Review of
Proposed Regulation to Implement the Low Carbon Fuel Standard
California Environmental Protection Agency
Air Resources Board

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Materials provided for review:

Proposed Regulation to Implement the Low Carbon Fuel Standard, Release Date, March 5, 2009.

Vol I: Staff Report: Initial Statement of Reasons.
Vol. II: Appendices

Guidance for review:

Reviewer was provided with a copy of the Oct. 21, 2008 memorandum from Dean C. Simeroth, Chief of the Criteria Pollutants Branch, Air Resources Board to Gerald W. Bowes, Manager of the Toxicology and Peer Review Section, State Water Resources Control Board, Request for External Peer Review of the Low Carbon Fuel Standard. The memorandum included a timeline for the review, Scientific Issues to be addressed, and other guidance regarding confidentiality of the review and limits on contact between reviewers and staff who prepared the report. The time line in the memo, requesting reviews to be completed by March 2, 2009 was adjusted in e-mail correspondence with Gerald W. Bowes. The review material was received on March 10, and the revised guidance was to submit the review within one month. The reviewer had no knowledge of other reviewers and did not discuss the report with any of the listed staff and experts involved in its preparation.

The scientific issues to be addressed included:

1. Greenhouse gas modeling
2. Land use modeling
3. Economic Impacts
4. Environmental and Multimedia Impacts
5. Credit Trading

Reviewers were also asked to comment on the "The Big Picture" noting in particular whether there are additional scientific issues that should be addressed and whether taken as a whole the scientific portion of the proposed rule is based "upon sound scientific knowledge, methods, and practices.

Areas of competence of the Reviewer:

My competence is strongest for scientific issues 2, 3, and 5. I can comment on issues of relevance to scientific issues 1 and 4 but do not have the technical background to assess whether the specific coefficients chosen for these components of the analysis are state of the art.

Review of Scientific Issues

1. Greenhouse gas modeling

The greenhouse gas modeling approach, using the GREET model, to calculate direct life cycle emissions for different emissions pathways is in general appropriate given the nature of the LCS and assuming GHG controls do not exist elsewhere. The emissions coefficients relies on technical work that appears sound. From a technical economic standpoint, however, a far more efficient approach to regulating GHGs is to put in place an economy wide GHG pricing system, either through a GHG tax or a cap and trade system. This would eliminate the need for life cycle analysis of the type employed in the GREET model. Since any GHG emission would be priced, the producers of alternative fuels would have an incentive to use less GHG-intensive production methods and to the extent that there were GHG emissions from these processes the prices of these alternative fuels would have embedded in them the GHG cost as producers would have to pass that on to consumers so as to recover costs. This approach to using either quantity or price mechanisms for environmental control is laid out in any standard environmental economic text book as a first best solution to environmental management. Unless specific evidence to the contrary is presented, one should presume approaches that do not match this standard achieve environmental objectives at higher cost. Pricing the GHG consequences of land use change would extend these efficiency characteristics to indirect emissions as well and would then eliminate the need for the development of coefficients for indirect emissions associated with land use change. (See e.g., Reilly and Asadoorian, 2007).

That said there are good reasons why California cannot achieve this ideal and so there is need to consider life cycle emissions. In particular, an "economy-wide" GHG pricing system in this case would require a fully realized global policy where all countries priced GHG emissions from all sources including land use change. Under a partial system, border adjustments—where alternative fuels are generated by non regulated entities—are likely needed to limit the possibility of leakage. Here I define leakage specifically as an increase in emissions beyond the regulated entities that is spurred by the policy imposed on the regulated entities. (The report defines leakage as a vague concept applied to economic leakage as well—that concept has a shakier foundation as it does not comport with standard economic principles of trade and comparative advantage.) Thus, even if

California were to establish an economy-wide cap and trade system to replace the LCS it would likely be necessary to assess the life cycle emissions of fuels imported into California to establish an appropriate border price adjustment on these fuels. As the report describes a hope that in devising these regulations California sets a standard for other jurisdictions it seems necessary to investigate the efficiency loss from choosing a third or fourth best policy alternative to that of a first or second best. Acknowledging that the first best—a global economy-wide policy—is not possible at this time it is useful to have in mind how one could transition to such a first best solution. This comments spills over into the economic assessment and "big picture" issues but the various technical economic inefficiencies of the proposed LCS and how that affects technical estimates will be a recurring theme of my comments.

