Preliminary Review of the CARB Staff Analysis of the Proposed Low Carbon Fuel Standard (LCFS)

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CARB staff has performed an economic analysis for its proposed Low Carbon Fuel Standard (LCFS) concluding that adoption of the standard will result in a cost savings to California motorists of up to $3.4 billion per year by 2020 ($11 billion over the period from 2010 to 2020). The staff's emissions analysis also concludes that there will be a significant reduction in greenhouse gas (GHG) emissions and a net reduction in criteria pollutants. In contrast, as explained in more detail below, we estimate that fuel costs will increase by approximately $3.7 billion per year in 2020, oxides of nitrogen (NOx) emissions will increase by more than 5 tons per day, and there will be no detectable change in climate. It should also be noted that the estimates of alternative fuels costs, including our own, are based on paper studies that assume economies of scale yet to be demonstrated in practice. The economic analysis in the Initial Statement of Reasons[1] (ISOR) fails to account for the uncertainty associated with such studies. This is especially a concern given that a study[2] published subsequent to the preparation of the ISOR projects higher costs than earlier studies.

Specific problems with the ISOR include the following:

1. Only the low end of the baseline costs for conventional fuels (which CARB staff did not use in its economic analysis) is consistent with historical oil price trends. As a result, the economic analysis assumes future costs for conventional fuels that are too high, which contributes to an underestimate of the costs of LCFS fuels by over one billion dollars per year.

2. Cost estimates for alternative fuels are unrealistically low due in part to unrealistic estimates for feedstock cost, unrealistic estimates of the cost of emissions control requirements on biomass refineries, and unrealistic assumptions regarding the cost of capital—the combination of these factors leads CARB staff to underestimate the cost of the LCFS by over two billion dollars per year.

3. The ISOR assumes that the federal $1.01 per gallon tax credit for cellulosic ethanol scheduled to expire at the end of 2012 will be extended indefinitely and subtracts this tax credit from the net cost. Similarly, the ISOR assumed that the federal $1.00 per gallon tax credit for biodiesel scheduled to expire at the end of 2009 will be extended indefinitely and subtracts this tax credit from the net cost.

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[1] "Staff Report: Initial Statement Of Reasons, Proposed Regulation To Implement The Low Carbon Fuel Standard," California Air Resources Board, Stationary Source Division, March 5, 2009.

[2] D. Hsu, "Techno-economic comparison of biochemical, gasification, and pyrolysis conversion of corn stover to biofuels," National Renewable Energy Laboratory, March 20, 2009.

4. In addition to assuming that low carbon intensity biofuels will be available in large quantities with federally subsidized costs below those for gasoline and Diesel fuels, CARB staff assumes that grid electricity and, to a lesser extent, hydrogen will be available as transportation fuels in California at costs below those for gasoline and Diesel fuels. To support this assumption, CARB staff credits electric and fuel cell vehicles with greater efficiencies than appear warranted based on previous agency assessments, and not only ignores the incremental costs of these vehicles but also in some cases assumes that they will be produced in numbers far greater than required by the current Zero Emission Vehicle (ZEV) regulation. Depending on the compliance scenario, these incremental costs range from about $14 billion to $47 billion over the period 2010 to 2020, as compared to the staff's claimed $11 billion cost savings for the LCFS.
5. Contrary to the conclusions of the ISOR, implementation of the proposed LCFS would cause an increase in criteria pollutant emissions of at least 5 tons/day and perhaps more, given that the staff has not performed any realistic assessments of how its assumed volumes of electric and fuel cell vehicles impact the Low Emission Vehicle, ZEV, and Pavley regulations. Another consequence of this latter fact is that CARB staff may be overestimating the greenhouse gas reductions achieved in the transportation sector by the combination of the Pavley and LCFS regulations. In any case, the increase in criteria pollutants is not counterbalanced by any measurable effect on climate.

The Baseline Fuel Price Should Be at the Low End of CARB's Range

As stated in the ISOR, "staff used forecasts of prices for crude, gasoline, and diesel that are included in the Energy Commission's document 'Transportation Energy Forecasts for the 2007 Integrated Energy Policy Report (IEPR).' To be consistent with the assumptions used in preparing the AB 32 Scoping Plan, approved by the Board in December 2008, staff used the 'high case' values in the report." As shown in a detailed table, the assumed range of oil prices was $66-88 per barrel, which was translated into gasoline prices of $2.42 to $2.92 per gallon, excluding all state and federal taxes. The corresponding range for Diesel prices is $2.48 to $2.99 per gallon.

Staff acknowledges that "the economic analysis of the LCFS is greatly affected by future oil prices" and that economic factors that might keep crude oil prices lower than the prices used in the forecast "could result in overall net costs, not savings, for the LCFS. For the reasons set forth below, we consider that the low end of the range considered in the ISOR (i.e., $2.42 per gallon for gasoline and $2.48 per gallon for Diesel) is more consistent with what would be expected based on long-term oil price trends.

For purposes of this report, we accept the assumed relationship between crude oil prices and gasoline prices used by the staff. We believe, however, that it is more realistic that the low end of assumed crude oil prices, i.e., $66 per barrel, should be used for the entire period through 2020.

As noted in the ISOR, there have been recent changes in the estimates of future oil prices by the U.S. Energy Information Administration (EIA) and the California Energy Commission. However, government forecasts of oil prices have been notoriously inaccurate ever since the first oil embargo in 1973. Following every event that causes a spike in oil prices, government forecasts are changed to show dramatically higher prices for the longer term. Every time this occurs, the higher price forecasts end up being shown to be an over-reaction. Extraction technology continues to improve, the economically feasible resource base grows, and the long-term cost of oil ends up being lower than the forecasts made following price spikes.

EIA acknowledges that, since 1982, it has overestimated future oil prices by 59% on average.[3] Shortly after the oil price spike in 1980, the forecast for the price of oil in 1995 ended up being high by 492.7%. Forecasts made since the most recent oil price spike have already demonstrated the same pattern of overestimation. As a result, gasoline prices based on a $66 per barrel oil price are a more reasonable benchmark for the future than any higher oil price forecast. Based on historical trends, actual prices may be lower.

