Report No. SR2010-08-02

Review of NESCAUM's Draft Data and Assumptions for LCFS Economic Analysis

prepared for:

American Petroleum Institute

August 27, 2010

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1. EXECUTIVE SUMMARY

1.1 Introduction

As part of the deliberations regarding the adoption of a Low Carbon Fuel Standard (LCFS) regulation by the New England and Mid-Atlantic states, the Northeast States for Coordinated Air Use Management (NESCAUM) is in the process of conducting an analysis of the potential economic impacts associated with the adoption of an LCFS regulation. To that end, in mid-August NESCAUM published the draft data and assumptions that it intends to use as the basis for the economic analysis.

In response, API retained Sierra Research, Inc. and MathPro Inc. to perform an independent review NESCAUM's analysis of the economic impacts of the adoption of a LCFS by the New England and Mid-Atlantic states (NE/MA). The findings of that review are summarized in the next section and documented in the body of this report. All opinions and analyses presented in this report are of those of Sierra Research, Inc. and MathPro Inc.

1.2 Key Findings

1. The Reference Cases in NESCAUM's Analysis Are Poorly Defined – NESCAUM's economic analysis starts from two "reference cases," which are intended to reflect possible future conditions during 2013 to 2023 without an LCFS. In general, these reference cases are not well defined and NESCAUM should provide a better explanation of what they are intended to represent. This is essential in understanding the methodology of economic analysis and is necessary to provide transparency.

   In defining the reference cases, NESCAUM assumes full compliance with existing greenhouse gas, other environmental, and energy regulations and programs in place at the federal, regional, state, and local levels. These programs include the federal Renewable Fuel Standard (RFS2); Corporate Average Fuel Economy/Greenhouse Gas (GHG) emission standards; the Regional Greenhouse Gas Initiative (RGGI); state Zero Emission Vehicle (ZEV) programs; as well as state renewable energy standards, biofuel mandates, and waste policies.

   The use of these assumptions in the reference cases of NESCAUM's economic analysis is inappropriate for several reasons. First, many of the above programs are technology-forcing and it is not at all clear that it will be technically feasible or cost effective to implement them. Second, while these existing programs entail considerable economic costs, NESCAUM will not attribute these costs to the LCFS in its methodology, but apparently it will take credit for their projected impact on carbon intensity. NESCAUM should redefine its reference cases to reflect the potential for the partial or complete failure of a number of the existing programs. Further, both the costs and the benefits of existing programs should be excluded from the economic analysis.

2. NESCAUM's Approach in Defining Future Scenarios is Flawed – The stated goal of the LCFS is to "spur faster development of *highly uncertain* emerging technologies." Yet each future scenario rests on the assumptions that technologies that are not yet commercially viable will become so by 2013 and will, along with associated infrastructure, be in place in the NE/MA region starting in 2013. In fact, each scenario has been defined by NESCAUM as a "success story" for one of three future scenarios, based on the successful substitution of large amounts of electricity, biofuels, or natural gas for gasoline and diesel fuel. In defining the scenarios, NESCAUM assumes that "success" will occur through the confluence of (1) technology breakthroughs, (2) favorable economic conditions, and (3) a favorable regulatory environment, all of which are further assumed to occur in a very short period of time. In addition, NESCAUM makes the implausible assumption that the imposition of an LCFS on existing fuel providers will be an economically efficient means of forcing the production of alternative fuels and alternative vehicle technologies, neither of which are, nor can be, directly controlled by existing fuel providers.

   Given the manner in which NESCAUM has defined the future scenarios, the results of its yet-to-be-performed economic analysis are already clear: each of the future scenarios will be found to both reduce greenhouse gas emissions and reduce costs in the transportation sector relative to both of the reference cases. This, in turn, will mislead policymakers into thinking that adoption of the NE/MA LCFS is a "win-win" situation regardless of the ultimate compliance pathways that policymakers might select.

   In order to achieve its asserted goal of establishing an "envelope" within which future realized costs are likely to lie, NESCAUM needs to redefine its future scenarios. NESCAUM should, at a minimum, modify the scenarios to reflect both best- and worst-case endpoints associated with the development of the technologies it is currently assuming are available for LCFS compliance.

3. The Electric Future Scenario is Based on Inappropriate Assumptions – The key assumptions of the NESCAUM "Electric Vehicle Future" scenario include the availability of electric (EV) and plug-in hybrid electric (PHEV) vehicles at zero incremental cost relative to conventional vehicles at levels far above those mandated in states that have adopted the California emission regulations. NESCAUM's assumptions regarding electric vehicle cost and availability are far

more optimistic than those being made by the California Air Resources Board (CARB), which is currently reviewing the regulations that have been adopted by the states included in the NESCAUM economic analysis. Further, even independent reviewers empanelled by CARB had criticized CARB's assumptions as being overly optimistic. NESCAUM should use reasonable assumptions regarding electric vehicle costs and volumes; if those assumptions do not support the concept of an Electric Vehicle Future, NESCAUM needs to make that very apparent to decision makers.

4. <u>The Biofuels Future is Based on Inappropriate Assumptions</u> – Of the three future scenarios defined by NESCAUM, the Biofuels Future may, on the surface, seem the most plausible given that there is significant activity underway to commercialize biofuels as a result of the federal RFS requirements. In defining this scenario, however, NESCAUM is again making assumptions that are inappropriate.

   First, the Biofuels Future scenario rests on the assumption that the annual volumes of advanced biofuels mandated by the Energy Independence and Security Act of 2007 (EISA) through 2022 will be met. However, the U.S. Environmental Protection Agency (EPA) has acknowledged that the mandate for 2011 will not be met, and almost surely will have to do so again next year. In *AEO2010*, the U.S. Energy Information Administration (EIA) projects domestic production of advanced biofuels falling well short of the mandated volumes through 2022 and beyond. In addition, NESCAUM's assumption that the annual mandated volumes will be met will result in NESCAUM attributing a significant share of the cost of meeting the NE/MA LCFS to the RFS program and then failing to consider that share of the cost in assessing the economic impacts of the LCFS. NESCAUM's assumptions regarding the RFS2 program include the assumption that the LCFS will draw low-carbon intensity biofuels into the northeast from other areas of the country. This phenomenon, which we refer to as "fuel shuffling," would yield little or no net reduction in the national CI of motor fuels as higher CI biofuels would simply be used elsewhere.

   Moving beyond the RFS2, NESCAUM is making unreasonable assumptions regarding both the cost of biofuel production and the level of biofuels production in the northeast. More reasonable assumptions with respect to biofuel production would lead to higher production cost estimates. In addition, NESCAUM's assumption that the low CI fuels produced as a direct result of the LCFS incentives are likely to be produced in the region appears implausible on its face and NESCAUM has provided no rationale for this assumption.

   As with the Electric Vehicles Future, NESCAUM should use reasonable assumptions in assessing the Biofuels Future; if those assumptions do not support the concept of a Biofuels Future, NESCAUM needs to make that very apparent to decision makers.

5. The CNG Future is Based on Inappropriate Assumptions – The assumptions made by NESCAUM in defining the CNG Future scenario include (1) the rapid introduction of a large number of CNG vehicles that are not currently being produced by more than a few manufacturers in limited volumes or in more than a few models; (2) the rapid development of the refueling infrastructure required to service those vehicles; and (3) breakthroughs that make the incremental cost of CNG vehicles—which require specialized equipment such as safe, crash resistant, high-pressure fuel storage tanks—zero compared to conventional vehicles. Not one of these assumptions is plausible. Again, NESCAUM must use reasonable assumptions in its economic analysis; if those assumptions do not support the concept of a CNG Future scenario, NESCAUM needs to make that apparent to decision makers.

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2. GENERAL COMMENTS AND REVIEW OF REFERENCE CASES

2.1 General Comments

The first general concern identified in the review of the currently available materials related to the NESCAUM report is that the materials are incomplete. In many instances, critical data and assumptions that will have substantial impacts on the analysis are simply missing at this time. Many of these omissions are identified in this document. This lack of data, coupled with the extremely short comment period provided by NESCAUM, makes it nearly impossible to conduct a thorough review or provide comprehensive comments on the NESCAUM analysis.