An important aspect of the regulations is the ability of Regulated Parties to propose additional pathways or to provide evidence for different values of coefficients to be used in existing pathways. This provides an incentive for Regulated Parties to improve methods of producing alternative fuels or to acquire fuels from sources that use improved methods along each generic pathway. This feature brings some of the efficiency characteristics of the first best solution by incentivizing process improvements that reduce GHG emissions but it requires a bureaucratic review process. As it is formulated, however, a concern is that this incentive process can create adverse selection bias. That is, those Regulated Parties whose production methods for these pathways, produce more GHGs than default values in the pathways developed by the ARB have no incentive to report higher emissions, but those who are below the average can request to use lower values. Thus, one would expect that those who continue to use the default values will have, one average, emissions above the default values. As a result the policy will fall short of its objectives. The extent of this slippage will depend on the variation in emissions from alternative fuel suppliers from the average value. The report should thus investigate not only the average value of emissions along each pathway but also the range. To the extent that a distribution of likely future emissions for each of the pathways could be established the ARB could then estimate how far it would fall short of the LCS goal assuming that those who did better than the average, requested a pathway emissions estimate reflecting their actual emissions, while those that did worse continued to use the default values.

One partial solution to the adverse selection problem is to assign a relatively high value to emissions for each pathway. One would then expect that most Regulated Parties would make a case that their emissions were lower and one would expect many of these to be approved. This process would in most cases force Regulated Parties to reveal the information on their actual emissions to the Air Resources Board, reducing the difficult task of the Board to go out and investigate whether the default values are seriously underestimating actual emissions. The Regulated Parties should be in a position to be relatively information rich on their own practices compared with the Board which would need to inspect and investigate facilities in order to understand how they might differ from an average. In principle, if one had a good estimate of the distribution of emissions along each pathway, the Board could set the default value at a predetermined upper point in the tail, and thereby estimate how much they would likely miss the actual target by

setting it at 1 standard deviation above the average, or the at the 10 or 5% tail. The nominal LCS could then be tightened to take account of estimated slippage.

One also needs to be concerned about the incentives created that might increase emissions associated with these alternative fuels pathways. If it becomes less expensive along a given pathway to produce fuels in a different manner that results in greater emissions, then there will be an incentive to alter the process in that way as long as the process is not altered so much as to clearly be a "different" pathway. For example, suppose natural gas becomes expensive and is supplemented somewhere in the world with syn-gas produced from coal, or transportation of the alternative fuel to California relies increasingly on fuels produced from oil sands or heavy fuels. Without a complete trace of these alternatives outside the California system, alternative fuels produced in this manner would continue to look like the default pathway. However, actual life cycle emissions would be higher than the default and this might then disadvantage California producers of alternative fuels who were subject to emissions controls on fuels used within the state, and therefore would not have an economic advantage to using these dirtier alternatives.

Clearly, another way to minimize adverse selection effects is to define a very large number of pathways with slightly different coefficients to meet ever finer ranges of production processes but that would place an ever greater burden on the Board. In contrast, setting the emissions at the high end creates an incentive for the Regulated Parties to produce pathways and reveal information that the Board can then assess. The potential behavioral response to changing incentives is more difficult to incentivize in the California system, short of regular investigation by the Board of possible changes and updating of the default values. These efficiency issues are created by choice of a third or fourth best control instrument and speak to the value of working toward a first best control approach.

