accounted for in the Business As Usual Scenario. All of the sectors described interact with water in some way, and some contribute to existing water quality problems (NOx deposition from cooling towers, nitrogen runoff from agriculture). In many cases, actions to reduce GHGs will also reduce potential water pollutants. Many of the measures will require further evaluation of water resource effects within their regulatory development.

Construction activities and facilities that either use raw water or produce waste water will have to comply with existing regulations to minimize impacts to water resources.

D. NATIVE SPECIES AND BIOLOGICAL RESOURCES

Currently there are 58 species on the endangered list in California. A growing population and associated development will also continue to stress California's native species and biological resources, by removing or impairing habitat, or severing habitat corridors. By 2020 several listed or endangered species have the potential to become extinct due to the continued degradation of the natural system. Pressures from population growth come from the development of land for population support infrastructure, the overharvesting of food species, the introduction of invasive species and predation by household pets, and other disturbances to natural features, like the alteration of stream flows.

The Attorney General suggested that it is difficult to provide a general statement regarding the impacts the changing climate has on the state's varied ecosystems. It is clear that rising temperatures, altered water supplies, and other environmental variations make some habitats less hospitable for sensitive plants and animals.

Regulatory Background

Native species and biological resources include native and introduced aquatic and terrestrial species, plants, and their habitats. Biological resources are regulated at both federal and state levels, and many water resource regulations also protect biological resources. These regulations help protect and recover resources, by requiring special review and permits of actions that may impact those resources.

Federal Laws and Regulations include:

> The **Endangered Species Act (ESA)** (16 U.S.C. 1531–1543) established a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The U.S. Fish and Wildlife Service (FWS) of the Department of the Interior maintains a worldwide list which includes 1574 endangered species (599 are plants) and 351 threatened species (148 are plants). Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. The law requires federal agencies, in consultation with FWS and/or the U.S. National Oceanic and Atmospheric Administration (NOAA) Fisheries Service, to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species. The law also prohibits any action that causes a "taking" of any listed species of endangered fish or wildlife.[80]
>
> The **Fish and Wildlife Coordination Act** (16 U.S.C. 661–666) requires government agencies to consult with FWS prior to modifying the waters or channel of a body of water, with a view to the conservation of wildlife resources. The Act also authorizes land and water acquisition by federal construction agencies for wildlife conservation and development.

[80] http://www.epa.gov/lawsregs/laws/esa.html

The **Coastal Zone Management Act** (16 U.S.C. 1456) establishes federal programs for the management of the nation's coastal resources and the Great Lakes in order to balance economic development with environmental conservation, and for the study of human influences on estuaries. The programs are administered by NOAA's Office of Ocean and Coastal Resource Management (OCRM).

State Laws and Regulations include:

The **California Endangered Species Act (CESA)** (Fish and Game Code §2050 et seq.) was enacted to protect or preserve all native species of fishes, amphibians, reptiles, birds, mammals, invertebrates, and plants, and their habitats, threatened with extinction and those experiencing a significant decline which, if not halted, would lead to a threatened or endangered designation. The Department of Fish and Game (DFG) is charged with enforcing the Act and with issuing permits authorizing incidental "take" to otherwise lawful development projects.

The **Native Plant Protection Act** (Fish and Game Code §1900–1913) was enacted to preserve, protect and enhance endangered or rare native plants of this state. Habitats are threatened with destruction, drastic modification, or severe curtailment, or because of commercial exploitation or by other means, or because of disease or other factors. DFG maintains a list of protected plants and negotiates agreements to protect threatened plants.

The **Natural Community Conservation Planning Act** (Fish and Game Code §2800 et seq.) expands the Endangered Species Act to conserve natural communities at the ecosystem scale while accommodating compatible land use. The program seeks to anticipate and prevent the controversies and gridlock caused by species' listings by focusing on the long-term stability of wildlife and plant communities and including key interests in the process. This program is implemented by DFG.

The **California Coastal Act** (Public Resources Code §30000, et seq.) is California's version of the federal Coastal Zone Management Act. To protect California's coastal resources, the California Coastal Commission reviews all proposed construction in the defined coastal zone.

Process of Evaluation

Where possible, existing studies, environmental documentation, and regulatory documentation for measures were reviewed for pertinent information. Documentation and studies for existing activities were used to estimate expansion of those types of activities. Where no information was available, ARB consulted experts at State agencies, including ARB and Climate Action Team agencies. More detailed information about the proposed regulations and the measures under evaluation is provided in Appendix C of the Scoping Plan, as well as in the discussion of the potential impact on air resources.

1. CALIFORNIA CAP-AND-TRADE PROGRAM LINKED TO WESTERN CLIMATE INITIATIVE

No direct impacts from the recommended measure were identified at this time that could adversely affect plant or animal species or the resources on which they rely as a result of a compliance-based trading program that complies with AB 32 requirements. Indirect impacts of this proposed measure would be evaluated as part of the rule development process.

2. TRANSPORTATION

(T-1) Pavley I and Pavley II-Light-Duty Vehicle GHG Standards 31.7 $MMTCO_2E$
Feebates – In-lieu of Pavley Regulations 31.7 $MMTCO_2E$
(T-4) Vehicle Efficiency Measures 4.5 $MMTCO_2E$

At times, the refining, marketing and distribution of gasoline adversely affects water quality due to leaks, spills, and wastewater discharge. These water quality impacts can also impair important habitat, or interfere with critical life-cycles of native species. Any reduction in fuel use would reduce the opportunity for such occurrences. Consequently, ARB staff projects that the proposed measures could have a positive impact on biological resources.

(T-2) Low Carbon Fuel Standard 15 $MMTCO_2E$

At times, the refining, marketing and distribution of petroleum fuels adversely affects water quality due to leaks, spills, and wastewater discharge. These water quality impacts can also impair important habitat, or interfere with critical life-cycles of native species. Any reduction in petroleum fuel use would reduce the opportunity for such occurrences.

Some biofuels feedstocks have the potential to affect native species and biological resources, if feedstocks are produced though conversion of important habitat to agriculture or increase agricultural activities in species' corridors.

Hydrogen production and use should have little or no affect on native species and biological resources outside of any potential effects from its energy and water source.

(T-5) Ship Electrification at Ports 0.2 $MMTCO_2E$
(T-6) Goods Movement Efficiency Measures 3.5 $MMTCO_2E$

Ports affect the coastal and ocean environments, intersecting with shallow aquatic habitat and species, pelagic species including migrating mammals, and bird species. Some of these species are endangered or threatened. Species and habitats can be impacted by physical activity within or changes to their habitat, water quality degradation through wastes and accidental discharges, and through the introduction of invasive species by international vessels. Ports regularly undertake programmatic and project-level CEQA documentation for their proposed activities, and many coastal environments in California have special environmental regulations and oversight.

One maintenance practice to be considered in the commercial harbor craft measure is the use of anti-fouling products on hulls to improve hull smoothness. The active ingredient of a number of anti-fouling products is copper. The copper is slowly leached out of the product and thereby inhibits the growth of species that foul vessel hulls. The potential adverse impacts to biological resources are associated with the leached copper, particularly in harbors and marinas that are relatively shallow and experience a reduced level of water circulation. The use of anti-fouling products containing copper could negatively impact biological resources. ARB staff would

promote the use of non-toxic anti-fouling products by vessel owner/operators and educate them about the dangers associated with other products. With non-toxic products, a vessel owner/operator would have to clean the hull more frequently than if they were to use copper-based anti-fouling products. However, non-toxic products do not need to be reapplied as often as copper-based products.

The recommended goods movement measures are to improve efficiencies in port activities to reduce GHG emissions. Many of these efficiencies could result in reduced fossil-fuel combustion. Reduced fossil-fuel combustion at ports has similar potential benefits described in the evaluation of measures T-1 and T-3. Improvements in ocean and harbor vessels could also potentially reduce regular and accidental discharges to water.

(T-7) Heavy Duty Vehicle GHG Emission Reduction – Aerodynamic Efficiency 0.93 MMTCO_2E

(T-8) Medium and Heavy-Duty Vehicle Hybridization 0.5 MMTCO_2E

Measures T-7 and T-8 are not expected to affect native species or biological resources, as they are not expected to change the number of vehicles in 2020. Measure T-7 is estimated to avoid some fossil-fuel combustion, and in that respect could have benefits similar to measures T-1 and T-3.

(T-3) Regional Transportation-Related Greenhouse Gas Targets 5 MMTCO_2E

Under this measure ARB would work with MPOs to establish passenger vehicle greenhouse gas emission reduction targets (regional targets) for 2020 and 2035. The specific land resource impacts of particular land use and transportation strategies applied to implement this measure would be evaluated under existing applicable regulatory structures as they are triggered, including CEQA. Generally, this measure encourages more low impact, compact growth in urban areas that can also emphasize biological-species friendly development, incorporation of wildlife corridors, conservation of open spaces and valuable habitat, and reduced overall footprint. These types of activities would benefit biological resources and native species directly. Indirectly, reducing impacts on water quality and air quality could also benefit biological resources and native species.

(T-9) High Speed Rail 1 MMTCO_2E

The Scoping Plan supports the implementation of a high speed rail system. The recommended HSR program has undergone environmental review under CEQA and NEPA. ARB reviewed this documentation for its analysis of biological resources. The programmatic EIR/EIS examined the impacts of the High Speed Rail on biological resources at a statewide level, finding that the HSR has the potential for significant impacts on biological resources and wetlands. This is largely due to the need for new infrastructure corridors in areas of biological resources. The PEIR/EIS identifies program design, mitigation, and further evaluation strategies to minimize these impacts.

3. ELECTRICITY AND NATURAL GAS

Regulatory Background

For large energy facilities, the **CEC Certification process** serves as an equivalent to the otherwise required state and local permitting requirements. The CEC has authority to certify (permit) the construction and operation of thermal electric power plants 50 megawatts or larger

and all related facilities. The site certification process provides a review and analysis of all aspects of a proposed project, including water supply availability and wastewater impacts, equivalent to the CEQA process. This is also a public process. Smaller facilities with no potentially significant environmental impacts can apply for an exemption process, similar to a mitigated negative declaration approach under CEQA.

The CEC works with local governments to ensure a functionally equivalent permitting process. CEC prepare the necessary evaluation in a "Preliminary Staff Assessment", working with federal, state, and local government to ensure it provides the information needed for the respective agencies to approve the project and either serves as the appropriate permit or basis for the appropriate permit.

SWRCB's "**Water Quality Control Policy on the Use and Disposal of Inland Waters Used for Powerplant Cooling**" (Order No. 75-58) encourages the use of alternative sources of cooling water and/or the use of alternative cooling technology. Alternative sources of cooling water identified in the policy include wastewater, irrigation return flows, and naturally brackish water. The policy also encourages the evaluation of dry or wet/dry cooling technology for those facilities that may require water from the Sacramento-San Joaquin River Delta. A fundamental purpose of this regulation is to protect species from impingement and entrainment by cooling tower intakes and from thermal discharges of cooling towers.

(E-1) Energy Efficiency (Electricity) 15.2 MMTCO_2E
(CR-1) Energy Efficiency (Natural Gas) 4.3 MMTCO_2E

These measures are not expected to directly affect native species or biological resources. Avoided demand for electricity would potentially result in a reduction of the number of power plants constructed in the future, some of which may have developed in areas with important habitat.

(CR-2) Solar Water Heating 0.1 MMTCO_2E

This measure is not expected to affect native species or biological resources, as they are located in developed areas. Avoided demand for electricity would potentially result in a reduction of the number of power plants constructed in the future, some of which may have developed in areas with important habitat.

(E-4) Million Solar Roofs 2.1 MMTCO_2E

This measure is not expected to directly affect native species or biological resources, as they are located in developed areas. Avoided demand for electricity would potentially result in a reduction of the number of power plants constructed in the future, some of which may have developed in areas with important habitat.

(E-2) Increase Combined Heat and Power 6.7 MMTCO_2E

This recommended measure would not directly impact native species or biological resources, as CHP systems would be installed in existing facilities. Avoided demand for electricity could potentially result in a reduction of the number of power plants constructed in the future, some of which may be developed in areas with important habitat.

(E-3) Renewables Portfolio Standard 21.3 MMTCO$_2$E

This recommended measure would increase the overall percentage of renewable energy sources such as wind, solar, biomass and geothermal, of each utility's energy sources. This requirement could be met through any potential mixture of renewable energy sources, and will most likely be driven by a number of factors, including the availability of renewable sources within the geographic region of each utility. For these reasons the benefits and impacts of each renewable resources are evaluated relative to natural gas, and are not individually quantified for potential air emissions.

Wind, solar, and geothermal facilities are located where they can best harness these resources, often in rural areas. Although biological resources and native species are best addressed on a project-level basis, a higher-level analysis indicates that projects in rural areas and using greater amounts of land have a significantly greater potential for impacts than their urban, small acreage counterpoints.

Wind energy projects have potential direct and indirect impacts to birds and bats, including death. Siting and design of wind turbines and related infrastructure can minimize potential impacts. Advances in turbine and wind farm design have resulted in the use of fewer, more powerful turbines and better protection for birds. Wind project developers can also use guidelines developed by the California Energy Commission and the California Department of Fish and Game to evaluate and minimize these impacts.

A solar thermal plant requires around 50 times more land than combined-cycle natural gas-fueled power plant per MW. Construction activities associated with solar thermal plants disturb the land, and fencing can interfere with wildlife corridors. Specific impacts will depend on the biological characteristics of the land being developed for solar thermal plants, and sensitive populations and habitat should be avoided as a matter of state policy. The 2007 Environmental Performance Report from the California Energy Commission identifies and discusses the potentially significant and cumulative impacts of a large number of solar plants proposed on Bureau of Land Management (public) lands, including impacts on sensitive species in the Mojave Desert. Projects located in areas where the vegetation and habitat have already been disturbed are preferable. There are also potential issues associated with uncompleted projects, where vast amounts of land are disturbed in facility preparation, but plants are not constructed. Nitrogen dioxide deposition from cooling towers can also degrade vegetation, which is generally mitigated through additional provision of habitat compensation.

There are no current large-scale **solar photovoltaic** plants operating in California, although there are several proposed. Photovoltaic plants use more land per MW than solar thermal plants, and about 80 times the acreage of a combined-cycle natural gas plant per MW. The 2007 Environmental Performance Report states that current technological advances may reduce the land footprint by up to 50 percent. Affects on biological resources and native species would be determined by the location of the plant.

Biomass (forest or agricultural residuals), **anaerobic digesters**, and combustion of **landfill** gases are not expected to affect biological resources and native species outside of their physical construction impacts.

Geothermal projects are frequently located in rural areas and undisturbed areas, but have a relatively small footprint. It is possible that new projects would impact biological resources and would be required to reduce or minimize those impacts through habitat compensation. Nitrogen dioxide deposition from cooling towers can also degrade vegetation.

Small hydropower projects could potentially affect biological species and native species, if they are present in the already-disturbed habitat that manmade channels may provide.

New transmission infrastructure can also impact biological resources and native species through habitat disturbance and alteration (during and following construction) and through direct harm of birds and bats from operating power lines. The RETI project is examining these issues and is expected to have recommendations this year.

4. WATER

Regulatory Background

Water infrastructure includes reservoirs, dams, canals, aqueducts, pipelines, pumping stations, and water treatment plants. Before a facility can be constructed or substantially changed, it must obtain permits to emit air pollutants, use water resources, and to develop land. In this process it must also determine whether it has the potential to impact biological resources, and if so, must comply with existing laws protecting these resources.

(W-1) Water Use Efficiency 1.4 MMTCO$_2$E

This measure identifies the potential for statewide water use efficiency improvement through implementation of individual i.e. per capita voluntary water conservation goals. Increasing statewide, total water demand can be met through individual end use efficiency improvements (appliances and fixtures that use less water than existing appliances and fixtures) and through individual water conservation (changes to behavior and practices). Water demand is expected to grow under the BAU scenario, but it is not clear precisely what the net change in water demand will be in 2020. If water conservation reduces surface water diversions, it can have positive impacts on biological resources by increasing water available for in-stream flows and by reducing aquatic species' mortality at water diversions. If water conservation allows for increased growth, it can impact biological resources where the growth occurs.

(W-2) Water Recycling 0.3 MMTCO$_2$E

This measure proposes to increase water supply reliability to meet increasing demand by increasing water recycling in locations where the energy associated with recycling is less than the energy associated with transporting and treating water. Recycled water is used primarily for landscaping and industrial processes, and is water that would otherwise need to be disposed of, most frequently to a surface water or ocean water. Redirecting this discharge can have positive impacts on receiving water quality, and on the aquatic species in the receiving waters.

(W-3) Water System Energy Efficiency 2.0 MMTCO$_2$E

This measure proposes to reduce the amount of energy used to transport, treat and deliver water. Reductions in air emissions are directly relative to reductions in energy use. ARB expects that this measure will have little to no impact on biological resources. Any projects that have the potential to impact biological resources would be subject to CEQA and other permitting requirements.

(W-4) Reuse Urban Runoff 0.2 $MMTCO_2E$

This measure proposes to increase local surface and groundwater supplies by adopting stormwater management strategies, such as Low Impact Development (LID). LID increases infiltration in urban areas increasing regional stormwater capture and storage. Constructing neighborhood facilities to capture and reuse dry weather flows also increases local supply. These water supplies (270,000 - 333,000 acre-feet) can be used to avoid the need for new imported water supplies with higher energy-intensity. These types of actions have the potential to either impact or benefit biological resources. Increasing infiltration and capturing dry weather flows can benefit biological resources if they reduce surface water diversions and free up water for in-stream flows. They can also interrupt the recharge of surface waters and negatively affect habitat values and they can have localized impacts on biological species through their construction and operation. The design and location of such projects will determine their potential effects on biological resources (direct and indirect), and they should be examined and minimized or mitigated on a project by project basis.

(W-5) Increase Renewable Energy Production 0.9 $MMTCO_2E$

This measure proposes to develop renewable energy projects on lands associated with California's state and local water infrastructure. The potential biological resource impacts associated with these types of projects are evaluated in measure E-3.

(W-6) Public Goods Charge for Water TBD $MMTCO_2E$

This measure proposes to impose a monetary charge on water use and use resulting funds to reduce the GHG emissions from water-related energy use, as described in measures W-1 through W-5. Measures W-1 through W-5 are evaluated separately.

5. INDUSTRY

Regulatory Background

Before a facility can be constructed, it must obtain various permits to emit air pollutants, use water resources, and to develop land. If the proposed facility construction occurs in a location with identified habitat or species, or occurs in the vicinity of a surface water or protected area, the stationary source must comply with:

> **CEQA** requires proposed electricity and natural gas facilities to analyze and describe the potential for environmental impacts, identify ways to reduce adverse impacts and offer alternatives to the project, and to disclose this information to the public.

(I-1) Energy Efficiency and Co-Benefits Audits for Large Industrial Sources TBD $MMTCO_2E$

These measures are not expected to affect native species or biological resources, as all actions would occur on already developed lands.

(I-2) Oil and Gas Extraction GHG Emission Reduction 0.2 $MMTCO_2E$
(I-3) GHG Leak Reduction from Oil and Gas Transmission 0.9 $MMTCO_2E$

These measures are not expected to affect native species or biological resources, as all actions would occur on already developed lands.

(I-4) Refinery Flare Recovery Process Improvements 0.33 $MMTCO_2E$
(I-5) Removal of Methane Exemption from Existing Refinery Regulations 0.01 $MMTCO_2E$

These measures are not expected to affect native species or biological resources, as all actions would occur on already developed lands.

6. RECYCLING AND WASTE MANAGEMENT

Regulatory Background

Before a facility can be constructed, it must obtain various permits to emit air pollutants, use water resources, and to develop land. If the proposed facility construction occurs in a location with identified habitat or species, or occurs in the vicinity of a surface water or protected area, the stationary source must comply with:

> **CEQA** requires proposed electricity and natural gas facilities to analyze and describe the potential for environmental impacts, identify ways to reduce adverse impacts and offer alternatives to the project, and to disclose this information to the public.

(RW-1) Landfill Methane Control Measure 1.0 $MMTCO_2E$
(RW-2) Additional Reductions in Landfill Methane: Increase the Efficiency of Landfill Methane Capture TBD $MMTCO_2E$

These measures are not expected to directly affect native species or biological resources, as they do not affect land or water resources critical to native species or biological resources.

(RW-3) High Recycling/Zero Waste 9 $MMTCO_2E$

Commercial Recycling proposes to institute mandatory commercial recycling goals. Benefits to biological resources are related to avoiding new landfills and to avoiding production of raw materials.

Increasing Production and Markets for Compost recommends halving the amount of organic material diverted to landfills by creating compost instead. This would require development of new facilities or expansion of existing facilities that produce compost. Siting can be difficult for these facilities because of the nature of their operations and their associated dust and odors. Some facilities are sited at a landfill site, which minimizes their potential individual impact. Biological resource impacts would be similar to siting of other facilities, and would be most relevant on a project-level basis.

Anaerobic digesters are not expected to affect biological resources and native species outside of their physical construction impacts, and their reduction of physical and water wastes.

Extended Producer Responsibility proposes to incorporate the costs of treatment and disposal into the total cost of a product. This should result in environmentally preferable products, as manufacturers seek to reduce overall product costs by minimizing treatment and disposal costs. **Environmentally Preferable Purchasing** would encourage the purchase of environmentally preferable products, products which use less energy, water, virgin materials and hazardous chemicals to produce. These measures intent is to reduce environmental impacts of product manufacturing. Because of the broad spectrum of products, and the geographical extent of extraction and manufacturing, it is not possible to specifically describe potential benefits to

biological resources in California, although some of these benefits would be the reduced demand for landfills and reduced demand for virgin materials.

7. FORESTS

(F-1) Sustainable Forest Target 5 $MMTCO_2E$

This measure recommends establishing and implementing a target to sustain current levels of net carbon sequestration in the Forest sector with actions such as reforesting areas lost to wildfires and improving forest management to reduce the risk of catastrophic wildfires in the state. Deforestation from wildfires or overharvesting can have negative impacts on forest habitat and associated water habitat, particularly by introducing silt and organic carbon into surface waters and by reducing riparian shading. Silt and organic carbon can change water chemistry and can either directly or indirectly affect dissolved oxygen levels, temperatures, and spawning areas crucial to biological resources. Afforestation and reforestation has a potentially significant benefit for biological resources in the state.

8. HIGH GWP

(H-1) Motor Vehicle Air Conditioning Systems: Reduction of Refrigerant Emissions from Non-Professional Servicing 0.26 $MMTCO_2E$

The primary purpose of this Discrete Early Action is to reduce the emissions of the high GWP gas HFC-134a from activities associated with DIY charging. It is not expected to affect biological resources as leaks do not affect biological resources and their reduction will not affect the amount or operation of vehicles or professional service shops.

(H-2) SF_6 Limits in Non-Utility and Non-Semiconductor Applications 0.3 $MMTCO_2E$

This Discrete Early Action measure will consider a potential ban on the use of SF_6 where technologically feasible and cost-effective alternatives are available, as well as a performance standard for other uses. The use of SF_6 or its replacement gases are not expected to affect biological resources, either directly or indirectly through land, air, or water resources.

(H-3) High GWP Reduction in Semiconductor Manufacturing 0.15 $MMTCO_2E$

This measure recommends requiring manufacturers to use process optimization, alternative chemistries, and abatement technologies in combination or separately to reduce high GWP emissions from semiconductor manufacturing. These changes would occur within existing fabricator processes and would not affect biological resources.

(H-4) Limit High GWP Use in Consumer Products 0.25 $MMTCO_2E$

The objective of this measure is to reduce the use of compounds in consumer products with high GWP when alternatives are available. These changes would occur on existing manufacturing sites and would not affect biological resources.

(H-5) High GWP Reductions from Mobile Sources 3.3 $MMTCO_2E$

Each of these measures recommends ways to reduce leaks from refrigerant uses in mobile applications. These changes would not affect biological resources because liquid refrigerants evaporate quickly at room temperature and they are not toxic when airborne.

(H-6) High GWP Reductions from Stationary Sources 10.9 $MMTCO_2E$

Each of these measures recommends ways to reduce leaks from refrigerant uses in stationary applications. These changes would not affect biological resources because liquid refrigerants evaporate quickly at room temperature and they are not toxic when airborne.

(H-7) Mitigation Fee on High GWP Gases 5 $MMTCO_2E$

This measure recommends attaching a fee to the use of high GWP gases. This measure would support the goals and therefore have similar effects as Measures H-1 through H-6.

9. AGRICULTURE

(A-1) Methane Capture at Large Dairies 1.0 $MMTCO_2E$

Methane from dairy manure can be captured through the installation and use of anaerobic digesters. This measure recommends installing anaerobic digesters on new and existing dairies, 89 percent of which are located in the Central Valley. Anaerobic digesters are compatible with agricultural land uses and would be constructed in areas already in use for agriculture. There are no anticipated affects on biological resources from construction of digesters on existing dairies. New dairies would go through environmental review for impacts on biological resources. Pipelines to transmit natural gas to power plants could temporarily impact biological resources during construction, but would also have to undergo a project-specific evaluation and permitting process.

10. SUMMARY

For the most part, recommended measures in the Scoping Plan will occur on already impacted or developed lands, minimizing any potential impacts to native species in biological resources. Measures that result in new facilities to generate power or produce alternate fuels will have the potential to impact native species and biological resources if they are sited in sensitive areas. Special consideration should be given to minimize the impact of new facilities on biological resources, through thoughtful site selection and compliance with existing regulations. Improvements to air quality, water quality, and waste disposal should also benefit native species and biological resources, depending on where they occur.

E. WASTE DISPOSAL AND HAZARDOUS WASTE

Regulatory Background

Solid waste and hazardous materials are regulated at a federal level by U.S. EPA.

> Solid and hazardous waste management is regulated through the **Resource Conservation and Recovery Act** (Title 40 of the Code of Federal Regulations parts 239 through 299)**.** RCRA established a solid waste program (subtitle D) which set guidelines for solid waste management and disposal facilities and prohibits open dumping; a hazardous waste program (subtitle C) which established a "cradle to grave" approach of hazardous material handling; and an underground storage tank program (subtitle I) which regulates tanks storing hazardous substances and petroleum products.

States have developed permitting programs to implement RCRA. In California, there are a number of statutes:

> **Title 14 of the California Code of Regulations (CCR)** enacted the State's solid waste management program. **Title 27 CCR** imposes restrictions on land disposal to protect water resources. CIWMB is the state agency charged with overseeing enforcement of these regulations. Local agencies are responsible for developing, implementing, and enforcement waste management programs that are certified and enforced by the CIWMB.
>
> The Department of Toxic Substances Control (DTSC) implements and enforces California's hazardous materials management program **(Title 22 Division 4.5 CCR)**, in conjunction with Certified Unified Program Agencies (CUPA). Hazardous materials are codified as materials that are toxic, reactive, ignitable or corrosive and have special disposal requirements. Hazardous materials are tracked from generator to waste facility, and handlers have to meet tracking and handling requirements.

Much of the environmental protections around solid waste management are implemented at a local government level. State waste management programs are primarily carried out through **local solid waste enforcement agencies (LEAs)**. LEAs have the primary responsibility for ensuring the correct operation and closure of solid waste facilities in the state. They also have responsibilities for guaranteeing the proper storage and transportation of solid wastes.

> **Integrated Waste Management Plans (IWMPs)** are prepared and implemented by local governments and include waste characterization, source reduction, recycling, composting, solid waste facility capacity, education and public information, funding, special waste (asbestos, sewage sludge, etc.), and household hazardous waste, as well as descriptions of how the IWMP complies with state waste management goals. IWMPs also identify facility locations and are required to work with local governments to ensure that facilities are consistent with land use designations. IWMPs must be locally approved, submitted to, and periodically reviewed for compliance by the CIWMB.

Process of Evaluation

Where possible, existing studies, environmental documentation, and regulatory documentation for measures were reviewed for pertinent information. Documentation and studies for existing activities were used to estimate expansion of those types of activities. Where no information was available, ARB consulted experts at state agencies, including at ARB and Climate Action Team agencies. More detailed information about the proposed regulations and the measures under evaluation is provided in Appendix C of the Scoping Plan, as well as in the discussion of the potential impact on air resources.

1. CALIFORNIA CAP-AND-TRADE PROGRAM LINKED TO WESTERN CLIMATE INITIATIVE

The recommended measure is not anticipated to result in a substantial increase in the generation of solid or hazardous wastes. There may be a potential for GHG emission reduction technologies to result in the use of hazardous materials (e.g., ammonia from electricity generation). The cap and trade program will comply with the environmental considerations required by AB 32 as well as existing state and federal regulations. As part of the regulatory development of this measure, this potential will be further examined.

2. TRANSPORTATION

(T-1) Pavley I and Pavley II-Light-Duty Vehicle GHG Standards 31.7 MMTCO$_2$E
Feebates – In-lieu of Pavley Regulations 31.7 MMTCO$_2$E
(T-4) Vehicle Efficiency Measures 4.5 MMTCO$_2$E

These measures are not expected to affect waste disposal or hazardous materials, as they do not propose to significantly materially change vehicles. Reduced upstream transport of fuels would reduce the potential for accidental spills.

(T-2) Low Carbon Fuel Standard 15 MMTCO$_2$E

Biodiesel: Biodiesel production uses sodium hydroxide, hexane, sulfuric acid, and methanol. These will be present in any waste generated. Stearates are also likely generated during the esterification process. Glycerol is a by-product that contains unused catalyst, salt, water, methanol, and soaps, and may require special disposal handling.

Ethanol: Current state-of-the-art dry milling plants are expected to generate minimal waste, but any waste materials such as hydraulic oil that is generated would require appropriate disposal if it cannot be reused or reprocessed.

Hydrogen: Precious metals, such as platinum, are expected to be recovered from fuel cells at the end of their useful life. Carbon fiber used in hydrogen tanks is highly valuable as a recycled material.

(T-5) Ship Electrification at Ports 0.2 MMTCO$_2$E
(T-6) Goods Movement Efficiency Measures 3.5 MMTCO$_2$E

These measures are not expected to affect waste disposal or hazardous materials, as they do not propose to significantly materially change vehicles, vessels, structures, or equipment. Reduced upstream transport of fuels would reduce the potential for accidental spills.

One maintenance practice to be considered in the commercial harbor craft measure is the use of anti-fouling products on the hulls to improve hull smoothness. The active ingredient of a number

of anti-fouling products is copper. Excess product, spray mixture, and rinsate associated with the application of copper-containing anti-fouling products must be treated, and disposed of, as hazardous waste if it cannot be used or chemically reprocessed. The encouragement of non-toxic anti-fouling product use and education of owners/operators on the toxicity of copper should reduce the use of and improper disposal of these chemicals

(T-7) Heavy Duty Vehicle GHG Emission Reduction – Aerodynamic Efficiency 0.93 $MMTCO_2E$

(T-8) Medium and Heavy-Duty Vehicle Hybridization 0.5 $MMTCO_2E$

These measures are not expected to affect waste disposal or hazardous materials, as they do not recommend significantly or materially changing vehicles. Reduced upstream transport of fuels would reduce the potential for accidental spills.

(T-3) Regional Transportation-Related Greenhouse Gas Targets 5 $MMTCO_2E$

Under this measure ARB would work with MPOs to establish passenger vehicle greenhouse gas emission reduction targets (regional targets) for 2020 and 2035. The specific land resource impacts of particular land use and transportation strategies applied to implement this measure would be evaluated under existing applicable regulatory structures as they are triggered, including CEQA. Generally, this measure encourages low impact, compact growth in urban areas that have the potential to result in reduced waste disposal due to changes in building and infrastructure construction and operation.