Role and Costs of Existing Programs – A keystone of NESCAUM's economic analysis seems to be the definition of two "reference cases" intended to reflect possible future conditions in the 2013 to 2023 period in the absence of a LCFS. However, these reference cases are not well defined and a better explanation of what they are intended to represent is essential in understanding the methodology of economic analysis consistent with NESCAUM's goal of transparency. Specifically, NESCAUM should clearly explain that the reference cases do not imply that the baseline CI values will not change absent the implementation of an LCFS. Rather, the reference cases embody projections of the assumed effects of existing GHG and energy regulations, programs, and incentives at state, regional, and federal level (to the extent described below). These existing programs are projected to reduce the AFCI by a certain percentage, which should count toward meeting the 10% reduction goal of the NE/MA LCFS. The NE/MA LCFS must meet only the shortfall between its 10% reduction goal and the reductions that will be achieved by other programs in effect at the same time. This shortfall is the true metric to be used in the analysis of the NE/MA LCFS and the estimation of associated incremental costs and benefits.

The existing programs entail considerable economic costs; however, in NESCAUM's analytical framework, these costs will not be attributed to the LCFS. The economic analysis therefore should clearly estimate the transportation fuel AFCI reductions of the existing programs as percentages of the 2006 baseline in both reference cases. LCFS program costs should be associated with the incremental percent reduction (i.e., less than 10%) above and beyond the existing programs. Also, NESCAUM should estimate the fraction of the costs of those existing programs that offer LCFS benefits so that policymakers and the public can understand the full costs of reducing transportation fuel AFCI by 10% and the portion of those costs and CI reductions that could be attributed fairly to the NE/MA LCFS.

Under both reference cases, as well as the three "futures" scenarios, NESCAUM assumes full compliance with existing greenhouse gas (GHG), other environmental, and energy regulations and programs in place at the federal, regional, state and local levels. These programs include the federal Renewable Fuel Standard (RFS2), Corporate Average Fuel Economy (CAFE)/GHG emissions, Regional Greenhouse Gas Initiative (RGGI) and Zero Emission Vehicle (ZEV) program, as well as state renewable energy standards (i.e., RPS), biofuel mandates, and waste policies. Many of these programs are technology forcing and it is not at all clear that their implementation will be technically feasible or cost effective.

Therefore, it is unreasonable to assume in all scenarios that these programs will be in place and, to the extent that this assumption unreasonably lowers NESCAUM's estimates of the cost of compliance with the NE/MA LCFS, NESCAUM's analysis will underestimate the magnitude of potential economic impacts. Therefore, the NESCAUM analysis should include, for both the reference cases and future scenarios, additional sensitivity cases that assume the complete or partial failure of some of the above programs. (This point is discussed further in Section 3.)

2.2 General Comments on the NESCAUM Data Tables

This section presents detailed comments regarding the spreadsheet data tables released by NESCAUM, along with the August 12th presentation materials.

Tables 1A & 1B – These tables calculate projected energy use and prices for the NE/MA region based on regional projections from *AEO2010* ("*AEO*") for the Reference and High Oil Price cases. The tables accurately represent data from *AEO* and employ a reasonable methodology for translating *AEO* projections for the New England, Mid-Atlantic, and South Atlantic regions into projections for the 11-state NE/MA region. However, as discussed below, there are some problems and ambiguities with the tables.

Energy Use – Outlined below are several issues related to energy use.

- Motor gasoline energy use reported in the tables reflects use in the transportation sector, rather than total use. Although the difference between transportation and total use is small, an LCFS program likely would pertain to all gasoline, because of the inherent difficulty of identifying end use for gasoline. Therefore, the tables should represent total gasoline energy use. (Diesel and CNG are appropriately drawn from the transportation sector.)

- E85 is not included in the tables. E85 is a distinct energy use category projected in *AEO* and should be combined with gasoline energy use to calculate the combined projected energy use/demand of conventional gasoline-powered vehicles and FFVs. The combined energy use/demand should be reflected in the data series portrayed in NESCAUM's Slides 18 and 22 from the August 12th presentation.

- Ethanol energy use reported in the tables appropriately reflects *AEO*'s regional projections. However, energy use associated with ethanol already is incorporated in *AEO*'s projections of gasoline and E85 energy use, i.e., it is not an additional category of energy use.

- Biodiesel energy use projections in the tables do not appear to come from *AEO*'s regional projections. The source or derivation of these projections should be identified. As with ethanol, energy use associated with biodiesel is subsumed in the diesel fuel category in *AEO*'s projections.

Sales Volumes – In addition to issues related to the values for energy use, there are several problems with the projected sales volumes.

- The tables use *AEO*'s projected prices for E85 in combination with ethanol energy use to calculate ethanol sales. *AEO* does not project regional ethanol prices. However, because *AEO* projects E85 and gasoline prices to be nearly identical on an energy-adjusted basis, it probably is reasonable to use the E85 price as an approximation for the price of ethanol.

- The tables should show E85 sales, after E85 energy use is added to the tables.

- In calculating sales volumes, NESCAUM converts 2008 dollars to 2010 dollars using a Producer Price Index for gasoline of 0.83. This index is inappropriate for converting to 2010 dollars. A more appropriate index is the GDP deflator (which is > 1 for the period in question). NESCAUM could simplify its analysis by adopting *AEO*'s convention of reporting in 2008 dollars.

Reference Case Biofuel Volumes – During the conference call held on August 11, NESCAUM indicated that it did not intend to base biofuel projections in its Reference Cases A and B on the biofuel projections in *AEO*'s Reference and High Oil Price cases. Instead, NESCAUM indicated that it plans to assume that the RFS2 program is fully implemented (i.e., projected national biofuel volumes satisfy the EISA schedule) and that California, to meet its LCFS requirements, would absorb some portion of the advanced biofuels required by EISA.

This approach implies that (1) *AEO*'s projected regional volumes of biofuels (which reflect EIA's assessment that the RFS2 mandate volumes are not met) must be replaced with new projections of biofuel volumes reflecting higher national use of such fuels; (2) the composition and carbon intensity of the projected regional biofuel volumes must be estimated; and (3) the hydrocarbon component of gasoline energy use (including E85) and transportation diesel fuel must be calculated. The spreadsheets shown in Tables 1A & 1B do not contain such calculations.

Our understanding from the August 11th conference call is that NESCAUM contemplates modifying Reference Cases A and B for the CNG Future and Electric Vehicle Future scenarios to reflect lower penetration of biofuels in the NE/MA region and elsewhere. Again, the current set of spreadsheets does not contain such calculations.

Table 1C – This table shows *residential* electricity price and consumption projections for the NE/MA region based on corresponding *AEO* projections. Projected *total* electricity consumption for the NE/MA region also should be provided, because the "average" and "marginal" energy sources used to generate electricity would be influenced by total electricity use, rather than by residential energy use alone.

Table 2 – This table appears to include a number of landfills that have been closed for more than five years. This is contrary to the stated selection criterion that only landfills that either are operating or have been closed for less than five years could supply municipal solid waste for biofuel production.

Table 10A – The listed low-end CI value for corn ethanol (48 gCO2e/MJ) is significantly lower than EPA's estimates (≈ 74 gCO2e/MJ for natural gas-fired plants with base corn crop yield, ≈ 72 gCO2e/MJ for natural gas-fired plants with high future corn crop yield, and ≈58 gCO2e/MJ for biomass-fired plants).

The table does not include CI values for thermochemical cellulosic ethanol. The CI values for the thermochemical route are significantly higher than those for the biochemical route. EPA, in its RFS2 RIA, projects future production of cellulosic ethanol to be evenly split between these two production routes.

2.3 Carbon Intensities of Refined Products in Ref Case B

NESCAUM indicates[*] that Reference Case B (High Energy Prices) incorporates the assumption that "higher fuel prices will result in greater development of higher carbon petroleum resources" than in Reference Case A (Baseline). We assume that, as a consequence of this assumption, NESCAUM intends to assign somewhat higher carbon intensities to baseline gasoline and diesel fuel in Ref Case B than in Ref Case A. NESCAUM could achieve some useful simplification of the analysis by neglecting this factor because (1) as discussed below, the posited change in global crude production likely would have only minimal effect on the average CI of refined products supplied to the NE/MA region; and (2) estimating the magnitude of that (small) change would be difficult and complex, involving a number of detailed assumptions about the future global flow patterns of crude oils and refined products.

By way of background, the NE/MA region receives its petroleum product supplies from refineries within the region; refineries in the Gulf Coast refining centers; "short-haul" export refineries (in Eastern Canada, Puerto Rico and the Virgin Islands), a large portion

[*] NESCAUM, August 12, 2010 presentation, Slide 21.

of whose capacity is dedicated to supplying U.S. markets; and remote refineries (mainly in Western Europe and the Middle East) that are "opportunistic" (i.e., marginal) suppliers.