Another question I have with regard to the greenhouse gas modeling that is somewhat related to the above issue are the electricity pathways. At several points in the document the report expresses the idea that there is sufficient electricity capacity to meet the demand for these electric vehicles because of idle capacity. The suggestion is that households would choose to recharge overnight and during off-peak hours when there is idle capacity. The situation may be different in California but in many parts of the country the baseload generation is coal-fired power plants that ideally would be run through the night, and utilities could then time of day price to encourage more effective use of this low cost base-load capacity. However, if this baseload capacity is heavily based on coal it is likely more carbon intensive than the average mix. If the goal is to use idle baseload capacity then the "marginal electricity mix of natural gas and renewables" is mostly not relevant unless perhaps, some renewable such as wind, is not well matched to current power demand peaks and it is hoped that energy produced from such sources can actually be useful because one now has the capacity to shift the recharging demand to periods when these sources are available. However, unless one has a very persistent diurnal pattern it would seem difficult to take advantage of a lot of the variability in renewables since at best the recharging can be shifted around by some hours within the

day but not over seasons, since these vehicles will need to be recharged on a daily basis. Thus, similar to using relatively high emissions coefficients for other pathways, it would seem that the default pathway for electricity should assume the average GHG coefficient of baseload power, and regulated entities could make then make the case for lower emissions where they can document that indeed something other than baseload power is being used. Otherwise I find that the discussion of this goal of using existing off-peak capacity is inconsistent with the defined pathways that assume average emissions or lower carbon "marginal" additions to the system.

Also at issue with PHEVs are the incentives, or lack thereof, in these standards to use them predominantly on their all electric range. The PHEV pathway must make some assumption about the proportion of time the vehicle will be run on the electric versus the internal combustion engine. Ideally a GHG control policy would create incentives for drivers to use the vehicle in battery mode as much as possible. As far as I can tell, there will be an assumption of this embedded in the GREET pathway that may or may not be accurate. Since there is no experience with how PHEV owners might actually use their vehicles this seems speculative. Again, a first best solution that priced GHGs in fuel would further encourage drivers toward short trips, and recharging more frequently to avoid using the vehicle beyond its all electric range. Since many drivers place a high value on convenience (i.e. their time) if recharging is slow or facilities inconveniently located owners may rely much more on the internal combustion engine of the PHEV. In the LCS approach to regulation this will result in the target reduction being exceeded. In a cap and trade system, if this fuel is sold it will necessitate reductions elsewhere to meet the cap and the desired cap will be met. Again, an inefficiency of using a third or fourth best alternative.

The indirect emissions issue identified in the report is an important topic and as the report identifies it is the biofuels alternative where current research has shown this to be most important. As the report indicates this is a very new area where research that could establish with confidence such indirect emissions is in its infancy. Ideally one would want to like to have had the scientific community investigate these issues and to have published competing estimates, resolving among them better or worse approaches and identifying uncertainties. The work developed in this report to estimate these indirect emissions is far beyond anything else that has been done in this regard. However, since there is virtually nothing else out there that is comparable it is difficult to determine how accurate these estimates are. The nature of the problem is that it requires a full model of the global economic system to separate out the partial effect of increased demand for biofuels on land use change, and this requirement is recognized in the report. The report accurately describes how any direct empirical evidence from recent changes in biofuels production, corn and soybean exports, and land use change are highly confounded by simultaneous changes in demand abroad for other purposes and possible supply-side shocks.

Since the evidence is that there are likely land use implications of biofuels expansion, my judgment coincides with that expressed in the report, that including an estimate of these indirect emissions is better than leaving this emissions source out completely because of

uncertainty. Elsewhere I expressed the view that using a relatively high value, and allowing Regulated Parties to provide evidence for lower values, would create incentives to reveal actual emissions as they vary among actual pathways of different parties and to avoid adverse selection. For the most part the indirect emissions along a particular pathway would seem to be less likely to vary by Regulated Party using the pathway—the indirect emissions are the result of the interaction of global markets in response to, e.g. more use of corn for ethanol—which would be common for any Regulated Party using that pathway. (Although with different trade elasticities and such, the source of biomass feedstock could result in different indirect emissions.) Thus, it is less clear to me that choosing an average coefficient will lead to adverse selection and the likelihood that the LCS goals will not be met..