(T-9) High Speed Rail 1 $MMTCO_2E$

The Scoping Plan supports the implementation of a high speed rail system. The recommended HSR program has undergone environmental review under CEQA and NEPA. ARB reviewed this documentation for its analysis of biological resources. The programmatic EIR/EIS examined the impacts of the High Speed Rail on waste and hazardous resources at a statewide level, finding no specific statewide impacts on waste and hazardous materials, but identifying the need to further evaluate this issue through the subsequent project-level EIR/EIS.

3. ELECTRICITY AND NATURAL GAS

(E-1) Energy Efficiency (Electricity) 15.2 $MMTCO_2E$

(CR-1) Energy Efficiency (Natural Gas) 4.3 $MMTCO_2E$

Appliance and building efficiency standards are designed to reduce energy and water consumption. Overall, the appliance and building turnover rate would not change with this recommended measure, so the production of waste would not be accelerated. Efficiency standards occasionally result in the use of new or new versions of products that contain hazardous materials and require special recycling. One example of this is the fluorescent lamp, which uses a small amount of mercury vapor. To minimize impacts on the environment and landfills, new technologies are being researched and consumers are being encouraged to recycle the lamps.

(CR-2) Solar Water Heating 0.1 $MMTCO_2E$

(E-4) Million Solar Roofs 2.1 $MMTCO_2E$

In operation, solar water heaters do not produce any waste materials. However, some solar cell manufacturing requires trace amounts of potentially toxic chemicals, and many solar cells are being manufactured in California. The Public Interest Energy Research Program of the California Energy Commission investigated this issue and concluded:

"The greatest environmental risk with silicon cells is associated with the use of gases (arsine and phosphine) during the manufacturing process. Thin-film technologies, such as cadmium telluride cells and copper indium diselenide cells, are being developed to increase conversion efficiency and decrease production costs. The most likely routes for environmental release of trace elements are from accidental spills during the manufacturing process. At sites with installed PV modules, release of trace elements from sealed modules is unlikely except due to explosion or fire. Leaching of trace metals from modules is not likely to present a significant risk due to the sealed nature of the installed cells and the plan for recycling of spent modules in the future."[81]

(E-2) Increase Combined Heat and Power 6.7 MMTCO$_2$E

Waste or hazardous materials associated with combined heat and power systems are a function of the fuel used for the system. Natural gas would not produce physical waste. Potential waste impacts of biomass, solar, wind, and fuel cells are discussed in the Electricity and Natural Gas section.

(E-3) Renewables Portfolio Standard 21.3 MMTCO$_2$E

Wind projects do not generate waste during operation, or require hazardous materials for construction.

Solar thermal plants do not produce any waste materials or require toxic or hazardous materials to manufacture. **Photovoltaic** operation and manufacturing is discussed under measures CR-2 and E-4.

Biomass energy is a promising use of waste to create energy and reduce the lands needed for landfill, or the air pollutants associated with open-air combustion. Waste materials used for biomass include corn stover, rice hulls, wheat straw, orchard prunings, forest residuals wooden construction debris, and yard and tree trimmings. The combustion by-product (ash) can be mixed with soils for use as landfill cover, or in pavement aggregate. The refinement of methane gas requires the removal of hydrogen sulfide gas, which produces a liquid waste that is classified as hazardous due to its acidity. This waste will have to be treated to decrease its acidity prior to disposal.

Anaerobic digestion is a form of biological waste processing that destroys harmful biological microorganisms, reduces odors, and physically reduces overall waste mass. This anaerobic process produces methane that would otherwise need to be vented or combusted.

Landfill gas is a byproduct of our current waste management practices, which can be harvested either as natural gas or through combustion.

Municipal solid waste may contain hazardous materials, which could result in solid and gaseous hazardous by-products. Air emissions and ash can be treated to reduce this hazard, ash can be shipped to special landfills, or hazardous materials can be diverted from the waste prior to combustion.

[81] *Potential Health and Environmental Impacts Associated with the Manufacture and Use of Photovoltaic Cells,* EPRI, Palo Alto, CA, and California Energy Commission, Sacramento, CA:2003, 1000095.

Geothermal projects do not produce waste or hazardous materials, other than those described in the air and water resources sections.

Small hydropower projects do not generally have any waste or hazardous materials impacts.

4. WATER

(W-1) Water Use Efficiency 1.4 MMTCO$_2$E

This measure is not expected to affect waste disposal or hazardous materials, as it would not materially change the overall amount of appliances or equipment.

(W-2) Water Recycling 0.3 MMTCO$_2$E

Increased water recycling is not expected to substantially change the amount of biosolids produced and requiring disposal.

(W-3) Water System Energy Efficiency 2.0 MMTCO$_2$E

This measure is not expected to affect waste disposal or hazardous materials, as it would not materially change the overall amount of appliances or equipment. Should this measure result in new water infrastructure, it could have temporary construction-related waste disposal or hazardous materials issues, dependent on the location of construction.

(W-4) Reuse Urban Runoff 0.2 MMTCO$_2$E

This measure could introduce a minor increase in disposal needs, as sediments and pollutants collect in storm water collection basins and need to be removed and disposed as part of the operation and maintenance of these types of facilities. Disposal needs and volume would be a function of location and design of facility, and quality of storm water.

(W-5) Increase Renewable Energy Production 0.9 MMTCO$_2$E

This measure proposes to develop renewable energy projects on lands associated with California's state and local water infrastructure. The potential waste impacts associated with these types of projects are evaluated in measure E-3.

(W-6) Public Goods Charge for Water TBD MMTCO$_2$E

This measure proposes to impose a monetary charge on water use and use resulting funds to reduce the GHG emissions from water-related energy use, as described in measures W-1 through W-5. Measures W-1 through W-5 are evaluated separately.

5. INDUSTRY

(I-1) Energy Efficiency and Co-Benefits Audits for Large Industrial Sources TBD MMTCO$_2$E

The potential energy efficiency improvements that may result from this measure are not expected to impact waste disposal.

(I-2) Oil and Gas Extraction GHG Emission Reduction 0.2 MMTCO$_2$E
(I-3) GHG Leak Reduction from Oil and Gas Transmission 0.9 MMTCO$_2$E

These measures are not expected to affect waste disposal or hazardous materials.

(I-4) Refinery Flare Recovery Process Improvements 0.33 MMTCO$_2$E
(I-5) Removal of Methane Exemption from Existing Refinery Regulations 0.01 MMTCO$_2$E

These measures are not expected to affect waste disposal or hazardous materials.

6. RECYCLING AND WASTE MANAGEMENT

(RW-1) Landfill Methane Control Measure 1.0 MMTCO$_2$E
(RW-2) Increase the Efficiency of Landfill Methane Capture TBD MMTCO$_2$E

These measures recommend reducing the impacts of current landfill practices on GHG emissions and toxic air contaminants, so they reduce the environmental impact of the State's current waste management practices.

(RW-3) High Recycling/Zero Waste 9 MMTCO$_2$E

Commercial Recycling recommends instituting mandatory commercial recycling goals. This would reduce the demand for landfill space in California and replace materials produced from virgin materials. There are no hazardous materials associated with commercial recycling.

Increasing Production and Markets for Compost recommends halving the amount of organic material diverted to landfills by creating compost instead. This would reduce the demand for landfill space in California and replace composts from virgin materials. There are no hazardous materials associated with green waste composting.

Anaerobic digestion is a form of biological waste processing that destroys harmful biological microorganisms, reduces odors, and physically reduces overall waste mass.

Extended Producer Responsibility recommends incorporating the costs of treatment and disposal into the total cost of a product. This should result in environmentally preferable products, as manufacturers seek to reduce overall product costs by minimizing treatment and disposal costs. **Environmentally Preferable Purchasing** would encourage the purchase of environmentally preferable products, products which use less energy, water, virgin materials and hazardous chemicals to produce. These measures intent is to reduce environmental impacts of product manufacturing. Because of the broad spectrum of products, and the geographical extent of extraction and manufacturing, it is not possible to specifically describe potential benefits to biological resources in California, although some of these benefits would be the reduced demand for landfills.

7. FORESTS

(F-1) Sustainable Forest Target 5 MMTCO$_2$E

This measure recommends establishing and implementing a target to sustain current levels of net carbon sequestration in the Forest sector with actions such as reforesting areas lost to wildfires and improving forest management to reduce the risk of catastrophic wildfires in the state. Harvested materials would either go to manufacturing as virgin materials, to biomass facilities (evaluated under measure E-3), or to landfills. One of the objectives of this target is to maximize the diversion of forest waste from landfills to biomass facilities. As the details for this measure are developed, ways to minimize potential impacts on landfills will be evaluated.

8. HIGH GWP

(H-1) Motor Vehicle Air Conditioning Systems: Reduction of Refrigerant Emissions from Non-Professional Servicing 0.26 $MMTCO_2E$

The primary purpose of this Discrete Early Action is to reduce the emissions of the high GWP gas HFC-134a from activities associated with DIY charging. HFC-134a is not a hazardous material. DIY charging is done through the use of disposable cans. This measure is not expected to affect waste disposal or hazardous materials except to the degree that disposable cans are not produced and replaced with the use of reusable canisters by professional servicers.

(H-2) SF_6 Limits in Non-Utility and Non-Semiconductor Applications 0.3 $MMTCO_2E$

This Discrete Early Action measure will consider a potential ban on the use of SF_6 where technologically feasible and cost-effective alternatives are available, as well as a performance standard for other uses. The use of replacement for SF_6 are not expected to affect waste disposal or increase hazardous materials, as this measure would not increase the volume of gases used and the currently identified replacement gases are non-toxic.

(H-3) High GWP Reduction in Semiconductor Manufacturing 0.15 $MMTCO_2E$

This measure recommends requiring manufacturers to use process optimization, alternative chemistries, and abatement technologies in combination or separately to reduce high GWP emissions from semiconductor manufacturing. These changes would occur within existing fabricator processes and would not affect waste disposal or hazardous materials.

(H-4) Limit High GWP Use in Consumer Products 0.25 $MMTCO_2E$

The objective of this measure is to reduce the use of compounds in consumer products with high GWP when alternatives are available. These changes would occur on existing manufacturing sites and would not affect waste disposal or hazardous materials.

(H-5) High GWP Reductions from Mobile Sources 3.3 $MMTCO_2E$

High GWP gases and their proposed replacement gases are not classified as hazardous materials; therefore, none of these measures would affect hazardous materials.

The **Air Conditioner Refrigerant Leak Test during Vehicle Smog Check** measure recommends reducing the number of in-use MVACs that leak excessively by identifying them through the existing Smog Check program and requiring their subsequent repair. This additional test procedure and repair requirement would occur on existing commercial sites and would not require replacing any equipment, therefore it would not affect waste disposal.

The **Refrigerant Recovery from Decommissioned Refrigerated Shipping Containers** measure recommends recovering refrigerant remaining in the decommissioned containers' cooling systems, reducing leakage from these containers, and ensuring proper disposal as they approach their end-of-life. This measure is not expected to significantly change the current disposal methods of refrigerated shipping containers, but could possibly allow a greater reuse of containers; therefore, this measure is not anticipated to affect waste disposal.

The **Enforcement of Federal Ban on Refrigerant Release during Servicing or Dismantling of Motor Vehicle Air Conditioning Systems** measure recommends improving compliance with existing regulations prohibiting the venting of certain types of refrigerant, including HFCs, to the

atmosphere when MVAC equipment is serviced or dismantled. Venting is avoided by recovering refrigerants with specialized equipment before dismantling or servicing. Improved compliance with existing regulations would not affect waste disposal.

(H-6) High GWP Reductions from Stationary Sources 10.9 MMTCO$_2$E

High GWP gases and their proposed replacement gases are not classified as hazardous materials; therefore, none of these measures would affect hazardous materials.

Two measures are proposed as the **High GWP Stationary Equipment Refrigerant Management Program.** The **Refrigerant Tracking/Reporting/Repair/Deposit Program** measure recommends requiring commercial and public facilities with large stationary air conditioning and refrigeration equipment to minimize emissions of high GWP refrigerants through reporting, leak repair, improved servicing, and end-of-life control. The **Specifications for Commercial and Industrial Refrigeration Systems** measure proposes new specifications for commercial and industrial refrigeration systems to both reduce emissions of high GWP refrigerant and to increase energy efficiency of the units. These changes would occur on as existing equipment is replaced and would not affect waste disposal.

Insulation foam that is diverted to landfills emits high GWP gases into the atmosphere. The **Foam Recovery and Destruction Program** measure recommends minimizing these emissions to as close to zero as possible by diverting waste foam away from landfills and destroying the foam at high temperatures, or by capturing the high-GWP GHGs within the foam and destroying the foam gas. This program could reduce the amount of waste foam diverted to landfills.

The **SF_6 Leak Reduction and Recycling in Electrical Applications** measure recommends reducing emissions of SF_6 within the electric utility sector and at particle accelerators by requiring the use of best achievable control technology for the detection and repair of leaks, and the recycling of SF_6. Additionally, particle accelerator industry representatives are considering the use of possible substitute mediums. These changes could replace a small amount of equipment earlier than expected, but otherwise would not affect waste disposal.

The **Alternative Suppressants in Fire Protection Systems** measure recommends evaluating the use of alternative suppressants in total flooding (fixed) and streaming (portable) fire suppression systems. The use of alternative suppressants is expected to have only minor operational impacts at existing commercial and residential sites; therefore, the measure would not affect waste disposal.

The **Residential Refrigeration Early Retirement Program** measure recommends partnering with existing voluntary programs to retire inefficient residential refrigeration appliances such as refrigerators and freezers. Appliance early retirement includes the recovery of high-GWP refrigerants and blowing agents for reclamation or destruction to avoid GHG emissions. This program could accelerate diversion to landfills of older appliances (post-refrigerant recovery), but is not expected to significantly increase the overall diversion to landfills.

(H-7) Mitigation Fee on High GWP Gases 5 $MMTCO_2E$

This measure recommends attaching a fee to the use of high GWP gases. This measure would support the goals and therefore have similar effects as Measures H-1 through H-6.

9. AGRICULTURE

(A-1) Methane Capture at Large Dairies 1.0 $MMTCO_2E$

Methane from dairy manure can be captured through the installation and use of anaerobic digesters. Anaerobic digestion is a form of biological waste processing that destroys harmful biological microorganisms, reduces odors, and physically reduces overall waste mass. The waste materials are generally combined with other dairy solid manure wastes as a soil amendment or fertilizer for dairy feedstocks, and would not increase the amount of dairy manure waste.

The refinement of methane gas requires the removal of hydrogen sulfide gas, which produces a liquid waste that is classified as hazardous due to its acidity. This waste may be able to be used to amend alkaline soils to restore pH, otherwise it would have to be treated to decrease its acidity prior to disposal.

This measure recommends voluntary installation of anaerobic digesters on new and existing dairies, 89 percent of which are located in the Central Valley. Anaerobic digesters are compatible with agricultural land uses and waste processes and would mostly be constructed in areas already in use for agriculture. New dairies would go through environmental review for impacts on biological resources.

10. SUMMARY

Recommended measures in the Scoping Plan will not substantially affect waste disposal or hazardous materials, when compared with the Business As Usual Scenarios. The benefits of the Scoping Plan come through measures that reduce demands for new facilities, water, and products, as well as measures that reduce diversions to landfills and transition to less hazardous products.

4. PUBLIC HEALTH AND SAFETY

Public health and safety in California can be expected to be adversely impacted by climate change. Several recent studies have addressed potential implications for human health at the national and international levels.[82] Greater climate variability and changes in climate patterns would potentially cause both direct and indirect health effects. Direct health and safety impacts would result from extreme events, such as heat waves, droughts, increased fire frequency, and increased storm intensity resulting in flooding and landslides. Secondary or indirect health effects would be associated with damages to infrastructure that cause, for example, sanitation and water treatment problems that increase water-borne infections. Air quality impacts such as increases in tropospheric ozone due to higher temperatures would also have health impacts.

A. AIR QUALITY-RELATED PUBLIC HEALTH

ARB has many program and plans that are designed to identify and mitigate public health problems due to air quality throughout the state. ARB has identified harbor communities and sensitive populations as a priority when addressing toxic and criteria air contaminants. The Proposed Scoping Plan builds on ARB's priorities and on-going efforts to reduce air pollution. Within this environmental evaluation ARB staff has quantified, where possible, the potential changes to NOx, VOC, primary and secondary PM2.5, and air toxics that would result from implementation of the recommended measures in the Scoping Plan.

For this section of the evaluation, staff estimated the health impacts associated with PM2.5 exposure on a state level. This evaluation focuses on PM 2.5 because this pollutant accounts for the majority of premature deaths associated with air pollution in California. Although we have estimated statewide changes to emissions of key criteria pollutants in 2020, we have not specifically assigned emission changes to individual facilities or transportation corridors. Because of this, we cannot reliably model future air quality conditions across the state. Without such modeling, it is difficult to estimate health outcomes of criteria pollutants like ozone, whose chemistry is highly dependent on precursors and weather conditions and whose health outcomes are highly dependent on length and magnitude of exposure.

We have estimated statewide health outcomes for PM2.5 because the sources of PM2.5 are distributed in similar proportions and patterns to populations, and are not strongly dependent on meteorology for their formation or for their direct emission and exposure pathways. Staff based the evaluation on the GMERP public health methodology.[83] There are many assumptions made in this exercise which add to the uncertainty of the estimates, including translating regional emission and health outcome information to statewide information, estimating criteria pollutant reductions for measures, and assuming that emissions and exposures are geographically proportional. This analysis is intended to provide comparative information on the recommended measures.

[82] Patz et al., 2000.
[83] http://www.arb.ca.gov/planning/gmerp/gmerp.htm.

Regulatory Background

ARB's first priority continues to be the protection of public health, and now it joins with other agencies, states, and countries to protect public health on a global level, through the reduction of greenhouse gases. All of the recommended measures and measures under evaluation in this Scoping Plan are designed to reduce greenhouse gases, and many of these measures would also contribute to ARB's goals of reducing criteria pollutants and toxic air contaminants. Some of the recommended measures may result in minor increases to co-pollutants, but these minor increases must be evaluated in the overall context of both the AB32 program and existing ARB programs, which are briefly described below:

Federal clean air laws require areas out of attainment with national ambient air quality standards to prepare **State Implementation Plans (SIP)** identifying actions to bring areas into compliance in a set timeframe. Under State law, ARB has the responsibility to develop SIP strategies for mobile sources and consumer products, to coordinate SIP strategies with the Bureau of Automotive Repair and the Department of Pesticide Regulation, and to oversee local district programs for stationary sources. In 2007, ARB adopted the State Strategy for Implementation of Ozone and PM2.5 Standards.

The Air Toxics "**Hot Spots**" Information and Assessment Act (AB 2588, 1987, Connelly) requires stationary sources to report the types and quantities of certain substances routinely released into the air. The goals of the Air Toxics "Hot Spots" Act are to collect emission data, to identify facilities having localized impacts, to ascertain health risks, to notify nearby residents of significant risks, and to reduce those significant risks. The public has access to facility emissions and risk data for specific facilities. The "Hot Spots" Act also requires local air districts to prioritize which facilities must perform a health risk assessment based on the potency, toxicity, and quantity of emissions released from the facility to determine if the facility poses a significant risk. High-risk facilities must reduce their toxic emissions and risk to acceptable levels that are determined by the local air districts. District annual reports summarize the results and progress of health risk assessments, and rank and identify facilities that pose a risk to public health.[84]

An important source of directly emitted PM2.5 is diesel exhaust. The particulate matter from diesel-fueled engines (diesel PM) was identified as a toxic air contaminant by ARB in 1998. Nearly 70 percent of the known cancer risk caused by air toxics in California is attributed to diesel PM. In 2000, ARB adopted a **Diesel Risk Reduction Plan** to reduce diesel PM emissions by 85 percent by 2020. ARB has since adopted a number of regulatory measures to reduce diesel PM emissions statewide including requirements for in-use trash trucks, public agency-owned trucks, buses, stationary engines, transportation refrigeration units, cargo handling equipment, and off-road equipment. ARB will soon consider adoption of a regulation to reduce emissions from in-use heavy-duty trucks. Diesel control measures reduce both direct diesel PM and NOx emissions through a combination of engine retrofits and replacements. Upcoming mobile source fleet measures to reduce diesel PM and NOx emissions are a critical part of the new State Implementation Plan strategy, Diesel Risk Reduction Plan, and the Scoping Plan.

[84] http://www.arb.ca.gov/ab2588/reports.htm

The **Emission Reduction Plan for Ports and Goods Movement in California (GMERP)**, approved by ARB in April 2006 identified key new measures necessary to meet federal air quality standards and reduce health risk in communities near ports and railyards. Ships are the largest source of SOx emissions in the state. Heavy-duty trucks move most goods within and through the state, and are the largest statewide source of NOx emissions. This makes it essential to address goods movement emissions in order to meet PM2.5 air quality standards. Likewise, emission reduction targets for ozone will not be met without reducing emissions related to goods movement.

The strategies included in the GMERP target ships and trucks, as well as the other three main sources of goods movement emissions: harbor craft, cargo handling equipment, and locomotives. By 2020, these strategies will cut statewide goods movement emissions of NOx by 63 percent, SOx emissions by 78 percent, and will also reduce the statewide health risk from goods movement-related diesel particulate matter by 85 percent.

Many of the strategies in the GMERP are adopted and will provide essential new emission reductions needed for regional attainment, while they reduce the air pollution-related health risk for those who live near our ports, rail yards, distribution centers, and other goods movement facilities. Emission reductions from those GMERP strategies that were not adopted by the end 2006 are identified as new measures in the 2007 SIP as new measures.

In addition, ARB's **Harbor Communities Monitoring Study (HCMS)** is designed to improve tools for measuring pollutant concentrations in the air and detecting areas where concentrations of these pollutants are high. This study consists of three types of air pollution sampling: a network of passive samplers, a mobile platform, and a network of particle counters. The sampling will characterize temporal and spatial variations of air pollution in the study region. The sampling was conducted during 2007. The pollutants being measured include, but are not limited to black carbon, carbon monoxide, nitrogen oxides, particulate matter, ultrafine particles, volatile organic chemicals, and hydrogen sulfide.

The communities being studied include Wilmington and parts of San Pedro, West Long Beach, and Carson. These communities were chosen because of the emission sources in the area and the close proximity of residents to these emission sources. The Harbor Communities are located just north of the Ports of Los Angeles and Long Beach, which handle 40 percent of all container traffic entering the United States; the area is also surrounded by some of the most heavily traveled freeways in Southern California, is home to several large refineries, and a number of rail facilities.

Health Impacts of Ozone (Criteria Pollutant)

The formation and health impacts of ozone are well studied.[85] Ozone is a highly reactive gas that forms in the atmosphere through reactions between chemicals emitted from motor vehicles, industrial plants, consumer products and many other sources. It forms in greater quantities on hot, sunny, calm days making the summer season the key exposure period.

[85] CARB, 2005; Anderson, et al, 2004; Thurston, et al 2001; Stieb, et al, 2003; Bell et al, 2004; Levy et al, 2001; and Gryparis, et al, 2004.

Considerable research over the past 35 years has investigated how people respond to inhaling ozone. These studies have consistently shown that inhalation of ozone can lead to inflammation and irritation of the tissues lining the human airways. This causes inflammation and causes the muscle cells in the airways to constrict, thus reducing the amount of air that can be inhaled. Symptoms and responses to ozone exposure vary widely, even when the amount inhaled and length of exposure is the same. Typical symptoms include cough, chest tightness, and increased asthma symptoms. Ozone in sufficient doses can also increase the permeability ("leakiness") of lung cells, making them more susceptible to damage from environmental toxins and infection.

Studies of large populations have found that ozone exposure is associated with an increase in hospital admissions and emergency room visits, particularly for lung problems such as asthma and chronic obstructive pulmonary disease. Several studies have also associated ozone exposure with increased premature mortality in elderly people with chronic diseases of the lungs and circulatory system.

People who exercise or work outdoors are at greater risk of experiencing adverse health effects from ozone exposure because they inhale more ozone. Current evidence has linked the onset of asthma to exposure to elevated levels of ozone in exercising children. Children and adolescents are at increased risk because they are more likely to spend time outdoors engaged in vigorous activities than adults and because they inhale more ozone per pound of body weight.

In order to protect public health, the federal government previously set the national ozone standard at 0.08 parts per million for 8 hours, not to be exceeded, based on the fourth highest concentration averaged over three years. ARB and local air districts have proposed a State Implementation Plan describing the strategies and measures that California will pursue to reduce ozone.[86] However, in March 2008, due to new studies that show health effects at lower concentrations of ozone, U.S. EPA set a new 8-hour ozone standard at 0.075 parts per million. States have less than one year (from March 27, 2008) to provide air quality information to U.S.EPA, which will be used to designate non-attainment areas by 2010. By 2011, states must submit SIPs demonstrating how they will attain the new, more stringent, standard.

Health Impacts of PM2.5 (Criteria Pollutant)

Particulate matter (PM) air pollution is also well studied. Particulate matter pollution is a complex mixture that consists of dry solid fragments, solid cores with liquid coatings, and small droplets of liquid. PM can be directly emitted into the air in forms such as dust and soot. It can also be formed in the atmosphere from the reaction of various gases. Inhalable particulate matter is less than 10 microns in diameter (a micron is one-millionth of a meter) and is called PM10. Even smaller particles, those 2.5 microns or less in diameter, are called "fine particles" or PM2.5. PM2.5 is a component of PM10. Diesel PM is particulate matter emitted from diesel-fueled combustion; diesel PM has been classified as a TAC by ARB.

Extensive research has shown that PM can be inhaled into the deep portions of the lungs. Some inhaled particles are exhaled again, but others deposit in the lungs, which can lead to inflammation in both the lungs and the circulatory system. PM2.5 poses an increased health risk because it can penetrate deeper into the lungs and may also enter the bloodstream.

[86] http://www.arb.ca.gov/planning/sip/2007sip/2007sip.htm

Population-based studies in hundreds of cities around the world have demonstrated a strong link between exposure to elevated particulate matter levels and premature death, especially in people with pre-existing heart or lung disease. The two most relevant of these studies were performed in many cities in the United States, and have been ongoing for over 15 years. Both of these studies found a strong relationship between long-term PM exposure and premature death. Scientists have observed higher rates of hospitalization, emergency room visits and doctor's visits for respiratory illnesses or heart disease during times of high PM concentrations. During these periods of high PM levels, scientists also observed the worsening of both asthma symptoms and acute and chronic bronchitis, and reductions in various measures of lung function.

The elderly and people with heart and/or lung diseases are particularly at risk of experiencing adverse effects from PM exposure. Studies have also shown that children may be particularly vulnerable to PM effects. There is evidence from the ongoing Children's Health Study, funded by ARB for over ten years, that in communities with high levels of PM children's lungs develop more slowly and that at maturity they tend to have lower lung capacity than children who grow up in communities with lower levels of PM. Just as with ozone, children and infants may also be more at risk of experiencing adverse effects from PM because they inhale more air per pound of body weight than do adults, they breathe faster, and have smaller body sizes. In addition, there is some evidence that children's developing immune systems may cause them to be more susceptible to the effects of PM than adults.

Health Outcomes

ARB most recently updated its methodology for quantifying the health impacts of fine particulate matter during the development of the Goods Movement Emissions Reduction Plan (GMERP). This methodology has been peer-reviewed during the development of the GMERP. To develop quantitative health outcome estimates in the GMERP, ARB reviewed relevant scientific literature on health impacts associated with air pollution exposure and chose a subset of the studies based on strength of methodology and applicability to California residents or conditions. From these studies, concentration-response functions,[87] a measure of observed relative risk, and the associated error terms (95 percent confidence intervals) were obtained for the following health outcomes:

- **Premature death:** A death that occurs at a younger age than would be expected. Air pollution is not implicated as the *cause* of death, but rather a contributing factor in someone whose health is typically already compromised, thereby accelerating the time of death by 14 years.
- **Hospital admissions for respiratory and cardiovascular causes:** Hospitalization admissions for conditions including pneumonia, chronic obstructive pulmonary disease (COPD), asthma, heart attack, stroke, congestive heart failure and cardiac arrhythmia.
- **Asthma and lower respiratory symptoms:** Symptoms such as cough, phlegm production, chest pain, or wheeze, associated with the lower respiratory tract (windpipe, lungs, and airways leading to/associated with the lungs).
- **Acute bronchitis:** Inflammation of the main airways to the lungs, resulting in symptoms such as hacking cough and phlegm production.

[87] A concentration-response function relates changes in exposures to ambient concentrations of a pollutant to changes in an adverse health effect.

- **Work loss days:** Days of missed work for members of the population age 18 through 65.
- **Minor restricted activity days:** Days when a person is not able to engage in their usual range of activities due to minor health conditions. This does not include work loss or bed confinement.

The methodology that ARB uses for quantifying premature death and other health outcomes from PM exposure is based on a peer-reviewed methodology developed by U.S. EPA[88] for their risk assessments. This methodology is regularly updated by ARB staff as new epidemiological studies and other related studies are published that are relevant to California's health impacts analysis.

Estimation/Quantification Process

For this analysis, ARB used a methodology similar to the GMERP process.[89]

Estimated Health Outcomes

The health outcomes estimated for those measures where NOx and PM2.5 reductions were estimated are presented in Table H-8. These outcomes are the result of the 61 TPD NOx and 15 TPD PM2.5 emission reductions described in Table H-7. By 2020, the economic value of these health outcomes is projected to be on the order of $4.4 billion.

Table H-8: Estimates of Statewide Health Outcomes of Recommended Scoping Plan Measures[a]
(mean number of cases)

Health Endpoint	Health Benefits of 2007 SIP *mean*	Health Benefits of Recommended Scoping Plan Measures (Transportation and Electricity and Natural Gas Sectors) *mean*
Avoided Premature death	12,000	780
Avoided Hospital admissions for respiratory causes	1,300	87
Avoided Hospital admissions for cardiovascular causes	2,600	170
Avoided Asthma and lower respiratory symptoms	190,000	12,000
Avoided Acute bronchitis	15,000	980
Avoided Work loss days	1,200,000	77,000
Avoided Minor restricted activity days	7,000,000	450,000

[a] Uncertainty intervals for each estimated benefit range within 20-70 percent of the mean benefit (presented in this table). For example, the number of premature deaths avoided due to the scoping plan could be between 230 and 1,400.

[88] U.S. Environmental Protection Agency, *Regulatory impact analysis for the final Clean Air Interstate Rule*, Office of Air and Radiation, EPA-452/R-05-002, 2005.
[89] http://www.arb.ca.gov/planning/gmerp/gmerp.htm.

B. OTHER POTENTIAL PUBLIC HEALTH AND SAFETY ISSUES

Electric, Hydrogen, and Hybrid Vehicles: High voltage wiring within electric-drive vehicles must be handled appropriately in the case of an accident. Emergency response personnel are trained to identify high voltage wiring to avoid electric shock in the case of an extraction. Hydrogen appears to be as safe as gasoline as a vehicle fuel. Hydrogen is extremely light and buoyant, so it dissipates into the open air very quickly, making any flammable concentration of hydrogen unlikely.

