The Role of a Low Carbon Fuel Standard in Reducing Greenhouse Gas Emissions and Protecting Our Economy

Executive Summary

Transportation accounts for more than 40% of California's annual greenhouse gas (GHG) emissions and the state relies on petroleum-based fuels for 96 percent of its transportation needs. Petroleum use contributes to climate change and dependency on oil leaves workers, businesses and consumers vulnerable to price shocks from an unstable global energy market. No business should be hostage to a single supplier for its most critical raw materials; neither should any state or nation. To protect our jobs and wages, clean our air and maintain our way of life, we must diversify our fuel sources and reduce our reliance on oil.

As one of the world's largest energy consumers and the national leader in energy efficiency, alternative energy and greenhouse gas reduction, California has the opportunity and ability to diversify its transportation fuel supplies, decrease the greenhouse gases emitted from those fuels, and establish a sustainable market for cleaner-burning fuels. Accordingly, by Executive Order the Governor will establish a first-of-its-kind policy to reduce the greenhouse gas impact from California's use of transportation fuels and in so doing diversify the state's transportation fuels portfolio.

Specifically, Executive Order S-XX-07 will establish:

1. A Low Carbon Fuel Standard (LCFS) for transportation fuels sold in California, and
2. An initial LCFS goal of reducing the carbon intensity of California's passenger vehicle fuels by at least 10 percent by 2020.

The LCFS is the world's first global warming standard for transportation fuels, and as with other groundbreaking California policies, it may serve as a model for state, federal and international standards. This historic action will reduce California's reliance on fossil fuels and help the state reach its AB 32 emissions targets.

The LCFS will require fuel providers[1] in California to ensure that the mix of fuel they sell into the California market meet, on average, a declining standard for GHG emissions measured in CO_2-equivalent gram per unit of fuel energy sold. The standard will be measured on a lifecycle[2] basis in order to include all emissions from fuel consumption and production, including the "upstream" emissions that are major contributors to the global warming impact of transportation fuels.

In order to realize these GHG reductions at the lowest cost and in the most consumer-responsive manner, the LCFS will utilize market-based mechanisms to allow providers to choose how they reduce emissions while responding to consumer demand. For example, providers may purchase and blend more low-carbon ethanol into gasoline products, purchase credits from electric utilities supplying low-carbon electrons to electric passenger vehicles, diversify into low-carbon hydrogen as a product and more, including new strategies yet to be developed.

By 2020, the LCFS will produce a 10 percent reduction in the carbon content of all passenger vehicle fuels sold in California. This is expected to replace 20 percent of our on-road gasoline consumption with lower-carbon fuels, more than triple the size of the state's renewable fuels

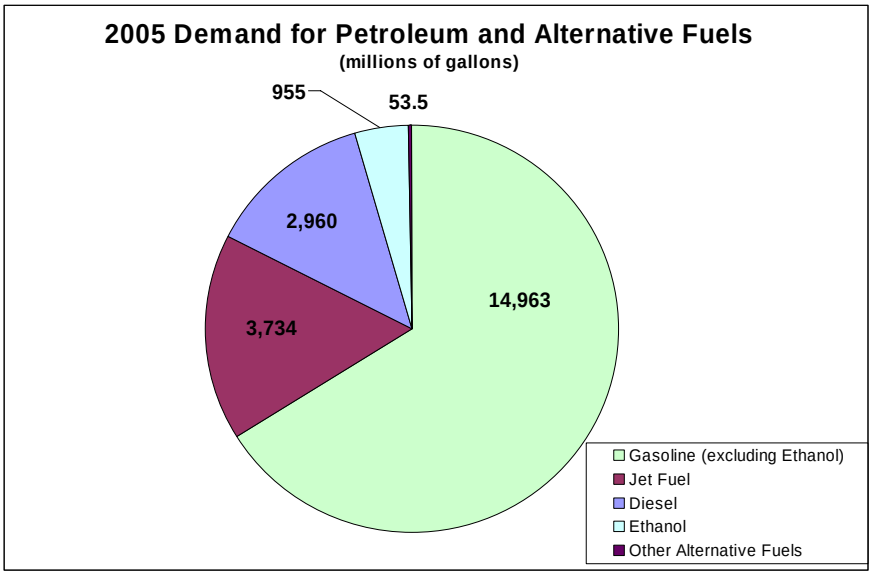
market, and place on California's roads more than 7 million alternative fuel or hybrid vehicles (20 times more than on our roads today).