Using CARB's estimate for gasoline prices when oil is $66 per barrel, the baseline fuel prices, excluding taxes, are $2.42 per gallon for gasoline and $2.48 per gallon for Diesel.

Costs for Low Carbon Fuels

Although cost estimates are provided in the ISOR for several alternative fuels, it is clear that cellulosic ethanol is the key alternative for demonstrating compliance with the LCFS. (The infeasibility of greater reliance on so-called "zero emission vehicle" technologies under staff scenarios 3 and 4 is discussed below.) Our critique is focused on scenario number 1, which assumes the maximum use of cellulosic ethanol.

ISOR estimates for cellulosic ethanol range from $2.31 to $3.74 per gasoline gallon equivalent (gge), excluding taxes. The low end of this range is below our estimate of the baseline gasoline price; however, the $2.31 per gge estimate assumes the feedstock is municipal waste with a feedstock cost of $0.00. At the volumes required to comply with the federal Renewable Fuel Standard and the proposed regulation, the primary feedstocks will need to be forest residue, agricultural residue, and herbaceous crops (e.g., switchgrass). Assuming such feedstocks, the ISOR estimates range from $2.70 to $3.74 per gge. The low end of this spectrum exceeds our estimate of the baseline gasoline price by $0.28 per gge. However, our independent analysis of cellulosic ethanol cost indicates that actual cost will be higher than estimated in the ISOR.

The key elements of cost occur in the following categories:

1. Feedstock (and associated transportation);
2. Amortization of capital equipment required for feedstock conversion;
3. Operating costs for feedstock conversion; and
4. Distribution and marketing costs.

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[3] "Annual Energy Outlook, Retrospective Review: Evaluation of Projections in Past Editions (1982-2008)," U.S. Department of Energy Report No. DOE/EIA-06403(2008), September 2008.

Feedstock Costs – Assuming wood chips are the feedstock for cellulosic ethanol, the ISOR lists the feedstock cost at $29/dry ton based on a 2008 study by the National Renewable Energy Laboratory (NREL). Detailed tables in the ISOR identify municipal solid waste (MSW) as the primary feedstock for biorefineries assumed to be located in urban areas and the cost for MSW is listed as $0.00 per dry ton. However, there is also this statement in the section of the ISOR identifying common assumptions:

> *Wood chips, green waste, and corn stover are the common feedstock sources for both cellulosic and advanced renewable ethanol fuels.*

As described in more detail below, there are serious questions as to whether a biorefinery can be constructed in urban areas (especially Southern California) given the limited availability of emissions offsets for new sources and the issues associated with relatively high volumes of truck traffic. Also, the additional processing required for using "free" MSW adds uncertainty to the total system cost. We have therefore independently estimated the cost of cellulosic ethanol based on the assumption that the feedstock would be a more consistent source of cellulosic or ligno-cellulosic feedstock. (This is consistent with the assumption regarding feedstocks stated in the ISOR.)

The recent Sandia/GM study[4] identified biomass feedstock cost at $40 per ton at the farm, not including the cost of transportation to the production facility. Estimating delivered feedstock cost at $49/ton, feedstock costs would be $0.73 gallon of ethanol, which is $1.08 per gge. This estimate was made by adjusting the feedstock cost in another NREL study[5] cited in the ISOR to account for a $49/ton delivered price.

Amortization of Capital Investments – As stated in the ISOR, "staff used a capital recovery factor of 14.90 percent, based on an eight percent real discount rate per year with a capital recovery period of 10 years." This is an extremely optimistic capital recovery factor for technology that has never been demonstrated in commercial scale and for which there are serious questions about economic feasibility. Although it is stated that the capital recovery factor is "intended to reflect the risk in investing in new biorefinery technologies," it clearly does not reflect that risk. An average venture capital return rate exceeds 20%.[6]

The ISOR estimates a capital investment for ethanol produced from ligno-cellulose at $309.7 million for a 50 million gallon per year production facility. This estimate is based on the capital cost in a previously referenced NREL study,[7] adjusted to reflect changes in the consumer price index. However, a more recent NREL study estimates the capital cost for a similarly sized facility at $376 million.[8] (The recent NREL study focuses on corn

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[4] "90-Billion Gallon Biofuel Deployment Study," Sandia National Laboratories, February 2009.

[5] R. Wooley, et al., "Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis Current and Futuristic Scenarios," National Renewable Energy Laboratory Report No. NREL/TP-580-26157, July 1999.

[6] Joseph W. Bartlett, "Venture Capital: A Primer," e-Journal USA, U.S. Department of State, Volume 13, No. 5, May 2008.

[7] R. Wooley, et al., op. cit.

[8] D. Hsu, op. cit.

stover rather than wood chips; however, NREL's previous studies have shown the capital cost for facilities using corn stover to be slightly lower.) At $309.7 million for 50 million gallons per year, the assumed 8% discount rate and 10-year amortization assumed in the ISOR produces a capital recovery cost of $1.37 per gge. In addition to not reflecting a more current capital cost estimate, this estimate does not account for the cost of compliance with local air pollution control district regulations. The emissions compliance cost used in the ISOR is totally unrealistic.

For cellulosic ethanol production facilities, the process heat requirements are higher than they are for existing facilities that produce ethanol from corn. To minimize costs, the design of commercial-scale production facilities assumes combustion of biomass feedstock to generate the necessary heat and electric power. Based on the above-referenced NREL study, heat input required for a 50 million gallon per year facility using ligno-cellulosic feedstock is 931 million BTU/hour.