Three additional technical issues on indirect emissions:

(1) The yield response that is modeled and that then reduces the amount of converted land (and indirect emissions from land use change) is a process of intensification of production on existing land. The process of intensification generally involves using more inputs as a substitute for land. The intensification process likely involves increases in GHG emissions. Some of the most substantial aspects of intensification are likely to be increased use of fertilizer, especially nitrogen, increased irrigation, and denser livestock management. Increased use of nitrogen would lead to increased emissions of N_2O, a potent greenhouse gas. This increase in nitrogen is on intensified conventional agricultural land and is a further indirect effect of biofuels expansion. The report identifies water use as an issue. However, in addition to water issues themselves, water use has GHG implications. Pumping of groundwater is relatively energy intensive and to the extent surface water is diverted for irrigation, limiting hydropower production there are likely GHG implications of producing that power with alternatives that are likely to include some mix of fossil fuel generation sources. Intensive livestock management is often associated with confined livestock facilities and manure management practices that result in methane emissions, another potent GHG.

(2) Intensification may also result in increased carbon stores in soils, especially if it results in land improvements on low productivity or lands degraded from use in grazing and pasture. Generally increased fertilizer and water use can greatly increase the amount of biomass produced on low fertility or water limited land, and even with removal of the harvested portion of the crop the biomass left behind can greatly increase the soil carbon. It is hard to judge how important these may be and they are highly variable depending on exactly what land is being used (see e.g. Reilly et al, 2006) but these issues at least worth investigating. Again, a first best solution that was pricing emissions throughout the economy would avoid the need to assess these.

(3) The report concludes that there are likely no land use implications of use of waste materials such as fats and oils or of corn stover. For true waste materials—fats and oils from food preparation that would otherwise be disposed of—that is probably true. However, most fat and oils from the meat industry, for example, are used in feed and food production and are consumed. If they were redirected to biofuels production, then

other products such as soybean or corn oil would need to be used in place of them with potential land use and GHG implications. Similarly, waste biomass such as corn stover has in some cases other uses (livestock bedding) that would need to be replaced and if not and it is left in the field it is a carbon source that remains out of the atmosphere for some time and contributes to soil carbon levels. If that source of carbon replenishment of the soil is systematically removed, then soil carbon stocks will fall, contributing to increases in atmospheric carbon. Organic matter is also a source of nitrogen and it typically releases nitrogen more gradually than inorganic sources and in tune with regrowing plants and thus emits less N_2O than would applications of commercial fertilizer. Thus, higher N_2O emissions with increased fertilizer use required because of removal of corn stover (or similar agricultural waste) is a likely additional indirect effect.

2. Land use modeling

Comments above about indirect emissions coefficients addressed indirectly some of the land use modeling issues. In general, the developments made in the Report on modeling land use/agriculture and indirect emissions have advanced this area of research. Thus, the ARB in investigating this area is at the state-of-the art. As noted above, and by the ARB Report this field is in its infancy. The analysis in the Report does an admirable job of testing the sensitivity of results to key parameters. More important than parametric uncertainty, however, may be structural uncertainty. Gurgel *et al.*, 2007, Antoine *et al.* 2008) find big differences in land use response depending on the structure of the model. The GTAP model approach is heavily conditioned on a relatively short run response to marginal changes. It is probably appropriate for an LCS operating in limited jurisdictions (e.g. California) with a time horizon of 15 years. Unfortunately, climate change is a global problem that requires management over many decades to centuries. Much more investigation is thus needed to see whether the properties of this regulatory regime have any value over the longer time span and when expanded to enough jurisdictions so that it would actually have a noticeable affect on slowing climate change. It is well accepted in empirical economics that there are many short run irreversibilities that lead to elasticities of response to be smaller in the short run than in the long run. As Gurgel et al (2007, 2008) argue, these elasticities are highly simplified representations of other structural element of the system. Some issues: observations on land conversion elasticities may reflect short term rigidities, and often price pressures do not persist for decades. If biofuels expansion occurs broadly and globally, the price pressure to convert could persist over many decades at levels well beyond recent observations rendering elasticities based on observation questionable. On the other hand, if "demand" for unconverted land grows with income and that demand is expressed by protecting more land either through private or public ownership, this factor may more than offset pressure from biofuels development (see, Gurgel et al., 2008). Armington trade elasticities are also suspect. While highly used, it is not hard to generate hard to explain divergence in regional prices when differential pressures exist over the long term. Thus, sector prices that are 2, 3, or 5 times higher in one region than another can easily develop with Armington specifications. While an explanation for price divergence can be differences in the "product" of the sector in each country—US automobiles differ from German or Japanese automobiles—it is still hard to justify large price gaps beyond those that already

exist because of the mix of vehicles. The problem is even greater for more homogenous bulk commodities such as corn. Evidence on trade elasticities inevitably reflect longer term contracts and relationships, existing shipment and production capacities, and other short run irreversibilities which in the long are reversible.