Rationale for Policy

Low Carbon Fuels Support the Goals of Diversifying Fuel Supply and Reducing Greenhouse Gases

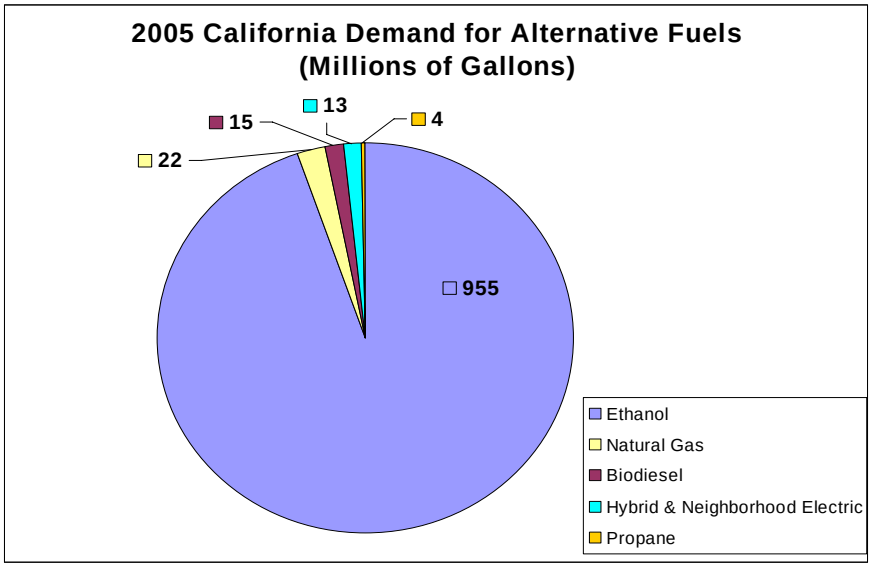
Diversify fuel supply. California relies excessively on one fuel to meet its transportation needs. Figure 1 demonstrates that petroleum-based fuels supply 96 percent of California's transportation needs. The other four percent is a combination of various alternative fuels (see Figure 2). Fuel diversity has 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].

Figure 1



Sources: California State Board of Equalization Taxable Motor Fuel Sales, and CEC PIIRA database.

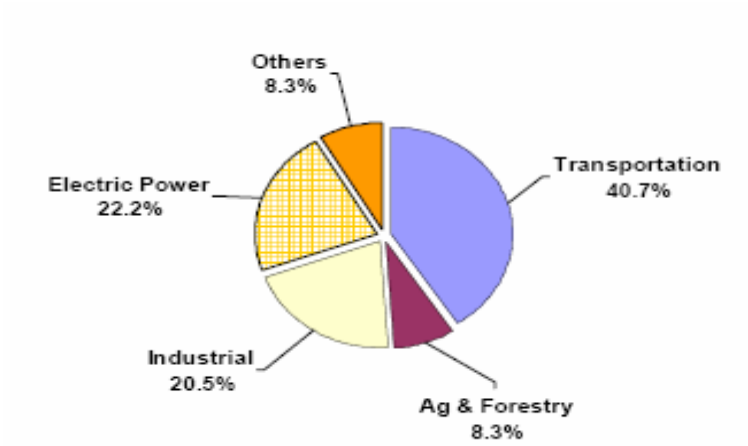
Figure 2



Sources: Analysis of California State Board of Equalization taxable gasoline sales figures and CEC data.

Reduce GHG emissions. Large-scale use of lower-carbon transportation fuels is necessary to meet the AB32 requirement that GHGs generated in the state be reduced to 1990 levels by 2020. Transportation fuels are responsible for over 40 percent of annual greenhouse gas emissions in California (Figure 3).