The ISOR assumes that Selective Catalytic Reduction (SCR) systems will be used to reduce NOx emissions by 90%. However, 90% efficient SCR systems have not been demonstrated to be commercially feasible with biomass combustion due to the catalyst fouling problems caused by the high particulate concentrations in the combustion products and variations in biomass fuel. Seven biomass-fired boilers have recently been permitted with 80% efficient SCR systems in the state of Ohio. With the SCR system, NOx emissions from the boilers are estimated to be 0.09 lbs per million BTU. Assuming 8,000 hours of annual operation, this generates 335 tons per year of NOx emissions at a facility with a 931 MMBTU/hour heat input rate. At current offset costs (which are expected to increase over time), $18.4 million would be required to purchase offsets for facilities located in the Central Valley.[9] (In the South Coast Air Basin, the offset costs would be more than twice this amount, assuming the rules were changed to give biorefineries access to the "priority reserve" of NOx offsets.) Based on our independent analysis,[10] an additional $4.3 million is required to cover the cost of the SCR system. Ignoring permit fees, the air pollution control requirements increase NREL's most recent capital cost estimate for a 50 million gallon per year facility to $399 million. Assuming a very conservative 10% discount rate to recover the capital investment over the same 10-year period assumed in the ISOR, the amortization costs translates to $1.30 per gallon of ethanol, which is $1.94 per gge.

<u>Operating Costs</u> – The ISOR assumes a $0.66 per gge cost for the operating costs of a cellulosic ethanol production facility using wood chips for feedstock, based on the above-referenced NREL study. Our independent analysis of operating cost estimates in the 1999 NREL study produces a similar result. The results of the most recent NREL study reflect a substantially higher operating cost than NREL's earlier estimates for the same feedstock. However, because the most recent study assumes corn stover as the feedstock rather than wood chips, we are using the less expensive production cost derived from the 1999 study.

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[9] Calculated based on a NOx offset cost of $55,000 per ton/year and a 1.5 offset ratio.

[10] Personal communication with Tom Andrews, Sierra Research, Inc., March 19, 2009.

One subcategory of operating cost for some alternatives is co-product credit. For its lowest-cost cellulosic ethanol scenario, the ISOR assumes a co-product credit of $0.14 per gge, presumably to account for the value of surplus electricity generated from the biomass combustion. Our independent analysis produced an almost identical value for the co-generated electricity at a biomass-fueled facility. With the co-product credit, the net operating cost is $0.52 per gge.

Distribution and Marketing Costs – The ISOR estimates the storage, transport, and distribution cost for cellulosic ethanol produced in California at $0.34 per gge, which is the same cost assigned to storage transportation and distribution of corn-based ethanol from the Midwest. In describing the rationale for this cost for ethanol produced in-state, the ISOR states that the cost for shipping ethanol from Northern California to Southern California is estimated at $0.20 to $0.30 per gallon. This seems to be inconsistent with the assumption that all ethanol production facilities are going to be located close to the point of end use. It is also clear from the detail provided that the storage, transport, and distribution category does not cover any markup/profit for the retailer that eventually sells the finished product.

Based our previous analysis of EIA gasoline price data, the per-gallon cost of distributing gasoline to retail outlets is $0.18 when oil is $66/bbl. Adjusting for energy density, this would translate to $0.27 per gge for ethanol. Considering the extra transportation distance required for ethanol, the $0.34 per gge cost estimate for storage, transport, and distribution does not appear to be unreasonable. However, an additional $0.10 per gge must be added to account for profit at the retail level, which was ignored in the ISOR. This brings the total cost for storage, transport, and distribution to $0.44 per gge.

As shown in Table 1, our estimate for the net cost, excluding taxes, of cellulosic ethanol is $3.98 per gge, which exceeds the estimated baseline fuel cost by 64%. With approximately 3 billion gallons of ethanol required in fuel for gasoline vehicles, the annual cost increase to California motorists is approximately $3.1 billion.[11] This is the cost only for the gasoline portion of the regulation. (This reflects the cost of all required ethanol, some of which would be required under the federal RFS.)

Table 1
Cellulosic Ethanol vs. Gasoline Cost
(Cost per Gasoline Gallon Equivalent)

Cost Category	ISOR Ethanol	Sierra Ethanol	Gasoline[a]
Feedstock	$0.47	$1.08	-
Capital Amortization	$1.37	$1.94	-
Production	$0.66	$0.66	-
Co-Product	-$0.14	-$0.14	-
Distribution and Marketing	$0.34	$0.44	-
TOTAL, excluding taxes	**$2.70**	**$3.98**	**$2.42**

[a] CARB estimate at $66/bbl crude cost.

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[11] Calculated by multiplying 67% of the difference in cost per gge by 3 billion to account for the increased cost over using the baseline gasoline to provide the same amount of energy.

As described above, there are several differences between our independent cost estimates for cellulosic ethanol and those contained in the ISOR related to feedstock, refining, and marketing and distribution. However, more significant differences result from the assumptions used in the ISOR regarding tax credits and the allocation of certain capital costs.

According to the ISOR, tax incentives are provided for biofuels "in order to assist the US with improving energy independence and security and with improving the environment." According to the ISOR (Vol 1, pp VIII-8 to -9):

> *Staff reduced the overall cost of production of the lower-CI fuels…by the amount of the tax incentives, where applicable. The credits are assessed on a gallon of ethanol or biodiesel blended or produced and on the volume of CNG sold. Although some incentives could expire in the near future, staff assumed the incentives would be extended, as has been the case with incentives that had recently expired.* (emphasis added)

More specifically, the ISOR analysis has assumed, with no supporting justification, that the $1.01/gal tax credit for new cellulosic biofuels that was established by the 2008 Farm Bill—which took effect on January 1, 2009, and is set to expire on December 31, 2012—will be extended at least through 2020. Similarly, for ethanol and biodiesel blenders, the ISOR states:

> *As of January 1, 2005, the federal tax credit was $0.51 per gallon of pure ethanol blended, $1.00 per gallon of agricultural biodiesel (derived from virgin oils), and $0.50 per gallon of 'waste grease' biodiesel (derived from vegetable oils and animal fats). The Food Conservation and Energy Security Act of 2008 (2008 Farm Bill) reduced the ethanol credit to $0.45 per gallon of ethanol blended, effective January 1, 2009. The Emergency Economic Stabilization Act of 2008 eliminated the disparity in credit for biodiesel and agri-biodiesel (now providing $1.00 per gallon of biodiesel blended), and extended the credit through the end of 2009.*

In the final analysis of how the proposed regulation will affect the cost of fuel, the subsidies assumed to continue beyond current expiration dates are not treated as costs. If they were, the net cost of the LCFS would be positive, not zero or negative as claimed by CARB staff. In addition, the final cost analysis in the ISOR excludes certain costs that are claimed to be associated with the federal RFS, as described below.