High Speed Rail: The High Speed Rail PEIR/EIS evaluated the potential for public safety issues related to electromagnetic frequency exposures due to the wireless communication system associated with the project. The evaluation concludes that the potential adverse effects could be avoided or mitigated to a less-than-significant level.

Regional Transportation-Related GHG Targets: Various studies suggest that community design has an impact on public health. A greater mix of land uses in a neighborhood can produce a number of public health benefits. A more diverse neighborhood can reduce trips and therefore facilitate walking, biking, and use of transit. Studies show that more compact development is correlated with increased walking and transit trips. Additionally, public health research has shown that there is a direct connection between compact development and lower boy mass indices, lower levels of obesity and decreased instances of hypertension. Although there are limitations with the studies, the findings suggest that low impact development may improve quality of life in many ways. The following co-benefits represent just a few of the many improvements in quality of life.[90]

Social capital has various components. It is generally described as the sense of belonging and civic participation experienced in a community. It is a series of social networks that provide trust and reciprocity and promote cultural and political life. Studies indicate that social capital may increase as people spend less time alone in their vehicles due to improved transportation planning and conducive land uses.[91] Improved social capital has been linked with improved mental health, prolonged life and better overall health.[92] More pedestrian- and cyclist-friendly development and amenities may also help to increase public safety, furthermore strengthening community ties.

There are also many potential health benefits, such as increased access to health care via public transit for people without access to vehicles, and decreased violence and pedestrian injuries and fatalities due to more pedestrian- and cyclist-friendly development. As open spaces and desirable locations (such as shopping, entertainment, schools, etc) become more plentiful, proximate and accessible to pedestrians and cyclists, residents are likely to increase their levels of physical activity. Moderate physical activity reduces many serious health risks, including coronary heart disease, diabetes mellitus, hypertension, anxiety and depression, and obesity.

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[90] Many of these benefits are taken from the CCAP report "CCAP Transportation Emissions Guidebook" (http://www.ccap.org/safe/guidebook/guide_complete.html) and "Understanding the Relationship between Public Health and the Built Environment" report prepared for the LEED-ND Core Committee.
[91] Sullivan and Kuo 1996, Community & Environment Design, 2006.
[92] Ibid.

Access to green space has also been shown to lessen the impacts of mental fatigue and improve cognitive functioning in children.[93]

Decreased commute times and traffic congestion lessen driver-induced stress and the number of traffic injuries and fatalities. Less vehicle use translates into improved air quality and reductions in adverse health impacts, such as death, cancer and exacerbation of asthma, which are most realized in particularly vulnerable populations, the elderly, the young and the health-impaired.

In order to bring about positive change, as well as avoid situations where attempts to solve one problem exacerbate another, it is essential that all levels of government continue to consider other societal, economic and environmental priorities in their decision-making processes related to land use, transportation, and local government operations. For example, some compact development may increase proximity to large sources of pollution, such as high traffic arterials, distribution centers, and industrial facilities, which increases exposure to vehicle air pollution and other toxics and particulates. Communities should be designed to ensure that sensitive land uses such as residences and schools are an adequate distance from these sources. In addition community design should decrease vehicle use, through increasing transit service and walkability, and include buildings with indoor air quality mitigation to further reduce exposure. Agencies should also consider housing supply and affordability needs so that long term housing affordability is not compromised. To maximize benefits and minimize unintended consequences, agencies will need to continually balance multiple priorities through an integrated planning approach.

Agencies should also consider housing supply and affordability needs so that long term housing affordability is not compromised. To maximize benefits and minimize unintended consequences, agencies will need to continually balance multiple priorities through an integrated planning approach.

Green Buildings and Indoor Environmental Quality: U.S. EPA promotes the building industries changing focus to create greener buildings, which includes using healthier, less polluting and more resource-efficient practices. Buildings can be *designed* to improve indoor air quality, lighting, sound, and odor, and public health through their choice of materials and through ensuring frequent circulation of fresh air.[94] ARB encourages the incorporation of these elements into Green Buildings to leverage their external environmental benefits. ARB and CDPH both have programs studying the sources of poor indoor air quality.

Refrigerants: All refrigerants pose both chronic and acute toxicities to people when they are exposed to high enough concentrations. Acute toxicity relates to the dangers posed by short-term exposure to very high concentrations of refrigerant gases, which can increase adrenalin in the body (sensing danger) and deprive exposed individuals of vital oxygen. Chronic toxicity relates to the dangers from long-term regular worker exposure. Refrigerants are studied to determine their risk levels and exposure limits are set to eliminate chronic risks. Workplace guidelines exist to minimize the possibility of acute exposures. In addition to its risks as a refrigerant, N_2O is managed to avoid potentially hazardous interactions with other chemicals.[95]

[93] NACCHO 2008.
[94] http://www.epa.gov/iaq/greenbuilding/index.html.
[95] http://www.osha.gov/SLTC/healthguidelines/nitrousoxide/recognition.html

Refrigerant use is highly regulated and the measures recommended in this plan are not anticipated to significantly change the amount of or way which refrigerants are used. Though any alternatives will be subject to approval under U.S. EPA's Significant New Alternative Program (SNAP) to ensure their safety, it is possible that certain alternatives that industry selects may have a higher flammability index than the substances they replace. Also, certain systems may operate at higher pressures thus requiring additional technician training to properly and safely service the equipment.

Compressed Gas in Consumer Products: Some types of consumer products containing compressed gases (for example, whipped cream or computer dusters) are used inappropriately to deprive the brain of oxygen and experience a "high." This deprivation of oxygen can be fatal and can also result in long-term brain damage. The measure recommended in this plan will not change the amount of consumer products or reduce the risk of oxygen deprivation when inhaled. The recommended mitigation fee could make these products more expensive, because of increased costs for the compressed gases.

Wildfire Prevention: Wildfires pose direct and indirect risks to public health and safety. Directly, wildfires can kill and can destroy property, and can, under the right meteorological conditions, result in dangerous levels of ozone and PM2.5. Wildfires pose occupational hazards and exposures to fire fighters. Indirectly, deforestation can result in higher loads of organic carbon in raw water sources, which can react to form potential carcinogens in the drinking water treatment process.

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Regional Assessment of Air Quality-Related Public Health Benefits of Scoping Plan: South Coast Air Basin

Overview

California has a long history of reducing the traditional "criteria" air pollutants that have direct health impacts, including ozone and airborne particulate matter (PM). Many of the sources addressed in the Scoping Plan also emit pollutants that can lead to the formation of ozone or PM, making it likely that the Scoping Plan will provide additional reductions of these precursor emissions and help California meet its health-based air quality goals.

This section addresses the potential reductions in precursor emissions, and the resulting air quality related health benefits, associated with select Scoping Plan strategies. Air pollution levels are regional in nature, influenced by local emission sources, weather patterns, and topography. Similarly, health impacts estimates reflect local pollution and population patterns. As a result, it is appropriate to analyze the co-benefit on a regional basis. This analysis evaluates the co-benefits in the South Coast Air Basin (South Coast) as an example of potential benefits.

Emissions Benefits

California's State Implementation Plan (SIP) identifies strategies designed to ensure that even the state's smoggiest areas will meet air quality standards established by U.S. EPA. Numerous SIPs have been adopted and implemented for various standards, resulting in significantly cleaner air despite growth in the state's population and economy. SIP revisions adopted in 2007-2008 (the 2007 SIP) identify the additional strategies needed to meet the national 8-hour ozone and fine particulate matter (PM2.5) standards that were adopted in 1997 and 2002, respectively.

Table H-9 presents the estimated Scoping Plan co-benefits that will occur in the South Coast as well as the reductions projected from rules and regulations that are already in place, and the reductions that are projected to occur as a result of the recently adopted 2007 SIP. Additional ozone strategies will be developed to meet the 2023 emission target. The discussion that follows provides an explanation of each of the inventory scenarios, and the methodology used to estimate the Scoping Plan co-benefits used in this analysis.

Table H-9: Decreasing Emissions in the South Coast Air Basin (remaining emissions, tons per day)[96]

	NOx	ROG	SOx	PM2.5
Current Emissions	1100	790	61	75
2020 Emissions Projection (existing programs)	530	540	52	71
2020 Emission Projection with new 2007 SIP Measures	380	470	26	60
2020 Emission Projection with Scoping Plan Reductions ("co-benefits")	360	470	26	58

[96] Table H-12 does not include the criteria pollutant co-benefits of additional GHG reductions that would be achieved from the recommended cap-and-trade regulation because we cannot predict in which sectors they would be achieved. PM2.5 emission estimates include combustion sources and paved road dust.

Current Emissions: These emission estimates reflect the benefits of California's comprehensive state and local air pollution control programs. The benefits substantially increase each year as new, cleaner technologies are put in place. Included are mobile source controls such as emission standards for new cars and trucks, smog check, emission standards for new off-road engines, cleaner gasoline and diesel fuels, regulations to reduce evaporative emissions from consumer products, paints, and refueling, and regulatory programs that reduce emissions from stationary source emissions.

2020 Emissions Projection: The 2020 emissions projection reflects current air pollution control requirements along with projections of population and economic activity levels in 2020.

2007 State Implementation Plan: The South Coast is one of several areas in the state that do not meet the national 8-hour ozone standard, and one of only two California regions with PM2.5 levels above the national annual PM2.5 standard. In September 2007, ARB adopted the State Strategy for California's 2007 State Implementation Plan (2007 State Strategy). The control strategies identified in the 2007 State Strategy, together with emission reduction commitments in the locally adopted Air Quality Management Plan, are projected to result in attainment of the national PM2.5 standard by 2014 and significant progress towards ozone attainment. Additional strategies will be developed to bring the region fully into ozone attainment by 2023. Table H-10 summarizes the projected 2020 NOx and PM2.5 emission benefits associated with control measures in the 2007 SIP for the South Coast Air Basin.

The 2007 State Strategy focuses on reducing emissions from the state's mobile sources such as trucks, construction equipment, and ocean-going ships. The diesel engines in many of these sources are designed to last for decades – as a result, there are opportunities to reduce emissions by upgrading or replacing older vehicles in these fleets. The 2007 SIP uses a combination of regulatory requirements and incentive programs to reduce emissions from business and commercial fleets. NOx emissions are precursors to both ozone and PM2.5. New State and local control strategies in the 2007 SIP for the South Coast Air Basin are projected to reduce NOx emissions by about 29 percent from 2020 projections. The 2007 SIP together with the Scoping Plan co-benefits will reduce 2020 emissions by about 31 percent.

The 2007 SIP also includes local commitments for further development and exploration of 22 measures for which emission reductions cannot be quantified at this time.

Scoping Plan Reductions: Table H-9 also shows pollutant emission reductions anticipated to occur in the South Coast Air Basin as a result of the Scoping Plan. The projected Scoping Plan benefits are at least one order of magnitude smaller than the reductions attributed to the existing program and the 2007 SIP, in large part because of the effectiveness of the ozone and PM2.5 controls that will be in place by 2020. The methodology used to estimate the co-benefits focused on the most significant Scoping Plan measures and is described below.

Table H-10: 2007 SIP New NOx and PM2.5 Measures
Estimated Emission Reductions in 2020
in the South Coast Air Basin
(tons per day)

	NOx	$PM_{2.5}$
MOBILE SOURCES		
Passenger Vehicle Smog Check Improvements	8	0
Expanded Passenger Vehicle Retirement	1	0
Cleaner In-Use Heavy-Duty Trucks	27	2
AB923 Medium-Duty Vehicle High-Emitter Identification Program	1	0
Auxiliary Ship Engine Cold Ironing and Other Clean Technology	28	0
Cleaner Main Ship Engines and Fuel	32	3
Port Truck Modernization	8	0
Accelerated Introduction of Cleaner Line-Haul Locomotives	12	0
Clean Up Existing Harbor Craft	5	0
Cleaner In-Use Off-Road Equipment	19	2
AREAWIDE SOURCES		
Wood-Burning Fireplaces and Wood Stoves	0	1
Under-Fired Charbroilers	0	1
New and Redevelopment Projects	1	0
STATIONARY SOURCES		
NOx Reduction from Non-RECLAIM Ovens, Dryers and Furnaces	4	0
Further NOx Reductions from Space Heaters	2	0
Facility Modernization	2	1
REGIONAL TOTAL	**150**	**10**

Co-Benefits Estimation Methodology

Co-benefits were estimated for the four major sectors addressed in the Scoping Plan, as discussed below. Scoping Plan emission benefits for criteria pollutants were based on the ARB greenhouse gas inventory methodology. This inventory is comparable, but not identical to that used in the SIP.

Electricity Generation: The Scoping Plan reflects the goals of increasing California's Renewables Portfolio Standard (RPS) for the mix of power generation to 33 percent by 2020 (measure E-3), increasing the energy efficiency of new and existing buildings (measure E-1), and California's solar roof initiative (measure E-4). Statewide, these measures are designed to reduce fossil fuel generation by 88.1 terra watt-hours (TW-hrs) per year in 2020 – fossil fuel electrical generation is projected to account for 369 TW-hrs per year without the Scoping Plan strategies. The reduction in fossil fuel-based electrical generation – approximately 24 percent

beyond today's renewable energy level – was applied to forecasted electrical generation emissions in the South Coast Air Basin in 2020 to calculate the potential regional benefits of these measures in 2020.

Residential/Commercial Fuel Combustion: The Scoping Plan considers energy efficiency improvements in the residential and commercial fuel combustion area that would reduce natural gas combustion rates by 826 million therms (MMtherms) in 2020 (measures CR-1 and CR-2). This value was divided by the statewide forecasted natural gas combustion rate in the residential and commercial sectors of 8,171 MMtherms to derive a reduction fraction of 10 percent. This reduction fraction was applied to the combined emissions of residential and commercial fuel combustion in the South Coast Air Basin to calculate the benefits of this measure in 2020.

Gasoline Measures – On-Road Motor Vehicles: The Scoping Plan identifies greenhouse gas benefits from full implementation of AB1493 Pavley Phase I and Phase II for on-road passenger vehicles (measure T-1), from increased vehicle efficiency measures (measure T-4), such as tire pressure regulation, and from reduced growth in vehicle miles-traveled (VMT) (measure T-3). These measures are estimated to provide additional reductions in gasoline combustion beyond what was accounted for in the SIP baseline emission inventory. The statewide estimate of Scoping Plan benefits from these measures was used to estimate benefits for the South Coast Air Basin using the ratio of VMT in the South Coast Air Basin in 2020 to statewide VMT in 2020.

Diesel Measures: Diesel Measures: The Scoping Plan includes measures that would reduce vehicular diesel combustion emissions, including aerodynamic improvements (measure T-7), and medium/heavy-duty hybridization (measure T-8). The South Coast co-benefits for these measures were calculated from the statewide estimate, distributed by regional VMT. The regional co-benefits estimate for goods movement efficiency measures (measure T-6) was determined using the region's portion of statewide emissions from ocean-going vessels and harborcraft.

Industrial Measures: The Scoping Plan also recommends placing industrial sources in an emissions cap, an energy-efficiency audit for large industrial sources including refineries, and measures to reduce fugitive methane emissions from oil and gas transmission and extraction, fugitive emissions and flaring and from refineries. The fugitive emissions in the South Coast region from oil and gas transmission and extraction, and refineries are small. Reduced flaring is expected to result in a small reduction in criteria pollutants due to reduced natural gas combustion.

Health Benefits Analysis

Ambient air quality standards are established to protect people from adverse health effects of associated with air pollution. The health impacts associated with ozone and PM2.5 range from respiratory effects to premature death. This section discusses the projected changes in health impacts that will occur as a result of the co-benefits of the Scoping Plan in the South Coast Air Basin, California's most polluted region.

The methodology that ARB uses to quantify premature death and other health impacts from exposure to air pollutants is based on a peer-reviewed methodology developed by U.S. EPA. ARB augmented EPA's methodology by incorporating the results of new epidemiological studies relevant to California's population, including regionally specific studies, as they became

available. The methodology was described in ARB's March 2006, *Emission Reduction Plan for Ports and Goods Movement (Goods Movement Plan*), and was updated in the recent staff report for estimating premature death from exposure to particulate matter.[97]

Table H-11 shows relative benefits of the existing programs, the 2007 SIP, and the Scoping Plan in the South Coast in 2020. There is uncertainty inherent in the values shown here, which represent the mean of a range of estimated impacts. These estimates do not provide an absolute number of health impacts avoided. Instead, they provide a way to compare the relative contribution of Scoping Plan co-benefits to the improvements in public health expected from ARB's ongoing pollution control program. Health impacts are defined on page H-97.

Table H-11: Estimated Air Quality-Related Health Benefits of Existing Program, 2007 SIP, and Scoping Plan in the South Coast Air Basin, 2020[a]
(mean number of cases)

Health Impacts / Scenario	Benefits from Existing Program	Additional Benefits from 2007 SIP	Additional Co-Benefits from Scoping Plan
Premature Deaths Avoided	4,800	2,000	360
Hospitalizations Avoided – Respiratory	550	230	40
Hospitalizations Avoided – Cardiovascular	1,100	440	77
Asthma & Lower Respiratory Symptoms Avoided	80,000	35,000	6,200
Acute Bronchitis Avoided	6,400	2,800	500
Work Loss Days Avoided	510,000	220,000	38,000
Minor Restricted Activity Days Avoided	3,000,000	1,300,000	220,000

[a]Uncertainty intervals for each estimated benefit range within 20-70 percent of the mean benefit (presented in this table). For example, the number of premature deaths avoided due to the Scoping Plan could be between 110 and 640.

[97] Air Resources Board. *Methodology for Estimating Premature Deaths Associated with Long-term Exposure to Fine Airborne Particulate Matter in California.* October 24, 2008. http://arb.ca.gov/research/health/pm-mort/pm_final.pdf (accessed December 9, 2008)

Community Level Assessment of Air Quality-Related Public Health Benefits of Scoping Plan: Wilmington Example

Summary

For this assessment, ARB evaluated criteria pollutant emission reductions in the Wilmington study area assuming that the source-specific quantified greenhouse gas measures are implemented. It was further assumed that the non-source specific program elements such as the proposed cap-and-trade program result in a 10 percent reduction in fuel combustion by affected sources within the study area. For example, it is estimated that industrial sources would achieve greenhouse gas emission reductions through efficiency measures that reduce on site fuel use by 10 percent either in response to a cap-and-trade program, or due to the results of the facility energy efficiency audits. While it is likely that the actual onsite reductions will differ across individual facilities from the assumed uniform 10 percent reduction,[98] the analysis identifies how reductions at these facilities affect the overall level of co-benefits.

The estimated NOx co-benefit of about 1.7 tons per day is small relative to the projected reductions of 24 tons per day that will occur as a result of the SIP and other measures. For example, an 8 ton per day NOx reduction is expected from cleaner port trucks. In comparison, the potential NOx benefit from a 10 percent efficiency improvement in major goods movement categories is estimated at about 1.5 tons per day. The estimated PM2.5 co-benefits, on the order of 0.12 tons per day, are also small relative to the projected reductions of 2.3 tons per day that will occur as a result of the SIP and other measures. Approximately 30 percent (0.04 tons per day) of the PM 2.5 co-benefit reduction is associated with assumed energy efficiency measures at the four large refineries in the study area, while another 30 percent would occur due to a 10 percent efficiency improvement by goods movement sources.

The co-benefit emission reductions in the study area would produce health benefits for the population in the study area (approximately 300,000 area residents) as well as regional benefits among a much larger population. Health benefits due to reductions in NOx are mostly at the regional levels, since NOx emissions have usually travelled some distance before they are transformed into PM via atmospheric reactions. Point source combustion PM emissions persist in the atmosphere and increase exposures both in the area where they are emitted and broadly throughout the region. Based on previous modeling studies of the impact of port and rail yard PM emissions in the South Coast Air Basin conducted by ARB, PM exposures will be reduced far beyond the study area, and a majority of the health benefits are expected to occur in areas outside of the Wilmington community.[99] Using the previously described methodology that correlates emission reductions in the air basin with expected health benefits there would be approximately 24 avoided premature deaths. There is considerable uncertainty inherent in the health impact estimates, particularly for a very localized area such as this. However, the impact estimates are provided here as a way to compare the relative contribution of Scoping Plan co-benefits to the improvements in public health expected from ARB's ongoing pollution control program.

[98] The reductions at any one facility could be much greater or lesser than 10 percent For example very small or no reductions might occur because available cost-effective industrial emission reductions have already been implemented at a particular site.

[99] ARB staff analysis indicates that no more than one-third of the health benefits would occur in the Wilmington area.

Overview

Air quality throughout California continues to improve, even with population and economic growth, due to extensive statewide programs that address the smog-forming criteria pollutants and toxic air contaminants. Overall emissions are declining in all communities, although the rate may vary depending upon the nature of local sources. Mobile sources are the dominant source of pollution exposure in communities statewide. Criteria pollutant emission reductions of hundreds of tons per day are estimated statewide by the 2020 timeframe from a combination of longstanding requirements and new measures in ARB adopted plans such as:

- Diesel Risk Reduction Plan (adopted September 2000)
- Goods Movement Emission Reduction Plan (adopted April 2006)
- State Implementation Plan (SIP) (adopted September 2007)

In addition, there will be incremental additional criteria pollutants reductions as a co-benefit of new actions under the AB 32 Scoping Plan for greenhouse gases, primarily due to measures that reduce fuel combustion. This analysis provides preliminary estimates of emission changes for the example community of Wilmington, between 2005 and 2020, due to current programs and the potential incremental co-benefits of measures recommended in the Scoping Plan. The magnitude of criteria pollutant co-benefits for a single community will generally be quite small (less than two tons per day of emission reductions in this example), compared to the benefits of all the existing public health programs to reduce air pollution.

Table H-12 summarizes the emission reductions estimated for NOx and PM2.5. Current emissions in the Wilmington community and projected emission levels in 2020 were derived from ARB's ozone modeling inventory. The combined impact of existing programs and new measures in the 2007 SIP is a projected 40-45 percent reduction in 2020 NOx and PM2.5 emissions levels, taking into account projected growth. Scoping Plan measures are estimated to reduce Wilmington area emissions by an additional one to two percent. The methods used to estimate the emissions impact, and the potential public health benefits, are discussed in this document.

Table H-12: Summary of Estimated Emission Reductions – Wilmington Study Area
(tons per day)

	NOx	**PM2.5**
Current Emissions	52.2	5.6
2020 Emission Reductions		
Reductions from existing programs and 2007 SIP	23.7	2.3
Reductions from Recommendation in Scoping Plan	1.7[a]	0.12
2020 Emissions	28.0[a]	3.2

[a] See text: Due to RECLAIM for NOx, we have not counted stationary source NOx reductions here.

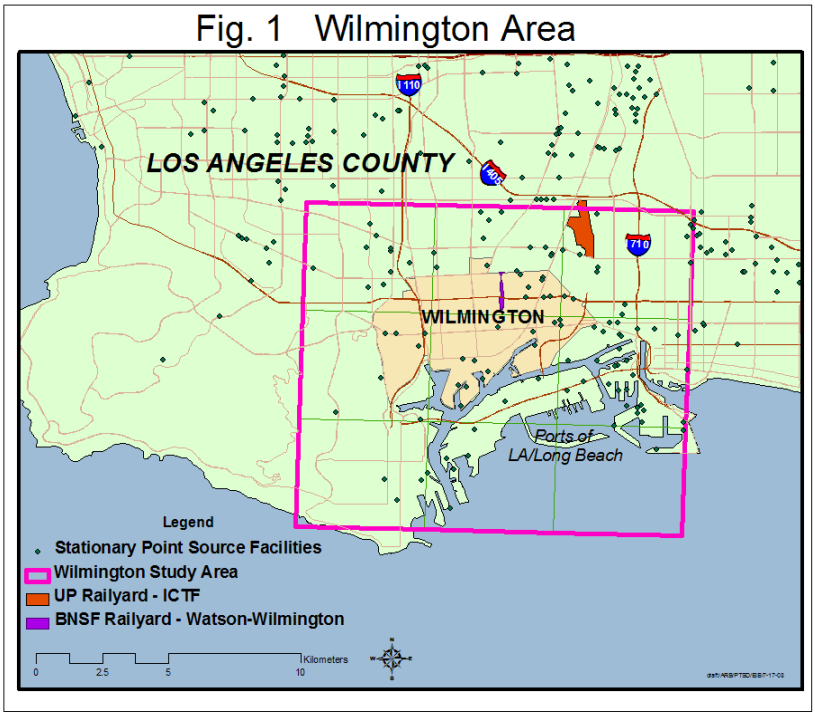
Methods

To illustrate the potential co-benefits of the Scoping Plan to local communities, ARB evaluated projected NOx and PM2.5 emission reductions by 2020 for the community of Wilmington, in the

Los Angeles area. Current emissions were represented by the 2005 SIP modeling inventory. To place the reductions in context, the analysis considers two cases: 2020 reductions due to existing programs and 2007 SIP measures, and 2020 reductions due to the incremental co-benefits from the Scoping Plan. The 2020 emission projections take into account growth, as well as the combined benefits of existing programs and new SIP measures as they apply to emission sources in the Wilmington community.

The Wilmington area in southern Los Angeles County is within the South Coast air basin, and includes a diverse mix of sources: the ports of Los Angeles and Long Beach, major transportation corridors, railyards, refineries, and other industrial/commercial operations. The best available data to characterize base and future year emissions for the full array of source types in this region was the gridded modeling inventory developed by ARB staff for southern California ozone modeling. The modeling inventory includes all mobile, stationary, and area wide source types – all on a spatial grid – for the 2005 base year and for projected 2020 levels. The modeling inventory already incorporates growth factors to account for economic and population growth affecting each sector, and control factors to account for the emission reductions in 2020 due to current regulatory programs, including all the existing programs and 2007 SIP measures. The Wilmington study area for this analysis has been represented as a 12 km by 12 km area, centered on the Wilmington ZIP code 90744, and defined as 9 cells excerpted from the southern California modeling grid domain. The Wilmington "9 cell" area used in this analysis has a population of approximately 300,000 and is shown in Figure H-3.

Figure H-3: Wilmington "9 Cell" Area



For the Wilmington grid study area, the staff compared the modeling inventory 2005 base year with projected 2020 levels of NOx and PM2.5 emissions for two cases:

1. **2020 reductions due to existing programs and 2007 SIP Measures – "before" the Scoping Plan:** This "before" case includes all rules/measures for air pollution control

adopted by December 31, 2006, plus SIP Measures. We collectively refer to this case as the "Existing and SIP Measures" case[100];

2. **2020 reductions due to the additional co-benefits "after" the Scoping Plan:** This "after" case represents the incremental additional criteria pollutant reductions due to co-benefits from the recommended measures in the Scoping Plan.

Reductions in the NOx and PM2.5 as a co-benefit of the Scoping Plan are expected mostly as a result of avoided fuel combustion. For example, improved energy efficiency programs in the electricity sector will result in the need for less fossil fuel combustion for power generation, resulting in concurrent reductions in criteria pollutant emissions.

Some criteria pollutant co-benefits are distributed over wide areas (e.g., reduced diesel and gasoline combustion from vehicles). Other GHG reductions (whether through source-specific regulations or the cap-and-trade regulation) will occur at individual stationary sources (such as efficiency improvements at industrial facilities) or will concentrate at specific sites (such as ports). This example quantification of co-benefits of the Scoping Plan at the community level is done for comparative purposes to illustrate the likely scale of potential co-benefits in the context of existing programs.

NOx and PM2.5 Co-Benefits – "After" Scoping Plan

This analysis of co-benefits from the Scoping Plan measures focuses on the major categories that, due to measures that reduce GHG emissions, are likely to reduce NOx and PM2.5 emissions by the 2020 timeframe, and for which data exist to quantify reduction estimates. (Several other measures are discussed qualitatively.) Many of these criteria pollutant co-benefits are expected due to net reduced/avoided fossil fuel combustion (e.g., through electrification or energy efficiency). In this analysis, approximate percentage-based or fractional-based reductions were estimated for many categories in order to scale the statewide benefits to the particular sources in the localized Wilmington study area. While it is likely that the actual onsite reductions at industrial sources will differ across individual facilities from the assumed uniform 10 percent reduction,[101] the analysis identifies how reductions at these facilities affect the overall level of co-benefits. Given the uncertainties in available information and the type of analysis used, estimated co-benefits could be greater or smaller than estimated here. As individual measures are developed better estimates of co-benefits should be possible.

[100] The "before" case includes what we collectively refer to here as the "Existing and SIP Measures", representing existing programs that focus on direct control of criteria and toxic air pollutants, and reflecting all adopted rules and measures through December 31, 2006, and SIP measures. The "before" case already includes major goods movement measures (ships, port trucks, cargo handling equipment); diesel risk reduction measures; reformulated gasoline and low-sulfur diesel fuel measures; New Source Review and stationary source permitting; the LEV/ZEV program; life-cycle benefits from the initial Pavley I measures for vehicles; consumer products regulations; railroad MOUs; and many other measures. Collectively, the "Existing and SIP Measures" will provide substantial improvements to air quality by 2020, which are greater than – and independent of – the additional co-benefits in the "after" Proposed Scoping Plan case. More information regarding SIP Measure quantification factors can be found in the State Implementation Plan.

[101] The reductions at any one facility could be much greater or lesser than 10 percent. For example, very small or no reductions might occur because available cost-effective industrial emission reductions have already been implemented at a particular site.

Table H-13: Emissions in 2020 Reflecting Existing and SIP Measures and "Before" Scoping Plan – Wilmington Study Area
(tons per day, selected categories)

	NOx	ROG	SOx	PM25
STATIONARY SOURCES				
Electrical Utilities	0.83	0.04	0.01	0.02
Oil and Gas Production (Combustion)	0.06	0.11	0.00	0.00
Petroleum Refining (Combustion)	3.36	0.64	2.00	0.90
Manufacturing and Industrial	0.94	0.10	1.00	0.12
Service and Commercial	0.38	0.09	0.02	0.04
Other Fuel Combustion	0.73	0.02	0.50	0.04
AREA SOURCES				
Oil and Gas Production	0.03	0.14	0.00	0.00
Petroleum Refining	1.92	1.10	4.32	0.36
Petroleum Marketing	0.00	2.58	0.00	0.00
Residential Fuel Combustion	0.15	0.02	0.01	0.02
MOBILE SOURCES				
On-Road Motor Vehicles	3.42	1.78	0.04	0.27
Aircraft	0.02	0.02	0.00	0.00
Trains	0.82	0.06	0.00	0.02
Ships and Commercial Boats	12.9	1.32	1.91	0.42
Recreational Boats	0.06	0.34	0.00	0.03
Off-Road Equipment	1.54	1.05	0.00	0.04
Fuel Storage and Handling	0.00	0.09	0.00	0.00
STUDY AREA TOTAL	**28.5**	**15.3**	**10.1**	**3.3**

The basic approaches for estimating the NOx and PM2.5 co-benefits of the Scoping Plan measures are described in the following sections by category.

Electricity Production

Renewables Portfolio Standard (Measure E-3): The Scoping Plan reflects the goal of increasing California's Renewables Portfolio Standard (RPS) for the mix of power generation to 33 percent by 2020. The increased use of renewables would mean displacement of other electricity generation, primarily combustion-related operations, largely natural gas. Using the California Energy Commission's estimate that about 70 percent of electricity is generated in-state, we assume 70 percent of the benefit will occur in-state. This measure is expected to result in avoided statewide generation (and associated avoided line losses) of approximately 48,000 GWh, which is approximately 13 percent relative to the estimated 2020 total state

generation of 370,000 GWh. For simplicity, we assume for Wilmington the overall 13 percent average in displaced electricity generation (primarily natural gas units).[102]

For power production related to the localized Wilmington study area, the modeling inventory shows the 2020 levels for electric production "before" the Scoping Plan measures to be 0.83 tons per day NOx and 0.02 tons per day of PM2.5 (using the Electric utilities category from Table H-13), resulting in an estimated Scoping Plan co-benefit of 0.076 tons per day NOx and 0.002 tons per day of PM2.5.