Figure 3 – Greenhouse Gas Emission Inventory - 2005



A Low Carbon Fuel Standard Allows Markets, not Governments, to Determine the Lowest Cost Path to Achieving the Goals and Meeting Consumer Demand

Regulatory certainty promotes development of low carbon fuels and new energy industries. The LCFS provide certainty to the growing clean energy market that sustainable markets for their products will exist but does so in a manner that does not select which alternative fuels will prevail in the marketplace. Technology and other companies then compete with one another to

sell into that market, allowing price and quality considerations to determine eventual winners. Reducing risk through regulatory certainty is also a benefit to energy companies.[5]

Expands consumer choice. The LCFS will communicate to producers and consumers that the GHG reduction requirements of AB32 will be met by *expanding* rather than limiting consumer choice. Because consumers will continue to seek the lowest prices for their transportation fuels and the new standard will allow fuel providers to meet its requirements in a flexible and consumer-responsive manner, the LCFS will inspire competition among creators and suppliers of low-carbon products seeking to sell their products to fuel providers needing to meet the new standard.[6]

The Design of a Low Carbon Fuel Standard[7]

A Performance-based Standard with Averaging, Banking and Trading

The LCFS will require fuel providers (defined as refiners, importers, and blenders of passenger vehicle fuels) to ensure that the mix of fuel they sell into the California market meets, on average, a declining standard for GHG emissions measured in CO_2-equivalent gram per British Thermal Unit (BTU).[8] All relevant greenhouse gases will be included (i.e., CO_2, CH_4, and N_2O) and be measured on a "full fuel cycle" basis (i.e., upstream feedstock extraction, fuel refining, and transport to market).[9]

Each fuel provider will need to demonstrate, on an annual basis, that the fuel mix provided to the market met the standard, including if necessary, by using credits previously banked or purchased. Providers of fuels that exceed the performance standard for the compliance period will be able to generate credits in proportion to the degree of over performance and the quantity of fuel provided. These credits can be banked for future use[10] or sold to other regulated fuel providers. Penalties for noncompliance will be determined during the Implementation Process (see below).

Numerous studies have demonstrated that performance-based standards drive least cost compliance by catalyzing unanticipated innovations.[11] Examples include the national Acid Rain Trading Program and the California Low Emission Vehicle program. With both of these programs, the actual cost of compliance was much lower than predicted by regulators. For example, in the case of the Acid Rain Trading Program, actual compliance costs were roughly one-third to one-half of those estimated in the first five years, saving an estimated $350 million to $1,400 million per year.[12]

Options for Compliance

Under the LCFS, fuel providers will have at least three different options with which to comply:

- Blend or sell an increasing amount of low-carbon fuels (for examples, see Table 1)
- Use previously banked credits
- Purchase credits from fuel providers who have earned credits by exceeding the standard.

One of the critical benefits of this performance-based approach is that it does not dictate the mix of fuels that fuel providers are obligated to deliver. Fuel providers will have flexibility to choose what types of fuels in what volumes they sell as long as their sales-weighted average meets the standard. In this way, the market will determine the least-cost and most consumer-responsive outcome for the fuel mix while ensuring decreasing GHG emissions.

Table 1. Possible Low Carbon Fuel Strategies

Low Carbon Fuel Strategy	Description
E10 (10% ethanol, 90% gasoline by volume)	Increase blending of ethanol from today's 5.7 percent by volume to 10 percent.
E85 (85% ethanol, 85% gasoline by volume)	Sell high blend ethanol (85 percent ethanol, 15 percent gasoline) for use in Flex Fuel Vehicles (FFVs).
Switch to Low-Carbon Ethanol	Switch to ethanol made from cellulosic materials (e.g., agricultural waste, switchgrass)l that has 4-5 times lower GHG emissions than today's corn.
Electricity	Either in pure battery electric vehicle or in plug-in hybrid vehicle that can be recharged from the electricity grid.
Hydrogen	Used in zero-emitting fuel cell vehicles or internal combustion engine cars modified.
CNG, LPG	Compressed Natural Gas and Liquefied Petroleum Gas burned in modified internal combustion engine cars.
Other biomass based fuels	For example, BP and Dupont are developing biobutanol as a possible additive and Chevron is exploring petroleum-like products synthesized from biomass (so-called "biocrude")
Other?	Future strategies to be developed by fuel providers and outside innovators.