> *The total potential capital cost of the proposed LCFS regulation—in the absence of the overlapping RFS2 requirements—is estimated at $10 billion over the next decade. However, if the RFS2 mandates are met and California receives its proportional share of RFS2 fuel, virtually all of the capital costs associated with the liquid fuels (ethanol and alternative diesel) would be borne by RFS2, not the LCFS. These would include the biorefineries, the ethanol storage tanks, and the E85 dispensers.*

As explained above, the ISOR seems to be suggesting that the federal Renewable Fuel Standard will result in the construction of greater biorefinery capacity than is required for compliance. This would be an economically irrational outcome for which we can see no conceivable explanation.

Biodiesel Cost – The production of biodiesel fuel (methyl esters) using soybeans is an energy efficient process but it is very expensive because of the high feedstock cost and the potential for extending fuel supplies is extremely limited. The International Energy Agency (IEA) has estimated that 60% of U.S. soy production (most of which is currently used for food and feed production) would be needed just to displace 5% of Diesel fuel demand.[12] As noted in the ISOR, biodiesel produced from waste vegetable oils avoids the high feedstock cost, but supplies of waste oils are so limited that the price of the volumes required under the proposed LCFS will not be significantly affected by the use of waste oil feedstock.

As shown in Table VIII-8 of the ISOR, the feedstock cost for biodiesel alone is estimated to be $2.62 per gallon of fuel produced, which already exceeds our $2.48 per gallon baseline cost estimate. When other cost factors are accounted for, the ISOR estimates the total price for biodiesel at $3.15 per gallon. With another 3% added to account for profit at retail, the total cost, excluding taxes, is $3.24 per gallon, 31% higher than the price of the baseline fuel. Assuming 838 million gallons are required for compliance, the cost increase to motorists is $637 million per year.

Additional Details Regarding the ISOR Cost Analysis

As described above, the analysis of the net cost contained in the ISOR is driven more by the assumptions regarding tax credits for low carbon intensity ethanol and biodiesel than by differences in the estimated costs of fuel production. However, another important factor for several of the gasoline and Diesel scenarios examined by CARB staff is the assumed cost of electricity and hydrogen, the assumed cost of electric and fuel cell vehicles, and CARB's assumptions regarding their efficiency relative to gasoline vehicles.

Energy Economy Ratios for Electric and Fuel Cell Vehicles Relative to Gasoline – The proposed LCFS regulations purport to account for the greater efficiency of electric and fuel cell vehicles relative to gasoline vehicles through the use of the energy economy ratios (EERs). Conceptually, the EERs represent the ratio of the miles traveled by an electric or fuel cell vehicle using a given quantity of energy compared to the miles that a gasoline vehicle would travel using that same quantity of energy. In the economic analysis, application of these factors reduces the effective cost of electricity and hydrogen used as gasoline substitutes. According to Appendix C-1 of the ISOR, the EERs of 3 for battery-electric vehicles and 2.3 for fuel cell vehicles are based on very limited comparisons between what the ISOR purports to be comparable vehicles, with some attempt made to account for future increases in the fuel economy of the gasoline vehicles.

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[12] "Biofuels for Transport, An International Perspective," International Energy Agency, 2004.

The EER values for electric and fuel cell vehicles in the LCFS analysis are inconsistent with the treatment of these exact technologies under the Pavley regulations (Section 1961, Title 13, California Code of Regulations). The Pavley regulations set standards for greenhouse gas emissions from new vehicles and one can simply estimate EERs for electric and fuel cell vehicles from these standards and emission factors assigned by the regulations to electric and fuel cell vehicles. For example, for purposes of the Pavley regulations, all electric vehicles are assigned an emission rate of 130 grams of CO_2 equivalent emissions per mile while all fuel cell vehicles are assigned a value of 210 grams per mile. Standards for passenger cars are 301 grams per mile for the 2010 model year and 205 grams per mile for the 2016 model year. These values would indicate that the EER for electric vehicles should change over time and start at about 2.3 for 2010 model year vehicles and decrease to 1.6 for 2016 model year vehicles. In either case, the value is far lower than the 3.0 in the proposed LCFS regulations. Similarly, the EER for hydrogen vehicles would decrease over time from 1.43 in the 2010 model year to 0.98 for the 2016 model year.

As noted above, use of lower EERs like those that are effectively imposed by the Pavley regulations would increase the estimated cost of the LCFS regulation in the gasoline substitution scenarios and decrease the estimated reductions in greenhouse gases emissions. Conversely, substitution of the EERs from the LCFS in the Pavley regulation would greatly reduce the effective CO_2 emission rates for electric and fuel cell vehicles and decrease the degree to which manufacturers would have to improve the fuel efficiency of other vehicles in order to comply with the Pavley standards. In any case, there is no rationale as to why these vehicles are assumed to have different greenhouse gas emission rates from one CARB regulation to the next.

In addition to the EER values of 3 and 2.3 for electric and fuel cell light-duty vehicles, the LCFS also proposes EER values of 2.7 and 1.9 for electric and fuel cell heavy-duty vehicles, respectively. Again, these values are based on limited data.

As a result of the EERs assumed for electric and fuel cell vehicles, the costs assumed for electricity and hydrogen by CARB staff translate to $1.00 and $2.83 per gge, respectively, both of which are lower than the $2.92 assumed for gasoline in 2020. In particular, the cost differential for electricity contributes significantly to the cost savings staff claims for the LCFS, especially for those scenarios where high volumes of plug-in hybrid vehicles (PHEVs) and battery electric vehicles (BEVs) are assumed.

<u>Costs for Specialized Vehicles</u> – The economic analysis in the ISOR for the proposed LCFS regulation assumes that substantial numbers of light-duty PHEVs, BEVs, and fuel cell vehicles (FCVs) will be sold in California at volumes at least equivalent to those required by the current ZEV regulations and at far higher volumes in some scenarios.