The High Energy Price case in *AEO2010* (the basis for Reference Case B) contemplates that higher oil prices would call out additional volumes of Canadian oil sands crudes and Venezuelan heavy crudes: the "higher carbon" crudes in question. The "natural home" (in terms of refining economics) for Canadian oil sands crudes is the U.S. Midcontinent (PADD 2) and Gulf Coast (PADD 3) refining centers. East Coast refineries have neither pipeline access to Canadian oil sands crudes nor the coking capacity to process large additional volumes of Caribbean heavy crude. Similarly, the short-haul refineries have no access to Canadian crude and would have to invest in additional coking capacity to handle additional heavy crude. European refineries have essentially no coking capacity. Only the Gulf Coast refining center would be likely to process more Canadian oil sands crude and Venezuelan heavy crudes in a high oil price scenario, but these refineries supply relatively small volumes of refined products to the NE/MA region.

Consequently, NESCAUM may wish to consider using the same CIs for petroleum-based gasoline and diesel fuel in both Reference Cases A and B.

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3. REVIEW OF "FUTURE" SCENARIOS

3.1 General Comments

Flaws in Analysis Design – The stated goal of the NE/MA LCFS is to "spur faster development of *highly uncertain* emerging technologies" [emphasis added] (Slide 7). Yet each policy scenario rests on the assumption that a cluster of technologies not yet in commerce (e.g., cellulosic ethanol production, PHEVs) proves technically feasible at commercial scale and is deployed in the region starting in 2013 in order to reach the LCFS target by 2023. Further, each scenario assumes not only the timely development, commercialization, and local market penetration of the specified set of technologies, but also the emplacement of all associated infrastructure.

In other words, each scenario is a "success story" for a particular technology set, in which a featured technology set achieves 6 percent points of the desired 10 percent point reduction in the CI of transportation fuels in the NE/MA region (e.g., 60% of the total LCFS goal), through the confluence of (1) technology breakthroughs, (2) favorable economic conditions, and (3) a favorable regulatory environment, including retention of all federal and state policies aimed at promoting the featured technology set and implementation of new policies (unspecified) to call out FFVs and EVs in the numbers called for by the various scenarios. In addition, NESCAUM makes the implausible assumption that imposing a LCFS on existing fuel providers will be an economically efficient means of forcing the production of alternative technology vehicles and the development of associated infrastructure, neither of which can be effectively controlled by existing fuel providers.

In general, in studies organized around alternative scenarios the scenarios necessarily must be designed to capture the range of plausible future outcomes (some of which may be unfavorable or unwanted). The NESCAUM scenarios do not do that. Instead, NESCAUM has adopted a methodology that (1) rests on a set of assumptions such that all three policy scenarios achieve the desired CI reduction; (2) suggests (implicitly) that all three are equally plausible; (3) focuses on changes in fuel volumes and vehicle characteristics; but (4) fails to delineate the public policies needed to induce the necessary advances in technology, improvements in production economics, and changes in consumer preferences and behavior.

Failure to Address Regulatory Failure – NESCAUM's methodology does not address the possibility of regulatory failure—that is, the possibility that none of the compliance pathways specified in the policy scenarios might attain NE/MA's objectives by 2023.

An LCFS has characteristics that make it unlike any other regulatory program affecting motor fuel suppliers.

- It would call for widespread commercialization of technologies whose technical feasibility and cost are uncertain; start-up and rapid growth of entirely new industries; and significant market penetration of one or more new alternative vehicle technologies whose costs relative to conventional vehicles are uncertain and which may not have characteristics that lead consumers to purchase them.

- It would rely heavily on an array of recently enacted regulatory programs whose effectiveness would depend on the development and commercialization of uncertain technologies and the emergence of new industries.

- It would require transportation fuel suppliers to rely on the development and commercialization of "low CI fuels" by industries over which they have no control.

Available evidence, however, suggests that the confluence of favorable developments described above is not likely to occur and that there is a distinct possibility of regulatory failure—the inability of fuel suppliers to comply with carbon reduction standards.

NESCAUM's methodology does not acknowledge this possibility. Instead, NESCAUM has adopted an accounting methodology in which program costs are estimated under alternative combinations of layered, mostly favorable, assumptions regarding government subsidies, technical feasibility, cost, availability of low CI alternative fuels, and consumer acceptance. Application of this methodology only creates the illusion that the NE/MA LCFS can be met at low cost and by multiple compliance routes. It fails to warn policymakers of potential adverse economic impacts and regulatory problems.

Accordingly, NESCAUM should restructure its methodology to include the economic impacts associated with the failure of the LCFS, not just the successes that are currently assumed.

Failure to Address Technical and Economic Feasibility Issues – NESCAUM's methodology does not consider the technical and economic feasibility of achieving the desired CI reduction in the specified time in any of the scenarios. This is a significant omission in light of the number and central importance of the technological advances needed to achieve feasibility and reduce costs, the potential barriers to infrastructure development, and the institutional factors on which each scenario's success story depends.

In the absence of such feasibility assessments, the results of the analysis will offer little guidance to policymakers and stakeholders as they weigh the merits of the NE/MA LCFS program and compare the prospective alternatives available for meeting the program's stated objectives. Therefore, NESCAUM's analysis should include an assessment of the probability that the compliance pathways defined by the scenarios actually can achieve the NE/MA LCFS' objectives.

For example, with respect to fuel and vehicle costs, NESCAUM has indicated that it recognizes the technology-forcing role of the LCFS as a performance standard.[*] By intent, the NE/MA LCFS would shift demand away from conventional fuels (i.e., gasoline [E10] and diesel) to low-CI alternatives, most of which are not in commerce today and—if and when they enter commerce—would be more costly than the conventional fuels. Thus, the "demand" created by regulation and not the market will increase the overall cost of transportation fuels, not reduce it. Similarly with regard to alternative technology vehicles, available data show that they carry significant incremental costs relative to gasoline and diesel vehicles. While it may be that economies of scale may reduce production costs from current levels, there is no evidence to suggest that all of the current incremental costs of alternative vehicles are the result of small-scale production inefficiencies. This is especially true of EVs and PHEVs, which bear excess material costs of batteries, as well as CNG vehicles, which require high-pressure fuel storage tanks.

Given the uncertainties in incremental vehicle costs, alternative fuel costs, and alternative fuel CI values,[†] NESCAUM should, at a minimum, evaluate both the best- and worst-case endpoints of the assumed ranges of these parameters. In addition, as discussed elsewhere, many of these assumed ranges should also be revisited and expanded.

<u>Use of Unreasonable Policy Scenarios</u> – NESCAUM has constructed its three policy scenarios so that they represent a set of "favorable" assumptions for the major source of CI reduction (the 6% source) in combination with "less favorable" assumptions for the minor contributors to CI reduction (the two 2% sources). The assumptions for each future scenario are summarized in Table 3-1.

The problems with this approach can be easily illustrated, using, for example, the Electric Vehicle Future scenario. For this scenario, NESCAUM indicates that it plans to make the following assumptions:

- The costs and CI of CNG and biofuels would be at the high end of the indicated ranges and all non-EV tax credits would expire; but
- The cost of incremental electricity is at the low end of estimated ranges and the CI of incremental electricity would be the average CI for the grid, rather than the CI associated with incremental load; and
- The incremental cost of EVs would be zero and EV subsidies would continue.

[*] NESCAUM August 12, 2010 presentation, Slide 53.
[†] NESCAUM, August 12, 2010 presentation, Slide 5.

Table 3-1 Future Scenario Assumptions			
	Policy Scenario		
Assumption	Electricity Future	Biofuels Future	CNG Future
EV Incremental Cost	Zero	$5K	$5K
Cost of Electricity	Low	High	High
Carbon Intensity of Electricity	Current Average	High	High
CNG Vehicle Incremental Cost	$7K (LDV) $40K (HDV)	$7K (LDV) $40K (HDV)	Zero (LDV) Zero (HDV)
Cost of CNG	High	High	Low
Carbon Intensity of CNG	High	High	Low
Cost of FFVs	$100	Zero	$100
Cost of Biofuels	High	Low	High
Carbon Intensity of Biofuels	High	Low	High

The second assumption, regarding the source of incremental electricity, is extremely important. The source of incremental electricity may be high-CI coal-fired plants, as is assumed in the Biofuel Future and CNG Future scenarios. But this is an analytical factor that should be established not by "assumption," but by analysis. If the primary fuel used to generate electricity to meet incremental demand associated with electric and plug-in hybrid vehicles is likely to be coal, the Electric Vehicle Future scenario may not even be viable.