Energy Efficiency (Measure E-1) and Million Solar Roofs (Measure E-4): The Scoping Plan considers further energy efficiency improvements in the electricity sector that will decrease demand for electricity (e.g., building/appliance standards, utility energy efficiency programs), and the Million Solar Roofs program. These measures are expected to result in avoided generation (and associated avoided line losses) of approximately 35,000 GWh and 4,800 GWh, respectively, which is approximately 11 percent relative to the estimated 2020 total state generation of 370,000 GWh. Applying the reduction to the electric utility category emissions in the localized Wilmington study area corresponds to a co-benefit reduction of 0.058 tons per day of NOx and 0.001 tons per day of PM2.5.

Combined Heat and Power (Measure E-2): The Scoping Plan considers a statewide usage of 32,000 GWh of combined heat and power (CHP). CHP systems generate electricity and thermal loads at a facility, such as a school, hospital or manufacturing site, replacing onsite thermal generators (boilers) and grid electricity. This replacement results in a net energy savings between a CHP system and a power plant, because the power plant also generates a thermal load but is unable to use it. Additional benefits include avoided line loss for electricity saved. However, this shift can also change the location of co-pollutants, as CHP systems can generate the same, more, or fewer co-pollutants than the power plant, depending on the system's design and operation and on what type of industrial boiler the system is replacing. CHP systems also have a wide range of sizes, so their regulatory requirements can vary, and at this time the specific locations where CHP will be deployed are not known. Because of this uncertainty, we have assumed a shift between power plant and CHP that is neutral, and we have not assumed co-benefits in criteria pollutant reductions from CHP.

Limitations of Analysis: Several caveats should be noted regarding the power production calculations for this analysis. It is difficult to scale both the statewide electricity usage and statewide electricity production accurately to this localized Wilmington study area. The electricity usage may be higher in the region than an average across all other areas, due to the heavy industrial and port-related uses in this region. At the same time, the power production operations (power plants, etc.) associated with "Electric Utilities" that are included in the 9-cell modeling inventory may not correspond exactly to the production locations of the electricity that is consumed in Wilmington. Given the uncertainties, the benefits of greener electricity could be greater or smaller for this region.
A further consideration is that most major stationary source facilities (including power plants) in the South Coast Air Basin are included in the district's RECLAIM program for NOx emissions

[102] This renewable energy analysis assumes that if any new facilities are built, they are either located outside the Wilmington study area or they do not result in a net increase in criteria pollutant emissions compared to the prevailing power production sources already in the area. The estimate of reduced combustion-related electricity generation should be sufficiently conservative to ensure we have not overstated the potential co-benefits of the RPS.

trading. This makes the estimation of Scoping Plan local or even regional co-benefits of NOx reductions from stationary sources in this region more uncertain. Therefore, we have not included any NOx co-benefits estimates from stationary sources.

Residential/Commercial Fuel Combustion

Energy Efficiency (Measure CR-1) and Solar Water Heating (Measure CR-2): The Scoping Plan considers energy efficiency improvements and solar water heating in the residential and commercial fuel combustion area. We have assumed that this would result in a 10 percent reduction in energy demand, and that 90 percent of this would be reduction in natural gas combustion. The modeling inventory categories "Service and Commercial" and "Residential Fuel Combustion" (Table H-13) in the Wilmington 9-cell area together give an estimate of approximately 0.53 tons per day NOx and 0.06 tons per day PM2.5 in the "before" Scoping Plan case. Applying the reduction fractions, we would estimate a Scoping Plan co-benefit reduction of 0.048 tons per day NOx and 0.0054 tons per day PM2.5 in the localized Wilmington area.

Gasoline Measures – On-Road Motor Vehicles

The Scoping Plan considers the benefits from full implementation of AB 1493 Pavley Phase I and Phase II for on-road passenger vehicles (measure T-1). (It assumes eventual authority to implement the AB 1493 regulation or use of other measures such as "feebates" if needed to achieve equivalent reductions.) The base case scenario "before" the Scoping Plan measures has already included some adjustment for life-cycle benefits of the initial Pavley Phase I measures, as included in the Existing and SIP Measures. The additional measures (measures T-3 and T-4) and full implementation of all phases of Pavley (measure T-1), recommended by the Scoping Plan, are estimated to provide an additional 20 percent reduction in gasoline combustion, i.e., beyond what was accounted for in the "before" scenario. Therefore, for this analysis, we have assumed that the Wilmington area would experience this same additional 20 percent reduction in gasoline combustion in the on-road motor vehicle usage and a corresponding 20 percent reduction in emissions.

In the Wilmington 9-cell study area, the emissions from gasoline combustion from on-road passenger vehicles are estimated to be 1.03 tons per day NOx, 0.03 tons per day SOx, and 0.11 tons per day PM2.5.

Applying the 20 percent reduction in gasoline combustion, we estimate a co-benefit reduction of 0.022 tons per day of PM2.5. We have not assumed any NOx reductions, because we allow for the possibility that NOx reductions would be credited toward the LEV regulation. However, NOx reductions could occur. Some additional benefits are expected from avoided fuel delivery emissions, but these would be small for this local analysis and have not been quantified.

Diesel Measures – On-Road Motor Vehicles

The Scoping Plan considers measures that would reduce vehicular diesel combustion emissions, including aerodynamic improvements (measure T-1) and medium/heavy-duty hybridization (measure T-8). We have assumed a 5 percent reduction in diesel combustion in on-road diesel vehicles from these combined measures. In the Wilmington 9-cell study area, the emissions from diesel combustion from on-road motor vehicles are estimated to be 2.2 tons per day NOx, 0.01 tons per day SOx, and 0.1 tons per day PM2.5.

Applying the 5 percent reduction in diesel combustion, we estimate co-benefit reductions of 0.11 tons per day NOx, and 0.005 tons per day PM2.5.

Goods Movement

Many Goods Movement measures are already accounted for in the Existing and SIP Measures, so their benefits are counted in the "before" scenario. This includes rules for port trucks, cargo handling equipment, commercial harbor craft, ocean-going vessel rules such as shore power, and others, and it includes Vessel Speed Reduction provisions, already in place at the Ports of LA/Long Beach.

The Goods Movement efficiency measure (T-6) recommended in the Scoping Plan is additional to the SIP, but has not been developed in enough detail to provide well-defined estimates of co-pollutant benefits. However, the study area contains a very large concentration of goods movement sources, and the potential co-benefit from the recommended measure in the Scoping Plan could be significant. The Scoping Plan considers diverse system-wide efficiency improvements across the whole goods movement sector. It is difficult at this time to characterize exactly what will be achieved in the localized Wilmington area, but they should be substantial. Some of the potential strategies are described below.

Commercial Harbor Craft Education/Outreach for Maintenance and Design Efficiency: The Goods Movement efficiency measure considers improvements in harbor craft efficiency through various measures, the benefits of which are not yet individually quantified. We have not estimated reductions in the Wilmington area, but because the study area includes the ports and railyard activity, co-benefits in reduced NOx and PM2.5 would be expected.

Anti-Idling Measures for Cargo Handling Equipment: The Goods Movement efficiency measure considers reductions in idling emissions for cargo handling equipment at ports and railyards through anti-idling measures, the benefits of which are not yet individually quantified. Because the area includes ports and railyard activity, co-benefits in reduced NOx and PM2.5 would be expected.

TRU Electrification at Distribution Centers and Energy Efficiency Guidelines: The Goods Movement efficiency measure considers measures which would expand on the existing transport refrigeration unit (TRU) ATCM regulations, both with energy efficiency guidelines and limitations on using internal combustion engine power for cold storage at distribution centers and grocery stores. There are cold storage distribution facilities in the Wilmington study area, and there are likely to be NOx and PM2.5 co-benefits for these TRU measures in the area.

Port Trucks: Benefits for the Port Truck rule were already estimated in the "before" case for the Existing and SIP Measures, including a NOx reduction of ~8 tons per day for the South Coast Air Basin, estimated from the Port Truck rule. We are not assuming any additional measures resulting in co-benefit reductions for the "after" Scoping Plan case. However, in the modeling inventory analysis, the benefits due to the Port Truck rule were spatially distributed along with all other heavy-duty trucks using the SCAG heavy-duty truck model. In reality, proportionally more benefits of the ~8 tons per day NOx reduction would be expected to be highly localized near the Wilmington area than are likely to have been captured by the SCAG truck model.

Modeled Co-Benefit Reduction: Although the specific regulations and strategies to improve efficiency in the goods movement sector have not yet been identified, it is reasonable to assume

a 10 percent reduction in emissions from ships, trains, and off-road equipment in the Wilmington study area. This would provide 1.5 tons per day of NOx reductions and 0.05 tons per day of direct PM2.5 reductions. We believe this is a conservative estimate, as the recommended measure in the Scoping Plan assumes a 20 percent reduction in greenhouse gas emissions from goods movement sources by 2020.

Reductions at Industry Facilities

The Scoping Plan identifies 6 measures for various industrial categories. The modeling inventory for the Wilmington 9-cell area identifies numerous point source facilities in the categories of petroleum refineries, oil and gas production, and others. (Cement and glass manufacturing facilities do not occur in the Wilmington area.) The emissions inventory data also identify the processes that are combustion related, such as boilers over 10 MMBtu/hr.

One further consideration is that most major stationary source facilities (including refineries, oil and gas production facilities, and many other major industrial sources) in the South Coast Air Basin are included in the district's RECLAIM program for NOx emissions trading. This makes the estimation of local or even regional co-benefits of NOx reductions from stationary sources in this region more difficult. Therefore, we have not included any NOx co-benefits estimates from any stationary sources in the final totals. (PM2.5 reduction estimates are not affected by RECLAIM.)

Specific source types are discussed further below. For the purposes of this evaluation, it was necessary to make assumptions about potential emission reductions at industrial sources in the Wilmington area. We assumed that industrial sources would achieve greenhouse gas emission reductions through efficiency measures that reduce onsite fuel use by 10 percent, either in response to a cap-and-trade program, due to the results of the facility energy efficiency audits or due to measures to reduce fugitive emissions from oil and gas extraction and refineries, and refinery flaring. While it is likely that the actual onsite reductions will differ across individual facilities from the assumed uniform 10 percent reduction,[103] the analysis identifies how reductions at these facilities affect the overall level of co-benefits. Some information is available about the emission reductions potential and possible cost for of reductions at these sources.

Energy Efficiency and Co-Benefits Audits at Large Industrial Sources (measure I-1): The Scoping Plan recommends the use of audits to identify efficiency improvements to produce cost-effective GHG emission reductions at large industrial sources. The measure is also intended to provide additional information to evaluate whether cost-effective greenhouse reduction measures would also provide criteria pollutant and/or air toxics reductions as a co-benefit. Some level of reduction in NOx and PM2.5 from energy efficiency measures at large industrial facilities in the Wilmington area is likely, but it is not possible to quantify reductions at this time.

Refineries: The Scoping Plan includes three measures that target GHG reductions from the refinery sector. One measure would remove the methane exemption for VOC sources (measure I-5), and the second would reduce flaring (measure I-4). The third measure would place refineries under a cap. In general, the analysis suggests that many refineries could implement efficiency measures (such as boiler replacements or efficiency "tune-ups") that could reduce GHG emissions at relatively low cost. Together, for these measures, a fuel savings on the order

[103] The reductions at any one facility could be much greater or lesser than 10 percent. For example very small or no reductions might occur because available cost-effective industrial emission reductions have already been implemented at a particular site.

of 10 percent seems feasible. If implemented statewide, this could produce a PM2.5 co-benefit on the order of 0.14 tons per day.

In order to illustrate the possible co-benefits of refinery GHG reductions in Wilmington, ARB assumed uniform reductions of 10 percent at each refinery in the study area. The area's four large refineries account for just under 30 percent of the refining capacity in the state, and the potential benefits of a 10 percent improvement in refinery fuel use efficiency could produce about a 0.04 ton per day reduction in PM2.5. No NOx reductions are estimated because each refinery in the area is under the RECLAIM program, so additional NOx reductions at a refinery are likely to be offset by NOx emissions elsewhere at the facility or in the region.

Oil and Gas Extraction: The Scoping Plan recommends regulating fugitive emissions from oil and gas extraction and placing combustion sources in the sector under an emissions cap (measure I-2). For this localized analysis, we have assumed a 10 percent efficiency improvements applied to combustion-related processes at these facilities in the Wilmington study area as a result of the regulation and the cap. The modeling inventory shows approximately 0.06 tons per day NOx and minor PM2.5 from combustion processes occurring at oil and gas production facilities in the Wilmington 9-cell area. Applying a 10 percent factor would result in co-benefit reductions in emissions of 0.006 tons per day of NOx and a minor amount of PM2.5. As discussed above, we are focusing on the PM2.5 reductions, due to RECLAIM considerations affecting NOx from stationary sources.

Industrial Boiler Efficiency and Internal Combustion Engine Electrification: The Scoping Plan would place industrial boilers and engines under an emissions cap. For this preliminary evaluation, we have assumed 10 percent efficiency improvements applied to boilers larger than 10 MMBTU/hr and internal combustion (IC) engines at facilities in the Wilmington study area as a result of the cap. The modeling inventory includes 0.42 tons per day NOx, 0.026 tons per day SOx, and 0.093 tons per day PM2.5 from boilers larger than 10 MMBTU/hr and IC engines occurring at facilities in the Wilmington 9-cell area (other than power plants, refineries, and oil and gas production). Applying a 10 percent reduction factor for these boilers and engines results in estimated emission reductions of 0.042 tons per day NOx, 0.003 tons per day SOx, and 0.009 tons per day PM2.5. As discussed above, we are focusing on the PM2.5 reductions due to RECLAIM considerations affecting NOx.

Summary of Emission Co-Benefits

Table H-14 summarizes the estimated co-benefit emission reductions estimated for the Wilmington study area resulting "after" the Scoping Plan recommended measures.

Table H-14: Estimated 2020 Emission Reduction Co-Benefits "After" Scoping Plan for the Wilmington "9-cell" Study Area
(tons per day)

Category	NOx	PM2.5	Predominant Fuel
Electricity			
Renewables Portfolio	0.076 [a]	0.002	Natural gas
Efficiency & Million Solar Roofs	0.058 [a]	0.001	Natural gas
Combined Heat and Power	[c]	[c]	Mixed
Residential/Commercial Fuel	0.048	0.0054	Natural gas
On-Road Gasoline	-- [b]	0.022	Gasoline
On-Road Diesel	0.11	0.005	Diesel
Goods Movement	1.5	0.05	Diesel
Industrial			
Refineries	*	0.04	Mixed
Oil and Gas	0.006 [a]	minor	Mixed
Boilers & IC Engines	0.042 [a]	0.009	Mixed
Subtotal of calculated reductions	**1.8**	**0.12**	
TOTAL Non-RECLAIM Reductions *	**1.7**	**0.12**	

[a] For stationary sources we focus only on the PM2.5 reductions, due to RECLAIM considerations that affect NOx in the South Coast air basin. See text.
[b] No NOx reductions are assumed from reduced gasoline combustion under Pavley provisions, however, such reductions could occur. See text.
[c] No criteria pollutant co-benefits from this category are assumed to occur in the Wilmington study area since the specific locations and types of changes are not known at this time. See text.

Health Benefit Estimate

As an illustration of the benefits of existing programs and the co-benefits of the climate change Scoping Plan, the reduced health impacts associated with these NOx and PM2.5 emission reductions were considered. The health impacts associated with ozone and PM2.5 range from respiratory effects to premature death. This section discusses the potential decrease in adverse health effects associated with emission reductions that will occur in Wilmington as a result of the Scoping Plan.

The methodology that ARB uses to quantify premature death and other health impacts from exposure to air pollutants is based on a peer-reviewed methodology developed by U.S. EPA. ARB augmented U.S. EPA's methodology by incorporating the results of new epidemiological studies relevant to California's population, including regionally specific studies, as they became available. The methodology was described in ARB's March 2006, *Emission Reduction Plan for Ports and Goods Movement (Goods Movement Plan*), and was updated in the recent staff report for estimating premature death from exposure to particulate matter.[104]

[104] Air Resources Board. *Methodology for Estimating Premature Deaths Associated with Long-term Exposure to Fine Airborne Particulate Matter in California.* October 24, 2008. http://www.arb.ca.gov/research/health/pm-mort/pm-mort_final.pdf (accessed December 9, 2008)

The co-benefit emission reductions in the study area would produce regional health benefits. A relatively small portion of these benefits would occur in the study area (approximately 300,000 area residents). Health benefits due to reductions in NOx are mostly at the regional levels, since NOx emissions have usually travelled some distance before they are transformed into PM via atmospheric reactions. Point source combustion PM emissions persist in the atmosphere and increase exposures both in the area where they are emitted and broadly throughout the region. Based on previous modeling studies of the impact of port and rail yard PM emissions in the South Coast Air Basin conducted by ARB, PM exposures will be reduced far beyond the study area, and a majority of the health benefits are expected to occur in areas outside of the Wilmington community.[105]

Using the previously described methodology that correlates emission reductions in the air basin with expected regional health benefits there would be approximately 24 avoided premature deaths attributed to emission reductions that occur in Wilmington as a result of the Scoping Plan.

[105] ARB staff analysis indicates that about 20 percent of the health benefits would occur in the Wilmington area.

Overview of Regulatory Programs for Criteria and Toxic Air Pollutants in California

1. Local District Stationary Source Programs

Large industrial sources, such as refineries, factories, and power plants, as well as the smaller retail gasoline service stations, dry cleaners, and bakeries, are known as "stationary sources." The air pollution associated with growth in these stationary sources is addressed in regulatory programs independent of AB32. The following provides background information on how the air pollutant emissions from stationary sources are addressed in California.

Regulatory Structure

The regulation of stationary sources is conducted at three levels of government in California: federal, state, and local. The federal Clean Air Act requires states to directly regulate both stationary and mobile sources through a state implementation plan (SIP) to provide for implementation, maintenance, and enforcement of health-based national ambient air quality standards. The SIP outlines all of the national, statewide, and regional strategies that will be used to meet air quality standards by a given date. At the federal level, U.S. EPA is responsible for implementation of the federal Clean Air Act. Some portions of the Act are implemented directly by U.S. EPA. Other portions are implemented by state and local agencies.

Responsibility for attaining and maintaining ambient air quality standards in California is divided between ARB and the 35 independent local air pollution control and air quality management districts (districts, AQMDs and APCDs). In addition to the federal Clean Air Act, ARB and districts implement requirements of state law including the California Clean Air Act. Both State and federal law address pollutants like ozone and fine particulate matter, as criteria pollutants, and toxic pollutants like benzene and lead, as TACs.

State law vests ARB with direct authority to regulate pollution from mobile sources, fuels, and consumer products. Primary responsibility for controlling pollution from stationary sources lies with the districts. ARB, however, is responsible for submitting plans and maintaining a program that is in compliance with federal regulations, should any district fail to meet its responsibilities. As a result, ARB has an oversight role in assuring district compliance with federal requirements. The federal government retains the exclusive authority to regulate interstate trucks registered outside California, certain new farm and construction equipment, new locomotives, ships, and aircraft.

U.S. EPA, ARB, and the districts work together to complement each other's efforts to achieve clean air. ARB and districts collaborate on many air quality programs throughout California, including the development of the SIPs for achieving the national ambient air quality standards. Those portions of the plans which are federally required are then approved by ARB and subsequently U.S. EPA before becoming part of the federally-required SIP.

The State-to-local delegation of authority to the districts over stationary sources carries with it the responsibilities of developing region-specific rules, permitting, enforcement, collecting data associated with emissions inventory, and the preparation of local air quality plans. The districts may obtain authority from U.S. EPA to be the primary implementing and enforcing agency for certain federal requirements, such as new source performance standards (NSPSs), national emission standards for hazardous air pollutants (NESHAPs), and the prevention of signification deterioration (PSD) program.

Stationary Source Permitting

This section summarizes the primary legal requirements for permitting stationary sources of air pollution in California. Each district has adopted a set of rules to meet State and federal ambient air quality standards. District rules define the procedure and criteria districts use in permitting stationary sources. Although specific rules vary in scope and level of stringency by district depending on the region's air quality status, the general procedure for permitting new and expanding sources is the same throughout the state. Pollutant-emitting sources must obtain an authority to construct before beginning construction, and a permit to operate after the completed facility demonstrates compliance with district rules and the facility's permit conditions. Where applicable, district permit programs incorporate federal stationary source program requirements.

District requirements for stationary sources generally fit into two categories. The first category of rules applied to stationary sources is permitting rules for the construction and operation of new and expanding stationary sources. These rules are referred to as the New Source Review (NSR) program. A second category of requirements is rules which every source, or every source in a certain category of sources, must meet. These are often referred to as prohibitory rules. They apply whether or not a source is new or existing.

New Source Review. The NSR program is the foundation of stationary source emission control in California and allows industrial growth to continue in polluted areas while not undermining progress toward meeting clean air standards. NSR rules apply in areas that do not comply with ambient air quality standards (i.e., nonattainment areas). Because most districts are nonattainment for at least one criteria pollutant, NSR is a key component of stationary source permitting programs. NSR rules regulate new or expanding stationary sources that emit or have the potential to emit any criteria pollutant (or precursor) for which there is a State or federal ambient air quality standard. NSR is intended to allow growth while limiting emissions from new or expanded sources. Therefore, NSR programs provide mechanisms to (1) reduce emission increases up-front through clean technology, (2) provide for a no net increase in emissions, and (3) result in a net reduction in emissions. This is accomplished through two major requirements in each district NSR rule: best available control technology (BACT) and offsets.

> **Best Available Control Technology** is required for new and expanding equipment or processes at stationary sources that result in emission increases above designated thresholds. BACT requires use of the cleanest, state-of-the-art technology to achieve the greatest feasible emission reductions. Significant reductions in criteria pollutants have

been achieved using this strong technology-based approach to air pollution control. For example, BACT emission levels for oxides of nitrogen (NOx) in California are 98 percent less for power plant gas turbines than in 1982 and 91 percent less for gas-fired industrial boilers than in 1983.

In addition to BACT requirements, owners of new or expanding sources may be required to mitigate, or **offset**, the increased emissions that result after installation of BACT. Offsetting is the use of emission reductions from existing sources to offset emission increases from new or expanding sources. The amount of offsets required depends on the distance between the source of offsets and the new or expanding source. Offsets are generally required at a greater than 1-to-1 ratio so that when the new or expanded facility begins operation, more emissions are reduced than are increased. If a source obtains emission offsets outside the local area (i.e., interbasin), or if one type of pollutant is offset against another type (i.e., interpollutant), the source must use air quality modeling to show that these offsets will result in a net benefit. Some districts have pre-established ratios for interpollutant offsets in their rules.

If a stationary source reduces emissions below actual emission levels allowed by the district, in some cases that source may "bank" the reduction in emissions to offset emissions from future projects. Emissions banked in this manner are called **emission reduction credits (ERCs)** and can be used as offsets by the source or sold to other sources. ERCs must meet specific criteria before they can be issued. Criteria include that the actual emission levels reduced be adequately documented via records, emissions are in addition to that which are required by law, and there be mechanisms in place to ensure those reductions continue into the future.

Prohibitory Rules. Each district also has rules aimed at limiting emissions from existing stationary sources, known as prohibitory rules; however these rules apply to new sources as well. Prohibitory rules may be generic, such as limiting the maximum level of a particular pollutant (such as NOx) at any facility, or they may address specific equipment, such as a turbine, a boiler, or a reciprocating internal combustion engine. Sources are also subject to a general nuisance rule which provides authority to the district to control the discharge of any air contaminants that will cause injury, detriment, nuisance, endangerment, discomfort, annoyance, or which have a natural tendency to cause damage to business or property. To date, the 35 districts in total have adopted hundreds of prohibitory rules aimed at reducing criteria and toxic air pollutant emissions. Except where a source is exempt from permit, the proponent of a new or expanding source will normally have to demonstrate compliance with both NSR and prohibitory rule requirements in any permit application submitted to the district.

Toxic Air Contaminant Requirements: Most districts include TAC review coincident with permit review of criteria pollutants. Sources emitting TACs must comply with district requirements regarding the risk assessment and mitigation of TAC emissions. Some districts have established acceptable levels of health risk. Screening analyses and health risk assessments may be performed as part of the permitting process, or as part of the State AB2588 Hot Spots Program. In the case of significant health risks, districts may require

mitigation sufficient to reduce increased risk to tolerable levels. In addition, a new or expanding source, as well as existing sources, may be subject to either a federal NESHAP, a State-mandated airborne toxic control measure promulgated by ARB, or both.

Health Risk Assessment (HRA): As mentioned above, the impacts from any TACs that are emitted from a stationary source project are addressed using a health risk assessment, or HRA. An HRA is an evaluation of the potential for adverse health effects that can result from public exposure to emissions of toxic substances. The information provided in an HRA can be used to decide if or how a project should proceed. Some districts have regulations, or established policies, on HRAs for making risk management decisions. An HRA addresses three categories of health impacts from all pathways of exposure: acute health effects from inhalation only, chronic non-cancer health effects, and cancer risks from multiple exposure paths. Acute health effects generally result from short-term exposure to high concentrations of pollutants. Chronic non-cancer health effects, such as lead intoxication affecting the nervous system, and cancer risks may result from long-term exposure to relatively low concentrations of pollutants.

Air dispersion models are used to predict the ambient air concentrations of the toxic substances emitted by the source. The output from modeling is combined with pollutant-specific factors called unit risk factors (for cancer effects) or reference exposure levels, for acute and chronic non-cancer health effects. Combining this information will provide an estimate of the potential cancer risk (in chances per million) and potential non-cancer impacts expressed as a hazard index. Depending on the results, the district may approve the project as is, require additional pollution controls that represent the best available control technology for reducing toxic emissions (T-BACT), or may reject the project altogether.

Ambient Air Quality Impact Analysis: In California, most district permitting rules require evaluation of the air quality impact of a project to be based on proposed emissions of the project. Rarely will district source permitting rules determine permitting requirements using projections of air quality impacts generated by air quality models. Usually, air quality analyses are only required when emission offsets are not provided. In most cases, only NSR requirements are imposed by California districts since PSD requirements are mostly enforced by U.S. EPA. As a result, air quality modeling is mostly used to demonstrate that the project does not create a new violation of a State or federal ambient air quality standard, or exacerbate an existing one. If there are projected new violations of standards or, in some cases, PSD increments, the project may not be approved, unless acceptable mitigation measures are provided. The project is assumed to meet the net air quality benefit requirement if it complies with all district emission offset requirements. The emission threshold level at which offsets are required varies by district and is in accordance with minimum requirements of the California Clean Air Act.

Federal Program: In addition to the district rules, there are also federal rules which govern the permitting of new or expanding stationary sources—federal NSR and PSD. The purpose of federal NSR is to ensure that air quality does not deteriorate any further in areas with bad air quality (“nonattainment areas”), while PSD ensures that areas with good air quality

will continue to maintain good air quality ("attainment areas"). Many district rules incorporate these federal regulations by reference.

Review of Significant Effects on the Environment

Before the district can issue or deny a permit for a project which may have a significant effect on the environment, the project must comply with the California Environmental Quality Act (CEQA). The purpose of CEQA is to ensure that a project's environmental impacts and alternatives are disclosed to governmental decision-makers and the general public, and that any impacts are mitigated to the maximum extent feasible. CEQA applies to governmental decisions that require the exercise of judgment or deliberation (i.e., "discretionary activities"), as opposed to decisions involving only objective measurements without the use of personal subjective judgment regarding the wisdom or manner of carrying out a project. In addition, CEQA does not apply to statutorily or categorically exempt projects, which are defined in CEQA. Regulatory agencies issue permits after the project has been approved by the lead agency. The lead agency is generally the agency with the broadest discretionary authority in approving the project; this is typically the local land use agency such as a county planning department.

The CEQA Process: If a project is not exempt from CEQA review, it is analyzed to determine if there is the possibility of a significant effect on the environment. If a significant effect is possible, the lead agency prepares an initial study to evaluate the potential for an effect. If there are no potential impacts, a negative declaration is issued by the lead agency. If a potential impact exists which the project proponent can and will commit to mitigate, a mitigated negative declaration can be issued. Otherwise, the lead agency will issue a notice of preparation (NOP) of an environmental impact report (EIR). At this point, responsible agencies may comment on the required content of the EIR. These comments are then used by the lead agency to produce a draft environmental impact report (DEIR). The purpose of a DEIR is to assess any significant effect on the environment by the project and to evaluate potential mitigation measures. This report is available for review by responsible agencies and the public during the public review period. Comments on the DEIR by any of these parties may be submitted prior to the end of the public review period on such topics as completeness and accuracy of the draft EIR. The lead agency then reviews these comments and prepares a final EIR with responses to comments on the draft EIR. The final EIR is used by the lead agency in approving the project and by responsible agencies in issuing permits.

CEQA analyses must consider: impacts of facility construction; indirect emissions from increased mobile source activity; and the cumulative impacts of projects within the area. For example, construction impacts might include fugitive dust emissions raised by mobile construction equipment. Indirect emissions may include emissions from trips to and from work by employees as well as increases in emissions from commercial vehicles using the facility. Cumulative effects means the individual effects from the project are considered with the effects of past projects, other current projects, and reasonably foreseeable future projects. If there is a significant impact, the lead agency will evaluate the need for mitigation measures identified in the EIR before approving the project.

2. Statewide Programs

Efforts at the state level supplement local district stationary source permitting programs through activities that target the reduction of air toxics and criteria pollutants at both stationary and mobile sources. With respect to air toxics, the process of identifying and developing regulations to reduce the public health risks from TACs is led by ARB through a comprehensive statewide Toxic Air Contaminant Program. State-level mobile source programs assist in reducing the localized air quality impacts of stationary sources, as mobile source emissions associated with traffic to and from and within stationary sources can be significant—particularly with stationary sources that serve as transportation hubs such as distribution centers, ports, and rail yards. The major State programs are described below.

Air Toxics Program

California's air toxics program began in 1983 with the adoption of the Toxic Air Contaminant Identification and Control Act. The goal of the air toxics program is to protect the public health. Since 1990, the estimated cancer risk from toxic air pollutants, measured statewide, has been reduced by 45 percent even though California has had significant growth in the number of motor vehicles and industry.

To decide what toxic air pollutants are the most important, ARB has a comprehensive process to prioritize the identification of substances and to develop control measures. ARB conducts research and uses the most up-to-date scientific information on the chemicals used in California's industry and commerce. Based upon reviews of exposure and health effects information, ARB identifies the priority toxic air pollutants that pose the greatest health threat. While there are thousands of chemicals emitted into the air, ARB's ongoing review ensures resources are focused on control actions that most benefit public health. The Air Toxics Program has indentified almost 200 substances which are hazardous to the people of California, and the list continues to grow. Among those listed are asbestos, environmental tobacco smoke, and, diesel particulate matter (diesel PM).