The ZEV regulations were originally adopted in 1990 and required BEV sales beginning with the 1998 model year. The regulations have since been changed numerous times in order to delay production requirements for BEVs due their high cost and limited performance relative to conventional vehicles. The latest assessments of battery and fuel cell technology indicate that these problems with cost and performance will continue into the future and suggest that additional changes to the ZEV regulations to delay production requirements will continue to occur. Again, because of the high cost of batteries, PHEVs are also considerably more expensive than conventional gasoline vehicles. The actual price premiums expected for these vehicles generally exceed the lifetime fuel cost for a 30 mpg gasoline vehicle. For example, when taxes are added to the baseline gasoline price, gasoline costs approximately $3 per gallon. In 150,000 miles, a vehicle averaging 30 mpg consumes 5,000 gallons of gasoline. The total fuel cost is $15,000. Assuming this cost is incurred over a period of 12 years at a uniform rate, the present value of the fuel cost is $9,400 using a discount rate of 8%. As shown below, this is substantially less than the price premium for either a BEV or an FCV before even accounting for the fuel costs for these vehicles.

Ultimately, the price premium for PHEVs, BEVs, and FCVs, combined with the limited driving range of the latter two and the lack of refueling infrastructure, makes them commercially infeasible for anything other than niche markets that cannot absorb the volumes of these vehicles required under the current ZEV regulations. Given this, the ISOR assumptions in the LCFS regarding the volumes of PHEVs, BEVs, and FCVs that will be in operation in the 2011 to 2020 time frame are unrealistic. We would also note that, despite the almost 20 years that have passed since the first adoption of the ZEV mandate, the regulation has never resulted in the production or sale of meaningful numbers of ZEV vehicles. Therefore, although CARB staff assumes that the current ZEV regulation will be implemented and that manufacturers will comply, there is no reason to believe that, when faced with the fact that ZEVs are still not feasible, a future Board will not again modify the regulation to postpone the date at which significant numbers of ZEVs are required.

In addition to the PHEVs, BEVs, and FCVs, the ISOR assumes there will be large increases in the number of flexible fueled vehicles (FFVs) sold in future model years and that those vehicles will operate exclusively on E85. Should the assumption of exclusive operation on E85 not be correct, the ISOR states that the effect can easily be offset through the sale of even greater numbers of FFVs. As with staff's assumptions regarding electric and fuel cell vehicles, there are a number of problems with the staff's assumptions regarding FFVs. First, although FFVs are currently produced by a number of manufacturers, FFV production is not required under any current CARB regulation. The primary motivation for those manufacturers currently producing FFVs is that federal law provides limited credits that can be used towards compliance with Corporate Average Fuel Economy (CAFE) standards. Not all manufacturers have sought such credits, however, and those manufacturers that have done so have limited the number of FFV models they produce because of the limits on the available CAFE credits; in addition, with the enactment of the Energy Independence and Security Act of 2007, the credits that are available to FFVs will be phased out over the 2015 to 2020 model years, eliminating any incentive manufacturers have to produce FFVs. Given the above, there is no reasonable basis upon which to conclude that the large volumes of FFVs assumed by CARB staff will be produced.

Another issue associated with FFV certification in California during future model years is that CARB's ZEV regulations require manufacturers to certify large volumes of new vehicles as "Partial Zero Emission Vehicles" (PZEVs), which means they must comply with Super-Ultra-Low Emission Vehicle (SULEV) exhaust emission standards, 150,000-mile emission warranty requirements, and Zero Evaporative Emissions standards. Such compliance is proving very difficult for vehicle manufacturers[13] and we are not aware of any FFV that has been certified as a PZEV to date.

Although it appears to be highly unlikely that the volumes of FFVs, PHEVs, BEVs, and FCVs assumed in the ISOR economic analysis will actually be sold in California during the period from 2010 through 2020, it is instructive to examine the assumed volumes and to note that all four of these vehicles cost more than conventional vehicles.

The volumes of FFVs, PHEVs, BEVs, and FCVs assumed can be found in Appendix E of the ISOR. The volumes are reported in terms of millions of each type of vehicle assumed to be in operation in California in any given year. The incremental volume of each type of vehicle required to enter the California vehicle fleet each year over the period from 2011 to 2020 can be computed by subtracting the number of vehicles of a given type assumed to be in the fleet in a given year from the value for the previous year. Most of the specialized vehicles assumed in the economic analysis enter the fleet during the 2015 to 2020 period. Table 4 summarizes by vehicle type the number of specialized vehicles assumed to enter the California fleet each year for each of the five gasoline scenarios. These numbers are translated into the percentage of total vehicle sales each year in California in Table 5 based on an assumption of annual light-duty vehicle sales of 1.5 million units per year. At the bottom of each table, “SUM” is the combined total of FFVs, PHEVs, BEVs, and FCVs for each scenario.

As shown in the tables, by 2018 to 2020, CARB staff assumes that FFVs account for more than 50% of vehicles sold in California under four of the five scenarios despite the fact that federal CAFE credits will have been dramatically reduced or eliminated by that time. In contrast to estimates of up to one million FFVs per year in the ISOR (Table F6-1), estimated FFV sales for 2009 (when substantial CAFE credits are available) is less than 350,000.[14] Similarly, PHEV, BEV, and FCV sales volumes and fractions assumed by CARB staff also are unreasonably high given that virtually none of these vehicles are sold today in California and their costs are exorbitant.

As noted above, the ISOR economic analysis ignores the incremental costs associated with specialized vehicles when calculating the net cost of the LCFS. With respect to FFVs, page 48 of Appendix F of the LCFS ISOR indicates that the marginal cost of producing FFVs is $200 per vehicle. No basis for that estimate is provided, however, and it does not appear to include costs associated with the changes required to certify FFVs as PZEVs.

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[13] See, for example, “Fuel Economy & Emissions: Ethanol Blends vs Gasoline” presented by Kevin Cullen of General Motors, September 10, 2007.

[14] Herwick, G., “Opportunities for E85 in California,” presented to California Air Resources Board Meeting on Vapor Recovery for E85 Facilities, February 2, 2006.