Basis for 10 Percent Reduction Target

10 percent Reduction is Minimum Necessary to Achieve State GHG and Petroleum Goals

AB32 requires reductions from all sectors. To meet the AB32 goals of returning emissions to 1990 levels by 2020, all sectors will have to make substantial reductions. A 10 percent reduction in the carbon intensity of transportation fuels will contribute 13.4 million metric tons of CO_2 reductions, over half of the 24 million metric tons of CO_2 reductions needed to return passenger vehicles and light trucks to 1990 levels.[13]

A 10 percent reduction will also assist with the following state goals:

Replace 20 percent of on-road energy use with non-petroleum fuels by 2020. A low carbon fuel standard provides a route for compliance with the CEC *2003 Integrated Energy Policy Report* goal of 20 percent non-petroleum fuel use by 2020 while reducing greenhouse gas emissions.[14] On average, low carbon fuels employed to meet the LCFS will generate 50 percent lower greenhouse gas emissions than gasoline.[15] Therefore, a requirement of 10 percent reduction would result in replacing 20 percent of petroleum use with low-carbon fuels.

Governor's Bioenergy Action Plan goals. Governor's Schwarzenegger's *Bioenergy Action Plan* established targets for the use and production of biomass products for electricity and transportation fuels.[16] The Plan's target is to produce a minimum of 40 percent of bio-fuels within California by 2020. Establishing a large and growing market in California for low carbon fuels is essential to achieving this goal, which would be equivalent to 1.0 to 1.9 billion gallons of in-state ethanol production. California has the potential to produce 3 billion gallons by 2020 primarily by using agricultural and municipal waste material.[17]

10 Percent Reduction Goal is Achievable

To achieve a 10 percent reduction in carbon intensity, fuel providers will need to reduce the carbon intensity associated with their fuels from about 97.4 kg of CO2-eq/MMBTU to 87.7 kg/MMBTU. Table 2 shows *one* possible mix of strategies that could be used to achieve this goal by 2020. While at this time we believe the most likely strategies are E10, E85, switching to cellulosic ethanol, plug-in hybrids, and hydrogen fuel cells, markets will determine whether that mix or others (including options such as biobutanol or biocrude) will be employed to meet the standard.

Table 2. Possible Compliance Scenarios to Meet 10 Percent Reduction Target in 2020

Scenario Number-->	1	2	3
Total Petroleum Displaced by Low-Carbon Fuels (B gal)	3.0	3.1	3.2
Low-Carbon Fuels			
Total Ethanol Demand (B gal)	2.7	3.8	4.7
Number of FFVs (millions)	3.0	6.0	8.5
Number of PHEVs (millions)	4.1	1.7	0.0
FCVs (millions)	0.5	0.5	0.2

Source: Natural Resources Defense Council estimates[18]

Benefits of a Low Carbon Fuel Standard

Adoption of a Low Carbon Fuel Standard will substantially reduce global warming pollution, cut petroleum dependency and create a sustainable and growing market for cleaner fuels. Based on the mix of strategies shown in Table 3, we estimate that a fuel standard requiring an initial reduction of 10 percent in the greenhouse gas impacts of passenger vehicle fuels by 2020 will:

- Cut global warming pollution from the passenger vehicle fleet by 10 percent, equivalent to removing 3 million cars from the road.
- Displace 20 percent of on-road gasoline consumption with low-carbon fuels, reducing consumption by up to 3.2 billion gallons of gasoline per year, equivalent to the output of 2.5 average-sized California refineries.[19]
- Expand the size of the current renewable fuels market in California (already the largest in the nation) by 3 to 5 times. Instead of today's corn, over half of the ethanol is likely to be made from extremely low-carbon, cellulosic feedstocks such as agricultural waste and switchgrass.[20]
- Place on California's roads more than 7 million alternative fuel and hybrid vehicles, approximately 20 times the number of such vehicles on California's roads today.

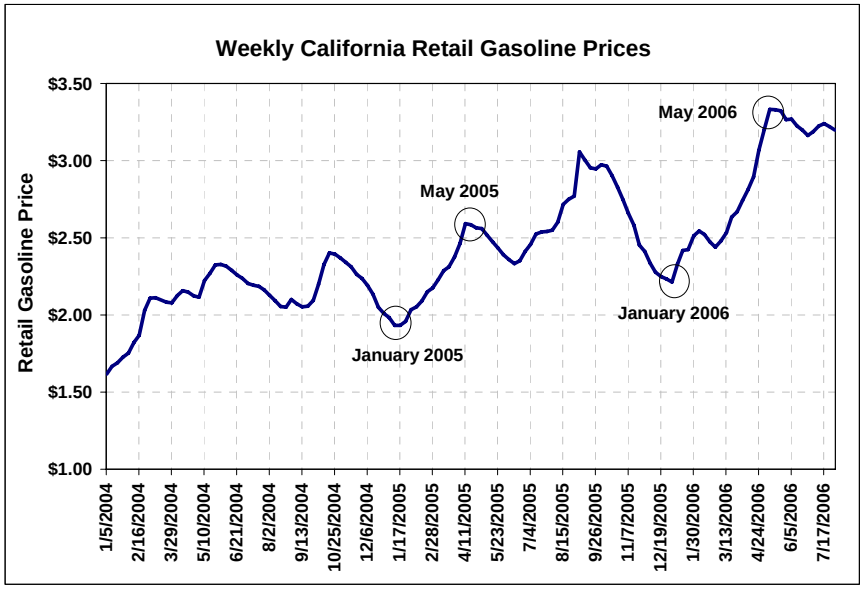
In addition, the LCFS can be expected to:

- Grow California's clean energy industry. California is well poised to lead the nation in the emerging "cleantech" business sector.[21]
- Help protect Western lands and discourage unclean energy developments. In the absence of a transition to clean fuels, industry is expected to develop highly polluting domestic resources, such as fuel from coal-to-liquids that doubles carbon pollution per

gallon and other "unconventional" oil resources such as tar sands and oil shale, that are not only much worse for the climate (as much as twice as polluting as conventional gasoline) but also destroy wilderness areas and use scarce water resources.[22]

- Reduce California's dependence on imported oil and keep more money in the state. According to the CEC, if no steps are taken to diversify our fuel sources, by 2020 about half of our oil will be imported from overseas.[23] A low carbon fuel standard, coupled with other policies to encourage clean fuel production, will keep a significant and growing fraction of that money in the state.
- Reduce risk to the state's economy. By reducing the sensitivity of its economy to oil price uncertainty and shocks resulting from refinery outages, cartel actions or disruptions in world oil supplies, California will reduce the risk to sales, wages and jobs. Figure 4 illustrates recent volatility of, and trends in, gasoline prices.

Figure 4 – Retail Gasoline Price Volatility in California, 2004 - 2006



Source: CEC staff analysis of Oil Price Information Service (OPIS) data.

Implementation Process

The Low Carbon Fuel Standard will move from a framework analysis to be conducted during summer 2007 to implementation by the end of 2008.

The LCFS will be implemented after the completion of a detailed report and regulatory proceedings. The signing of the Executive Order will initiate this process. The following is a brief description of how the LCFS will be implemented.

Analytical Report. The University of California will undertake a study, in partnership with the California Energy Commission (CEC) and the Air Resources Board (CARB), to develop the framework for the Low Carbon Fuel Standard (UC Study). Once this study is complete, it will be introduced into the California Energy Commission's current proceeding to develop a state strategy to increase the amount of alternative fuels in California pursuant to Assembly Bill (AB)1007 (Chapter 371, Statue of 2005).

Adopt the Low Carbon Fuel Standard. The CEC will incorporate the UC Study into the CEC's AB 1007 Report. The CEC will conduct public hearings on the AB 1007 Report and after deliberation, will propose a compliance schedule for the Low Carbon Fuels Standard as part of the AB 1007 Report. The Governor's Executive Order asks for the AB 1007 report to be finalized by June 30, 2007.

Implement the Standard. Upon CEC adoption of the AB 1007 Report, the CARB will initiate a regulatory proceeding which will establish and implement the Low Carbon Fuel Standard. In advance of this and by June 30, 2007, the CARB will determine if a Low Carbon Fuel Standard can be developed as a discrete early action measure pursuant to the Global Warming Solutions Act, and if so, will consider the adoption of a Low Carbon Fuel Standard on the list of early action measures. Also, because electric and natural gas utilities represent a source of transportation fuels, the Governor's Executive Order requests the Public Utilities Commission, in its current implementation of the GHG emissions cap adopted by Decision 06-02-032, to examine and address how investor-owned utilities can contribute to reductions in GHGs in the transportation sector.

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[1] Essentially producers, importers, refiners and blenders

[2] Sometimes called "full fuel cycle," "well-to-wheels" or in the case of biofuels "field-to-wheels"

[3] The CEC's 2003 IEPR stated a goal of 20 percent alternative fuel use by 2020 (California Energy Commission, 2003 *Integrated Energy Policy Report*, December 2003, 100-03-019.)