Control measures that reduce TACs (known as airborne toxic control measures, or ATCMs) adopted by ARB have resulted in significant reductions of toxic emissions. These ATCMs require stringent controls and in some cases, complete elimination of the use of the toxic air pollutants through pollution prevention. For ATCMs that apply to stationary sources, the districts typically adopt the State control measure into their own rules. To date, ARB has adopted 17 non-diesel PM toxic control measures that reduce the health impacts from both mobile and stationary sources. These measures include reducing chromium emissions from decorative chrome plating facilities, reducing benzene from retail gasoline service stations, prohibiting the sale and use of automotive coatings containing hexavalent chromium or cadmium, and prohibiting the use of asbestos-containing rock on unpaved roads.

Another component of California's air toxics program is the AB2588 Air Toxics "Hot Spots" program, which requires facilities to report their air toxics emissions. Facilities with emissions that pose a significant risk to public health must notify the local community of the potential risk and then take steps to reduce that risk.

Diesel Program

Particulate matter from diesel-fueled engines (diesel PM) contributes over 70 percent of the known risk from air toxics today and is the most common airborne toxic that Californians breathe. In addition, diesel PM is a significant fraction of the state's particulate pollution problem. In September 2000, ARB adopted an aggressive plan to require cleaner diesel fuel and cleaner diesel engines and vehicles. The Diesel Risk Reduction Plan will reduce diesel emissions from year-2000 levels by 75 percent by 2010 and 85 percent by 2020. This plan will retrofit new and existing engines with PM filters to reduce emissions. A major component of the plan calls for extensive use of low-sulfur diesel fuel. Traffic at industrial facilities, such as the trucks that deliver raw materials and remove products and waste, can be a large contributor to the impact of an industrial facility on a community. The Diesel Risk Reduction Plan is reducing emissions from diesel engines, thereby reducing the contribution from diesel trucks and engines. Since the adoption of the Diesel Risk Reduction Plan, some of the strategies in place today in reducing diesel PM include:

Cleaner diesel fuel: California's diesel fuel is the least polluting in the nation. In 2003, ARB adopted a new regulation lowering the sulfur content of diesel fuel to enable the use of advanced emission control technologies for diesel engines, such as diesel particulate filters. The sulfur level in diesel fuel was lowered to less than 15 parts per million in July 2006. California's fuel regulation applies to on-road, off-road, and stationary engines, while the federal low sulfur diesel rule applies only to on-road vehicles.

Cleaner new diesel engines: In 2001, ARB adopted new PM and NOx emission standards to clean up new on-road diesel engines that power big-rig trucks, trash trucks, delivery vans, and other large vehicles. The new PM standard is a 90 percent reduction from the existing PM standard. With respect to new off-road diesel engines, ARB has worked closely with U.S. EPA on developing new PM and NOx standards for engines used in off-road equipment such as backhoes, graders, and farm equipment. U.S. EPA has proposed new standards that would reduce the emissions from off-road engines to levels similar to the on-road engines by 2010 to 2012.

Cleaner in-use diesel engines: ARB has adopted regulations aimed at reducing PM and other pollutants from in-use diesel engines. The regulations generally rely on the following approaches to significantly reduce emissions from diesel engines: (1) replace the existing engine with a new diesel engine; (2) apply an ARB-verified diesel emission control system to the existing engine and fuel system (includes alternative fuels); (3) replace the vehicle with an alternative-fueled vehicle or a vehicle with a new, cleaner diesel engine; and (4) operational modification (includes reduced operating time, reduced idling, or use of electric power). Some of the specific regulations adopted by ARB are listed below:

- Requirements for Stationary Diesel Agricultural Engines (2006)
- Ocean-going Ship Auxiliary Engines (2005)
- Public and Utility Diesel Truck Fleets (2005)
- Heavy-duty Diesel Truck Idling Technology (2005)
- Commercial Motor Vehicle Idling Restrictions (2004)
- Transport Refrigeration Units (2004)
- Portable Engines (2004)

- Stationary Engines (2004)
- Waste Collection Trucks (2003)
- School Bus Idling Restrictions (2002)

Goods Movement Program. Air pollution from international trade and all goods movement in California is a major public health concern at both regional and community levels. Goods movement is now the dominant contributor to transportation emissions in the state. In April 2006, ARB approved the *Emission Reduction Plan for Ports and Goods Movement* in California to reduce the emissions and health risk in communities near ports, rail yards, and high-traffic corridors. The plan will reduce emissions of diesel PM, the NOx and sulfur oxides (SOx) that contribute to fine particles, and, to a lesser extent, the volatile organic compounds (VOCs) that mix with NOx in the atmosphere to form regional ozone. The plan envisions emission reductions at each step in the goods movement path—from ship to shore to truck or locomotive to the final destination. Plan strategies, as well as some near-term actions already taken at the state level, are described below:

> **Goal for Ships—Reduce today's emissions of diesel PM by half, NOx by one-third, and SOx by 80 percent by 2020**. The plan seeks to reduce emissions from all cargo and passenger vessels operating in California ports and up to 24 nautical miles from the California coast. Ship strategies include cleaner engines and fuels for main and auxiliary engines, expanded speed reduction near the coast, and shore-based electric power in port. In 2007, ARB adopted a regulation estimated to reduce hotelling diesel PM and NOx emissions from container ships, passenger ships, and refrigerated cargo ships by nearly 50 percent in 2014 and 75 percent in 2020. The emission reductions will occur in areas at and near ports where community impacts are of most concern.
>
> **Goal for Trucks—Reduce today's emissions of diesel PM and SOx by 85 percent and NOx by two-thirds by 2020**. The plan focuses on the heaviest diesel trucks capable of hauling cargo containers or substantial bulk goods. Introduction of 2010+ trucks with advanced technology will continue the decline in emissions. Cleaning up the older truck fleets (including the short-haul trucks serving ports), reducing traffic congestion and idling, routing trucks away from neighborhoods, and providing the cleanest diesel fuel are components of the overall truck strategy. Recent ARB actions include anti-idling rules, controls for refrigeration units, more inspections in communities, low sulfur fuel, and software upgrades for 1993-1998 trucks. In 2007, ARB adopted a regulation that establishes emission standards for in-use, heavy-duty diesel vehicles that transport cargo to and from California's ports and intermodal rail facilities.
>
> **Goal for Locomotives—Reduce today's emissions of diesel PM and NOx by over 80 percent, and SOx by 99 percent by 2020**. The plan seeks to reduce emissions from locomotives pulling cargo and passenger trains, both at rail yards and in long-haul service throughout California. Locomotives are subject to federal standards and two agreements negotiated with ARB in 1998 and 2005 that include phase-out of non-essential idling, and preparation of new health risk assessments for 16 major rail

yards and implementation of mitigation measures based on those results. Low sulfur fuels are being phased in, starting in 2007. Idling limits and inspection programs are already reducing diesel PM at rail yards by 20 percent. As U.S. EPA has the sole authority to adopt and enforce locomotive emission standards, ARB has been encouraging U.S. EPA to expeditiously require the introduction of the next generation (Tier 3) of locomotive emission standards.

Goal for Harbor Craft—Reduce today's emissions of diesel PM and NOx by roughly 70 percent by 2020. The plan addresses all commercial harbor craft (tugs, ferries, and fishing vessels) operating out of California ports. U.S. EPA requires 30-45 percent control on new harbor craft and ARB is requiring low sulfur diesel fuel as of 2007. In 2007, ARB adopted a regulation that establishes new and in-use engine emission standards for both auxiliary and propulsion diesel engines on ferries, excursion vessels, tugboats, and towboats.

Goal for Cargo Handling Equipment—Reduce today's emissions of diesel PM by over 95 percent and NOx by over 80 percent by 2020. Cargo handling equipment is used to move goods at ports and intermodal rail yards. In 2005 and 2006, ARB adopted two rules to clean up new and existing diesel equipment and gas forklifts. As an example, the diesel rule requires that all yard trucks be replaced with new, very low diesel PM engines (or cleaner alternative fuels), most within the next five years.

ARB received $1 billion from Proposition 1B, the *Highway Safety, Traffic Reduction, Air Quality, and Port Security Bond Act of 2006*, to reduce emissions from activities related to goods movement along California's four major trade corridors. These funds are allocated to high pollution areas to reduce the public health impacts of goods movement activities.

Appendix I: Measure Documentation

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Measure Documentation

The purpose of this appendix is to document the assumptions and calculations Air Resources Board staff (ARB or staff) used as the basis for greenhouse gas (GHG) emissions reduction measures in the Scoping Plan and Appendices. ARB developed the measures contained herein with technical help from other State agencies and the Climate Action Team subgroups.

General assumptions common to categories of measures or sectors are listed under the major headings below. Unless otherwise noted, cost for a measure is the sum of the annualized capital cost and program maintenance costs. Annualized Capital Cost is defined as the product of the capital expenditure and the capital recovery amortized over a specified period of time at an annual discount rate of 5%. The capital recovery factor (CRF) is calculated using the formula:

$$\text{Capital Recovery Factor} = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where i is the discount rate (5%) and n is the life of the capital. A real discount rate of 5% is chosen to match the rate of return on an inflation adjusted 10-year treasury security. The expected life of the capital is estimated for each measure. The amortization period is related to the expected life of the capital or an estimate of the period over which GHG reductions are expected. For example, measures that use a 20-year capital life, the CRF is 0.08024 or approximately $0.08 annually for each dollar of capital expenditure. Each measure described specifies the estimated capital life and associated CRF.

Savings are generally calculated from reduced energy used as a result of efficiency or other measure. For most measures the savings value listed in the tables results from a reduction in fuel or electricity use or the net reduction associated with fuel switching. In the Scoping Plan Appendix C the "Net Annualized Cost" is calculated by subtracting the savings from the annualized cost. A negative cost value indicates the measure is expected to have net savings.

In addition to documentation for the recommended measures, this appendix includes documentation for other measures that were used in the economic modeling as a surrogate for the types of reductions that would be made under the cap-and-trade program. The use of these measures in the economic modeling is discussed in Appendix G. The additional measures include the additional energy efficiency and several Industrial measures.

The values and assumptions documented here are preliminary and subject to change during the regulatory process.

Transportation

General Assumptions

For transportation measures that reduce fuel combustion, staff used 8.94 $kgCO_2E$/gallon (0.00894 $MMTCO_2E$/million gallons) of gasoline and 10.4 $kgCO_2E$/gallon (0.0104 $MMTCO_2E$/million gallons) of diesel in 2020. These GHG emission factors were also employed in developing the emissions inventory. The cost for fuel in 2020 is projected at $3.673 for gasoline and for $3.685 for diesel[106].

Measure T-1—Pavley I and II – Light-Duty Vehicle Greenhouse Gas Standards (Adopted Regulation)

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Pavley (AB 1493)	31.7	1,372	11,381	-10,009
Pavley II – Light-Duty Vehicle GHG Standards		594	1,643	-1,049

Overview

This measure reduces GHG emissions from passenger vehicles, based on a fleetwide average, through technological efficiency improvements to vehicles or other actions. The Pavley standards (Pavley I) regulate passenger vehicle GHG emissions starting with the 2009 model year and continuing through 2016. The second phase of the Pavley regulations (Pavley II) is expected to affect model year vehicles from 2016 through 2020.

Assumptions for GHG Emissions Reduction

The Pavley standards are estimated to achieve a reduction of approximately 27.7 $MMTCO_2E$ in 2020[107] resulting from a reduction of approximately 3.1 billion gallons of gasoline consumed statewide in 2020.

$$3098 \text{ Million gallons gasoline} \times 0.00894 \frac{MTCO_2E}{\text{gallon gasoline}} = 27.7 MMTCO_2E$$

The second phase of Pavley targets an additional 4 $MMTCO_2E$ starting with 2016 model year vehicles[108].

$$447 \text{ Million gallons gasoline} \times 0.00894 \frac{MTCO_2E}{\text{gallon gasoline}} = 4 MMTCO_2E$$

[106] Fuel costs are California specific from the California Energy Commission Transportation Energy Forecasts for the 2007 Integrated Energy Policy Report; http://www.energy.ca.gov/2007publications/CEC-600-2007-009/CEC-600-2007-009-SF.PDF page B-5. Costs are 2007$

[107] A detailed analysis of the Pavley standards is found at: http://www.arb.ca.gov/regact/grnhsgas/grnhsgas.htm

[108] More information is fount at: http://www.arb.ca.gov/cc/ccms/reports/final_pavleyaddendum.pdf

Assumptions for Costs and Savings

The average cost for control for passenger cars and small trucks/SUVs is estimated at $1050 for 2016 model year vehicles based on staff analysis[2]. The second phase of the Pavley regulations is expected to be approximately twice the average cost of a 2016 vehicle by 2020, or $2100. Fleetwide aggregate costs per vehicle ranging from $33-1910 (2009-2020 model years) for an estimated 1.3 million vehicles per year is annualized over 16-19 years resulting in $1,236M (in 2004$). Multiplying by a Consumer Price Index of 1.11 results in $1,372M in 2007$. For Pavley II the costs/vehicle are estimated at twice the average 2016 value for Pavley I. This results in $594M in cost for 1.3M vehicles annually.

Savings is calculated based on reduced fuel consumption multiplied by $3.673/gallon of gasoline as described above. Savings are based on 27.7MMTCO_2E and 4 MMTCO_2E for Pavley I and II, respectively.

$$3098 \text{ Million gallons gasoline} \times \frac{\$3.673}{\text{gallon gasoline}} = \$11{,}381\,M$$

$$447 \text{ Million gallons gasoline} \times \frac{\$3.673}{\text{gallon gasoline}} = \$1{,}643\,M$$

Measure T-2—Low Carbon Fuel Standard

GHG Reduction Measure	Potential 2020 Reductions MMTCO_2E	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Low Carbon Fuel Standard	15	11,000	11,000	0

Overview

This measure reduces GHG emissions by requiring a low carbon intensity of transportation fuels sold in California by at least 10% by the year 2020. The low carbon fuel standard regulation is under development and the reduction pathways are being analyzed.

Assumptions for GHG Emissions Reduction

The total projected transportation inventory for fuels affected by the LCFS regulation is approximately 215 MMTCO_2E. This estimate derives from the difference between the total transportation inventory (225.4 MMTCO_2E) and the portion of this inventory that is not affected by LCFS (approximately 10 MMTCO_2E of aviation, residual fuel oil and lubricants). Assuming that vehicle efficiency (Pavley I and II), land use, and goods movement efficiency measures reduce fuel use, the new projected inventory is approximately 167.9 MMTCO_2E with these reductions subtracted. A 10% carbon intensity reduction is therefore 16.8 MMTCO_2E (i.e. 0.1 x 167.9 = 16.8 MMTCO_2E). Because the calculated LCFS GHG emissions reduction has potential overlap with other transportation measures staff discount the calculated reduction of 16.8 MMTCO_2E by 10% to result in a 15 MMTCO_2E reduction for accounting purposes (i.e. 16.8 MMTCO_2E x 0.9 (90%) = 15 MMTCO_2E).

Assumptions for Costs and Savings

Staff assumes the costs of producing ethanol and biodiesel are highly competitive with the current and projected high prices of gasoline and diesel. Staff assumes that implementation of the LCFS will result in displacing approximately 20% of traditional petroleum derived products and replacing them with alternative fuels. This equates to approximately three billion gallons per year reduced consumption of traditional gasoline and diesel that the consumers would buy (savings) and equates to $11 billion dollars in lost sales of petroleum products. Secondarily, staff assumed that alternative fuels could be produced at prices at or below the pretax wholesale cost of petroleum fuels on an energy equivalent basis. Consumers would not necessarily get this benefit as the market price commanded by the alternative fuels would simply be the price of petroleum based products. Recovery of capital expenditure to produce alternative fuels would be recovered from the purchase of $11 billion worth of alternative fuels that replace the petroleum fuels that were displaced (costs). Therefore, staff estimates that there will be no net difference in the costs of producing fuels to meet the LCFS compared with the cost of producing traditional petroleum gasoline and diesel.

Measure T-3—Regional Transportation-Related Greenhouse Gas Targets

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Regional Transportation-Related Greenhouse Gas Targets	5	500	2,054	-1,554

Overview

This measure would reduce vehicle miles traveled (VMT) by approximately 4% through land use planning. Staff estimated a 4% reduction based on review of modeling literature[109].

Assumptions for GHG Emissions Reduction

A 4% reduction in VMT results in a 4% reduction in GHG emissions based on the affected portion of the emissions inventory. Passenger vehicles are projected to emit 160.8 $MMTCO_2E$ in 2020 which derives primarily (99.8%) from gasoline combustion. Measures in the Scoping Plan that reduce GHG emissions from reduced fuel consumption include Pavley I and II (measure T-1 reduces GHG emissions by 31.7 $MMTCO_2E$), vehicle efficiency measures (T-4 reduces GHG emissions by 4.5 $MMTCO_2E$) and high speed rail (1 $MMTCO_2E$). Subtracting the T-1, T-4 and T-9 reductions from the projected inventory results in approximately 124 $MMTCO_2E$ net GHG emission for passenger vehicles. A four percent reduction equates to 4.94 $MMTCO_2E$ which is rounded to 5 $MMTCO_2E$.

[109] Rodier, Caroline, UC Berkeley, Transportation Sustainability Research Center, *"A Review of the International Modeling Literature: Transit, Land Use, and Auto Pricing Strategies to Reduce Vehicle Miles Traveled and Greenhouse Gas Emissions," August 2008.* http://www.arb.ca.gov/planning/tsaq/docs/rodier_8-1-08_trb_paper.pdf

$$160.8MMTCO_2E - 31.7MMTCO_2E - 4.5MMTCO_2E - 1MMTCO_2E = 123.6MMTCO_2E$$

$$123.6MMTCO_2E \times 0.04(4\%) = 4.94MMTCO_2E$$

Note that the order in which the reductions are calculated changes the resulting expected GHG reduction for this measure. For example, if a 4% reduction in VMT were calculated from the business-as-usual projection of 160.8 $MMTCO_2E$, a GHG emissions reduction of more than 6.4 $MMTCO_2E$ would result (i.e. 0.04 [4%] x 160.8 $MMTCO_2E$ = 6.4 $MMTCO_2E$).

Assumptions for Costs and Savings

Staff conservatively estimates $100/ton of carbon reduced for costs and savings are based upon reduced fuel consumption. For 5 $MMTCO_2E$ this is a total cost of $500M. Savings is the result of reduced fuel use.

$$4.94MMTCO_2E \times \frac{1 \text{ gallon gasoline}}{0.00894MTCO_2E} = 553 \text{ million gallons gasoline}$$

$$553 \text{ million gallons gasoline} \times \frac{\$3.673}{\text{gallon}} = \$2{,}054M$$

Measure T-4—Vehicle Efficiency Measures

Includes Tire Pressure Program, Tire Tread Standard, Low-Friction Engine Oils, and Solar-Reflective Automotive Paint and Window Glazing. These measures are assumed to apply primarily to light-duty gasoline passenger vehicles. Vehicle population estimates that staff assumes to be affected by each measure are listed separately below. These measures are expected to primarily affect the light-duty vehicle fleet, however each measure assumes a specific targeted portion of this fleet based on staff engineering judgment.

Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($ Millions)	Savings ($ Millions)	Net Annualized Cost ($ Millions) [Cost-Savings]
Tire Pressure Program	0.55	152	224	-72
Tire Tread Standard	0.3	0.6	123	-123
Low Friction Engine Oils	2.8	520	1,150	-630
Solar Reflective Automotive Paints and Window Glazing	0.89	360	366	-6

Tire Pressure Program

Overview

This measure would increase vehicle efficiency by assuring properly inflated automobile tires to reduce rolling resistance. A proposed Tire Pressure Measure (Measure) would require all automotive service centers and test-only smog check service centers in California

to perform mandatory tire pressure inspections on vehicles being serviced at the facility and further requires that the tires be inflated to the manufacturer recommended levels. Increasing fuel efficiency reduces GHG emission by consuming less fuel.

Assumptions for GHG Emissions Reduction

1) The USEPA estimates that 54 percent of passenger cars and 62 percent[110] of light-duty trucks have under-inflated tires, of which:
    a. Twenty percent of passenger cars and 26 percent of light-duty trucks have severely under-inflated tires (6 pounds per square inch [psi] or more) that average 8.65 psi and 8.49 psi below the vehicle manufacturer's recommended specification respectively.
    b. Twenty-seven percent of passenger cars and 29 percent of light-duty trucks have moderately under-inflated tires (between 1 and 6 psi) that average 3.42 psi and 3.55 psi under-inflation respectively.
2) Fuel efficiency is reduced by 1 percent for every 3 psi of underinflation[5] (average of all 4 tires).
3) Tires lose pressure at a rate of approximately one psi per month[111]
4) A quarterly re-inflation period is assumed due to extensive outreach promoting regular tire inflation checks and the regulation affecting vehicles through automotive repair facilities.

Staff assumes that starting in the first year following the Program's regulatory and outreach components all vehicles with severely or moderately underinflated tires will have their tires properly inflated. Vehicles with underinflation of 1 psi or less are excluded from calculation assuming that this modest measurement variation arises from ambient temperature fluctuation or error in pressure gauges. Staff estimates that 47 percent of passenger cars and 55 percent of light-duty trucks will have moderately underinflated tires through 2020 averaging 3.42 psi and 3.55 under-inflation. Taking into account the air loss rate per month over a 3 month period, the average pressure correction of a tire inflated an additional 3.42 psi and 3.55 psi are 1.92 psi and 2.05 psi respectively (i.e. 0.649% and 0.693% efficiency increase) The 2020 light-duty GHG emissions inventory is 160.7 $MMTCO_2E$ from an expected 18 billion gallons of gasoline. In 2020, the measure is expected to save 0.55 $MMTCO_2E$ from an expected savings of 61 million gallons of gasoline.

<u>Passenger Cars</u>

$$8 \text{ billion gallons gasoline} \times 0.00649(\text{efficiency}) \times 0.47(47\% \text{ of vehicles}) = 24 \text{ million gallons gasoline}$$

[110] U.S. Environmental Protection Agency, Office of Transportation and Air Quality Fuel Economy Labeling of Motor Vehicle Revisions to Improve Calculation of Fuel Economy Estimates, EPA420-R-06017, December 2006.
[111] Bridgestone Firestone North American Tire, LLC website: www.tiresafety.com
Michelin North America, Inc. website: http://www.michelinman.com/tire-care/tire-saving-tips/air-pressure-tips/

$$24 \text{ million gallons gasoline} \times 0.00894 \frac{MTCO_2E}{\text{gallon}} = 0.22 MMTCO_2E$$

Light-Duty Trucks

$$9.7 \text{ billion gallons gasoline} \times 0.00693 \times 0.55 = 37 \text{ million gallons gasoline}$$

$$37 \text{ million gallons gasoline} \times 0.00894 \frac{MTCO_2E}{\text{gallon}} = 0.33 MMTCO_2E$$

Assumptions for Costs and Savings

Staff estimates costs associated with air compressors, air tools, tire gauges, equipment maintenance and Tire Guide/Yearbook. Cost assumptions for each affected facility are:

1) Air compressors are an average cost of $468 with a life expectancy of five years. Staff estimates that test-only smog check facilities will have to purchase an average of 1.5 compressors in 2010, 2015 and 2020.
2) Annual compressor maintenance at an average of $37.50.
3) Air tools and hoses are $50 every two years ($25/year).
4) High quality tire pressure gauge is $25 with a 2-year life expectancy.
5) Tire Guide/Yearbook is approximately $50 with a 3 year replacement need.
6) The number of test-only smog check facilities is 1,985 and automotive repair facilities is 33,692 (including test-only smog check facilities).[112]
7) Staff expects that one or two compressors and associated equipment will be purchased per test-only facility.
8) The estimated time to check and inflate tires is expected to be 3 minutes per vehicle at an average labor rate of $19.63/hour.
9) Eighty-two percent of drivers have their vehicle oil changed by professionals.[113]
10) Staff expects that the per-vehicle labor costs will be passed on to the consumer.

To calculate the 2020 annualized cost, staff uses the above assumptions and the capital recovery factor for either 2, 3 or 5 year amortization period (depending on capital expenditure). The result is an annualized cost of $152M and net annualized cost savings of $72M in 2020. Savings is the result of reduced fuel use (61 million gallons of gasoline at $3.673/gallon), which is $224M.

[112] California Department of Consumer Affairs, Bureau of Automotive Repair, Vehicle Information Database
[113] California Integrated Waste Management Board, Used Oil Source Reduction Study: *Busting the 3000 mile myth*, March 2007.

Calculation	Cost ($Millions)
Smog stations	
Capital cost in 2020 - Compressors	$1,531,516
2020 annualized capital cost using 5 year CRF (0.23097 x capital cost)	$353,741.54
Capital cost 2020 - Hoses	$245,435
2020 annualized capital cost using 3 year CRF (0.3672 x capital cost)	$90,125.91
Capital cost 2020 – Tire Guide Book	$109,082.32
2020 annualized capital cost using 3 year CRF (0.3672 x capital cost)	$40,055.96
Total capital cost for 2020 (sum of annualized costs)	$483,923.42
Operating cost 2020	$87,265.85
Total smog check cost for 2020	$571,189.27
Automotive Service Centers	
Capital cost in 2020 - Gauges	$888,654
2020 annualized capital cost using 2 year CRF (0.5378 x capital cost)	$477,922.65
Capital cost 2020 - Tire Guide Book	$1,742,459.52
2020 annualized capital cost using 3 year CRF (0.3672 x capital cost)	$639,846.06
Total automotive center cost for 2020	$1,117,768.71
Total Annual Labor Cost for 2020	$150,163,116
Total cost for 2020	$151.9
Total savings 2020 (61,000,000 gallons gasoline x $3.673/gallon)	$224.1

Tire Tread Standard

Overview

This measure would increase vehicle efficiency by creating an energy efficiency standard for automobile tires to reduce rolling resistance. A reduction in GHG emissions results from reduced fuel use. Staff estimates that reducing the rolling resistance of tires by 10% results in a 2% increase in fuel efficiency.

Assumptions for GHG Emissions Reduction

The tire tread program will provide information to consumers about the availability of tires which are identified as low rolling resistance. Staff uses the following assumptions in calculating the GHG reduction from this measure:

- In 2020, there will be approximately 25 million passenger vehicles in the fleet affected by this measure.
- Approximately 5.5 million vehicles are new and therefore not in the market to purchase new tires.
- New vehicles have low rolling resistance tires as original equipment from the vehicle manufacturer.

- Passenger vehicles affected by this measure drive an average of approximately 12,000 miles per year.
- The fleet average mileage for passenger vehicles affected by this measure is approximately 21 miles per gallon.
- Approximately 15% of tire purchases will be low rolling resistance (i.e. 15% market penetration)
- A 10% reduction in rolling resistance results in a 2% vehicle efficiency increase.

$$19{,}500{,}000 \text{ vehicles} \times 15\% = 2{,}925{,}000 \text{ vehicles} \times 12{,}000 \text{ miles} = 35{,}100{,}000{,}000 \text{ VMT}$$
$$35{,}100{,}000{,}000 \text{ VMT} \div 21 \text{ MPG} = 1{,}671{,}428{,}571 \text{ gallons} \times 2\% = 33{,}500{,}000 \text{ gallons}$$
$$33{,}500{,}000 \text{ gallons} \div 0.00894 MMTCO_2E / \text{million gallons} = 0.3 MMTCO_2E$$

Assumptions for Costs and Savings

Staff estimates that the there is little, if any, cost differential between tires of varying rolling resistance and therefore assumes no additional cost for choosing low rolling resistance tires. The annual program cost is estimated at $625,000 based on staff experience with programs of similar size and scope. Savings is the result of reduced fuel use.

$$33.5 \text{ million gallons gasoline} \times \$3.673 / \text{gallon} = \$123M$$

Low Friction Engine Oils

Overview

This measure would increase vehicle efficiency by mandating the use of engine oils that meet certain low friction specifications. The American Petroleum Institute has established "energy conserving designation" for certain oils. These specifications would be used as a starting point for the mandated oils under this measure.

Assumptions for GHG Emissions Reduction

Staff estimates a 2% efficiency increase based on results from research studies.[114] Staff estimates the efficiency will be achieved in about 85% of vehicles comprising the light-duty fleet. The 2020 GHG emissions inventory from light-duty vehicles is 160.8MMTCO$_2$E for all fuels.

$$0.02 \times 0.85 \times 160.8 MMTCO_2E = 2.8 MMTCO_2E$$

Assumptions for Costs and Savings

Staff estimates approximately $20 per vehicle additional operating and maintenance costs for 26 million vehicles affected by this measure in 2020. Existing oils meeting the low friction criteria are approximately $1/quart more than conventional oil. The $20 incremental cost is

[114] The Southwest Research Institute (SwRI) conducted a research program that evaluated the effect of engine oil on the fuel economy of gasoline and light-duty diesel engine passenger cars called the Mercedes-Benz M111 Fuel Economy Test—DCED L-54-T-96(http://www.swri.org)

based on use of 5 quarts of engine oil at $1 per quart additional for each of 4 oil changes per year. Savings is the result of reduced fuel use of 313 million gallons of gas at $3.673/gallon.

$$\$20 \times 26 \text{ million vehicles} = \$520M$$
$$\$3.673/\text{gallon} \times 313MG = \$1{,}150M$$

Solar Reflective Automotive Paint and Window Glazing

Overview

This measure would increase vehicle efficiency by reducing the engine load for cooling the passenger compartment with air conditioning. The use of solar reflective automotive paints and window glazing reduces heating of the automobile passenger compartment from the sun resulting in reduced air conditioning use. The result is both less frequent air conditioning use by drivers and smaller air conditioners specified by manufacturers for new vehicles.

Assumptions for GHG Emissions Reduction

Staff estimates approximately 170 million gallons of gasoline could be saved annually with full implementation of this measure based on results from a National Renewable Energy Laboratory research study and associated modeling results.[115] This translates into 1.5 $MMTCO_2E$. This measure is expected to affect 2012 and newer vehicles that are expected to comprise 43% of the 2020 fleet and account for 59% of VMT according to EMFAC2007[116]. The result is a reduction of 0.89 $MMTCO_2E$ in 2020.

$$0.59 \times 1.5MMTCO_2E - 0.89MMTCO_2E$$

Assumptions for Costs and Savings

Staff estimates that the additional cost per vehicle is approximately $250 for complying with this regulation. This includes $10-50/vehicle additional cost for solar reflective paint and $150-225/vehicle additional cost for window glazing. The annualized cost assumes a 14-year CRF (0.101) resulting in approximately $26 per vehicle. It is expected that 14 million vehicles will be affected by this measure resulting in total annualized capital cost of approximately $360M.

Savings is the result of reduced fuel use. Reduced fuel of about 99 million gallons results in a $366M savings annually

[115] National Renewable Energy Laboratory research study "Reduction in Vehicle Temperatures and Fuel Use from Cabin Ventilation, Solar-Reflective Paint, and a New Solar-Reflective Glazing" (Rugh, J.P *et al*. 2007-01-1194). http://www.nrel.gov/vehiclesandfuels/ancillary_loads/pdfs/40986.pdf

[116] The EMissions FACtors (EMFAC) Model is used by ARB to calculate emission rates and population of motor vehicles. Information is available at: http://www.arb.ca.gov/msei/onroad/latest_version.htm

Measure T-5—Ship Electrification at Ports (Adopted Regulation)

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Ship Electrification at Ports—Shore Power (Discrete Early Action)	0.2	0	0	0

Overview

This regulation requires ships meeting certain criteria to turn off (cold iron) auxiliary engines at port (hotelling) and acquire power from shore electrification or use another equally effective means of reducing emissions. This measure is motivated primarily by air toxics pollutant reductions but achieves a GHG benefit primarily by shifting electrical generation from high-emitting onboard engines to sources providing electricity to the grid, such as combined-cycle gas turbines.