Table 4
Annual Sales of FFVs, PHEVs, BEVs, and FCVs Assumed by CARB Staff

Vehicle Type	Scenario	Year 2015	2016	2017	2018	2019	2020
FFV	1	100,000	300,000	400,000	700,000	600,000	900,000
	2	100,000	300,000	400,000	800,000	800,000	1,000,000
	3	200,000	200,000	300,000	400,000	700,000	900,000
	4	0	0	100,000	500,000	500,000	700,000
	5	230,000	250,000	340,000	410,000	600,000	780,000
PHEV	1	40,000	40,000	50,000	70,000	70,000	60,000
	2	40,000	40,000	50,000	70,000	70,000	60,000
	3	80,000	70,000	80,000	80,000	140,000	150,000
	4	160,000	140,000	160,000	160,000	300,000	280,000
	5	80,000	70,000	80,000	80,000	140,000	150,000
BEV	1	11,000	10,000	10,000	5,000	25,000	20,000
	2	11,000	10,000	10,000	5,000	25,000	20,000
	3	20,000	25,000	29,000	35,000	40,000	60,000
	4	40,000	60,000	48,000	70,000	100,000	100,000
	5	20,000	25,000	29,000	35,000	40,000	60,000
FCV	1	6,000	5,000	5,000	17,000	18,000	15,000
	2	6,000	5,000	5,000	17,000	18,000	15,000
	3	10,000	12,500	15,000	18,000	20,000	32,000
	4	20,000	25,000	30,000	36,000	49,000	55,000
	5	10,000	12,500	15,000	18,000	20,000	32,000
SUM[a]	1	157,000	355,000	465,000	792,000	713,000	995,000
	2	157,000	355,000	465,000	892,000	913,000	1,095,000
	3	310,000	307,500	424,000	533,000	900,000	1,142,000
	4	220,000	225,000	338,000	766,000	949,000	1,135,000
	5	340,000	357,500	464,000	543,000	800,000	1,022,000

[a] The combined total of FFVs, PHEVs, BEVs, and FCVs.

Table 5
Annual Sales of FFVs, PHEVs, BEVs, and FCVs Assumed by CARB Staff in Terms of Percent of New Vehicle Sales (Based on 1.5 Million Total Sales Per Year)

Vehicle Type	Scenario	Year 2015	2016	2017	2018	2019	2020
FFV	1	6.7	20.0	26.7	46.7	40.0	60.0
	2	6.7	20.0	26.7	53.3	53.3	66.7
	3	13.3	13.3	20.0	26.7	46.7	60.0
	4	0	0	6.7	33.3	33.3	46.7
	5	15.3	16.7	22.7	27.3	40.0	52.0
PHEV	1	2.7	2.7	3.3	4.7	4.7	4.0
	2	2.7	2.7	3.3	4.7	4.7	4.0
	3	5.3	4.7	5.3	5.3	9.3	10.0
	4	10.7	9.3	10.7	10.7	20.0	18.7
	5	5.3	4.7	5.3	5.3	9.3	10.0
BEV	1	0.7	0.7	0.7	0.3	1.7	1.3
	2	0.7	0.7	0.7	0.3	1.7	1.3
	3	1.3	1.9	1.9	2.3	2.7	4.0
	4	2.7	4.0	3.2	4.7	6.7	6.7
	5	1.3	1.7	1.9	2.3	2.7	4.0
FCV	1	0.4	0.3	0.3	1.1	1.2	1.0
	2	0.4	0.3	0.3	1.1	1.2	1.0
	3	0.7	0.8	1.0	1.2	1.3	2.1
	4	1.3	1.7	2.0	2.4	3.3	3.7
	5	0.7	0.8	1.0	1.2	1.3	2.1
SUM[a]	1	10.5	23.7	31	52.8	47.6	66.3
	2	10.5	23.7	31	59.4	60.9	73.0
	3	20.6	20.7	28.2	35.5	60	76.1
	4	14.7	15.0	22.6	51.1	63.3	75.8
	5	22.6	23.9	30.9	36.1	53.3	68.1

[a] The combined total of FFVs, PHEVs, BEVs, and FCVs.

CARB's most recent estimates of the incremental costs of PHEVs, BEVs, and FCVs were published in February 2008.[15] Cost estimates are presented for different types of BEVs and FCVs for model years 2012–2014 and 2015–2017. Estimates are also included in the report regarding the expected volumes of different types of BEVs and FCVs that allow composite costs to be computed. Using this information, and the midpoints of CARB's published cost ranges, the incremental costs for PHEVs, BEVs, and FCVs were computed and are shown in Table 6. Cost estimates for 2018 to 2020 were estimated by halving the CARB cost estimates for 2015 to 2017, which is how CARB staff arrived at costs for the 2015–2017 model year vehicles relative to the cost-estimates for the 2012–2014 model years. CARB staff used this approach in its February 2008 analysis to account for assumed cost savings associated with higher production volumes and decreases in component costs.

Table 6
Costs for PHEVs, BEVs, and ZEVs Based on 2008 CARB Staff Estimates

Type	2010 to 2014	2015 to 2017	2018 to 2020
PHEV	$25,000	$12,500	$6,250
BEV	$67,000	$36,000	$18,000
FCV	$270,000	$136,000	$68,000

Estimates of the total incremental vehicle cost for the specialized vehicles assumed in the ISOR were computed for each calendar year using CARB's $200 incremental cost estimate for FFVs and the cost estimates shown in Table 6 for PHEVs, BEVs, and FCVs. Undiscounted total costs for each of the five gasoline scenarios evaluated by CARB are shown in Table 7. As shown, the total incremental costs from 2010 to 2020 that would be incurred range from about $14.5 billion in Scenario 1 to $47 billion in Scenario 4. These incremental vehicle costs are larger than the $11 billion fuel cost savings that CARB staff claims will occur over the same period and the ISOR is silent as to why the costs of the specialized vehicles assumed by CARB staff to be required to achieve the LCFS standard should not be attributed to the LCFS since the greenhouse gas reductions of those vehicles are generally being claimed for the LCFS.

It should be noted that while CARB staff assumes far fewer electric heavy-duty vehicles in its Diesel scenarios, the costs of these vehicles are also ignored in the economic analysis.

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[15] "Staff Report: Initial Statement Of Reasons 2008 Proposed Amendments To The California Zero Emission Vehicle Program Regulations," California Air Resources Board, February 8, 2008.