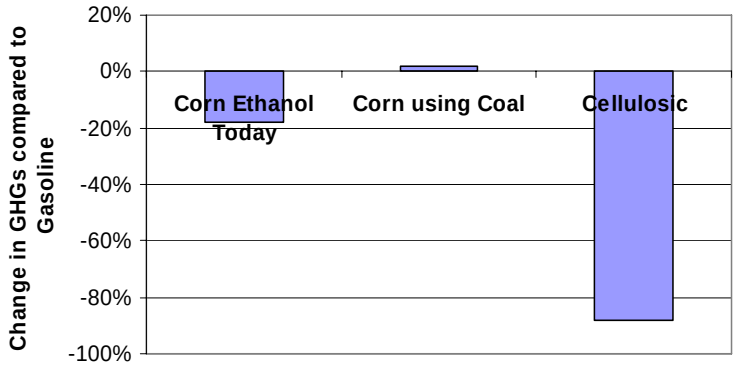
[4] Bioenergy Interagency Working Group, Bioenergy Action Plan for California, California Energy Commission, July 2006. CEC 600-2006-010

[5] A recent study by Environmental Entrepreneurs [Creating Cleantech Clusters: 2006 Update, www.e2.org] reported that, "Cleantech investors overwhelmingly agree that public policy can be an important driver for new job and investment growth: 91% of "cleantech" venture capitalists surveyed say that pro-environmental public policy can be a driver in bringing new business and investment to a state and 79% of cleantech venture capitalists surveyed say that current public policies (regulations, programs and incentives) are a prominent factor in their investment decisions."

[6] For example, refiners seeking the lowest-cost and most consumer-responsive methods by which to meet the standard will be able to choose among competing bio-fuel blends, credits from competing utilities providing clean electrons to the electric car marketplace, credits from clean hydrogen and more, and base their decisions on market and cost factors no different than the factors they employ in the ordinary course of business. Similarly, the new standard will expand investment in, and competition between, the infrastructures through which alternative fuels can be delivered to customers. Moreover, the standard will accomplish this without significant taxpayer investment and without government picking which alternative fuel or fuels will be the winners.

[7] Unlike the concept of Renewable Fuel Standards, the LCFS measures greenhouse gas impact over full fuel cycles, allows fuels other than ethanol to be used for compliance, and will discourage the development of high-carbon unconventional oil. In addition, there is great variation in the GHG reduction from ethanol depending on feedstock (i.e., corn, sugar crops, or woody plant material known as "cellulosic" feedstocks), cultivation methods (i.e., low-till, other) and processing (i.e., coal, natural gas, methane, other). E.g., a corn ethanol plant using coal would actually increase GHGs slightly (see Figure 5 below).

Figure 5: Low-Carbon Fuel Standard necessary to ensure greenhouse gas reductions from the use of biofuels



Source: Farrell et al., "Ethanol Can Contribute to Energy and Environmental Goals," *Science* , Jan 27, 2006.

[8] It is likely that vehicles with inherently greater efficiency, such as battery electric vehicles and hydrogen fuel cells, will need an adjustment factor to their emissions factors in order to accurately reflect their GHG benefits. For example, strictly in terms of kilograms of CO2-equivalent per BTU consumed basis, electricity is responsible for about 1.8 times more GHG emissions. However, when the greater inherent efficiency of electric drive is considered, the actual benefits of GHG displacement is about a two-thirds reduction.

[9] Sometimes referred to as "well to wheel," "full fuel cycle", or in the case of biofuels, "field to wheel" basis. To avoid double-counting, GHG emissions from the vehicles themselves would not be included since they are already regulated under the AB1493 vehicle standards. Likewise, emission reductions credited to the LCFS will not be eligible for credit towards other AB32 regulations, if any.