The trade elasticity issue may not show up as important in this analysis because as far as I can tell the analysis alters the land conversion elasticities but uses a common elasticity worldwide, thus it matter less where the crop is produced because one gets that same land response in all regions. This poorly reflects observation which shows greater willingness to convert land in the tropics than in the developed countries in temperate regions. Some estimates of this differential are reported in Gurgel et al. (2007) and also remain when the elasticity concept is replaced by an explicit recreation demand for land which varies by income as in Gurgel et al. (2008). It may thus be important to consider varying this elasticity by region as that could effect the relative indirect emissions of sugar cane versus corn ethanol, for example.

The highly aggregated carbon coefficients associated with land use change are also a major weak spot in the analysis. Mellilo et al. (2009) embed the Terrestrial Ecosystem Model into a general equilibrium model to more accurately compute indirect carbon and nitrogen implications of land use change and thereby likely better capture the regional variation in carbon stocks on different types of land and the changes in carbon stocks on the intensive margin due to intensification. That said, this work looks only at a single biofuel derived from cellulosic material and the published material does not report the nitrogen impacts but it points the direction this work must head.

Finally, the time profile of emissions from land use change and biofuels is a very thorny issue. Herzog, *et al.*(2003) address some aspects of this for leakage from ocean storage and the issue of gradual emissions from land use has some similarities, and Reilly and Asadoorian (2007) discuss additional aspects of how to address this issue for land use change. The problem confronted here is that there are emissions from land use change in the near term that with a long enough horizon will eventually be more than made up by the fossil fuel offset from using biofuels. Again, a first best solution, an economy-wide cap on all emissions including those from land use change would address this issue. The cap would be set to reach a desired concentration target. Thus, ignoring uncertainty in natural system response, that target would be met. If it made economic sense, given full GHG pricing, to deforest and release carbon, the broad cap would ensure that such releases would need to be met by larger reductions from other sources, and given that differences in timing of reductions were appropriately reflected in banking and borrowing rules the system would take care of itself. This does require the banking/borrowing rates which would need to reflect the time path of damage but as default value, I believe it is reasonable to consider that the marginal damage of emissions and different points in time as equal. One reason is that the lifetime of most gases are so long that there is a large overlap in terms of damages from emissions at different times. And absent much knowledge on where tipping points and irreversibilities exist in the system, and what they are, it seems as likely that we will cross some of these at almost any concentration. The climate risk has sometimes been described as a problem of future generations suggesting

marginal damages will be higher in the future, the new evidence suggests some of those tipping points may be much more immediate and so the view that marginal damages of near emissions is relatively low is probably inaccurate. I don't have a good way to convert this logic into coefficients such as a Fuel Warming Potential. However, my intuition is that the FWP is a deeply flawed concept, much more so than the Global Warming Potential indices used to compare GHGs. On GWP's see e.g Reilly and Richards, 1993)

3. Economic Impacts

While there is some room for variation because of the Federal/State tax/subsidy issue I believe that on technical economic grounds the estimate of economic impact on the State of California is done incorrectly because the tax and tax revenue implications are dealt with inappropriately. The report follows a typical approach by many Federal and State analytical agencies in assuming that current tax and subsidy policy remain unchanged. If one were merely computing the incentive effects for adopting various fuels there may be reason to follow such an approach, and analysts in government employ are frequently unwilling to project or guess how elected officials will change these policies in the future. However, the implication of this for analyzing the economic impact of these regulations is to assume that Californians will bear no responsibility for the tax expenditures created by these subsidies. Conversely, on tax increases because of the volumetric fuel tax, the assumption is that the tax revenue generates no useful product, or that the tax level is set without regard to potential uses. In reality since fuel excise taxes are used to maintain highways this implies these expenditures (and maintenance needs) will go up as a result of a switch to biofuels—or I guess go down if there is a switch to electricity. Since electricity is not subject to a fuel tax for highways, taking this to the extreme would suggest that if we switched to all electric vehicles all maintenance needs for highways would vanish. Clearly, they would not vanish and to continue to fund highway maintenance with a tax on the fuel used assuming that maintenance demand is related to miles driven, a tax would need to be levied on electricity at a high enough rate to make up for the fact that electricity on a MJ basis delivers miles more efficiently than other fuels.