Thus, as a consequence of NESCAUM's assumptions, the following should be noted with respect to the Electric Vehicle Future scenario:

- The estimated costs associated with the biofuels component likely will be small, because the CI reduction from biofuels is only 2% and NESCAUM is assuming that the RFS2 program is fully implemented by 2022;

- The estimated costs associated with the electricity component will be minimized due to the suite of favorable assumptions regarding the cost of electricity and of EVs and the CI of incremental electricity); and

- The estimated costs associated with the CNG component will be small—per-unit costs will be high but, because CI reductions from CNG would only account for 2% points of the 10% point CI reduction, CNG's contribution to aggregate costs might not be large. (Indeed, if it were large, CNG should not be assumed to be a significant contributor to CI reduction in the first place.)

Additionally, it appears that NESCAUM does not intend to include the cost of federal subsidies for fuels or vehicles in its tabulations of the cost of the Electric Vehicle Future scenario. The costs associated with such subsidies are borne by U.S. taxpayers generally and should be incorporated in NESCAUM's estimates. Otherwise, the estimated costs of the LCFS policy scenarios will reflect arbitrary assumptions regarding extensions of current subsidy programs. The other two scenarios have similar analytic problems.

NESCAUM has not clearly stated its rationale for selecting the most favorable endpoints of what are, as described below, already unreasonably optimistic projected ranges. While it is likely that the LCFS compliance pathway with the lowest total cost—be it electricity, biofuels, or CNG—will dominate, it is not clear that any of these pathways will ever realize the overly optimistic assumptions being used in the NESCAUM analysis. Given the way the NESCAUM analysis is structured in terms of these assumptions, the results are already clear: each of the future scenarios will be found to both reduce GHG emissions and reduce costs in the transportation sector relative to both of the reference cases. This, in turn, will mislead policymakers into thinking that adoption of the NE/MA LCFS will result in a "win-win" situation regardless of the ultimate compliance pathways.

Contrary to NESCAUM's assertions, the results of its analysis will not establish an "envelope" within which future realized costs are likely to lie. Instead, it will most likely lead to significantly understated estimates of the cost of an LCFS program with overstated carbon emission benefits.

<u>Failure to Assess Unintended or Unfavorable Consequences of NESCAUM Assumptions</u> – In addition to making unreasonable assumptions in constructing the future scenarios, it appears that NESCAUM is failing to consider unintended consequences associated with those assumptions that should be included in the economic analysis. For example, in the Electric Vehicle Future scenario, NESCAUM assumes that vehicle manufacturers will deliver more than three times the volumes of electric vehicles required under the ZEV regulations that are in place in many northeast states by virtue of their adoption of California's vehicle emissions regulations. However, NESCAUM does not appear to give any consideration to the impact that would have on manufacturers' decisions with regard to compliance with the other aspects of the CARB vehicle regulations that are in place in many of the northeast states. Clearly, sales of large numbers of ZEVs would allow vehicle manufacturers to sell greater numbers of less fuel-efficient conventional vehicles than they could at lower ZEV sales volumes and still comply with CARB's GHG emission standards. This impact could clearly reduce, if not eliminate, the GHG reductions associated with the reduction in fuel CI due to electric vehicles. The fact that manufacturers would be awash in ZEV credits, particularly given the credit multipliers available under the regulation, could also allow manufacturers to produce greater numbers of higher-emitting conventional vehicles, resulting in an increase in criteria pollutant emissions.

Similarly, NESCAUM assumes that various numbers and types of biofuel production facilities will be built in the northeast. However, those assumptions do not appear to have considered the consequences associated with having to comply with air quality regulations, limitations on emissions offsets, permitting and emission control system costs, or the impacts associated with high volumes of truck traffic needed to deliver feedstock.

NESCAUM also appears to assume no adverse consequences of the NE/MA LCFS on any part of the existing energy sector in the NE/MA states. However, the NE/MA LCFS would serve to reduce the region's demand for refined petroleum products, of which a substantial portion is supplied by the refineries located in the region. These in-region refineries are essentially dedicated to supplying markets in the Northeast. The other suppliers of refined petroleum products to the region—the "short haul" export refineries, Gulf Coast refineries, and remote refineries—are less dependent on markets in the NE/MA region and would be less affected by a drop in demand in the region. Achieving the objectives of the NE/MA LCFS would lead to excess refining capacity for supplying the NE/MA region, and the bulk of the excess capacity would be in the refineries in the NE/MA region. The refining economics of operating with substantial slack capacity are usually unattractive. Hence, an enduring excess capacity situation could lead to the shutdown of one or more of the region's refineries (the usual means of rationalizing capacity with demand).

<u>Issues with the Appropriateness of NESCAUM's Accounting for the Value of GHG Reductions in LCFS Benefits Analysis</u> – NESCAUM intends to estimate the prospective benefits of the NE/MA LCFS using estimates of the social cost of carbon developed this year by a federal task force as indicated in Slides 83 and 84 of the August 12th presentation to facilitate the valuation of GHG reductions. The federal estimates of the social costs of carbon presumably reflect the projected global costs, summed over the various adverse consequences envisioned as consequences of projected degrees of global warming by 2100. Using these estimated social costs may well be appropriate for assessing federal or international programs for GHG abatement; we question, however, whether they are appropriate for assessing a program undertaken not by a sovereign government, such as the U.S., but by a local or regional entity—in this instance, the NE/MA states. If the NE/MA LCFS program were to lead to tangible GHG abatement benefits, most of those benefits would likely accrue to other regions of the U.S. or other countries and not to the NE/MA states and their citizens. Also, as noted in our comments on the Biofuels Future scenario, if the RFS2 mandated volumes for advanced biofuels are achieved, then (all else being equal) the NE/MA LCFS may actually induce an increase in total U.S. GHG emissions. Such an increase could occur if the NE/MA LCFS causes low-CI advanced biofuel volumes to move to the NE/MA market and away from other markets that are closer to the regions in which biofuel production is concentrated. A full accounting of the effects of the NE/MA LCFS program on GHG emissions should consider this "fuel shuffling" and other out-of-region effects, but NESCAUM has given no indication that it intends to address these out-of-region effects in its analysis.

Consequently, in presenting its estimates of NE/MA LCFS benefits, NESCAUM should show as a separate line item the portion of the estimated benefits that are based on the estimated social costs of carbon.

The Specified Sensitivity Analyses Are Not Useful – NESCAUM plans to undertake three sensitivity analyses: the first would estimate the cost associated with a more (and less) stringent LCFS through simple linear extrapolation of costs; the second would lengthen the time period for compliance with an LCFS; and the third would partially incorporate heating oil into the program.

None of these "sensitivity" analyses would be informative. The first analysis likely would be an exercise in misinformation—compliance costs are unlikely to be linearly related to the percent reduction in CI required by an LCFS. A substantive assessment of the costs of a more stringent LCFS would require significant additional analysis of the technical feasibility and incremental costs of additional measures required to further reduce the CI of motor fuels. The second, for the most part, would simply string out the same estimated costs over a longer time period. The third appears to focus more on an implementation issue rather than cost.

3.2 Electric Vehicle Future

The key assumptions of the NESCAUM Electric Vehicle Future scenario include the availability of large volumes of pure EVs and PHEVs at zero incremental cost relative to conventional vehicles. As is well known, California first adopted its ZEV mandate in 1990, which imposed requirements directly on vehicle manufacturers for the sale of electric vehicles beginning in 1998. ZEV requirements also exist in many northeast states by virtue of their adoption of California's emission regulations.

The California ZEV regulation has been revisited by CARB several times since its original adoption primarily because, even with the imposition of production requirements directly on vehicle manufacturers, the high cost of ZEVs and likely problems with consumer acceptance made enforcement of the production quotas infeasible. It should also be noted that CARB is currently in the process of once again reviewing and revising its ZEV requirements. Given the northeast's position of following California with respect to ZEVs, this section reviews NESCAUM's assumptions regarding the Electric Vehicle Future scenario in light of CARB's recent ZEV-related assessments.

Sales Volumes of EVs and PHEVs – As noted earlier, both reference cases assume the successful implementation of the ZEV mandates that are in place in a number of the northeast states. The assumed annual sales volumes of EVs and PHEVs in Ref Cases A (Low) and B (High) are shown in Table 3-2, as taken from NESCAUM's Spreadsheet 4A. Table 3-2 indicates that only PHEVs are estimated to enter the market during 2014 through 2017; beginning in 2018, EVs will enter the market in numbers equal to PHEV sales. NESCAUM has apparently adopted the acronym "PEV" for the sum of EVs and PHEVs, which is also used in Table 3-2.