Table 7
Incremental Costs of Specialized Vehicles Assumed to Enter the California Vehicle Fleet between 2010 and 2020 in the Five Gasoline Scenarios

Scenario	Cost in Billions of Dollars
1	14.5
2	14.6
3	23.9
4	47.0
5	23.9

As noted above, the incremental costs associated with specialized vehicles have been ignored in the LCFS economic analysis. However, these are real costs that would be borne by some entity, most likely California consumers, and that would have an impact on California's economy.

In addition to ignoring the incremental costs associated with specialized vehicles, the ISOR analysis of the greenhouse gas reductions and the impact of the LCFS on emissions of traditional air pollutants ignores the fact that these vehicles are subject to the Pavley standards and CARB's Low Emission Vehicle standards. According to the CARB staff's analysis, the Pavley greenhouse gas standards for new vehicles will result in a reduction of approximately 27 million metric ton of CO_2 equivalent (MMT CO_2 eq) emissions in 2020. All of the specialized vehicles assumed by CARB staff to be operating in California in the LCFS gasoline scenarios are subject to the Pavley standards. To the extent that vehicle manufacturers produce these specialized vehicles instead of conventional vehicles, they will receive credit for the reductions in greenhouse gas emissions associated with their operation on E85 and electricity and those credits can be used by vehicle manufacturers to comply with the Pavley standards while minimizing or potentially avoiding the need to make fuel economy improvements to conventional vehicles. Reports describing how E85 FFVs can be used by manufacturers to assist in complying or to fully comply with the Pavley standards have been published by both Michael Jackson of Tiax[16] and K.G. Duleep of EEA.[17,18] Mr. Duleep also describes how BEVs and FCVs required under the ZEV mandate reduce the level of fuel economy improvement manufacturers will have to make to conventional vehicles.

Although CARB staff claims that it has accounted for a 1.8 MMT CO_2 eq reduction in emissions due to the ZEV mandate, it has not accounted for the impact that greater numbers of PHEVs, BEVs, and FCVS will have on manufacturer compliance with the

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[16] Jackson, M.D., "Alternative Fuels as a Compliance Option to Meet ARB's Greenhouse Gas Emission Standards," May 2, 2006.

[17] Duleep, K.G., "The Use of Ethanol Fuel to Meet Vermont Greenhouse Gas Emission Standards," August 2006.

[18] Duleep, K.G., "Technologies to Reduce Greenhouse Gas Emissions from Light-Duty Vehicles," April 2006.

Pavley regulations nor has the staff shown that it is not double-counting the GHG emission reductions associated with these vehicles.

Another important consequence of the impact of specialized vehicles on the Pavley regulation is that CARB staff has assumed that the Pavley regulations will result in a decrease in baseline gasoline demand over the period from 2010 to 2020. If that decrease in demand is smaller than estimated owing to the fact that manufacturers produce specialized vehicles rather than improving conventional vehicle fuel economy to the degree assumed by CARB staff, the volumes of lower carbon intensity fuels required to meet the LCFS standard will increase. Among other things, this could potentially mean that more bio-refineries are needed; feed stock demand, and therefore prices, will be greater; and there will be greater emissions increases associated with feedstock and biofuels transportation.

Similarly, in assessing the environmental benefits of the LCFS in Appendix F of the ISOR, emission reductions from ZEVs that have already been credited to CARB's Low Emission Vehicle standards are double-counted. When a manufacturer sells ZEVs, the fleet average NMOG standard allows manufacturers to sell conventional vehicles certified to emission standards higher than would otherwise be allowed under the regulations. To the extent that there are any emission benefits associated with increases in ZEV sales volumes, they have to be evaluated relative to emissions from the PZEVs they would likely displace, not the higher-emitting ULEVs that have been assumed in the ISOR environmental analyses, as indicated in Tables F8-2 and F8-3 of Appendix F.

As an illustration of the potential impacts associated with additional ZEV sales on criteria pollutant emissions, most BEVs will earn 3.0 ZEV credits during the 2015 to 2020 period while PZEVs and AT PZEVs will earn 0.2 and about 0.5 credits, respectively. As a result, the sale of each additional BEV above the minimum required for compliance with the ZEV mandate will relieve a manufacturer of the obligation to sell 15 (3/0.2) PZEVs or 6 (3/0.5) AT PZEVs. Depending on how constrained the manufacturer is by the fleet average NMOG standard of the LEV II regulations and the Pavley regulations, one likely scenario is that the ZEV purchased will replace a PZEV, which will result in an emissions reduction. As a result of the ZEV purchase, however, the manufacturer will then sell 14 SULEVs instead of 14 PZEVs, with the result being an emissions increase because the SULEVs are not required to meet 150,000-mile emissions control system warranty requirements and do not have to be certified to zero evaporative emissions standards. As a result, the emission reductions attributed by CARB staff to ZEVs in Table VII-13 of the ISOR are more likely emissions increases and the overall impact of the LCFS is likely to be an increase in criteria pollutants.

Another issue is CARB's assessment of the benefits of the federal Renewable Fuels Standard (RFS2). In the ISOR, CARB staff acknowledges that even in the absence of the LCFS, the RFS2 would yield about one-third of the total GHG reductions. What CARB staff fails to acknowledge is that all of these benefits will likely result from the use of renewable fuels in existing vehicles, rather than specialized vehicles, in which case the only costs that are material in the economic analysis are the costs associated with fuel production and distribution. CARB staff also fails to acknowledge that in order to achieve a significant fraction of the rest of the reductions claimed for the LCFS, it has had to assume that there would be large volumes of expensive specialized vehicles and a proper accounting would show the that the incremental cost-effectiveness of the LCFS relative to the RFS2 is poor.

Biomass Transportation Emissions

In order to estimate transportation emissions associated with biomass and biofuel transportation and distribution, the ISOR uses estimates adapted from a report prepared for the Western Governor's Association by U.C. Davis, Antares, and others.[19] This report identified candidate locations for biorefineries based in part on proximity to existing population centers. This was intended to help minimize transportation costs and "use population as a surrogate for availability of water and other essential services, including trucking, skilled labor, and materials." Assessment of air pollution emissions and the cost of air pollution controls was not a part of the study.