In general, the correct principle for estimating economic impacts is to assume revenue neutrality. That is, increased tax expenditure on subsidies must be made up for with increased taxes elsewhere. And similarly, increased tax collections are made up for with decreased tax rates, leaving the level of service provided by the tax collection unchanged. An issue does arise in dealing with Federal tax and subsidies as California can partly free ride on Federal subsidies or disproportionately contribute to Federal tax collection by paying for the higher volumetric tax rates on fuels if other jurisdictions in the US do not have additional incentives for these fuels as in the California LCS. This would occur if California is the only state that creates a large ethanol demand so that most of the Federal subsidy goes to subsidize fuel use in California, and then the increased taxes to pay for that subsidy is borne by US taxpayers generally. However, since the Report notes

interest in several other states of similar measures and has a goal of having the system adopted elsewhere, it seems that a neutral assumption would be that Californians would bear the full cost of tax expenditure on subsidies. Thus, these tax expenditures should be added on as a cost to Californians, and the expenditures should be increased by an amount to account for the deadweight loss associated with tax collections. That is the distortionary effect of tax collection. It should be assumed that any increase in tax collection will be offset by a reduction in the tax rate to keep the level of service constant.

It is reasonable to have a separate section of the Report on the tax implications of the LCS, calling attention to tax administrators of the implications of the LCS for tax revenue if rates are not adjusted. It can then be up to these Administrators/elected officials to decide whether increases or decreases in tax revenue are addressed with changes in the level of service or in the tax rate. Even if it is through level of service, the economic analysis based on revenue neutrality is relevant to the extent that the marginal value of changes in service is equal to the tax rate.

Another critical issue is the accounting of only fuel and administrative costs and not of vehicle costs. On the one hand I can see the rational of not accounting the PHEV vehicle if a pre-existing ZEV program is requiring this level of PHEVs anyway. The cost then really accrues to the ZEV policy rather than the LCS policy. However, since the LCS program is being touted as a model for other jurisdictions that do not have a ZEV program, it would be useful to estimate the cost of the PHEVs. My understanding is that the main early contender is the Chevy Volt, and recent estimates are that it will be introduced at a cost of $35,000 or so. Aimed at the mid-size car market, a comparable conventional vehicle is probably in the range of $20,000. This initial cost difference will not be made up for with lower electricity prices over the life of the vehicle and so this is a relatively expensive option. I also did not see discussion of the increases in the cost of vehicles to include flex fuel capacity. This is a relatively small cost per vehicle as I understand it but should not be ignored.

Related to the above points: If we take the analysis on face value, that these vehicles will exist anyway and that with existing subsidies these options are actually less expensive than conventional fuel then the drivers in the State should adopt these alternative fuels without the LCS. In fact, it is not clear why they would stop at just meeting the LCS goals and not substitute these fuels completely based on the assumptions in the report. Perhaps one might argue that drivers would adopt less environmentally friendly fuels such as Midwest corn ethanol or conventional fuel produced from tar sands—but then the baseline should reflect that these are actually lower cost than the conventional fuel and would set the price for fuels lower. The baseline thus is inconsistent with the cost assumptions for these various alternatives. Either one of the dirtier and cheaper alternatives would set the price of fuel lower than assumed in the baseline, and thus increase the cost of adopting the LC alternatives or the LC alternatives will be adopted without the LCS and the policy is redundant and unnecessary. In that case, the cost is the administrative costs of running an unnecessary program. Some logic needs to connect the idea that with subsidies these alternative fuels are so inexpensive that they will save consumers money, yet there is still a need for the LCS.