Table 3-2 New Electric Vehicle Sales, NE/MA						
	Ref Case A: Low			Ref Case B: High		
Year	EV	PHEV	PEV	EV	PHEV	PEV
2014	0	46,491	46,491	0	139,472	139,472
2015	0	63,246	63,246	0	189,738	189,738
2016	0	63,331	63,331	0	189,992	189,992
2017	0	63,829	63,829	0	191,488	191,488
2018	53,515	53,515	107,031	160,546	160,546	321,092
2019	54,539	54,539	109,079	163,618	163,618	327,237
2020	55,557	55,557	111,113	166,670	166,670	333,340
2021	56,210	56,210	112,420	168,630	168,630	337,260
2022	56,653	56,653	113,306	169,959	169,959	339,917
2023	57,154	57,154	114,309	171,463	171,463	342,926

Note: Estimated from graphic; changed to linear growth rates; assumed 20% vehicle share for NE/MA

A multitude of issues are associated with the EV and PHEV sales volumes assumed in the reference cases, and those issues are only magnified by the assumption in the Electric Vehicle Future scenario of sales volumes in order to achieve the electricity consumption target.

First, there doesn't appear to be a basis for NESCAUM's assumption of "equal market share for EVs and PHEVs."[*] As is well known, there is a fundamental difference between PHEVs and EVs with regard to vehicle range, with PHEVs having shorter all-electric ranges but (by virtue of their conventional engines and the existing refueling infrastructure for conventional fuels) extended overall range. Given this, the earlier introduction of PHEVs, and the fact that incremental PHEV costs are generally assumed to be lower than for EVs, it is difficult to understand why consumers seeking electric drive capability would not select PHEVs over EVs. It should also be noted that NESCAUM's assumption is inconsistent with CARB's LCFS analysis, which assumed annual PHEV sales volumes that were two to three times greater than those of EVs. NESCAUM should either modify this assumption or explain the basis for it in light of the assumptions made by CARB with respect to the same issue.

A second issue is the timing and magnitude of the assumed sales volumes for EVs and PHEVs for both reference cases. To support its justification for the adoption of the California LCFS, CARB optimistically assumed sales volumes for EVs and PHEVs at levels far higher than those required under the agency's ZEV mandate.[†] NESCAUM appears to be making the same types of assumptions in both reference cases and then

[*] NESCAUM, August 12, 2010 presentation, Slide 58.
[†] Austin, T.C., et al., "Preliminary Review of the CARB Staff Analysis of the Proposed Low Carbon Fuel Standard (LCFS)," Sierra Research, Inc., April 8, 2009.

pushing those highly optimistic assumptions even further in the Electric Vehicle Future scenario.

It is important to note that CARB's more recent EV and PHEV estimates differ markedly from those used in CARB's analysis of the LCFS.[*] There are two basic vehicle sales scenarios associated with the new CARB estimates: the first (ZEV1) is referred to by CARB as a "reference case," and the second (ZEV2) shifts the estimated sales curve for EVs forward by five model years relative to the reference case. PHEV sales are assumed to be the same in both the ZEV1 and ZEV2 scenarios. Figures 3-1 and 3-2 show the results of a comparison developed by Sierra. Note that the figures use the acronym "BEV" for "battery electric vehicle," which is synonymous with the term EV used by NESCAUM and the latter is used below in describing the information presented in Figures 3-1 and 3-2.

As shown in Figure 3-1, the number of PHEVs assumed to be sold in California during the period 2010 to 2020 is substantially greater under all of CARB's LCFS compliance scenarios than under CARB's ZEV analysis. Figure 3-2 shows that the ZEV1 scenario reflects EV sales fractions that are lower (in most cases considerably lower) than those reflected in CARB's LCFS compliance scenarios. In contrast, under the ZEV2 scenario where the sales curve is shifted forward by five years, EV sales volumes approximate those of the LCFS4 (high ZEV volume). However, the EV sales volumes under the LCFS4 and ZEV2 scenarios amount to approximately 880,000 vehicles in operation in California by 2020, which is incredibly optimistic and unlikely to occur.

As a result of CARB's inadequate documentation of its LCFS and ZEV analyses, Sierra needed to make a number of assumptions to compare the estimates shown in Figures 3-1 and 3-2. The first required assumption is the total number of vehicles sold in each model year from 2010 to 2020, for which we used CARB's projections from the EMFAC2007 model. The second necessary assumption is that the advanced vehicle populations published by CARB in the LCFS analysis are for the light-duty vehicle fleet and include both cars and trucks. A third assumption is that the distribution of car and truck sales from EMFAC2007, as modified to reflect a shift to sales fractions of 70% passenger car and 30% light-duty trucks over the 2010 to 2020 model year, represents what will occur in California during that period. Finally, because the ZEV analysis results are generally presented only in terms of EVs plus fuel cell vehicles (FCVs), some assumptions regarding the split between EVs and FCVs were necessary; these were made using the limited information provided by CARB regarding EV and FCV sales introductions and sales volumes.

[*] See Attachment B to the November 25, 2009 "White Paper" at *http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol2.pdf*.

Figure 3-1
Sierra Research Comparison of CARB Assumptions of PHEV Sales Fractions in LCFS and ZEV Scenarios

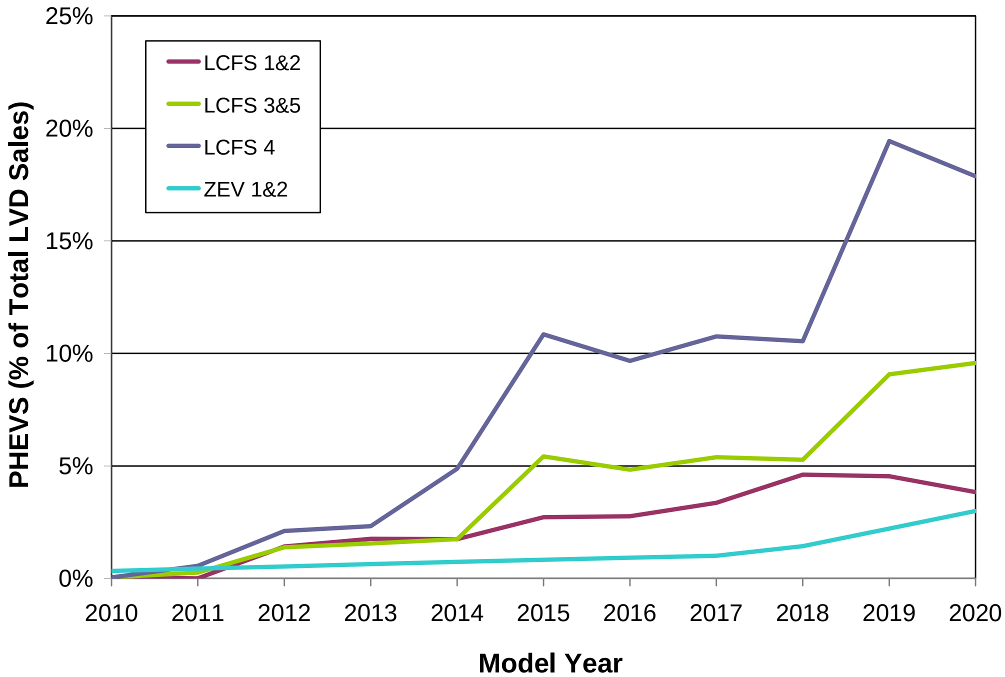
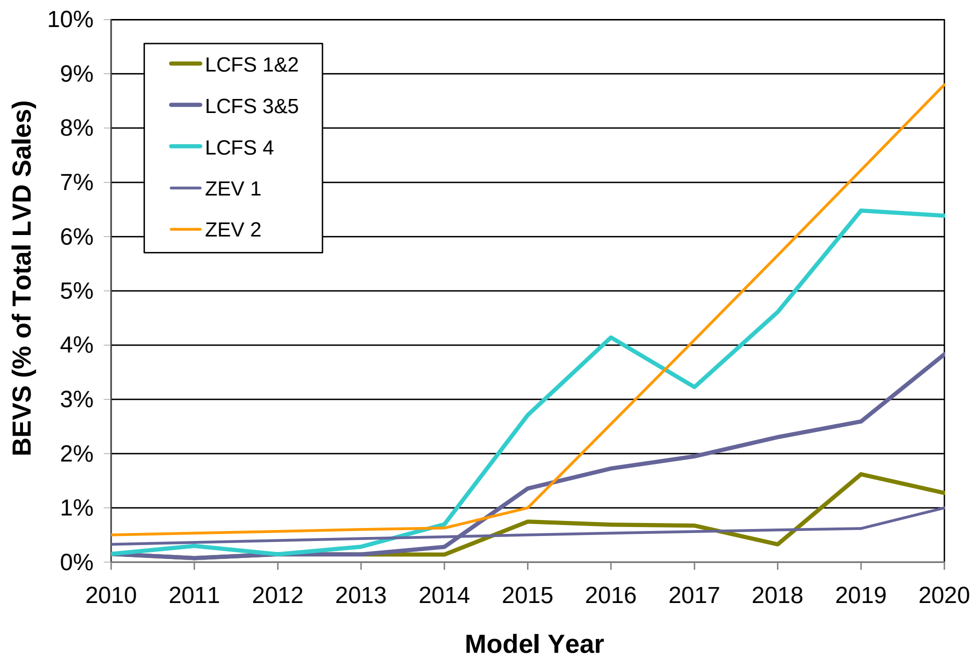


Figure 3-2
Sierra Research Comparison of CARB Assumptions of EV Sales Fractions in LCFS and ZEV Scenarios



Another issue associated with the NESCAUM assumptions regarding PHEV and EV volumes is whether PHEV and EV sales are assumed to occur in all states that would be subject to the LCFS or just those where the California motor vehicle regulations, including the ZEV mandate, are in place. It is only appropriate to assume that PHEV and EV sales would occur in ZEV-mandate states, as manufacturers have considerable incentives to restrict sales, particularly in the 2013 to 2023 timeframe, in order to facilitate compliance with the California motor vehicle regulations in those states.