Assumptions for GHG Emissions Reduction

Staff calculated the GHG emission reduction as a ratio of the per megawatt-hour emissions from onboard ship auxiliary power to the shore power emission multiplied by the MWh of electricity supplied to the ship. Staff used 690g/KWh (6.9×10^{-7} $MMTCO_2E/MWh$) for auxiliary ship engines. A total estimated 715GWh (715,000MWh) of electricity is used by hotelled ships.[117]

$$6.9 \times 10^{-7} MMTCO_2E / MWh \times 715{,}000 MWh = 0.493 MMTCO_2E$$

$$4.37 \times 10^{-7} MMTCO_2E / MWh \text{ (2020 Line Value)} \times 715{,}000 MWh = 0.312 MMTCO_2E$$

$$0.493 MMTCO_2E - 0.312 MMTCO_2E = 0.18 MMTCO_2E$$

Assumptions for Costs and Savings

The cost and savings associated with this measure are assigned to the diesel risk reduction program and therefore no net cost has been included in the Scoping Plan.

Measure T-6—Goods Movement Efficiency Measures

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Goods Movement Systemwide Efficiency Measures	3.5	TBD	TBD	0

[117] The Initial Statement of Reasons (ISOR) for the Shore Power rule (adopted December 2007) is found at http://www.arb.ca.gov/regact/2007/shorepwr07/tsd.pdf. The ISOR details criteria pollutant and GHG emissions and electricity supplied to hotelled ships.

Overview

This measure targets systemwide efficiency improvements in goods movement to achieve GHG reductions from reduced diesel combustion. Staff is developing strategies to achieve the 3.5 $MMTCO_2E$ target. The 3.5 $MMTCO_2E$ target represents about a 22% reduction from the 2020 projected goods movement inventory.

Assumptions for GHG Emissions Reduction

A target of 3.5 $MMTCO_2E$ is established in the Scoping Plan. For the purposes of this analysis, staff estimates the targeted reduction will result from reduced diesel combustion from efficiency (90%) and electrification of equipment currently fueled by diesel (10%). However, because this measure is expected to provide flexibility to the industry in determining the emission reduction approaches that work best for them, the proportion of emission reductions from efficiency improvements and electrification may be different than estimated here. The reduction target is the net of GHG emissions reductions from reduced diesel use plus the increased emissions from electrification.

Additional assumptions used are as follows:

- All fuel used by engines under measure is diesel fuel
- Diesel fuel density of 7 lbs. per gallon
- Diesel GHG emissions of 10.4 kg CO_2E per gallon diesel fuel

<u>For conversion from diesel engine to grid power</u>

- Grid power emission factor of 437 g CO_2E/kWh
- Average diesel engine brake specific fuel consumption value (BSFC) of 250 grams diesel/kWh for the diesel engines covered. Available BSFC data for a sampling of marine, locomotive, and TRU engines ranged from about 200 to 250 g diesel/kWh. Upper end of range (250 g/kWh) used to account for transient operation with lower fuel consumption (higher BSFC).
- CO_2 emission factor of 790 g/kWh for all engines covered under the measure (estimated using 250 g fuel /kWh BSFC and 10.4 kg CO_2E/gallon)

Calculations:

A. <u>Reduction in fuel consumption that will result in 90% of the total 3.5 MMT CO2 emission reduction</u>:

3.5 $MMTCO_2E$ x 90% = 3.15 $MMTCO_2E$ reduction
3.15 $MMTCO_2E$ x (1x 10^{12} g CO_2)/MMT x kg CO_2/1000 g CO_2 x gall diesel/10.4 kg CO_2
= <u>303 million gallons diesel reduced</u>

B. <u>Increase in grid power (and decrease in diesel consumption) associated with conversion from diesel engine power to grid power that will result in 10% of the 3.5 MMT CO2 emission reduction:</u>

3.5 $MMTCO_2E$ x 10% of reduction = 0.35 $MMTCO_2E$ reduction

0.35 $MMTCO_2E$ reduction = [E kWh x 790 g CO_2/kWh from diesel engines] –
[E kWh 437 g CO_2E/kWh from power plants]

Note: The 0.35 $MMTCO_2E$ emissions reduction is represented in this equation as the difference in CO_2 emissions between diesel engines and the grid when supplying the unknown value for energy E. This assumes that when converting from diesel engines to grid power, the same amount of energy will be provided. Solving for E provides the increase in grid power.

0.35 $MMTCO_2E$ = [353 g CO_2/kWh] x E
E= 0.35 $MMTCO_2E$/353 x 10^{-12} MMT/kWh
E= 991 million kWh = 0.991 million MWh~1 million MWh increase

Diesel fuel reduced = 991 million kWh x 250 g diesel/kWh x lb/454 g x gall/7 lbs = 78 million gallons reduced

C. Total decrease in diesel fuel consumption (galls) and increase in grid power used (MWh):

Overall decrease in diesel fuel consumed: ~380 million gallons
Increase in grid power: ~ 1 million MWh

Assumptions for Costs and Savings

Staff is developing the strategies to achieve reductions from goods movement systemwide energy efficiency. The preliminary assumption is that costs and savings will be approximately equivalent.

Measure T-7—Heavy-Duty Vehicle GHG Emission Reduction (Aerodynamic Efficiency)

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Heavy-Duty Vehicle GHG Emission Reduction (Aerodynamic Efficiency)	0.93*	1,616*	2,137*	-521*

*This measure is estimated to result in 6.4 $MMTCO_2E$ nationwide emissions reduction of which 0.93 $MMTCO_2E$ is counted toward the AB32 GHG emissions reduction goal in the Scoping Plan. In the economic modeling, the net annualized cost of this measure incorporates the total cost of the equipment associated with nationwide benefits; savings in the economic model accounts for the nationwide fuel savings that is realized by all affected entities.

Overview

This measure would increase heavy-duty vehicle (long-haul trucks) efficiency by requiring installation of best available technology and/or ARB approved technology to reduce aerodynamic drag and rolling resistance. Board consideration of the Heavy-Duty Vehicle GHG Emission Reduction regulation is scheduled for December 2008.[118]

[118] For more information on this proposed regulation see: http://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm

Assumptions for GHG Emissions Reduction

Staff estimates the 2020 GHG reduction is approximately 6.4 $MMTCO_2E$ nationwide of which 0.93 $MMTCO_2E$ (9%) is estimated to occur within California. This reduction is derived from an estimated fuel efficiency improvement of 8% with approximately 1.5% and 6.5% increased efficiency resulting from improvements to the tractor and trailers, respectively. A baseline fuel efficiency of 6 miles per gallon (MPG) is estimated to calculate the benefit from efficiency improvements resulting in an improved mileage of 6.5 MPG (6 MPG x 1.08 = 6.48 MPG). The 2020 California VMT for heavy-heavy duty diesel trucks is being refined as part of the regulation development process. Staff initially estimates that approximately 6.7 billion miles are traveled in California by trucks affected by this measure resulting in a GHG emissions reduction of 0.93 $MMTCO_2E$ in California. The estimated fuel reduction nationwide is approximately 615 million gallons of diesel which results in a GHG emissions reduction of 6.4 $MMTCO_2E$.

$$\frac{6{,}675{,}600{,}000 \text{ miles}}{6 \text{ miles/gallon}} = 1{,}113{,}000{,}000 \text{ gallons} \times 8\% = 89{,}000{,}000 \text{ gallons}$$

$$89{,}000{,}000 \text{ gallons diesel} \times 0.0104 \frac{MMTCO_2E}{\text{million gallons diesel}} = 0.93 MMTCO_2E \text{ in California}$$

$$615{,}000{,}000 \text{ gallons diesel} \times 0.0104 \frac{MMTCO_2E}{\text{million gallons diesel}} = 6.4 MMTCO_2E \text{ Nationwide}$$

Assumptions for Costs and Savings

The incremental costs include for tractors included purchase of tires ($100/tire incremental), and for trailers includes side skirts ($1700), front gap fairing ($800), tires ($100/tire incremental x 8 tires = $800) and installation ($800). An industry-average 2.5 trailers per tractor is used to estimate the total cost. The sum of truck retrofit ($1000) plus trailer retrofit ($4100 x 2.5 = $10,250) is $11,250. Staff used $12,000 as an estimate for calculating total costs.

Cost and Savings Calculation	
2020 discounted capital cost (estimated at $12,000/truck-trailer)	$1,616M
California estimated fuel reduction	89M gallons diesel
Diesel combustion emission factor	10.4 $kgCO_2E$/gallon
California-only GHG emissions reduction	0.93 $MMTCO_2E$
Nationwide estimated fuel reduction	615M gallons diesel
Value of nationwide fuel savings	$2,268M
Operational costs	$131M
Net cost savings (fuel savings-operational costs)	$2,137M
Net annualized cost (cost-savings)	*-$521M

*The estimates here are subject to change during the regulatory process

Savings is the result of reduced fuel combustion and increased operational costs. The estimated 615 million gallons of diesel reduced is multiplied by $3.685/gallon to result in a

nationwide savings of $2,268M. Additional operations costs of approximately $131M result in a net savings of $2,137M and a net annualized cost of -$521M. Staff is working to refine estimates of the cost, savings and GHG emissions reduction as part of the regulation development process.

Measure T-8—Medium- and Heavy-Duty Vehicle Hybridization

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Medium- and Heavy-Duty Vehicle Hybridization	0.5	93	177	-85

Overview

This measure would regulate or incentivize GHG reductions from medium- and heavy-duty vehicles used in vocational applications such as parcel delivery trucks, garbage trucks, utility trucks and transit buses. Hybrid electric technology offers the potential to significantly reduce GHG emissions and improve vehicle efficiency from these vehicles.

Assumptions for GHG Emissions Reduction

Staff estimates the potential 2020 GHG emission reduction from the use of hybrid technology on heavy-duty trucks is 0.5 $MMTCO_2E$. This assumes that all new class 3 to 5 (10,001 to 19,500 pounds GVWR) trucks sold in California beginning in 2015 use hybrid technology. Model year 2015-2020 class 3 to 5 trucks are estimated to represent 20 percent of the same class fleet and 30 percent of the same class VMT in 2020 according to EMFAC2007.

From EMFAC2007	CY 2020 (MY 2015-2020)	CY 2020 (ALL MYs)	Assumptions
Vehicles (10,001 to 19,500 lbs)	53,421	273,739	• Fuel economy improvement: 26% • Base truck fuel economy: ~7 mpg
Daily Vehicle Miles (10,001 to 19,500 lbs)	3,694,200	12,166,000	
GHGs Reduced in 2020	0.5 $MMTCO_2E$	1.7 $MMTCO_2E$	

$$\frac{3{,}694{,}200 \text{ miles/day}}{7 \text{ miles/gallon}} = 527{,}742 \text{ gallons/day} \times 347 \text{ days/year} \times 26\% = 47{,}610{,}383 \text{ gallons}$$ [119]

$$47{,}610{,}000 \text{ gallons diesel} \times 0.0104 \frac{MMTCO_2E}{\text{million gallons diesel}} = 0.5 MMTCO_2E$$

[119] The VMT output for EMFAC2007 is in units of miles/day for weekday mileage. Annual miles are calculated using a factor of 347 to account for reduced weekend and holiday mileage.

Assumptions for Costs and Savings

	Base Diesel Truck	Parcel Hybrid Truck	Assumptions
Cost ($)	$40,000	$70,000	Cost of the base truck is from a truck dealership. Incremental cost is from a hybrid builder: $30,000 (75% above cost of base truck) for pre-production parcel trucks. ($10,000, or 25% above cost of base truck for production volume of 10,000 trucks or more)
Life of the vehicle (years)	10	10	Source: Parcel delivery truck fleet operator
Maintenance Cost	Unknown	Unknown	Being pre-production vehicles, the parcel fleet operator has not realized maintenance savings because of problems in software, transmission, parking brake, etc.
Assumed maintenance costs: ($/mile)	$0.16	$0.20	Hybrid truck maintenance cost is assumed to be about 4% lower than base truck for conventional maintenance, but 10% greater when a one-time battery replacement cost of $5000 to $8000 at 22,000 miles/year is included.

Cost and Savings Calculation	
Number of vehicles 2015-2020	53,421
Per vehicle capital cost	$10,000
Capital cost 2015-2020	$534,210,000
10-year CRF at 5% discount rate 0.1295	0.1295
Capital cost 2020 CRF X capital cost	$69.2M
Operating cost	$0.20/mile
Annual miles	22,000
Operating cost per vehicle	$440/year
Operating cost 2020	$23.5M
Total cost 2020	$92.7M
Total fuel reduced	48 million gallons diesel
2020 diesel cost	$3.685
Savings from reduced fuel use	$177M
Net annualized cost (cost-savings)	-$85M

Measure T-9—High Speed Rail

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
High-Speed Rail	1	0	0	0

Overview

This measure supports implementation of plans to construct and operate a High Speed Rail (HSR) between Northern and Southern California. Development of HSR presents a significant opportunity to reduce GHG emissions by offering more GHG-efficient travel options and alternatives to business as usual.

Assumptions for GHG Emissions Reduction

Staff analysis of estimated net CO_2 emission reductions are based on the HSR operating a Phase 1 system between San Francisco and Anaheim for 2020. Cambridge Systematics forecasts 93.9 million annual passengers (MAP) ridership for the full system in 2030. For planning purposes, staff assumes that in 2020 ridership is 26% of this amount, or approximately 24.5 MAP and that operating the HSR will require 50% of the energy that it will use in 2030.

Staff assumes the ridership will include 17% from air passengers, 76% from motor vehicle passengers, and 7% from conventional rail and induced trips.[120]

- Air passenger displacement from HSR ridership: Air passengers would number about 4.2 MAP with an associated reduction of 0.33 $MMTCO_2E$ based on 350 air miles per passenger trip and 0.5 pounds CO_2 per air passenger mile.
- Motor vehicle passenger displacement from HSR ridership: Motor vehicle passengers would number about 18.7 MAP resulting in CO_2 emission reduction of 1.27 $MMTCO_2E$ based on 250 miles per average motor vehicle trip, 1.5 average occupants per vehicle trip, 22 miles per gallon, and 8.94$kgCO_2E$/gallon of gasoline.
- Riders from other modes would total 1.7 MAP and would displace about 0.04 $MMTCO_2E$, assuming trips in these modes use about 1/3rd the energy per passenger - mile compared to motor vehicle trips.
- The total emissions reduction is the sum of benefits equaling1.65 $MMTCO_2E$ per year (0.33 + 1.28 + 0.04).
- A preliminary estimate of total electric energy to operate the HSR in Phase 1 in 2030 is 2.3 million megawatt-hours per year. Staff estimates the electricity required in 2020 would be about 50% of this amount, or 1.15 million MWh.
- Using the 2020 emission factor of 4.37×10^{-7} $MMTCO_2E$/MWh, the energy to operate the HSR would be about 0.5 $MMTCO_2E$. Thus, the net benefit for the Phase 1 HST would be about 1.15 $MMTCO_2E$ (1.65 – 0.50) in 2020.
- Net reduction for HSR is rounded to 1 $MMTCO_2E$.

[120] http://www.cahighspeedrail.ca.gov/images/chsr/20080128135423_R9a_Report.pdf

Assumptions for Costs and Savings

Costs of the measure are the result of existing state policy direction and therefore are not attributed to the AB 32 GHG emissions reduction program.

Electricity and Natural Gas

General Assumptions

Measures in the Scoping Plan to reduce electricity and natural gas use are developed based on reducing an amount of energy use and calculating the reduction of GHG emission using an emission factor.

For electricity, measures are assumed to replace in-state natural gas electricity generation. This emission factor is 4.37×10^{-7} $MMTCO_2E/MWh$ (963 $lbsCO_2E/MWh$).

For natural gas combustion, the emission factor is 5.3156×10^{-8} $MMTCO_2E/MMBTU$ for Commercial and Residential combustion and 5.3072×10^{-8} $MMTCO_2E/MMBTU$ for Industrial and Electric Power use. All conversion constants are 2020 values.

The calculation of cost and savings rely on $7.94/MMBTU ($0.80/therm) for natural gas, and an average cost of $86.09/MWh for other electricity generation. When appropriate, ARB assumed a 7.8% line loss associated with in-state electricity transmission. The benefits from avoided line loss are pointed out in the specific measures below. Avoided line loss is calculated as:

$$\text{Avoided line loss} = \frac{x}{1-0.078} - x, \text{ where } x \text{ is the reduced grid demand}$$

Measure E-1 and CR-1—Energy Efficiency

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Electricity Energy Efficiency (32,000GWh)	15.2	3,402	5,065	-1,663
Natural Gas Energy Efficiency (800 million therms)	4.3	963	1,433	-470
Measures Evaluated in Economic Modeling as a Surrogate for Cap-and-Trade Program				
Additional Electricity Efficiency (additional 8000GWh)	3.8	1,276	1,266	9.5
Additional Natural Gas Efficiency (additional 200 million therms)	1.1	369	367	2.8

Overview

This measure would reduce GHG emissions by increasing statewide energy efficiency for electricity and natural gas beyond current demand projections.

Assumptions for GHG Emissions Reduction

For measure E-1, a target of 32,000 GWh reduced demand is assumed. The benefit from reduced line loss (2,707 GWh) is also included.

$$32{,}000GWh + 2707GWh = 34{,}707GWh$$

$$34{,}707{,}000MWh \times 4.37 \times 10^{-7} MMT/MWh = 15.2MMTCO_2E$$

For measure CR-1 a target of 800 million therms reduced consumption is assumed.

$$800{,}000{,}000\,therms \times {}^{1\,MMBTU}\!/_{10\,therm} = 80{,}000{,}000\,MMBTU$$

$$80{,}000{,}000MMBTU \times 5.3156 \times 10^{-8} MMTCO_2E/MMBTU = 4.3MMTCO_2E$$

Additional electricity and natural gas efficiency, low-cost options modeled as a surrogate for the cap-and-trade program, of 8,000GWh reduced electrical demand and 200 million therms reduced natural gas consumption staff calculates 3.8 $MMTCO_2E$ and 1.1 $MMTCO_2E$, respectively.

$$8{,}000GWh + 677GWh = 8{,}677GWh$$

$$8{,}677{,}000MWh * 4.37 \times 10^{-7} MMT/MWh = 3.8MMTCO_2E$$

$$200{,}000{,}000\text{ therms} \times {}^{1MMBTU}\!/_{10\text{ therm}} = 20{,}000{,}000MMBTU$$

$$20{,}000{,}000MMBTU \times 5.3156 \times 10^{-8} MMTCO_2E/MMBTU = 1.1MMTCO_2E$$

Assumptions for Costs and Savings

Staff estimated the cost and savings from energy efficiency using the Climate Action Team Updated Macroeconomic Analyses Final Report.[121] Costs (2006$) of $217 per ton and savings of $323 per ton of CO_2E reduced as derived from the CAT report are used to calculate the net annualized cost for both electricity and natural gas efficiency.

The net cost and savings per $MTCO_2E$ are derived from the average cost and savings in the CAT Macroeconomics report for building and appliance standards and IOU efficiency programs. The values in the 2007 CAT report are 2006$ and are updated to 2007$ here by multiplying the 2006$ by a Consumer Product Index of 3.3% (1.033). Staff estimates the cost for additional efficiency under evaluation is 50% greater than the cost for the preliminarily recommended efficiency measures (i.e. $224/MT x 1.5 = $336/MT).

[121] The Climate Action Team Updated Macroeconomic Analysis of Climate Strategies for combined electricity and natural gas energy efficiency is found in Exhibit 11 on page 24 of: http://www.climatechange.ca.gov/events/2007-09-14_workshop/final_report/2007-10-15_MACROECONOMIC_ANALYSIS.PDF.

Measure	GHG Reduction	Cost (at $224/MTCO$_2$E) $Millions	Savings (at $333/MTCO$_2$E) $Millions
E-1	15.2	3,402	5,056
CR-1	4.3	963	1,433
Additional Efficiency (Low Cost Measures Modeled as a Surrogate for the Cap-and-Trade Program			
Measure	**GHG Reduction**	**Cost (at $336/MTCO$_2$E) $Millions**	**Savings (at $333/MTCO$_2$E) $Millions**
+8000GWh	3.8	1,276	1,266
+200M therms	1.1	369	367

*Costs for additional efficiency are assumed at 50% greater than the cost for the recommended measure. Savings for additional efficiency are assumed to be equivalent to the recommended measure.

Energy Efficiency Cost and Savings from the CAT-Macroeconomics Update Final Report					
Reduction Strategy	**GHG Reduction MMTCO$_2$E**	**Cost (2006$)**	**Savings (2006$)**	**Cost per MTCO$_2$E**	**Savings per MTCO$_2$E**
Building Standards	2.14	$255M	$658M	$119.16	$307.48
Appliance Standards	4.48	$509M	$1,489M	$113.62	$332.37
IOU Energy Efficiency Programs	3.66	$987M	$1,186M	$269.67	$324.04
Additional IOU Energy Efficiency programs	5.60	$1,690M	$1,790M	$301.79	$319.64
Total (2006$)	15.88	$3,441M	$5,123M	**$216.69**	**$322.61**
Total (2007$) using CPI of 1.033)	15.88	$3,555M	$5,292M	**$223.84**	**$333.25**

Measure CR-2—Solar Water Heating (AB 1470 goal)

GHG Reduction Measure	Potential 2020 Reductions MMTCO$_2$E	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Solar Water Heating (AB 1470 goal)	0.14	0	0	0

Overview

This measure would reduce natural gas use for commercial and residential water heating by installing 200,000 solar water heaters by 2020 per AB 1470 (Huffman). A reduction in GHG emissions of 0.1 MMTCO$_2$E is calculated. Solar heating is an alternative, zero emission, energy source to heat residential water that works with traditional water heating to replace a

portion of the natural gas that would normally be burned. The proposed measure is estimated replace 26 million therms of residential natural gas use each year.

Assumptions for GHG Emissions Reduction

Each solar water heater is assumed to reduce annual natural gas use by 130 therms[122]. In early years of the program, Staff estimates that 5,000 heaters will be installed annually, increasing up to 10,000, 15,000, 25,000 and finally 50,000 installations each year to meet the total 200,000 installed solar water heaters goal.

$$130 \text{ therms/he ater} \times 200{,}000 \text{ heaters} = 26{,}000{,}000 \text{ therms}$$

$$26{,}000{,}000 \text{ therms} \times {}^{1MMBTU}\!/_{10 \text{ therm}} = 2{,}600{,}000 MMBTU$$

$$2{,}600{,}000 MMBTU \times 5.3156 \times 10^{-8} MMTCO_2E / MMBTU = 0.14 MMTCO_2E$$

Assumptions for Costs and Savings

Costs of the recommended solar water heating measure are the result of existing state policies (AB 1470) and therefore are not attributed to the AB 32 GHG emissions reduction program.

Cost and Savings Calculation	
Cumulative capital cost	$5,636M
Estimated Lifetime	20 years
CRF (20 year amortization and 5% discount rate)	0.080242587
Annualized capital cost in 2020 (CRF x total capital cost)	$452M
Natural gas savings	201.5M therms
Value of natural gas saved in 2020 (@ $0.80/therm)	$160M
Net annualized cost (cost-savings)	$292M

Measure E-2—Increase Combined Heat and Power

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Increase Combined Heat and Power by 30,000 GWh	6.7	362	1,673	-1,311

Overview

This measure would encourage the use of efficient combined heat and power co-generation, targeting an increase in installed generation capacity of 4000MW by 2020.

[122] Personal communication, California Center for Sustainable Energy from implementing the CPUC's pilot project.

Assumptions for GHG Emissions Reduction

For purposes of calculating GHG reductions, Staff estimated the electric generation potential from CHP (of the amount of electricity offset from the grid, based on an assumed 85% capacity factor), the total amount of fuel consumed onsite, and the amount of waste heat generated for useful thermal purposes (which was then used to calculate the amount of fuel not consumed to produce that amount of thermal energy). Staff estimated that 80% of the cogeneration units would be less than 5MW (i.e. small and medium CHP) and 20% greater than 5MW (i.e. large CHP)[123].

The following table details the assumptions for installations, total electricity generation, amount of natural gas used to make both electricity and heat, the amount of reduced natural gas used in the displaced original heat load, and the net fuel consumption.

	Annual Installations (MW)		Total Electricity Saved (GWh)[124]	Annual MMTherms For Electricity & Heat		Annual MMTherms Displaced heating load		Net Fuel Consumption (MMTherms)
Year	<5MW	>5MW		<5MW	>5MW	<5MW	>5MW	
2009	267	67	2,692	219	48	129	22	116
2010	267	67	5,384	437	97	258	44	232
2011	267	67	8,076	656	145	387	65	349
2012	267	67	10,768	875	194	516	87	465
2013	267	67	13,460	1,094	242	645	109	581
2014	267	67	16,152	1,312	291	774	131	697
2015	267	67	18,844	1,531	339	904	153	814
2016	267	67	21,536	1,750	388	1,033	175	930
2017	267	67	24,228	1,968	436	1,162	196	1,046
2018	267	67	26,920	2,187	484	1,291	218	1,162
2019	267	67	29,612	2,406	533	1,420	240	1,279
2020	267	67	32,304	2,624	581	1,549	262	1,395
***Total**	**3,200**	**800**	**32,304**	**2,624**	**581**	**1,549**	**262**	**1,395**
	4,000 MW total			**3,206**		**1,811**		

The net GHG reduction is calculated as the difference between the GHG emissions from the grid displaced electricity (32,304GWh including the avoided line loss) and the GHG emissions from natural gas combusted to produce both heat and power onsite.

Net Natural gas GHG emission increase:

$$139{,}500{,}000 MMBTU \times 5.3072 \times 10^{-8} MMTCO_2E / MMBTU = 7.41 MMTCO_2E$$

[123] California Energy Commission, Draft Consultant Report, Assessment of California CHP Market and Policy Options for Increased Penetration. Prepared by the Electric Power Research Institute. April 2005.
[124] Total electricity saved includes the benefits of avoided line loss.

Grid supplied electricity GHG emission decrease:

$$29{,}784GWh \text{ (produced by CHP units)} + 2{,}520GWh \text{ (Avoided Line Loss)} = 32{,}303GWh$$

$$32{,}304{,}000MWh * 4.37 \times 10^{-7}\, MMT / MWh = 14.1MMTCO_2E$$

Net GHG Reduction:

$$14.1MMTCO_2E - 7.4MMTCO_2E = 6.7MMTCO_2E$$

Assumptions for Costs and Savings

The installed costs for CHP were estimated by averaging costs for several <5MW turbines ($1,300/kW for small CHP) and calculating the cost of one 40MW turbine ($1,750/kW for large CHP)[125].

	Annual Installations (MW)		Annual Installed Costs (millions $)**	
Year	**<5 MW**	**>5 MW**	**<5 MW @ $1,300/kW**	**>5 MW @ $1,750/kW**
2009	267	67	347	117
2010	267	67	347	117
2011	267	67	347	117
2012	267	67	347	117
2013	267	67	347	117
2014	267	67	347	117
2015	267	67	347	117
2016	267	67	347	117
2017	267	67	347	117
2018	267	67	347	117
2019	267	67	347	117
2020	267	67	347	117
*Total	3,200	800	4,164	1,404
	4,000		5,568	

[125] Staff estimated installed costs by evaluating actual equipment pricing (from a manufacturer) averaged for various sizes of gas turbines. Staff then added an assumed installation cost (which is roughly double the equipment cost) to get the total installed cost. ARB consulted with the equipment manufacturer in development of these costs.

Cost Calculation	
Capital cost	$5568M
30-year CRF at 5% discount	0.06505
Annualized capital cost in 2020 based on 30 year life	$362M
Savings Calculation	
Electricity savings 2020	32,304GWh
Value of electricity savings 2020 (@ $86.09/MWh)	$2,781M
Natural gas consumed for CHP 2020	1,395 million therms
Cost of natural gas consumed for CHP 2020 (@ $0.80/therm)	$1,108M
Net energy savings	$1,673
Net annualized cost (cost-savings)	-$1,311

Measure E-3—Renewables Portfolio Standard (33% by 2020)

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
33% Renewables Portfolio Standard	21.3	3,672	1,889	1,782

Overview

This measure would increase electricity production from eligible renewable power sources to 33% by 2020. A reduction in GHG emissions results from replacing natural gas fired electricity production with zero GHG emitting renewable sources of power.

Assumptions for GHG Emissions Reduction

The Renewables Portfolio Standard measure would require 33% of RPS-eligible retail electricity sales to be generated from eligible renewable sources. Measures that reduce retails sales of electricity, i.e. efficiency, co-generation, and other distributed generation, are subtracted from the projected demand in 2020 to calculate the amount of generation (in GWh) to meet the 33% renewables standard. The CEC electricity forecast for 2020 projects 308,070 GWh of RPS-eligible retail sales. The recommended measure in the Scoping Plan assumes 32,000 GWh of energy efficiency gains, approximately 30,000 GWh of combined heat and power generation, and approximately 4500 GWh of solar distributed generation. There are additional benefits from reduced line loss associated with these measures, which is assumed to be 7.8% statewide.

$$308{,}070GWh(RS) - 34{,}707GWh(EE) - 32{,}304GWh(CHP) - 4{,}845GWh(Solar) = 236{,}214GWh$$

$$236{,}214GWh \times 0.33(33\%\text{RPS}) = 77{,}951GWh$$

$$77{,}951GWh - 29{,}286GWh(\text{Current RPS}) = 48{,}665\text{GWh}(\text{RPS Target})$$

$$48{,}665{,}000MWh * 4.37 \times 10^{-7}\, MMT / MWh = 21.25MMTCO_2E$$

Where *RS* is 2020 projected retail sales, *EE* is energy efficiency and conservation plus reduced line loss benefits, *CHP* is generation from the combined heat and power measure, and *Solar* is the generation and reduced line loss benefits from the million solar roofs program. Using 4.37×10^{-4} $MMTCO_2E/GWh$ gives an emissions reduction of 21.3 $MMTCO_2E$.

The emissions reduction associated with going from 20% to 33% RPS is necessary for the cost and savings calculation below. Using the approach from above Staff calculates a net GHG emissions reduction for 20-33% RPS of 13.4 $MMTCO_2E$.

$$236{,}214\ GWh \times 0.2(20\%\ RPS) = 47{,}243\ GWh$$

$$47{,}243\ GWh - 29{,}286\ GWh\ (\text{Current RPS}) = 17{,}957\ GWh$$

$$17{,}957{,}000 MWh * 4.37 \times 10^{-7}\ MMT / MWh = 7.84 MMTCO_2E$$

$$21.25 MMTCO_2E - 7.84 MMTCO_2E = 13.4 MMTCO_2E$$

Assumptions for Costs and Savings

Cost and savings assumptions are derived from Energy and Environmental Economics, Inc.'s (E3) modeling of renewables.[126] Staff estimated costs at \$274/ $MTCO_2E$ and savings at \$141/ $MTCO_2E$ based on the E3 modeling work with a net cost of \$133/$MTCO_2E$ for a net GHG reduction going from 20-33% RPS of 13.4 $MMTCO_2E$. Costs for the GHG reduction associated with the existing 20% RPS are the result of existing State policies and therefore are not attributed to the AB 32 GHG emissions reduction program.

$$13.4 MMTCO_2E \times \$274 / MT = \$3{,}672 M$$

$$13.4 MMTCO_2E \times \$141 / MT = \$1{,}889 M$$

Measure E-4—Million Solar Roofs

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost (\$Millions)	Savings (\$Millions)	Net Annualized Cost (\$Millions) [Cost-Savings]
Million Solar Roofs	2.1	0	0	0

Overview

This measure follows the direction of Governor Schwarzenegger's Million Solar Roofs program to install 3000MW of photovoltaic electrical generation in residential and commercial applications by 2017.