[10] Credit life to be determined

[11] See for example: NESCAUM, "Environmental Technology and Technology Innovation: Controlling Mercury Emissions from Coal-Fired Boilers," Northeast States for Coordinated Air Use Management, September 2000; Anderson and Sherwood, "Comparison of EPA and Other Estimates of Mobile Source Rule Costs to Actual Price Changes," presented at the SAE Government Industry Meeting, DC, May 14, 2002, SAE 2002-01-1980; Harrington et al., "On the Accuracy of Regulatory Estimates," Resources for the Future, January 1999; and NESCAUM 2000. Cackette, "The Cost of Emission Controls, Motor Vehicles and Fuels: Two Case Studies," presentation at MIT, 1998

[12] Ellerman, A.D., P.L. Joskow, et al., Markets for Clean Air: the U.S. Acid Rain Program, Cambridge University Press, 2000

[13] Based on the *Climate Action Team Report to Governor Schwarzenegger and the Legislature (http://www.climatechange.ca.gov/climate_action_team/index.html)*. The remaining reductions in 2020 are projected to come from AB 1493 vehicle pollution standards and from better transportation planning reducing the amount of miles driven. For these estimates, we use the Climate Action Team GHG inventory convention of vehicle end-use only.

[14] For full report, go to http://www.energy.ca.gov/2003_energypolicy/index.html.

[15] For ethanol, this can be achieved through a mixture of 54 percent corn and 46 percent lignocellulosic ethanol. Electricity can reduce GHGs by 67 percent, according to analysis by CARB in support of the AB 1493 standards.

[16] For full report, see http://www.energy.ca.gov/bioenergy_action_plan/ .

[17] See Navigant Consulting, *Recommendations for a Bioenergy Action Plan for California*, draft consultant report prepared for the Bioenergy Interagency Working Group, March 2006, CEC-600-2006-004-D.

[18] Key assumptions for these scenarios:

- Baseline gasoline contains 5.7 percent ethanol derived from corn.
- All fuel providers increase the blending of ethanol to 10 percent by volume from today's 5.7 percent. The remainder of the ethanol is sold as E85 for use in flex fuel vehicles (FFVs.)

- On average, the ethanol mix used reduces GHGs by 50 percent compared to gasoline. This can be achieved through 50/50 mixture of corn ethanol at about 20 percent reduction and a cellulosic ethanol at 80 percent reduction.
- Plug-in hybrids (PHEVs) use electricity for 50 percent of their driving and using electricity reduces GHG emissions by 67 percent compared to gasoline.
- Hydrogen fuel cells reduce GHG emissions by at least 30 percent compared to gasoline, based on the goals of California Hydrogen Highway Network.

[19] To develop this estimate, we developed several scenarios of low-carbon fuel mix that could be used to meet the standard. The low-carbon fuels considered were: ethanol derived from corn, ethanol derived from lignocellulosic materials (or simply "cellulosic"), electricity and hydrogen. The primary vehicle use strategies were to increase blending to 10 percent by volume, use ethanol as E85 (85 percent ethanol, 15 percent gasoline), plug-in electric vehicles, and hydrogen fuel cell vehicles.

[20] California currently uses 5.7 percent ethanol by volume in its gasoline, about 900 million gallons per year, almost all of which is made from corn. Corn ethanol reduces GHG by about 18 percent compared to gasoline; in comparison, using "lignocellulosic" materials (including agricultural and municipal solid waste, and specially grown energy crops such as switchgrass) reduces GHG by 88 percent. See Farrell et al., "Ethanol Can Contribute to Energy and Environmental Goals," *Science*, January 27, 2006.

[21] See Calstart report, *California's Clean Vehicle Industry, How the Drive to Reduce Automotive Global Warming Pollution Can Benefit the California Economy*, 2004, and Environmental Entrepreneurs, *Creating the California Cleantech Cluster, How Innovation and Investment Can Promote Job Growth and a Healthy Environment*, September 2004.

[22] See Farrel and Brandt, "Risk of Oil Transitions," Environmental Research Letters, October 30, 2006. The LCFS will provide a powerful market signal, from one of the largest markets for gasoline in the world, to help slow and eventually stop the development of these unclean fuels. In this regard, a low carbon fuel standard for transportation fuels will perform a role similar to the groundbreaking SB1368 law, signed by the Governor in 2006, to encourage clean power plants and discourage investments in unclean coal power plants in the West.

[23] According to the CEC (http://energy.ca.gov/oil/statistics/crude_oil_receipts.html), foreign imports made up about 40 percent of petroleum use in 2005. Assuming CA production declines by 2 percent per year and Alaska can only make up 1 percent of that, foreign imports would be close to 55 percent in 2020. Fuel use, based on LDV data, is expected to grow 12 percent in the same time. Therefore, 55 percent of ~728 million barrels per year would be 400 million barrels per year and conservatively at $45 per barrel, this would be about $18 billion per year.

January 8, 2007
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