The point of the above is that CARB's most recent estimates of PHEV and EV sales volumes and timing differ markedly from those used by CARB in the analysis of the California LCFS and that new estimates are considerably lower. Given that NESCAUM's assumptions regarding PHEV and EV sales volume and timing in the NESCAUM reference cases and the Electric Vehicle Future scenario appear to be comparable to those used in the earlier CARB LCFS analysis, NESCAUM should review these assumptions and revise them to be consistent with CARB's current assumptions or explain the basis for its assumptions. Clearly, NESCAUM should be using reasonable assumptions regarding PHEV and EV sales volumes and timing. If those assumptions do not support the desired goals regarding the consumption of electricity in the transportation sector, NESCAUM needs to make that clear to stakeholders and decision makers.

<u>Assumptions Regarding EV and PHEV Cost</u> – For the period 2013 to 2023, NESCAUM is assuming that the incremental cost of PHEVs and EVs relative to conventional vehicles will be at most $5,000 and as little as $0. Again, one has to look only as far as CARB in order to find vastly different and much more pessimistic assumptions being used in analyses similar to that being performed by NESCAUM, particularly with respect to EVs. It should be noted, as is discussed below, that many believe that CARB's assumptions with respect to PHEV and EV costs are already extremely optimistic.

The most recent estimates of the incremental costs of PHEVs and EVs developed by CARB were published in February 2008.[*] Incremental PHEV costs were estimated to be $25,000 per vehicle through 2014 and $12,500 per vehicle through 2017. Incremental cost estimates were presented for different types of EVs for model years 2012–2014 and 2015–2017. These ranged from $35,000 to $120,000 per vehicle in the first time period and $15,000 to $60,000 in the second. Obviously, these costs are much higher than those assumed by NESCAUM. The use of these or similar estimates would have a profound impact on the estimated economic impacts associated with any program requiring the near-term introduction of large numbers of PHEVs and EVs.

Other recent CARB publications have referenced PHEV and EV cost estimates published in a recent study by the Massachusetts Institute of Technology (MIT).[†] This study

[*] "Staff Report: Initial Statement of Reasons 2008 Proposed Amendments to the California Zero Emission Vehicle Program Regulations," California Air Resources Board, February 8, 2008.
[†] See *http://web.mit.edu/sloan-auto-lab/research/beforeh2/otr2035/On%20the%20Road%20in%202035_MIT_July%202008.pdf*

estimates that (1) the incremental cost of PHEVs will range from $5,900 to $8,300 per vehicle relative to conventional passenger cars and light-duty trucks, respectively, in 2035; and (2) the incremental costs for EVs will range from $14,400 and $22,100 per vehicle for passenger cars and light-duty trucks, respectively, again in 2035. Given these estimates and the fact that they apply to vehicles that will not be produced until 25 years from now, it is difficult to see how NESCAUM can justify assuming incremental costs of $5,000 or $0 per vehicle during the 2013 to 2023 timeframe.

Independent Assessment of Current CARB Assumptions Regarding EV and PHEV Technology – NESCAUM must broadly consider the range of available data and information in the literature regarding EVs and PHEVs and not selectively use only the most optimistic estimates. For example, as noted above, CARB's latest estimates regarding EVs and PHEVS are far less optimistic than those used by that same agency in assessing the California LCFS regulation and those that NESCAUM is now using. However, even these most recent CARB estimates have been criticized as being too optimistic in an independent scientific review conducted by the following four experts, who were engaged by CARB:

1. Dr. Menahem Anderman,[*] Advanced Automotive Batteries;
2. Dr. David Greene, [†] Oakridge National Laboratory;
3. Dr. Joan Ogden,[‡] University of California, Davis; and
4. Dr. Giorgio Rizzoni and Dr. Vincenzo Marano,[§] Ohio State University.

According to Dr. Anderman, for example, battery costs and durability are and will continue to be major issues limiting the commercial viability of PHEVs and EVs. With respect to cost, Dr. Anderman remarked that PHEVs will not be cost competitive with conventional vehicles at gasoline prices below $7 per gallon and that even higher prices would be necessary for EVs. With respect to battery durability, he noted that there was no evidence that lithium-ion batteries would last anywhere near 10 years in customer service, and he was particularly critical of CARB staff's reliance on battery cost and performance data from Tesla Motors. With respect to those data, Dr. Anderman noted the following:

> *…we suggest avoiding the use of Tesla data as criteria for battery cost. Tesla uses computer cells that have a life expectancy on the order of 2 to 4 years, and there are no data in the public domain to project their durability and reliability in a vehicle battery. Tesla may have a business motivation other than profitability to sell an aftermarket battery option with the original vehicle.*

[*] See *http://www.arb.ca.gov/msprog/zevprog/2009zevreview/anderman_review.pdf*
[†] See *http://www.arb.ca.gov/msprog/zevprog/2009zevreview/greene_review.pdf*
[‡] See *http://www.arb.ca.gov/msprog/zevprog/2009zevreview/ogden_review.pdf*
[§] See *http://www.arb.ca.gov/msprog/zevprog/2009zevreview/rizzoni_review.pdf*

Dr. Anderman also issued the following caution to CARB staff with respect to its economic analysis of EVs:

> *…recognize that economic analyses of EVs based on a 10-year battery life will simply shatter if the actual battery life in the field does not meet this expectation, and two or more batteries are required over the useful life of the car*.

Similarly, with respect to CARB staff's use of electric vehicle cost data from a Massachusetts Institute of Technology study, Dr. Greene noted the following:

> *Even for conventional vehicles, the MIT studies point out clearly that supporting policies must be in place to insure that technologies are used to reduce GHG emissions rather than increase power, weight or accessories. The MIT study, however, is less optimistic about batteries and their future costs. Given the MIT projections, it is hard to see how BEVs will ever be commercially viable unless there is a breakthrough that the MIT researchers did not anticipate. This has implications for the ZEV program that should be examined because it has implications for the role of infrastructure provision and other supporting policies.*

Similarly, the review by Dr. Rizzoni and Dr. Marano, which focused primarily on PHEVs, took issue with CARB staff's projections for PHEV sales volumes, which were characterized as overly optimistic.

NESCAUM should examine the work of these reviewers and other available sources of information and data to establish reasonable ranges for the assumptions used in the economic analysis regarding EVs and PHEVs.

<u>Assumptions Regarding Recharging Time of Day and Electricity CI</u> – The Electric Vehicle Future scenario assumes that "smart charging" will occur such that 90% of EV charging will occur during off-peak hours, with 10% of charging occurring during peak hours. In contrast, the reference cases and the other policy scenarios assume that recharging will occur 50% on-peak and 50% off-peak. NESCAUM does not disclose the basis for these assumptions and it is not clear that either assumption is reasonable.

The assumptions regarding off-peak and on-peak charging are intended to impact the assumed cost of electricity used to power electric vehicles, as the cost of off-peak charging is generally lower because it is usually provided by the most economic sources. However, Tables 7A and 7B do not show NESCAUM's assumptions regarding the cost of electricity, so we cannot comment on the reasonableness of NESCAUM's assumptions regarding on- and off-peak rates.

In addition, NESCAUM assumes that the increase in regional power demand needed to accommodate electric vehicles will be met by existing and planned generating resources and that the average CI of this power will be equal to the average CI for electricity generated in the region. NESCAUM further assumes that the average CI of electricity will decline over time due to other GHG reduction initiatives.[*] To the extent that the GHG benefits of the change in electricity CI are attributable to these other programs, claiming them again for the NE/MA LCFS appears to represent a "double counting" of GHG reductions.