[126] Energy and Environmental Economics, Inc. (E3), http://www.ethree.com/GHG/E3_CPUC_GHGResults_13May08%20(2).pdf

Assumptions for GHG Emissions Reduction

Staff used a capacity factor for photovoltaic solar power of 17% in calculating the displaced grid electricity from this measure. The benefit from reduced line loss (a constant 7.8%) is also included.

$$3000MW \times 8760\ hours/year \times 17\% = 4{,}467{,}600MWh/year + 377{,}953MWh(\text{avoided line loss})$$

$$4{,}845{,}553MWh \times 4.37 \times 10^{-7}\ MMT/MWh = 2.1MMTCO_2E$$

Assumptions for Costs and Savings

Costs of the E-4 measure are the result of existing state policies and therefore are not attributed to the AB 32 GHG emissions reduction program.

Industry

Measure I-1: Energy Efficiency and Co-Benefits Audits for Large Industrial Sources

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Energy-Efficiency and Co-Benefits Audits for Large Industrial Sources	TBD	TBD	TBD	TBD

Overview

This measure would require an energy efficiency audit for large stationary GHG emissions sources to identify potential reductions that are cost-effective for GHG, criteria and toxics.

Assumptions for GHG Emissions Reduction

TBD

Assumptions for Costs and Savings

TBD

Measure I-2: Oil and Gas Extraction GHG Emission Reduction

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Oil and Gas Extraction GHG Emission Reduction	0.2	0.4	4.1	-3.7

Overview

This measure would address fugitive GHG emissions from the extraction of California's large oil and gas industry, including on and off-shore sources. Fugitive emissions—mostly methane—account for approximately 5% of the GHG emissions from this part of the sector and are estimated to be 0.3 $MMTCO_2E$. These emissions are from well and process equipment venting; leaks of flanges, valves and other fittings on the well and equipment; and from separation and storage units such as sumps and storage tanks. Controls for the fugitive sources range from applying simple fixes to existing technologies, to deploying new technologies to replace inefficient equipment and to detect leaks.

Assumptions for GHG Emissions Reduction

The reduction of 0.2 $MMTCO_2E$ comes from a limited amount of changing operating practices while taking compressors off-line; installing compressor rod packing systems; replacing high-bleed pneumatics with low-bleed pneumatics; improved leak detection; and installing electronic flare ignition devices. These estimations will be refined as a more robust

emissions inventory is developed via an industry-wide survey and the control approaches of the measure identified.

Assumptions for Costs and Savings

Cost and Savings Calculation	
Capital cost	$795,000
Estimated capital lifetime	5 years
5-year Capital Recovery Factor	0.2310
Annualized Capital cost 2020	$183,645
Operating cost in 2020	$217,000
Natural gas reduction	520,000 MMBTU
Value of Natural Gas Savings (@ $7.94/MMBTU)	$4.1M
Total 2020 cost	$400,000
Total 2020 savings	$4.1M
Net annualized cost (cost-savings)	-$3.7M

Measure I-3: GHG Leak Reduction from Oil and Gas Transmission

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
GHG Leak Reduction from Oil and Gas Transmission	0.9	0.5	17.7	-17

Overview

This measure would address fugitive emissions from the transmission and distribution of natural gas throughout California. These emissions come from venting, accidental releases of GHGs, and leaks from flanges, valves, and other fittings, all of which occur along pipelines. This measure would include improving operating practices and replacing older equipment (flanges, valves and fittings).

Assumptions for GHG Emissions Reduction

Changing operating practices while taking compressors off-line achieves almost all of the estimated 0.9 $MMTCO_2E$ emissions reduction. The measure would largely be based on the U.S. EPA's Natural Gas STAR program aimed at cost effective approaches to reducing methane emissions. Staff estimated the fugitive emissions reduction by applying the natural gas savings from the U.S. EPA's Natural Gas STAR program actions to a number of units in the current emissions inventory. These estimations will be refined as a more robust emissions inventory is developed via an industry-wide survey.

Assumptions for Costs and Savings

Cost and Savings Calculation	
Capital cost 2015	$24,500
Lifetime	5 years
5-year Capital Recovery Factor	0.2310
Annualized capital cost 2020	$5,660
Operating cost 2020	$502,000
Natural gas reduction	2,230,000 MMBTU
Value of natural gas savings (@ $7.94/MMBTU)	$17.7M
Total 2020 cost	$0.5M
Total 2020 savings	$17.7M
Net annualized cost (cost-savings)	-$17M

Measure I-4: Refinery Flare Recovery Process Improvements

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Refinery Flare Recovery Process Improvements	0.33	6.7	46.1	-39.5

Overview

This measure would reduce GHG emissions from refinery flares by increasing the efficiency of the flare gas recovery process Assumptions for GHG Emissions Reduction.

Measure	Description	Number of Units Affected	Estimated Capital Cost ($million)	Existing Emissions (MMT CO2E)	Emissions Reduction (MMT CO2E)	Percent Emissions Reduction
1.Increase Gas Recovery Capacity at Flares	Install additional compressors in flare systems	Flare systems at 19 refineries	71.3	0.67	0.33	50

Note: This measure entails providing adequate gas recovery capacity and best operating practices (fuel recovery savings)

Assumptions for Costs and Savings

Cost and Savings Calculation	
Capital cost 2020	$71M
Capital life	20 years
20-year CRF (@5% discount rate)	0.08024
Annual cost 2020 (Capital cost x CRF)	$5.71M
2020 operational costs	$0.94M
total annual cost 2020	$6.65M
Natural gas savings	5,800,000 MMBTU
2020 value of fuel savings (@ $7.94/MMBTU)	$46.1M
Total savings	$46.1M
Net annualized cost (cost-savings)	-$39.5M

Measure I-5: Removal of Methane Exemption from Existing Refinery Regulations

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Removal of Methane Exemption from Existing Refinery Regulations	0.014	3.3	2.7	0.57

Overview

This measure would remove the methane exemptions from the regulations applicable to equipment and sources employed in California's refineries.

Assumptions for GHG Emissions Reduction

ARB relied on the analysis performed by South Coast Air Quality Management District (SCAQMD) for the adoption of their Rule 1173, Control of Volatile Organic Compound Leaks and Releases from Components at Petroleum Facilities and Chemical Plants. ARB staff assumed that exempt hydrocarbons, assumed to be methane, could be reduced by a similar 80 percent if the equipment associated with the processing and piping of the methane-rich streams were subject to the leak detection and repair requirements of the rule. Staff also applied this factor to two refineries located in the San Joaquin Valley Unified Air Pollution Control District. The Bay Area Air Quality Management District rule for leak detection and repair already included methane.

Assumptions for Costs and Savings

ARB staff used the cost estimates provided by the SCAQMD analysis for Rule 1173, updated the labor costs, estimated that an additional five percent of valves, compressors, and

connections would be inspected and repaired, and applied these factors to the SCAQMD and SJVAPCD.

Cost and Savings Calculation	
Operational cost in 2020	$3.3M
2020 Savings	$2.7M
Net annualized cost (cost-savings)	$0.57M

Other Industrial Measures Evaluated by ARB

The following measures are included in the economic model runs as potential technical options that have been evaluated by staff as low cost (that is they cost less than the carbon price outlined in Appendix G) for achieving reductions of GHG emissions in the Industrial sector under the cap-and-trade program. These measures, although not part of the recommendation in the AB32 GHG emissions reduction program, were therefore used as a surrogate for the cap-and-trade program in the economic modeling.

Carbon Intensity Standard for Cement Manufacturers

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Carbon Intensity Standard for California Cement Manufacturers	1.9	19.4	22.8	-3.4

Overview

This measure evaluates a standard of 0.8 metric tons of CO_2/metric ton of cement as the average carbon intensity factors (CIF) for cement used in California. This standard would apply to imported cement as well as cement manufactured in California. The CIF is defined as metric tons CO_2 emitted per metric ton of cement produced. CIF improvements at the cement production level are expected to be met through alternative fuels or energy efficiency measures. There is very little addition of supplementary cementious materials (SCMs) that occur at the manufacturing plants today. Therefore, focuses on ensuring that lower carbon cement is produced by maximizing the use of alternative fuels and energy efficiency.

Assumptions for GHG Emissions Reduction

Alternative Fuels

The alternative fuel scenario is calculated based on the ARB inventory. The baseline year is 2004 for the cement production and GHG emissions from manufacturers. Staff assumed a 2% annual increase in cement production and imports are 40% of cement consumed in California. The 2004 statewide baseline numbers are as follows:

- Fuel combustion = 4.06 $MMTCO_2E$
- Calcination = 5.77 $MMTCO_2E$

- Electricity = 0.70 $MMTCO_2E$ (based on California Energy Commission emission factor and the Portland Cement Association external electricity output for 2005)
- Total CO2 emissions for California cement plants = 10.53 $MMTCO_2E$
- Clinker Production = 11.23 MMT (USGS, 2004)
- Cement Production = 11.92 MMT (USGS, 2004)

Based on ARB's analysis of potential alternative fuel options, we believe a 5 percent reduction in greenhouse gas emissions is feasible and cost-effective.

The estimated statewide CIF based on instate cement production is 0.895 metric tons CO_2 per metric ton cement. If the 5% reduction were implemented, the CIF for each one would be 0.855.

Improved Energy Efficiency

The improved energy efficiency is based on fuel and electricity intensity scenarios of 3.0 MBtu per short ton of clinker produced and 109 kWh per ton of cement produced with 2004 and 2005 California cement industry data. Staff estimated an emission reduction of 0.93 $MMTCO_2E$ and a 0.055 $MTCO_2E$/MT of cement reduction in the CIF value. When combining the alternative fuel and improved energy efficiency CIF value, the instate CIF value would decrease to below 0.8 $MTCO_2E$/MT cement.

GHG Calculation	
California Cement Produced	11.92 MMT
Current in-state CIF	0.895
CIF with measure under evaluation	0.8

Taking into consideration the 2% growth rate and a 16-year span from 2004 to 2020, reductions from BAU cement emissions would be:

$$(0.895 - 0.8) \times (11.92MMT) \times (1.02)^{16} = 0.095 \times 11.92MMT \times 1.37 = 1.55MMTCO_2E$$

Assumptions for Costs and Savings

The ARB 2004 baseline shows that cement manufacturers are using over 3.60 MBtu/ton clinker. Staff estimates, through improved energy efficient equipment and using less fuel, that the cement manufacturers would be able to meet a 3.0 MBtu/ton clinker. This number is stated in literature for 4 to 5-stage preheater/precalciner kilns. ARB estimates this will result in an initial capital investment of $220 million dollars with an annual fuel expenditure savings of $22.75 million.

Cost and Savings				
Year	Capital Costs ($millions)	Cost Savings from Energy Efficiency - Electricity ($millions)	Cost Savings from Energy Efficiency – Fuel ($millions)	Cost Increase from Alternative Fuels ($millions)
2012	220	11.66	17.45	11.46
2013		11.89	17.80	11.69
2014		12.13	18.16	11.93
2015		12.37	18.52	12.16
2016		12.62	18.89	12.41
2017		12.87	19.27	12.66
2018		13.13	19.65	12.91
2019		13.39	20.05	13.17
2020		13.66	20.45	13.43

Cost and Savings Calculation

Annualized Capital Expenditure:

$202.4 million*0.0802 = $16.23 million (CA cement manufacturers annualized capital cost)

$16.23 million + $1.35 million (annual operating cost) = $17.58 million (CA cement manufacturer's total annual cost)

$17.58 million*1.10 (10% of $17.58 million is the capital cost for imported cement) = $19.34 million

Annual Fuel Expenditure Savings:

$13.66 million + $20.45 million – $13.43 million = $20.68 million

$20.68 million*1.10 (10% of $20.68 million is the fuel savings for imported cement) = $22.75 million

Net Annual Savings: $3.41 million

Carbon Intensity Standard for Concrete Batch Plants

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Carbon Intensity Standard for Concrete Batch Plants	3.1	0	0	0

Overview

This measure evaluated by ARB would require concrete batch plants to have a lower carbon intensity factor (CIF) for cementitious material than the CIF required at the cement manufacturing facility. The standard would be set at 0.6 metric ton CO_2/metric ton of cementitious material used. The standard at the concrete batch plant could be met either by using cement with very low carbon intensity factors, by adding materials such as SCMs to replace cement in the concrete blend, or using a combination of both approaches.

Assumptions for GHG Emissions Reduction

Concrete batch plants can double the total amount of CO_2 reductions through blending of cement compared to the cement manufacturers. The scenario for the concrete batch plants is to blend SCMs in Portland cement to equal at least 15% or more of blended cement and meet a 0.66 CIF standard by 2012. In 2015, the cement that is used to manufacture concrete must meet a 25% blend of SCMs and comply with a 0.6 CIF standard.

The CIF standard for cement used by concrete batch plants in 2012 through 2014 would comply with 0.66 MT CO_2/MT cement. By 2015, the CIF for cement would be 0.6 $MTCO_2$/MT cementitious material. The calculation for GHG reductions in 2020 is below.

GHG calculation assumptions:

- California Cement Produced: 11.92 MMT
- CIF Factor Under Manufacturer Regulations: 0.8
- CIF Under Batch Plant Regulations: 0.6

Taking into consideration the 2% growth rate and a 16-year span from 2004 to 2020, reductions from BAU cement emissions would be:

$$(0.8-0.6)\times(11.92MMT)\times(1.02)^{16} = 0.2\times 11.92MMT\times 1.37 = 3.27MMTCO_2E$$

Assumptions for Costs and Savings

Currently, the cost of a ton of SCMs is approximately the same as the cost of a ton of cement (about $100/ton). Therefore Staff estimates there is no net cost or savings for this measure.

Waste Reduction in Concrete Use

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Waste Reduction in Concrete Use	1.2	55	83	-28

Overview

This measure evaluated by ARB would set a minimum waste requirement or establish emissions fees on unused returned concrete.

Assumptions for GHG Emissions Reduction

ARB estimates that approximately five to eight percent of the concrete that is made in California each year is returned to the plant as waste. Given cement is the main source of GHG emissions in concrete, a reduction opportunity over 1 $MMTCO_2E$ exists by 2020.

GHG calculation assumptions:

- Total Cement: 11.92 MMT
- Wasted Cement: (0.08)(11.92)= 0.954 MMT
- Current CIF: 0.895 $MTCO_2$/MT cement
- 2% Annual Growth Rate

$$0.08 \times 11.92 MMT \times 1.02^{16} \times 0.895 = 1.17 MMTCO_2E$$

Assumptions for Costs and Savings

ARB assumes $100 as an average cost per ton of concrete and an added operational cost of $70 per ton of wasted concrete to achieve maximum efficiency. This results in a net cost savings of $30/ton of cement and an annual savings of $28 million.

Cost and Savings Calculation	
Wasted Cement	0.954MMT
Net savings per MT concrete ($100-$70=$30)	$30
Annual savings	$28M

Refinery Energy Efficiency Process Improvements

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Refinery Energy Efficiency Process Improvements	3.4	64.5	415	-350

Overview

This measure evaluated by ARB would reduce GHG emissions from refineries by reducing fossil fuels consumption across a variety of refinery processes including process heaters, boilers, fluid catalytic crackers, and hydrogen plants.

Assumptions for GHG Emissions Reduction

Measure	Description	Number of Units Affected	Estimated Capital Cost ($million)	Existing Emissions (MMT CO2E)	Emissions Reduction (MMT CO2E)	Percent Emissions Reduction
1.Improve Efficiency of Boilers and Process Heaters	Improve efficiency of half of total units by 15%	300 of 600	272	14.8	1.0	6.8
2.Install FCC Power Recovery Turbine	Capture mechanical work from FCC regenerator flue gas	3 of 10	21	6.11*	0.47	7.7
3.Improve Catalyst Type at FCC	Reduce carbon buildup on catalyst	4 of 10	11	* included above	0.82	13
4.Modernize Hydrogen Plants	Use pressure swing adsorption technology	Reduce H_2 plant emissions by 20% overall	387	5.8	1.1	19
Totals			**691**	**26.7**	**3.4**	**13**[127]

Notes:

1. Improve efficiency of 300 boilers and process heaters from 73 percent to 88 percent (fuel savings)
2. Valero refinery in Houston uses pressure drop of regenerator gas to drive turbine and recover mechanical power to compress regenerator inlet air, saving 22MW of energy otherwise needed for this compression (assume fuel savings)
3. Less carbon buildup on catalyst means less combustion to remove it (fuel savings)
4. Pressure swing adsorption requires 20 percent less energy than amine systems per cubic foot of hydrogen produced (fuel savings)

[127] Total refinery GHG emissions are estimated at 35.2 MMT CO_2 E. Therefore, overall estimated refinery emissions reductions represent approximately 10 percent of that total.

Assumptions for Costs and Savings

Cost and Savings Calculation	
Capital cost 2020	$691M
Capital life	20 years
20-year CRF (@5% discount rate)	0.08024
Annual cost 2020 (Capital cost x CRF)	$55.5M
2020 operational costs	$9M
total annual cost 2020	$64.5M
Natural gas savings	51,800,000 MMBTU
2020 value of fuel savings (@ $7.94/MMBTU)	$406M
Operational savings	$9M
Total savings	$415M
Net annualized cost (cost-savings)	-$350M

Oil and Gas Extraction Combustion Related GHG Emission Reduction

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Oil and Gas Extraction Combustion Related GHG Emission Reduction	1.8	107	274	-167

Overview

This measure evaluated by ARB would address GHG emissions resulting from the extraction of California's large oil and gas industry, including on and off-shore sources. This measure focuses on extraction-related GHG emissions from combustion sources. These emissions are produced mainly from the combustion of natural gas in generators, boilers, pumps and other related equipment. The measure could include: repowering, retrofitting, replacing or repairing existing equipment; installing new combined heat and power; electrifying equipment; and possibly employing CO_2 injection to enhance oil recovery.

Assumptions for GHG Emissions Reduction

Replacement and retrofitting of boilers and steam generators with more efficient ones, as well as replacing internal combustion engine (ICE) pumps with electric motors, achieves an estimated 1.8 $MMTCO_2E$ reduction. These estimations will be refined as a more robust emission inventory is developed via an industry-wide survey and the control approaches of the potential measures are identified.

Assumptions for Costs and Savings

Cost and Savings Calculation	
Capital cost	$357M
Estimated capital lifetime	20 years
20-year Capital Recovery Factor	0.08024
Annualized Capital cost 2020	$28.6M
Operating cost in 2020	$23.3M
Non-energy cost savings in 2020	$8.8M
Electricity use	637,000 MWh
Value of electric use in 2020 (@ $86/MWh)	$55M
Natural gas reduction	33,400,000 MMBTU
Value of Natural Gas Savings (@ $7.94/MMBTU)	$265M
Total 2020 cost	$106.9M
Total 2020 savings	$274M
Net annualized cost (cost-savings)	-$167M

GHG Combustion Related Emissions Reduction from Oil and Gas Transmission

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
GHG Combustion Related Emissions Reduction from Oil and Gas Transmission	0.1	14.8	16.3	-1.5

Overview

This measure evaluated by ARB addresses combustion related GHG emissions from the transmission and distribution of natural gas throughout California. This measure would include installing more energy efficient equipment and switching to low carbon fuels to run the equipment.

Assumptions for GHG Emissions Reduction

Replacing just a handful of ICE pumps and compressors with electric motors achieves the entire 0.1 $MMTCO_2E$ emissions reduction. These estimations will be refined as a more robust emission inventory is developed via an industry-wide survey and the control approaches of the potential measure are identified.

Assumptions for Costs and Savings

Cost and Savings Calculation	
Capital cost 2015	$28.4M
Lifetime	20 years
20-year Capital Recovery Factor	0.08024
Annualized capital cost 2020	$2.27M
Electricity cost	139,000 MWh
Value of electricity cost in 2020 (@$86/MWh)	$12M
Natural gas reduction	1,900,000 MMBTU
Value of natural gas savings (@ $7.94/MMBTU)	$15.5M
Operating cost 2020	$0.54M
Non-energy cost savings in 2020	$1.2M
Total 2020 cost	$14.8M
Total 2020 savings	$16.3M
Net annualized cost (cost-savings)	-$1.5

Industrial Boiler Efficiency

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Industrial Boiler Efficiency	1	22.9	150	-127

Overview

This measure evaluated by ARB would require one or more of the following: annual tuning of all boilers, the installation of an oxygen trim system, and/or a non-condensing economizer to maximize boiler efficiency. A source could also replace an existing boiler with a new one that is equipped with these systems.

Assumptions for GHG Emissions Reduction

Assumptions:

- Estimated annual emissions based on draft Greenhouse Gas Inventory Forecast Estimates (February 6, 2008) 2020 projected emissions from natural gas: 24.19 $MMTCO_2E$
- Boiler efficiency measure applies to approximately 80% of the universe due to this natural gas usage
- Boiler Efficiency Measure accomplishes a 5% reduction in GHG emissions

$$(0.80)(24.19\ MMTCO_2E)(0.05) = 1.0\ MMTCO_2E \text{ reduction annually}$$

The Boiler Efficiency Measure requires the efficiency improvements summarized in the table below. Costs were estimated by determining the cost of each requirement and the approximate number of boilers that would need each type of the two retrofits or tuning.

Summary of Measure Requirements	
Applicability	**Requirement**
All permitted boilers	Annual tuning
Boilers rated at or over 10 MMBtu/hr	Retrofit with an oxygen trim system including parallel positioning and VFD
Boilers rated at or over 50 MMBtu/hr	Retrofit with a non-condensing economizer

Assumptions for Costs and Savings

- Total Capital Cost ($90,390,000)
    - The capital cost is derived from the cost of purchasing and installing equipment retrofits required by the measure multiplied by the approximate total number of installations. The total number of installations was estimated using engineering judgment, data from ARB's CEIDARS database, air district databases, and from information supplied by an industry sales representative and representatives of a consulting firm that administers a commercial and industrial boiler efficiency program.
- Annual Tuning requirement
    - Capital cost = $0.
- Retrofit of 10 MMBtu/hr boilers with oxygen trim, parallel positioning, VFD
- Equipment costs for retrofit assuming 600 boilers rated at or over 10 MMBtu/hr with oxygen trim, parallel positioning, and VFD ($96,000 per unit) = $57,600,000
- Note: Assumed 60% (600) of the 1000 boilers in CEIDARS inventory are not already equipped with oxygen trim, parallel positioning, and VFD and need the retrofit.
- Capital costs for retrofit of 105 boilers rated at or over 50 MMBtu/hr with a non-condensing economizer ($200,000 per unit) = $21,000,000
- Assumed 60% (105) of the 175 boilers in the State are not already equipped with a non-condensing economizer and need the retrofit. South Coast database shows there are 70 boilers in the District over 50 MMBtu/hr.
- Assuming South Coast has 40 percent of the inventory in the State, the total number of boilers over 50 MMBtu/hr in California is 70/0.4 = 175 boilers.
- Capital costs: $78,600,000
- Total installation costs (15 percent of capital costs) = $11,790,000
- Total capital and installation costs for boiler retrofits = $90,390,000
- Annual operating cost ($15,610,000)
- Annual maintenance costs for boiler retrofits (assumed to be 10 percent of capital costs) = $7,860,000
- Annual tuning costs for 3100 boilers ($2500 per unit) = $7,750,000
- Note: all the costs for the tuning requirement are considered to be an annual maintenance cost. The 2004 CEIDARS NO_x inventory showed approximately 3100 permitted natural gas boilers.
- Total annual operating costs (annual maintenance costs and annual tuning costs) = $15,610,000
- Lifetime Expenditures 2016 through 2020 ($168,440,000)
- $90,390,000 + (5 years)($15,610,000) = $168,440,000
- Cost Savings ($149,640,000)

- (There will also be an unknown electricity savings from the VFD.)
  - 1 $MMTCO_2E$)(10^6 metric ton/MMT)/(0.05306 metric tons CO_2/MMBtu) = 18,846,588 MMBtu natural gas annual savings
- Annual fuel cost savings ($7.94/MMBtu)(18,846,588 MMBtu) = $149,641,908
- Lifetime Cost Savings 2016 through 2020
- (5 years)($149,641,908) = $748,209,543

Summary Cost and Savings Calculation	
Total capital cost	$90.4M
Operating cost 2020	$15.6M
Estimated capital life	20 years
20-year CRF	0.08024
Annualized capital cost (capital x CRF)	$7.25M
Total cost in 2020	$22.86M
Natural gas savings	18,846,588 MMBTU
Value of Natural Gas Savings in 2020 (@ $7.94/MMBTU)	$149.7M
Net annualized cost (cost-savings)	-$127M

Stationary Internal Combustion Engine Electrification

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Stationary Internal Combustion Engine Electrification	0.3	17.9	25	-7.1

Overview

This measure evaluated by ARB would affect owners and operators of engines in industrial and commercial operations rates at over 50 hp and used as primary power sources ("prime" engines). This evaluated measure would not affect internal combustion (IC) engines used for emergency power generation. This evaluated measure would include the replacement of IC engines with electric motors (electrification).

Assumptions for GHG Emissions Reduction

In the Draft Scoping Plan ARB estimated the GHG emission reduction potential as approximately 0.1 to 1.0 $MMTCO_2E$. As ARB continued to evaluate this measure, it became apparent the high end of the range – 1 MMT, was unrealistic. Such a large reduction would require electrifying over two-thirds of the engines in this category by 2020. This level is not achievable due to both logistical difficulties (access to electrical service and/or required duty cycles) and high cost for engines that are not operated a high percentage of the time. To reflect this, ARB believes a more realistic range of potential reductions is 0.1 to 0.5. A targeted reduction of 0.3 $MMTCO_2E$ was evaluated as technologically feasible for the purposes of modeling surrogate reduction measures for the cap-and-trade program.

Assumptions for Costs and Savings

Cost and Savings Calculation	
Total capital cost	$50.7M
Operating cost 2020	$14M
Estimated capital life	20 years
20-year CRF (@ 5% discount rate)	0.8024
Annualized capital cost (capital x CRF)	$4.1M
Total 2020 cost	$17.9M
Natural Gas Savings	7,670,600 MMBTU
Value of Natural Gas Savings in 2020 (@ $7.94/MMBTU	60.9M
Diesel Savings in 2020	11.4 million gallons
Value of Diesel Savings 2020 (@ $3.685/gallon)	$41.9M
Increased electricity use in 2020	904,443 MWh
Cost of increased electricity (@ $86/MWh)	$77.9M
Net savings in fuel	25.04
Net annualized cost (cost-savings)	-$13M

Recycling and Waste

Measure RW-1: Landfill Methane Control

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Landfill Methane Control (Discrete Early Action)	1	52	0	52

Overview

This measure would reduce methane emissions from municipal solid waste landfills by requiring owners and operators to install gas collection and control systems at smaller and other uncontrolled landfills. Additionally, all affected landfills will be required to satisfy enhanced methane monitoring requirements to ensure that their gas collection and control system is operating optimally and that fugitive emissions are minimized.

Assumptions for GHG Emissions Reduction

Staff estimates 0.8 $MMTCO_2E$ GHG emissions reduction from the approximately 53 landfills having greater than 450,000 tons of waste-in-place that may generate sufficient gas to support the installation of a gas collection and control system with a flare. Staff estimated an additional 0.2 $MMTCO_2E$ GHG emissions reduction from enhanced monitoring requirements to ensure that the landfill's gas collection and control system is operating optimally and that fugitive emissions are minimized. The total estimated reduction is 0.8+0.2 = 1 $MMTCO_2E$.

Assumptions for Costs and Savings

Staff estimated a capital cost of $3,438,000 and annual operating cost of $706,397 for each of the aforementioned 53 facilities. The lifetime of the gas collection and control systems is estimated at 15 years. The total estimated cost is approximately $1M per facility in 2020. Total industry costs, included those for landfills with existing gas collection and control systems, will be estimated in the staff report for the landfill methane control measure. The costs and emission reduction estimates presented here are preliminary estimates.

Cost Calculation	
Per facility capital cost (53 facilities total)	$3,438,000
CRF for 20 year expected capital life	0.08024
Annualized capital cost (capital cost x CRF)	$275,874
2020 Operating cost per facility	$706,397
Total per facility cost (annualized capital cost + operating cost)	$982,271
Total net annualized cost (53 facilities x per facility cost)-Assumes no savings	$52M

High Global Warming Potential

Measure H-1: Motor Vehicle Air Conditioning Systems: Reduction of Refrigerant Emissions from Non-Professional Servicing (Discrete Early Action)

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Small Containers of Refrigerant	0.26	3	0	3

Overview

This measure reduces GHG emissions from the non-professional servicing of motor vehicle air conditioning systems by do-it-yourself individuals. The original option considered by the Board would restrict the sale and import of the small cans of refrigerant and allow only professional servicing of MVACs. However, additional research and analysis by staff indicates that this approach has the potential for significant cost impact to the consumer. An alternative and superior approach has been identified. Staff's recommendation focuses on reducing primarily the emissions from the can heel. This proposal would include: 1) the installation of a self-sealing dispensing valve on all small containers of refrigerant, 2) the implementation of a mandatory container recycling and refrigerant recovery program, 3) improved labeling on all containers, and 4) the implementation of a consumer education program.

Since this measure is a Discrete Early Action, the proposed regulation would become enforceable on January 1, 2010. The table above includes two rows, corresponding to the two proposals that were considered by Staff. The Scoping Plan Appendix C includes only the estimates associated with the Staff recommended mitigation proposal. The numbers above are refinements based on the most recent information emerging from the public process.

Assumptions for GHG Emissions Reduction

The recommended proposal is estimated to achieve a reduction of approximately 0.26 $MMTCO_2E$ in 2020 resulting from the recovery of the unused refrigerant in the containers and an increased consumer awareness of an optimum charging techniques arising from the improved labeling and the education program.

Assumptions for Costs and Savings

Industry has estimated that the installation of self-sealing valves and the implementation of the recycling program would result in a cost increase of one dollar per container. At 1.8 million cans per year, the increased consumer cost is $1.8 million. Assuming a 95% can return rate and a $10 deposit per can, the 5% of unclaimed deposits amounts to $0.9 million per year and will be an additional cost to the consumers. Total increased cost to the consumer is thus ~$3 million per year.

Measure H-2: SF_6 Limits in Non-Utility and Non-Semiconductor Applications (Discrete Early Action)

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
SF6 Liming in Non-Utility and Non-Semiconductor Applications (Discrete Early Action)	0.3	0.22	0.14	<0.1

Overview

This measure reduces sulfur hexafluoride emissions from non-utility and non-semiconductor-related applications. This includes, but is not limited to, magnesium casting, tracer gas uses, and recreational uses such as magic tricks.