4. Environmental and Multimedia Impacts

I understand the argument presented as to why the LCS does not fall under a change in fuel specifications and therefore does not, in the opinion, of the ARB lead to full multimedia environmental impact assessment. Whether that holds is likely a legal issue and it is beyond my competence to comment on. The small potential benefits of reduced particulate matter associated with biodiesel seen reasonable. However, I don't see why these are computed when other potential changes in fuels are not considered based on the fuel specifications argument. Perhaps I don't fully understand this issue, but computing these seem to open the door for asking why not consider the possible changes in volatility of the gasoline stock with changes in ethanol blending, or the potential changes in emissions of NOx, CO, etc. If this is clear to others in the context of California then perhaps the report is fine but it appears that the report has cherry-picked some potential benefits and ignored other changes that might have been negative.

The sustainability issues....which I interpret to be the broader environmental consequences of biofuels and land use change such as water quality, ecosystem loss, biodiversity changes, etc. are a potential long term concern. It is good that the Board plans to place some attention on these in the future. I can understand why these were not addressed in this Report given the time frame and the complexity of these issues. Melillo *et al.* (2009) discuss some of these issues.

5. Credit Trading

The credit trading provision offers a cost saving flexibility mechanism but the efficiency characteristics of this mechanism in achieving GHG reductions do not match that of a broad carbon cap and trade system for the many reasons I have laid out in the comments above. The ARB plans to not allow allowances from outside the system to be brought into the system because they interpret the goal of the LCS to be to meet the particular fuel standard, and to purchase allowances from other carbon trading systems would allow the LCS target reduction to be violated. This narrow interpretation has some narrow logic that seems hard to justify from a broader context. Clearly, the main intent of the LCS is to reduce GHG emissions. The entire implementation plan is based on that premise, carefully addressing life cycle emissions wherever they occur including indirect emissions that go well beyond direct life cycle emissions and regardless of whether California has direct jurisdiction for them. Yet a certified reduction in greenhouse gases through some other program cannot be credited. If we can save a forest or reforest through CDM, why is that forest carbon different than that avoided by correctly accounting for indirect land use emissions of fuel production? I guess the premise is that there is some unique barrier to low carbon fuel development that needs to be overcome and so a certain LCS standard will accomplish that. It's hard to see that diverse alternative fuels such as electricity and electric vehicles, cellulosic ethanol, and conventional sugar and corn ethanol face similar barriers so that the LCS works efficiently to overcome these barriers in each of these fuels. Existing R&D and

demonstration efforts, while probably far from perfect, seem more likely to address different barriers that exist across these diverse fuels. Thus, I see little rational for separating the LCS from a broader GHG market. And, I see little rational for fashioning an LCS that has poorer efficiency properties than a broad cap and trade program. This may go beyond the ARB authority given California legislative direction. However, since the stated intent of this is to create a model program for other jurisdictions it seems appropriate for analysis to compare this third of fourth best policy design with a first best solution. A proper economic analysis would contrast the cost of implementing this system with that of at least the second best system, where California has a broad cap and trade system including transportation and applies border taxes to account for emissions from fuels imported from jurisdictions without GHG policies.

Broader Issues

I am concerned that California proposes this inefficiency approach as a model for other jurisdictions and that the analysis in this report fails to demonstrate the inefficient nature of this proposed policy. The Report loosely describes the LCS as complementary to other policies in California that are aimed at GHG reduction. In what sense are they complementary or are they competing, redundant, or unnecessarily increasing the cost of GHG reduction in the State. If this language is to be used a careful technical definition of the word complementary is needed and technical analysis that analyzes and provides support for that conclusion is needed. I see no such analysis in this report.

There is some solid technical work underlying parts of this report, however, in putting together these technical pieces several problems arise. The economic analysis was done incorrectly. It does not meet technical standards of economics. The baseline assumptions are mutually inconsistent, and if these assumptions were executed in a proper model it would show that the LCS was unnecessary.

The good technical work on life cycle emissions and indirect emissions will be useful to policy development in this area, and it appears that much of the effort was devoted to that aspect of the Report. However, in spending much effort on these pieces apparently little effort was devoted to properly bringing these pieces together. While the report recognizes the need for a broad systems model for indirect emissions and sought the GTAP model, it failed to realize that many of these systems issues affect fuel markets and choice of fuels, and thus such a model is needed of fuels and fuel choices. With such a model the logical inconsistencies in the report would have been obvious because once introduced into the model they would have been demonstrated.

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