Another issue related to electricity CI and when charging occurs is whether there is a significant change in the regional CI of electricity that occurs during the course of the day due to changes in the mix of generating sources required to meet demand. NESCAUM appears not to have considered this potential issue and we recommend that it be investigated.

Similarly, studies have shown that the magnitude of "well to wheels" GHG reductions attributable to EVs is highly sensitive to the generating technology used to meet the incremental electrical demand. Likewise, the infrastructure costs of new generating capacity vary depending on whether EV charging is unrestricted, or subject to smart charging constraints. It is generally understood that a tradeoff exists between the costs of new generating capacity and GHG reductions. Specifically, unconstrained charging will require investment in new generating capacity, and therefore entail higher overall costs compared to smart charging. However, the new generating capacity can be assumed to have a lower CI than the existing portfolio average, thereby maximizing GHG reductions.

This conclusion was reached in the same Argonne National Laboratory study referenced above, which stated:

> *Unconstrained charging (with investments in new generation capacity) reduces GHG emissions (Figure ES.1, vertical axis) compared with smart charging (no needed investment in new capacity) because of the high efficiency and low carbon intensity associated with the added capacity in the unconstrained charging scenario.* [†]

Furthermore, depending on the generating technology and fuel, all-electric operation of EVs could result in <u>no GHG reductions</u> compared with conventional gasoline vehicles, and <u>increased GHG emissions</u> compared with current hybrid technology, as stated by Argonne:

> *PHEVs recharging from a mix with a large share of coal generation (e.g., Illinois marginal mix) produce GHG emissions comparable to those of baseline gasoline ICEVs (with a range from -15% to +10%) but significantly higher than those of gasoline HEVs (with a range from +20% to +60%). <u>The range of the results is primarily attributable to the different generation mix for the charging scenarios</u>*

[*] NESCAUM, August 12, 2010 presentation, Slide 28.
[†] Argonne National Laboratory, "Well-to-Wheels Analysis of Energy and Greenhouse Gas Emissions of Plug-In Hybrid Electric Vehicles," A. Elgowainy et al., June 2010, p. 3. Available at URL: *http://www.transportation.anl.gov/pdfs/TA/629.PDF*, Accessed August 20, 2010.

> *considered and the different PHEV types (power-split versus series designs).*[*] [emphasis added]

Argonne's final conclusion concerning GHG regulations from EVs is as follows:

> *To achieve significant reductions in GHG emissions, PHEVs and BEVs must recharge from a generation mix with a large share of nonfossil sources (e.g., renewable or nuclear power generation).*[†]

Because of the sensitivity of GHG reductions to the recharging generation mix, NESCAUM should evaluate multiple cases under the Electric Vehicle Future scenario, including both unconstrained and smart charging via both existing and new generation capacity. This evaluation should address a range of CIs for new generation capacity to reflect the uncertain levels of new renewable resources coming online.

<u>Energy Efficiency Ratios and Well to Wheels GHG Reductions for Electric Vehicles</u> – NESCAUM's use of the same Energy Efficiency Ratio (EER) assumptions that CARB used in its analysis of the California LCFS is a significant concern. In particular, CARB staff did not make any adjustments to the fuel economy estimates of EVs or conventional vehicles to reflect the impacts of actual operation. A recent study by Argonne National Laboratory[‡] has found that real-world EV operating conditions have an important influence on well-to-wheels GHG comparisons relative to conventional gasoline vehicles. Another important factor is ensuring that the EV is compared with a gasoline vehicle of equivalent performance. As data become available on real-world energy use by EVs and PHEVs, it is imperative that the EER value for EVs be re-evaluated.

Another example that shows the potential for the CARB EERs to be misleading can be seen in other CARB treatments of the issue in connection with the Pavley regulations (Section 1961, Title 13, California Code of Regulations). For purposes of the Pavley regulations, all EVs are assigned an emission rate of 130 grams per mile (g/mi) of CO_2 equivalent emissions. Standards for passenger cars are 301 g/mi for the 2010 model year and 205 g/mi for the 2016 model year. These values would indicate that the EER for EVs should change over time, starting at about 2.3 for 2010 model year vehicles and decreasing to 1.6 for 2016 model year vehicles.

Obviously, use of EERs that are too high for EV and PHEV operation will overstate the CI reductions those vehicles will be capable of providing. Again, NESCAUM needs to carefully examine all available information, not simply rely on questionable assumptions made by CARB staff in analyzing the California LCFS.

<u>Recharging Infrastructure</u> – While the capital costs estimates associated with electric vehicle recharging infrastructure appear reasonable (and it should be noted are of approximately the same magnitude of those assigned to the incremental costs of vehicles

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[*] Ibid.
[†] Ibid. p. 4
[‡] See *http://www.transportation.anl.gov/pdfs/TA/629.PDF*

even under the "high" cost case), it is not clear that NESCAUM has made appropriate assumptions regarding the number of units required, particularly in light of the different time-of-day charging assumptions being made in the analysis. Because electric vehicle infrastructure costs do not yet appear in NESCAUM Tables 7A and 7B, this important issue cannot be specifically addressed at this time.

3.3 Biofuels Future

Assumed Ethanol Blend Level, FFV Populations and E85 Consumption – NESCAUM indicates[*] that it is assuming that the ethanol-gasoline blend level will be 10% by volume and that the economic impact analysis will rely on EPA projections for FFV populations, required E85 infrastructure, and E85 consumption, presumably from the RFS2 RIA.

U.S. EPA is currently considering a fuels waiver request under the Clean Air Act submitted by Growth Energy. If approved by EPA, it could raise the allowable limit of ethanol in mid-level blends to 15% by volume. NESCAUM should consider the potential E10+ blends up to E15 in the reference cases and policy cases of the analysis.

With respect to the use of the assumptions made by EPA regarding FFVs, E85 use, and required infrastructure in the RFS2 RIA, Sierra has previously published a detailed analysis regarding those assumptions.[†] That analysis found that the RIA substantially overstated future ethanol use in FFVs as the result of unrealistic assumptions regarding FFV volumes and the propensity of motorists to fuel those vehicles with E85. NESCAUM's use of the same RIA assumptions will lead to a LCFS economic analysis that is similarly flawed, with issues that include an overestimation of the amount of E85 consumed and an underestimation of E85 infrastructure costs. We attach this report and urge NESCAUM to consider its implications to its current work.

One of the key EPA/NESCAUM assumptions regarding FFVs is that vehicle manufacturers will produce large volumes of these vehicles throughout the period ending in 2023. A number of issues are associated with this assumption.

First, although FFVs are currently produced by a number of manufacturers, FFV production is not required under any regulation. The primary motivation for those manufacturers currently producing FFVs is that federal law provides limited credits 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

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[*] NESCAUM, August 12, 2010 presentation, Slide 31.

[†] "Technical Review of EPA Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis for Non-GHG Pollutants," Sierra Research Report No. SR2010-05-01, May 2010.

FFVs. Given the above, it is not clear that large numbers of FFVs will in fact be produced, without new programs designed to call them out.

Second, it is not clear that FFVs can be certified to California emission standards—something that is critical in those northeast states enforcing California vehicle regulations. FFV compliance with the most stringent CARB emission standards is proving very difficult for some vehicle manufacturers and will become an increasingly important issue in future years.

Third, NESCAUM assumes that the incremental cost is either $100 per vehicle or $0 per vehicle depending on the scenario. In contrast, CARB assumed $200 per vehicle in assessing the economic impacts of the California LCFS, which did not include the costs of designing FFVs for compliance with the agency's most stringent emission standards. Thus, NESCAUM's assumptions that large volumes of FFVs will be in the fleet at a minimal cost do not appear to be reasonable.

<u>Concerns with NESCAUM's Assumptions Regarding Fuel Production Under the Biofuels Future Scenario</u> – The Biofuels Future scenario rests on the assumption that EISA's annual mandate volumes for advanced biofuels through 2022 will be met. However, EPA has acknowledged that the cellulosic biofuels portion of the mandate for 2011 will not be met, and almost surely will have to do so again next year. In *AEO2010*, EIA projects domestic production of cellulosic biofuels falling well short of the mandated volumes through 2022 and beyond. (In particular, *AEO* projects advanced biofuels production of about 8.2 billion gallons per year [bgy] in 2022 vs. the 21 bgy mandated by EISA.) In addition, the Biofuels Future scenario assumes that "the low-CI fuels produced as a direct result of the LCFS incentives are likely to be produced in the NE/MA region." For reasons discussed below, this may not be a realistic expectation.