Assumptions for GHG Emissions Reduction

ARB estimated a range of estimates for other uses (non-semiconductor, non-utility, and non-magnesium) is 0.13 – 0.34 (ARB 2008). Alternatives are available and a phase-out is possible for magnesium casting, tracer uses, and recreational uses. A reduction is not possible for medical uses. Alternatives are 98+ percent effective for magnesium casting and range from 50-90+ percent for tracer uses (EPA 2006). Recreational uses would either be eliminated or alternatives would have a near 100% reduction (ARB 2008). Based on alternative effectiveness, reductions from magnesium would be 0.1 $MMTCO_2E$. For other applications, an effectiveness of 90% was used to estimate reductions up to 0.2 $MMTCO_2E$. In total, reductions are estimated at 0.3 $MMTCO_2E$.

Assumptions for Costs and Savings

Due to a lack of data for other sectors, ARB was only able to calculate costs for the magnesium sector. The estimate will still be reasonable since alternatives to sulfur hexafluoride are generally either less expensive per pound or per use (less alternative needed per use) and other uses in this measure do not have capital costs since they do not require significant infrastructure changes.

For the magnesium sector, there are two sets of costs associated with alternate gases: upfront and annual costs. Based on Canadian data, upfront costs could run up to $573,000, which is annualized to approximately $94,000 after conversion to 2007 dollars and annualized using a 10 year lifetime (Environment Canada, 1998). The annual costs, based on the same Canadian study, are approximately $126,000 for training.

There could be an associated cost savings since one alternative is less expensive than sulfur hexafluoride. Based on U.S. EPA, the cost savings will be $140,000 in 2007 dollars.

If a change is made in the manufacturing process for certain industries, the caster must go through a requalification process. These costs are not currently included in the analysis but could be significant.

Measure H-3: Reduction of Perfluorocarbons in Semiconductor Manufacturing (Discrete Early Action)

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
High GWP Reduction in Semiconductor Manufacturing (Discrete Early Action)	0.15	2.6	0	2.6

Overview

This measure targets a reduction in emissions of several high global warming potential gases uses in the semiconductor manufacturing industry. Reductions are expected from process optimization, alternative chemistries and abatement technologies. This measure is currently in the regulatory process.

Assumptions for GHG Emissions Reduction

The proposed measure is designed to achieve at least a 50% reduction in emissions of high GWP gases from the semiconductor manufacturing industry. ARB recently conducted an industry survey of GHG emissions from more than 100 semiconductor and related devices facilities. This bottom-up accounting revealed approximately 0.3 $MMTCO_2E$ of emissions in 2006. Staff is proposing to target an emissions reduction of 0.15.

Assumptions for Costs and Savings

The cost of the proposed measure is based on the assumption that abatement technologies are used for compliance. The $2.6 million total annualized cost estimate ($3.3 million in 2007 dollars) was derived from a June 2001 U.S. EPA report[128]. This value included the capital, operating and maintenance costs as a single figure for etch abatement systems. The annualized cost is calculated assuming $23.4 million in capital costs, a 5% discount rate, and a 9 year life for the abatement systems.

[128]U.S. EPA June 2001, U.S. High Global Warming Potential (High GWP) Emissions 1990-2010: Inventories, Projections, and Opportunities for Reductions, Chapter 6 Cost and Emission Reduction Analysis of PFC, HFC, and SF_6 Emissions from the Semiconductor Manufacturing in the United States, pg. 6-6, June 2001.

Measure H-4: Limit High GWP Use in Consumer Products (Discrete Early Action)

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Limit High GWP Use in Consumer Products (Discrete Early Action)	0.25	0.06	0	0.06

Overview

The objective of this measure is to reduce the use of high GWP compounds in consumer products when alternatives are available. To achieve these reductions, consumer product formulations would need to be changed to reduce or eliminate the use of high GWP compounds.

Assumptions for GHG Emissions Reduction

The potential reductions for this measure for 2020 were estimated based on the perceived opportunities for reductions of GHG emissions from specific categories of Consumer Products. Emissions of GHG from the specific Consumer Products were determined from formal surveys of manufacturer's sales and formulation data that were conducted for the 2001, 2003 and 2006 sales years. Further, in June 2008, the Board approved a measure to reduce the GHG emissions from Pressurized Gas Dusters. This measure achieved approximately 0.23 $MMTCO_2E$ in 2020. It is anticipated that the remainder of the emission reduction goal could be achieved by adopting GHG standards for other categories of Consumer Products in future rulemakings.

Assumptions for Costs and Savings

The estimated costs attributed to this measure were based on previous consumer products regulations affecting similar categories of products from which emission reductions were anticipated to occur. Specifically, for the Pressurized Gas Dusters, it was estimated that the total costs of the regulation will be approximately $450,000 over ten years or $45,000 a year.[129] Additional costs to manufacturers and consumers will likely occur for additional categories that are regulated for GHG emissions. No savings is assumed.

[129]See "Initial Statement of Reasons for Proposed Amendments to the California Consumer Products Regulation, May 9, 2008. http://www.arb.ca.gov/regact/2008/cp2008/cp2008.htm.

Measure H-5: High GWP Reductions from Mobile Sources

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Low GWP Refrigerants for New Motor Vehicle Air Conditioning Systems	2.5	20.86	0	16
Air Conditioner Refrigerant Leak Test During Vehicle Smog Check	0.5		TBD	TBD
Refrigerant Recovery from Decommissioned Refrigerated Shipping Containers	0.2		TBD	TBD
Enforcement of Federal Ban on Refrigerant Release During Servicing or Dismantling of Motor Vehicle Air Conditioning Systems	0.1		TBD	TBD

Low GWP Refrigerants for New Motor Vehicle Air Conditioning Systems

Overview

This measure would reduce greenhouse gas emissions by replacing high GWP refrigerants used in California's MVACs with lower GWP alternatives that also represent better lifecycle climate performance than the current refrigerant. This measure is meant to initially cover those classes of vehicles not included in the AB 1493 (Pavley) regulation: heavy duty and off-road vehicles. The principal benefit of this measure is the reduction of the GWP impact of refrigerant releases through direct and indirect emissions.

Assumptions for GHG Emissions Reduction

An estimate of the statewide emission inventory is under development for MVAC refrigerants in 2020. Anticipated reductions for 2020 are expected to be 0.7 $MMTCO_2E$ for light duty vehicles and 1.8 $MMTCO_2E$ for heavy duty vehicles for a total of 2.5 $MMTCO_2E$ for a universal phase out of HFC-134a in new and in-use MVACs in California. These projections were based on the current estimated annual leakage rate of R-134a for light duty vehicles and heavy duty trucks. These estimations will be refined as a more robust emission inventory is developed and the likely replacement refrigerants are selected and the split in the market is predicted.

Assumptions for Costs and Savings

Only capital costs were considered in this cost estimate. Additional staff analysis is needed to determine operating costs, cost savings, and economic impacts. The life of potentially new air conditioning systems is expected to be the same as current systems. Capital costs for

the introduction of new refrigerants in the California fleet were estimated to be on the order of $150 million by 2020 based on assumptions that changes begin to phase in around 2013. This estimate is based on a European incremental cost per vehicle of $23 to $28 (at an average exchange rate for the following mentioned year) per LDV in 2003 with a six percent annual increase in cost. The estimate includes several vehicle categories: light duty vehicles, heavy duty vehicles, and off-road vehicles. Actual costs for maintenance will vary depending on the low GWP refrigerant selected. Significant additional analysis is needed to enable and improve cost and performance estimates of the various alternative technologies.

Air Conditioner Refrigerant Leak Test during Vehicle Smog Check

Overview

As originally conceived, the proposed measure may add a refrigerant leak check to the "pass" criteria for the California vehicular inspection and maintenance (I/M) program, Smog Check, for all vehicles that undergo the test. However, additional staff analysis indicates new issues associated with the technical feasibility of the measure that were not originally considered. Thus, further technical assessment is needed. If put in place, all vehicles that pass Smog Check would have motor vehicle air conditioning (MVAC) systems that either leak at or below natural leak rates (to be determined in the measure) or are empty and precluded from further use unless the identified excessive leak is repaired. Inspections of MVACs would be conducted by the Smog Check technician with a portable refrigerant "sniffer" that detects HFC leakage or other means to be determined in the measure. Protocols would be developed for the test, including use of equipment and identification of threshold values to establish repair criteria.

Assumptions for GHG Emissions Reduction

The potential for annual reductions are thus estimated to be from 0.95 $MMTCO_2E$/year as a standalone measure, to 0.48 $MMTCO_2E$/year when considered as an addition to other measures. The estimates are preliminary; realistic values could range from one half to twice the estimates provided. The estimates are based on the following:

- The program would begin in 2011
- All vehicles will use HFC-134a (GWP=1300) in 2011.

Annual sales of R-134a refrigerant in California are assumed to be emitted into the atmosphere annually due to service losses and due to leaking vehicles. These sales are approximately 1.9 $MMTCO_2E$ per year.

To determine order of magnitude estimates, it assumed that implementation of an MVAC test and repair requirement would reduce leaks and service losses by 50% to an annual leak rate of 0.95 $MMTCO_2E$/ year. (More detailed analyses of the potential reductions are currently underway).

Refrigerant entering the state as OEM charge is not included in the emission rate; and refrigerant captured at end of life is not subtracted from the emission rate. (More detailed analyses of the potential reductions are currently underway).

Reductions obtained by implementation of this measure might overlap with reductions obtained by other MVAC related measures. To determine order of magnitude estimates, it is assumed that 50% of the MVAC direct emissions will already have been mitigated by other measures, reducing the potential reduction from 0.95 $MMTCO_2E$/year to 0.48 $MMTCO_2E$/year. (More detailed analyses of the potential reductions are currently underway).

Assumptions for Costs and Savings

Each Smog Check station would have to spend about $200~$300 for each hand-held HFC detector. This assumes the hand-held detector approach proves to be the correct approach. Station owners or technicians would have to pay up to $280 per person to train the Smog Check technicians. The initial cost to Smog Check station owners and technicians would be $2M (Instrument costs) + $4M (Training costs) = $6M. These are one time start up costs. Continuing annual costs are not considered because they are assumed to be covered by increases in the consumer price of a smog check.

Due to the increased time required by technicians to test MVAC systems, the consumer price of a Smog Check is expected to increase by an amount that has yet to be determined.

Refrigerant Recovery from Decommissioned Refrigerated Shipping Containers

Overview

The purpose of this measure is to mitigate any impacts from releases, either intended or accidental, of refrigerant from decommissioned refrigerated shipping containers. Refrigerated shipping containers may accumulate in major ports and that the refrigeration systems on these containers may leak high-GWP refrigerants such as HFC-134a. In particular, the refrigerant remaining in the decommissioned containers, the leakage from these containers and refrigerant disposal as the containers approach end-of-life (EOL).

Assumptions for GHG Emissions Reduction

It is essential that a needs assessment be performed to get an accurate estimate the annual amount of refrigerants that are available for recovery from decommissioned refrigerated shipping containers. It has been estimated that shipping container activity could double by 2020. If it is assumed that this applies to the decommissioned refrigerated shipping containers as well, then the bank becomes 160,000 to 320,000 $MTCO_2E$ based on staff analysis. This estimate represents the upper bound for the possible reduction potential of this mitigation.

Assumptions for Costs and Savings

Very little information on costs and economic impacts is known today about this proposed measure. As part of measure development, an assessment will be performed in order to get a better understanding of the number of refrigerated shipping containers decommissioned each year, the amount of refrigerant remaining, whether there is refrigerant recovery, and the costs associated with the recovery and recycling processes for the remaining refrigerant.

Enforcement of Federal Ban on Refrigerant Release during Servicing or Dismantling of Motor Vehicle Air Conditioning Systems

Overview

An existing federal regulation (40 CFR 82.154) bans the release to the atmosphere of high-GWP refrigerant substance at the end-of-life or during equipment servicing. The current degree of compliance with 40 CFR 82.154 is poorly documented but under review. The goal of this non-regulatory strategy is improved compliance with this regulation prohibiting the venting of certain types of refrigerant, including HFCs, to the atmosphere when MVACs equipment is serviced or dismantled. Venting is avoided by recovering refrigerants with specialized equipment before dismantling or servicing. The recovered refrigerant can be re-used by the owner or transferred to re-processors approved by U.S. EPA for proper disposal.

Assumptions for GHG Emissions Reduction

Reductions from dismantling operations could be expressed as a baseline emission rate times the fraction that is practically recoverable times a goal for fraction of vehicle dismantlers who would be prompted to comply with the federal regulation. None of these values is well known at present.

A rough approximation of the potential reductions from dismantling (as presented in the March 2006 Climate Action Team Report and usable until a better alternative is developed) is 0.1 to 0.6 $MMTCO_2E$ per year in 2010 (assuming the program will be in effect then) and 0.07 to 0.3 $MMTCO_2E$ per year in 2020.

Assumptions for Costs and Savings

Some dismantlers may not have the latest compliant hardware for recovering refrigerants or any equipment at all. Each dismantler who must purchase the equipment would have to spend approximately $3000 to $5000 per unit. The number of units needed would depend on the size of the operation (vehicle throughput). However, this would be an expense that the dismantler has so far avoided only through failure to comply with the existing federal regulation. Thus, this is not a cost burden associated with the proposed strategy.

The same statements apply to obtaining certification for technicians who use the recovery equipment, but with minimal anticipated costs. Training for the U.S. EPA's certification program is offered by various commercial schools. In addition, the Mobile Air Conditioning Society offers free training (a downloadable pamphlet) and a nominal exam fee, so the expense for operator certification should be minimal.

There are costs for storage of recovered refrigerant, record-keeping, and the operators' labor. Again, however, these are expenses already obliged by the federal regulation.

Recovered HFC may have some salvage value, but it is slight.

Measure H-6: High GWP Reduction from Stationary Sources

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
High GWP Refrigerant Tracking/Reporting/ Repair/Deposit Program	6.3	1.0	3.6	-2.6
Specifications for Commercial and Industrial Refrigeration	4.0	1.24	0.66	1
Foam Recovery and Destruction Program	0.3	9	0	9
SF_6 Leak Reduction and Recycling in Electrical Applications	0.1	0.3	0.4	-0.1
Alternative Suppressants in Fire Protection Systems	0.1	2	0.2	2
Residential Refrigeration Early Retirement Program	0.1	18.9	24.8	-6

Stationary Equipment Refrigerant Management Program

The high-GWP Stationary Equipment Refrigerant Management Program integrates two AB 32 early action measures: High-GWP Recycling and Deposit Program and Specifications for New Commercial and Industrial Refrigeration Systems. These two measures, discussed below, target different areas of the refrigerant value chain for stationary equipment. The Stationary Equipment Refrigerant Management Program approaches the challenge of high-GWP gases management in a more holistic manner integrating all sectors of the value chain.

High GWP Refrigerant Tracking, Reporting, Repair, Deposit, and Recovery

Overview

The goal of this measure is to reduce leaks of high-GWP refrigerants from stationary refrigeration and air-conditioning systems and improve service practices that maximize reclamation and recycling of refrigerant. The proposed regulatory action would include facility registration; refrigerant leak detection, monitoring, reporting, and recordkeeping; refrigerant distributor, wholesaler, and reclaimer reporting and recordkeeping; refrigerant sales restrictions to only certified technicians; and a refrigerant cylinder deposit program.

Assumptions for GHG Emissions Reduction

Business as usual emissions are based on the U.S. EPA Vintaging Model adjusted to the California population, as provided below:

Business As Usual	Non-Kyoto	Kyoto	Total
Statewide annual emission estimate: 2004	18	5.3	23.3
Statewide annual emission estimate: 2020	15.3	6.6	21.9

The determination of potential GHG emission reductions from business as usual is based on a year-by-year estimate of 1) compliance rates for leak repair and monitoring, and 2) system retrofitting or retirement. Because the refrigeration and air-conditioning industries are already regulated for ozone depleting substances (ODS), the compliance rates are assumed to be higher for these refrigerants. The range of assumptions for the compliance rates with monitoring, leak repair, and system retrofit and replacement are as follows:

- ODS compliance rates begin at 10% and increase from 5% to 15% each year to reach 100% in 2020.
- HFC compliance rates begin at 5% and increase from 5% to 20% each year to reach 100% in 2020.

The replacement rate for ODS systems is high due to the phase-out of use of ODS as a result of the Montreal Protocol.

The incremental annual emission reduction would be the estimated BAU emissions multiplied by an incremental compliance rate. Take HFC as an example, the incremental annual emission reduction in 2011 is:

5.3 $MMTCO_2E$ x 5% = 0.26 $MMTCO_2E$

The incremental annual emission reduction in 2012 is also:

5.3 $MMTCO_2E$ x 5% = 0.26 $MMTCO_2E$

The total emission reduction for 2012 would be:
0.26 $MMTCO_2E$ + 0.26 $MMTCO_2E$ = 0.52 $MMTCO_2E$
The total emission reduction for 2019 would equal the sum of the incremental annual emission reductions for years 2011 through 2019 = 5.0 $MMTCO_2E$

The incremental annual emission reduction in 2020 based on the 2020 BAU emissions is:
6.6 $MMTCO_2E$ x 20% = 1.3 $MMTCO_2E$

The total emission reduction for 2020 would be:

Total 2019 emission reductions of 5.0 $MMTCO_2E$ + 1.3 $MMTCO_2E$ =
6.3 $MMTCO_2E$

Assumptions for Costs and Savings

Labor and capital costs for monitoring and leak repair and equipment replacement vary for air-conditioning versus refrigeration equipment.

The assumptions for cost and cost savings are as follows:

Monitoring Costs	Cost per Year / Installation
General Cost for Monitoring	$100
Monitoring Equipment	$2,500

Leak Repair Costs		
	Air Conditioning	**Refrigeration**
Labor	$2,000	$3,000
Parts & Refrigerants	$500	$8,000
Replacement	$20,000	$500,000

Facility Inventory		
	Air Conditioning	**Refrigeration**
Total Number of Systems	86,000	10,000
Assumes 10,000 facilities have both air condition and refrigeration.		

Specifications for Commercial and Industrial Refrigeration

Overview

The primary analysis to estimate possible direct emissions reductions was to assume new refrigeration systems installed would use secondary loop refrigeration technology, or technologies that meet the same performance standards as secondary loop technology. Additionally, ARMINES' also reviewed the energy savings impact of technical options being applied in all installations, e.g., floating head pressure controls and closed display cases.

Assumptions for GHG Emissions Reduction

Although commercial and industrial refrigeration inventory research remains in progress, ARB's refrigeration and air-conditioning (RAC) contractor, ARMINES', preliminary work (available at: http://www.arb.ca.gov/cc/commref/armines_report_03_625.pdf) suggests that the Total Equivalent Warming Impact (TEWI) of current direct expansion refrigeration systems commonly used is 0.0307 $MMTCO_2E$ (approximately two to three times that of a secondary loop system).

Based on literature review it is assumed that 250 new commercial refrigeration systems will be installed in California in the 2012 through 2020 time period – approximately 30 per year from 2012 to 2016 and then 25 from 2017 to 2020. The potential emissions from these new stores are estimated as:

Direct Expansion (BAU) = 250 stores * 0.0307 = 7.7 $MMTCO_2E$
Secondary Loop (Low Range) = 250 stores * 0.0085 = 2.1 $MMTCO_2E$
Secondary Loop (High Range) = 250 stores * 0.0126 = 3.1 $MMTCO_2E$

The range of potential emissions reductions are determined based on the difference between the total BAU emissions and the secondary loop systems, or similar technology, emissions – or 2.6 to 5.2 $MMTCO_2E$. This range is averaged and rounded resulting in the potential GHG emission reductions of 4.0 $MMTCO_2E$.

In addition to installation of secondary loop systems, ARMINES' also reviewed the energy savings impact of technical options being applied in installations of all commercial refrigeration equipment within a supermarket, e.g., floating head pressure controls and closed

display cases. The preliminary estimation of energy savings is 1.6 TWh per year (1,600 GWh per year) or 30% below baseline. This energy savings impact is a component of the 4.0 $MMTCO_2E$ discussed above.

Assumptions for Costs and Savings

Based on literature review and discussions with industry stakeholders, the following assumptions were made:

The installation costs increase for a secondary loop refrigeration system is 15-20%, or around $100,000, above current DX systems. Increased costs are due to contractor unfamiliarity with new technologies; installation costs are anticipated to reduce to equal installation costs of direct expansion systems after 2016.

Operation and maintenance costs for a secondary loop refrigeration system are up to 40% lower than direct expansions systems (annual cost savings of approximately $25,400).

Final Cost Estimates are determined as follows:
Total Capital Cost per Year = 30 stores * $100,000 = $3,000,000
Total Cost Savings per Year = 30 stores * $25,400 = $762,000 (2012 to 2016)
Total Cost Savings per Year = 25 stores * $25,400 = $635,000 (2017 to 2020)

Foam Recovery and Destruction Program

Overview

Plastic insulating foams containing high-GWP blowing agents are used in refrigerators, freezers, building insulation, transport refrigerated units, and miscellaneous sources. When the product or material has reached the end of its useful life, the insulating foam emits high-GWP GHGs after it is shredded or broken during recycling, or disposed of in landfills. The goal of the measure is to reduce these end-of-life emissions to as close to zero as possible, by recovering waste foam prior to disposal and landfilling, and destroying the high GWP GHGs within the foam.

Assumptions for GHG Emissions Reduction

Staff estimates for GHG reductions apply a best-case scenario that virtually all potential GHG emissions from waste insulating foam can be reduced at end-of-life by recovering waste foam and destroying the GHGs within the foam before it is recycled or landfilled. Based on literature review and discussions with industry stakeholders, the following assumptions were made:

Based on the U.S. EPA Vintaging Model estimates, the estimated annual emissions in the U.S. in 2006 from insulating foam were 71.4 $MMTCO_2E$, with 2.6 $MMTCO_2E$ from HFC, and the remaining from ODS.

Estimated based on the percent of U.S. population residing in California, HFC emissions in California from foams are estimated as 0.3 $MMTCO_2E$ in 2006.
2.6 $MMTCO_2E$ * 12.2% = 0.3 $MMTCO_2E$

The amount of HFC-containing waste foam has increased about 9 percent per year. By 2020, the estimated emissions of HFCs from waste foam in California will be approximately 1 $MMTCO_2E$ annually.

$0.3\ MMTCO_2E * (1 + 9\%)^{14} = 1.1\ MMTCO_2E$

Of this total, 0.3 $MMTCO_2E$ are expected to be reduced through recovery of appliance foam.

Assumptions for Costs and Savings

Cost estimates are preliminary and will be known with greater precision by July 2010 when an ARB research study will be completed for lifecycle analysis cost of recovery and destruction of high-GWP GHGs.

Costs to recover and destroy foam from appliances are about \$30/$MTCO_2E$ using an automated system. The annual cost of an appliance foam recovery and destruction program to reduce 0.3 $MMTCO_2E$ would be about \$9M per year, assuming all appliances were recycled using an automated system.

SF_6 Leak Reduction and Recycling in Electrical Applications

Overview

This measure will reduce emissions of SF_6 within the electric utility sector and at particle accelerators by requiring the use of best achievable control technology for the detection and repair of leaks, and by the recycling of SF_6.

Assumptions for GHG Emissions Reduction

Staff estimates an annual emission reduction of 0.07 $MMTCO_2E$ calculated from a U.S. EPA reduction estimate of 20% for leak detection and repair and 10% for recycling and recovery based on 2020 projected emissions of 0.22 $MMTCO_2E$ in California.

Assumptions for Costs and Savings

Annual operating cost is estimated to be \$300,000 for leak detection and repair and recycling. It is assumed that all SF_6 saved during leak detection and maintenance activities represents a cost savings because the facility SF_6 purchase and consumption rate will decrease. The cost savings from reduced consumption and purchase is estimated at \$420,000 annually, yielding a net cost savings of \$120,000.

Alternative Suppressants in Fire Protection Systems

Overview

This measure will reduce greenhouse gas emissions from fire suppression systems through a variety of potential reduction options including a GWP threshold for fire suppression agents in new systems, leak reductions strategies, and end of life requirements.

Assumptions for GHG Emissions Reduction

The goal of the measure is to reduce emissions to less than 0.1 $MMTCO_2E$ by 2020 with an effort to ensure that HFC banks grow no more than about 10% between 2012 and 2020. Leak reduction efforts could address installed capacity while alternative suppressants may be used to address emissions from future banks. The impact on emission levels will be greatest once a large percentage of the systems have moved to low GWP agents.

Assumptions for Costs and Savings

Costs will differ depending on the implementation of this measure. Costs presented here will be for using low/no GWP alternatives in new total flooding systems instead of HFC-227. Portable systems and leak reduction strategies are expected to be less expensive.

Based on U.S. EPA data and assuming replacement lower GWP agents in systems coming on-line between 2010 and 2015, one-time costs vary from $10 million to $12 million for 2012-2015 with annual costs ranging from $200,000 to a savings of $200,000, depending on the substitute gas. For systems coming online between 2015 and 2020 the one-time cost is approximately $3 to 4 million with annual costs ranging from $70,000 to a savings of $70,000. These estimates are in U.S. 2000 dollars. Converting these to 2007 dollars and annualizing the costs using a 15 year lifetime, the annualized capital costs are approximately $1.8 million. Annual operating costs are approximately $0.2 million and savings are approximately $0.2 million.

Residential Refrigeration Early Retirement Program

Overview

This measure involves establishing a voluntary program to upgrade pre-2000, less energy efficient residential refrigeration equipment such as refrigerators and freezers and ensure proper recovery of refrigerants and blowing agents that have a high-GWP. The measure would include developing strategies to support appliance take-back/upgrade and early retirement programs such as the U.S. EPA Responsible Appliance Disposal (RAD) program and EnergyStar program, in addition to programs administered by local utilities to address direct and indirect GHG emission reductions from domestic appliances.

Assumptions for GHG Emissions Reduction

Based on literature review and data available through the U.S. EPA RAD Program the following assumptions and determinations are made in the GHG reductions estimate:

- Currently in California up to 1.2 million refrigerators and freezers are disposed of annually.
- Appliances manufactured prior to 1996 used CFC-12 as the refrigerant and CFC-11 as the blowing agent; appliances manufactured from 1996 to 2002 used HFC-134a as the refrigerant and HCFC-141b as the blowing agent; appliances manufactured after 2002 used HFC-134a as the refrigerant and HFC=245fa as the blowing agent
- For domestic appliances the average refrigerant charge is estimated to be 0.5 pound; the average foam blowing agent used is estimated to be 1.0 pound.
- The primary result of this measure is a 25% increase in recycling of appliances to total 1.5 million per year; an increase of 300,000 appliances per year.

- At an appliance end of life 90% of the original refrigerant charge is recovered.
- At an appliance end of life 65% of the initial blowing agent is released – 25% during shredding and an additional 40% after disposal; this GHG emission is mitigated by this measure.

The total reduced emissions for a given year is calculated as follows:

Total Pre-1996 Refrigerator Emission Reduction	=	Total Refrigerators * % Pre 1996 Refrigerators * (½ pound CFC 12 * GWP * 90%) + (1 pound CFC-11 * GWP * 65%)
Total 1996 to 2002 Refrigerator Emission Reduction	=	Total Refrigerators * % 1996 to 2002 Refrigerators * (½ pound HFC-134a * GWP * 90%) + (1 pound HCFC-141b * GWP * 65%)
Total post 2002 Refrigerator Emission Reduction	=	Total Refrigerators * % 1996 to 2002 Refrigerators * (½ pound HFC-134a * GWP * 90%) + (1 pound HCF-245fa * GWP * 65%)
Total Emission Reduction	=	Total Pre-1996 Refrigerator Emission Reduction + Total 1996 to 2002 Refrigerator Emission Reduction + Total post 2002 Refrigerator Emission Reduction

Assumptions for Costs and Savings

Based on literature review and data available through the U.S. EPA RAD Program the following assumptions and determinations are made in the cost and cost savings estimate:

- Incremental costs for purchasing an EnergyStar appliance is $62, so consumer costs = 300,000 * $62, or $19 million.
- Energy savings during the life of an EnergyStar appliance is 700 kWh per appliance, so total energy savings is 700 kWh * 300,000, or 210 million kWh.
- Total utility company costs for appliance recycling programs is $0.03 per kWh saved * 210 million kWh, or $6.3 million.
- In a three-year budget cycle, the total investment in energy efficiency programs in California is $2.7 billion.
- Ratepayer resource savings are $5.4 billion over the life of the programs.
- The cost savings equals total investment of $2.7 billion – total resource savings of $5.4 billion, or $2.8 billion.

Agriculture

Measure A-1: Methane Capture at Large Dairies

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Methane Capture at Large Dairies	1	156	0	156[130]

Overview

This is a voluntary measure to encourage the installation of methane digesters to capture methane emissions from the decomposition of solid and liquid waste at large dairies. The methane could be used as an alternative to natural gas in combustion, power production, or as a transportation fuel.

Assumptions for GHG Emissions Reduction

Manure Management Emission Reduction Assumptions (dairies with 1,000 head or more)

1,781,799 Head	Total California Herd
6.55 Million Metric Tons	Uncontrolled GHG emissions from California Herd
1,392,888 Head	Total SJVAPCD Herd*
78%	SJVAPCD percentage of total California Herd
330,028 Affected Head	Assumes 73% of dairy cows at dairies with 1,000+ head will already be feeding digesters through voluntary action.
1,223,854 Head	Dairy cows, heifers, calves, and bulls at dairies with 1,000+ head not feeding an existing digester
3.676 tonnes CO2e/head	Includes CH4 and N2O
1.2 Million Metric Tons	Uncontrolled emissions from 330,028 head
86%	Control
1.0 Million Metric Tons	Reductions from 330,028 head
330	Dairies with 1,000 or more dairy cows, heifers, calves, and bulls not already feeding a digeser
1,628	Total dairies in California (2006 CDFA data)

*: Includes all cows in Kern County

Assumptions for Costs and Savings

Staff estimates an operating cost of $33M and an annualized cost for installation of digesters at $123M for this measure based on an average capital cost of $3.9M per digester. Savings are not estimated, but are possible through avoided electricity or natural gas purchases, or

[130] The methane capture at large dairies measure is voluntary and therefore not considered in the economic modeling calculations.

through sale of electricity or natural gas. However, the cost for this voluntary measure is not included in the economic modeling as the reduction is not required as part of the AB 32 GHG emissions reduction program.

Cost and Savings Calculation	
Cost per digester	$3.9M
# of large dairies (with more than 1000 head)	330
Capital cost	$1,280M
Capital life	15 years
15-year CRF	0.09634
Annualized capital cost 2020 (capital cost x CRF)	$123.3M
Operating cost 2020 ($100k)	$33M
Total cost 2020	$156M

Forests

Measure F-1: Sustainable Forest Target

GHG Reduction Measure	Potential 2020 Reductions $MMTCO_2E$	Annualized Cost ($Millions)	Savings ($Millions)	Net Annualized Cost ($Millions) [Cost-Savings]
Sustainable Forest Target	5	50	0	50

Overview

Reductions from this target will be achieved through conservation, forest management, reforestation, afforestation urban forestry and fuels management projects. The forest net flux, that is the balance between uptake and emissions, is currently -5 $MMTCO_2E$.

Assumptions for GHG Emissions Reduction

A target reduction of 5 $MMTCO_2E$ is required forest sector to maintain the current net flux based on inventory projections.

Assumptions for Costs and Savings

Staff estimates a net cost of $50M to achieve a 5 $MMTCO_2E$ reduction based on the current voluntary offset price of approximately $10 per $MTCO_2E$.