For 50 million gallon per year cellulosic ethanol plants, feedstock delivery per plant was estimated in the ISOR to require 110 truck trips per day per plant, with 50 miles for each round trip. The staff calculated emissions for all years from 2010 to 2020 using the assumption of 2020 emission factors. Assumed average travel distances and required number of truck trips for other feedstock deliveries varied by feedstock and plant type.

For the 19 new biorefineries considered in the ISOR, the total incremental truck VMT from delivery of biofuel feedstock by 25-ton trucks in 2020 was 41.5 million miles traveled (sum from Table F4-3, vol 2, pp F-31 to FF-33). Ethanol delivery for a 50 million gallon per year plant was assumed in the ISOR to require 20 additional truck trips per day per plant, and the statewide total of transportation and distribution emissions for 2020 biofacilities was estimated to include 5.2 tons per day of NOx and 0.102 tons per day of $PM_{2.5}$. According to the ISOR:

> *The major criteria pollutant emissions are associated with the additional biorefinery truck trips. On a statewide basis, these emissions may be offset by reductions in motor vehicle emissions. However, there still may be localized diesel PM impacts and localized facility emissions impacts.* (Vol 1, pg VII-2).

Later in the ISOR (Vol 1, pg VII-23), it is projected that, in the year 2020, 24 premature deaths, along with thousands of other non-fatal health impacts, are expected to occur statewide as a result of Diesel emissions from the increased truck traffic. There is no analysis contained in the ISOR in support of the statement that Diesel truck emissions "may be offset by reductions in motor vehicle emissions" on a statewide basis. In fact, available research suggests the opposite—increased ethanol concentrations in gasoline have been shown to increase NOx emissions from vehicles in the existing fleet and to increase permeation emissions of hydrocarbons from both on-road and off-road vehicles

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[19] "Strategic Development of Bioenergy in the Western States, Development of Supply Scenarios Linked to Policy Recommendations," Report for the Western Governors Association prepared under USDA/DOE Bioenergy Contract Number: DE-PS36-06GO96002F, June 2008.

and equipment using plastic fuel tanks and elastomeric fuel lines. These impacts have been completely ignored in the ISOR.

There Would Be No Measurable Effect on Climate

The introduction of the ISOR makes it clear that the LCFS is intended to address “climate change”; however, the ISOR contains no estimate of the effect the LCFS would have on climate. Our independent analysis of the effect of the ISOR estimates of CO_2 emissions reductions attributable to the proposed regulation were modeled using version 4.1 of a coupled, gas-cycle/climate model known as MAGICC (Model to Assess Greenhouse-gas Induced Climate Change). MAGICC has been the primary model used by the Intergovernmental Panel on Climate Change (IPCC) to produce projections of future global-mean temperature and sea level rise. A manual explaining the model in more detail is publicly available.[20] The parameters for the modeling were as follows:

- “Mid”-level response for the carbon cycle model;
- Carbon cycle climate feedbacks set to “on”;
- “Mid”-level response for aerosol forcing;
- 2.6°C sensitivity for doubled CO_2;
- “Variable” thermohaline circulation; and
- Vertical oceanic diffusion coefficient set to “2.3 cm^2/s.”

The 2.6°C sensitivity to doubled CO_2 is consistent with the assumptions used in the most recent IPCC report, which is based on the assumption that the surface temperature record accurately reflects the effect of greenhouse gas concentrations on ambient temperatures. (Recent studies indicate that this assumption substantially overstates the effect of greenhouse gases on temperature.) Explanations of the other parameters are available in the above-referenced technical manual.

The baseline case assumed a future in which fossil fuels will continue to be consumed in a “business as usual” manner, but with new sources of energy mixing in to supply a balance of non-carbon-emitting sources. Two different scenarios were run to evaluate the potential effect of the proposed LCFS. One scenario assumed the staff’s estimated reduction in CO_2 emissions from 2020 through 2050. The second scenario assumed the reductions estimated in the ISOR would be increased by a factor of 10 due to other jurisdictions adopting identical requirements.

Table 8 shows modeled changes in ambient temperature from a 1990 baseline temperature for each case. As shown in the table, the baseline case produces an estimated increase of 0.9980°C in calendar year 2050 over the 1990 baseline. The addition of the LCFS standard is estimated to reduce this temperature increase by one ten-thousandth (0.0001) of a degree. Assuming ten times greater emissions reductions, the temperature increase is reduced by 1.5 thousandths (0.0015) of a degree.

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[20] T.M.L. Wigley, “MAGICC/SCENGEN 4.1: Technical Manual,” National Center for Atmospheric Research, Colorado, October 2003.

Table 8
MAGICC Version 4.1 Model Results (°C) for Calendar Year 2050

Scenario	Temperature Change from 1990 Baseline	Change Due to LCFS
Baseline (IPCC Case A1B)	+0.9980	n.a.
Low Carbon Fuel Standard in California	+0.9979	-0.0001
10 Times LCFS Reductions	+0.9965	-0.0015

To put the modeling results in perspective, current measuring systems are estimated to achieve a precision of about 0.04°C/decade.[21] Since the modeled impact of the LCFS is much smaller than our observational systems are able to measure, the impact would therefore be undetectable.

It should be noted that the modeling results described above are based on the assumption that the mandated sale of low carbon fuels will have no impact on the use of higher carbon fuels in areas not subject to the regulation. This is an unrealistic assumption because, to the extent that a LCFS decreases the demand for higher carbon fuels, the cost of such fuels will tend to decrease in areas not subject to a LCFS regulation. Lower cost will lead to increased consumption, which has been completely ignored in this analysis. Similarly, the analysis ignores the effect on fuel demand of the lower prices for low carbon fuels projected in the ISOR. If low carbon fuels were actually lower in price than conventional fuels, demand would be higher than baseline demand and there would be less of a reduction in GHG emissions.

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[21] J.R. Christy, "Rebuttal Expert Report for the Plaintiffs," United States District Court for the District of Vermont, Case No. 05-cv-302, April 18, 2007.