The Logical Implications of NESCAUM's RFS2 Mandate Assumption – NESCAUM apparently assumes that the RFS2 program volumes would be fully achievable by 2022; that is, the national biofuel volumes mandated in EISA would be produced. Under that assumption, given the projected energy demands in *AEO*'s reference and High Oil Price cases and using EPA assumptions regarding (1) CI values for biofuels, (2) relative volumes of biofuels (from EPA's Primary Control Case), and (3) production technologies of choice for biofuels, the national CI of motor fuels in 2022 would be about <u>6½%–7½%</u> lower than that of the baseline 2006 motor fuel pool. If, instead, national biofuel volumes were as projected in *AEO*, the national CI of motor fuels in 2022 would be about 4% lower than the baseline 2006 motor fuel pool given the projected energy demands in *AEO*'s reference case and about 6% lower given the projected energy demands in *AEO*'s High Oil Price case.

Thus, NESCAUM's assumption that the RFS2 program would be fully implemented by 2022 allows it to claim a substantial share of its contemplated CI reduction, but fails to consider the costs associated with the RFS2 in assessing the economic impacts of the NE/MA LCFS.

In establishing its two reference cases, NESCAUM also apparently intends to allocate to California more than its "pro rata" share of advanced biofuels produced in the U.S. The assumption is that California will absorb advanced biofuels produced in distant locations, such as the Midwest, as a means of satisfying its LCFS program. (NESCAUM's methodology for estimating volumes of advanced biofuels shipped to California from distant regions has not yet been provided.) NESCAUM then apparently plans to allocate, on a "pro rata" basis, the remaining volumes of advanced biofuel (and corn ethanol) to all other regions of the country, including NE/MA.

But this methodology contains a logical market contradiction that affects the entire analysis of the various policy scenarios. Both California and the NE/MA region would have LCFS programs; if, by assumption, California would bid away advanced, low-CI biofuels from the rest of the country, then so too could NE/MA. Indeed, EPA's RIN system would facilitate this process. Further, most sources of advanced biofuels (Midwest- and Southeast-based cellulosic ethanol and imported sugarcane ethanol) would be closer to NE/MA than to California, so that NE/MA would have an economic advantage over California in bidding away these biofuels.

Under NESCAUM's assumption of full implementation of the RFS2 program, the CI of the national motor fuel pool in 2022 would be about 6½%–7 ½% less than the baseline CI; NE/MA probably could meet its 10% CI reduction target entirely through shifts in the sourcing of the biofuels it uses (relatively more advanced, low-CI biofuels would be used in the NE/MA, and relatively less of these fuels would be used elsewhere), with a resulting increase in transport costs and an increase in GHG emissions associated with transport over longer distances. This "shuffling" of biofuels volumes would yield little or no net reduction in the national CI of motor fuels—relative declines in California and in NE/MA would be offset by relative increases elsewhere.

Thus, the logical implication of the assumptions NESCAUM plans to make regarding the reference case is that the LCFS program would have little effect on (1) national GHG emissions and (2) the production of additional volumes of biofuels in NE/MA.

The Economics of Advanced Biofuels Production – Table 3-3 (showing values from NESCAUM Tables 7A & 7B) summarizes the estimated costs of production of cellulosic ethanol and other advanced biofuels to be used in the NESCAUM analysis. As discussed further below, the cost estimates shown in the table appear to contain some anomalies.

- NESCAUM does not spell out the nature of the Agricultural Biomass feedstock. Is it agricultural waste (e.g., corn stover), an on-purpose energy crop (e.g., switchgrass), or something else? Whatever the feedstock may be, its Low and High production costs are the same in Tables 7A & 7B.

- The capital charges for the Mixed Cellulosic, Municipal Solid Waste, and Woody Biomass production pathways are slightly *lower* than the capital charges for the Sugar Cane pathway.

Table 3-3

Estimated Production Costs of Advanced Biofuels in NESCAUM's Analysis ($2010/gal)
(from NESCAUM Tables 7A and 7B, August 13, 2010)

Feed Type	Cost Category	Production Cost ($/gal) Low	Production Cost ($/gal) High
Cellulosic Ethanol			
Mixed Cellulosic	Feedstock	$0.66	$0.85
	Capital	$0.28	$0.42
	Production	$0.10	$0.62
	Distribution	$0.17	$0.21
	Total	**$1.22**	**$2.10**
Municipal Solid Waste	Feedstock	$0.00	$0.85
	Capital	$0.28	$0.42
	Production	$0.10	$0.62
	Distribution	$0.17	$0.21
	Total	**$0.55**	**$2.10**
Woody Biomass	Feedstock	$0.29	$0.85
	Capital	$0.84	$0.42
	Production	$0.41	$0.62
	Distribution	$0.21	$0.21
	Total	**$1.74**	**$2.10**
Agricultural Biomass	Feedstock	$0.43	$0.43
	Capital	$0.75	$0.75
	Production	$0.71	$0.71
	Distribution	$0.21	$0.21
	Total	**$2.09**	**$2.09**
Sugar Cane Ethanol			
Sugar Cane	Feedstock	$0.44	$0.27
	Capital	$0.45	$0.47
	Production	$0.52	$0.46
	Distribution	$0.15	$0.41
	Total	**$1.56**	**$1.61**
	Tariff/Tax		$0.58
	Total + Tax		**$2.19**
Soybean Biodiesel			
Soybean Oil	Feedstock	$1.61	$1.61
	Capital	$0.07	$0.07
	Production	$0.22	$0.22
	Distribution	$0.14	$0.14
	Total	**$2.04**	**$2.04**
	Subsidy		
Cellulosic FT Diesel			
Wood Chips	Feedstock	$0.42	$0.42
	Capital	$1.49	$1.49
	Production	$1.02	$1.02
	Distribution	$0.14	$0.14
	Total	**$3.07**	**$3.07**
	Subsidy		

Given that (1) the process flow scheme for sugar cane ethanol is much simpler than those for any of the cellulosic ethanol pathways and (2) sugar cane ethanol production uses mature process technology, one would expect that the capital investment and resulting per-gallon capital charge for the cellulosic pathways would be substantially higher than for the sugar cane pathway (by a factor of about three for the Mixed Cellulosic, Municipal Solid Waste, and Woody Biomass production pathways). For example, an analysis conducted by MathPro Inc. for API in 2007 (and based on investment figures published by DOE and SRI International) indicated an investment cost of about \$6/gal/year and a capital charge on the order of \$1.20/gal (\$2007) for cellulosic ethanol production.

- The production cost of sugar cane ethanol is lower in the High estimate (\$0.46/gal) than in the Low estimate (\$0.52/gal).

- The Low estimates of total-per-gallon production costs for the Mixed Cellulosic and Municipal Solid Waste pathways (for ethanol, \$0.10/gal) seem extremely low, indeed they are lower than the cost of plant labor alone.

- The High estimates of total per-gallon production costs for all of the cellulosic ethanol pathways are virtually identical to one another and are slightly less than the estimated production cost (including tariff and taxes) of the sugar cane pathway.

- The Low and High estimates of the diesel pathways–Soybean Biodiesel and Cellulosic FT Diesel—are the same.

- The feedstock costs for Soybean Biodiesel appear to be too low. Recent USDA baseline projections place soy-oil prices at \$0.35–\$0.40/lb, corresponding to about \$2.65–\$3.00/gal. (*http://www.ers.usda.gov/Briefing/Baseline/data.htm*)

NESCAUM should reassess its estimates of the prospective future costs of cellulosic biofuels production before proceeding further with the analysis.

On first principles, the investment costs and plant operating costs of cellulosic ethanol production are likely to always be substantially, not marginally, higher than the corresponding costs of corn ethanol or sugar cane ethanol.

- Cellulosic ethanol production would be intrinsically more complex—requiring more processing steps, more severe operating conditions, and more energy—than conventional ethanol production.

- Production and preservation of the special biochemical agents used in cellulosic ethanol production would incur significant costs not incurred in corn ethanol production.

- Because of their seasonal nature, the most prospective feeds for cellulosic ethanol production—agricultural waste (e.g., corn stover) and on-purpose energy crops (e.g., switchgrass, poplar)—would incur higher costs of acquisition, storage, and handling than the corresponding costs for corn ethanol.

  Cellulosic ethanol plants using agricultural feeds would require facilities to receive a year's worth of feedstock (500–600 K tons) in a short time and then to store, dry, preserve, pre-process, and convey the feed ratably to the process plant over a year's operation. Analysis of a recent announcement by a prospective cellulosic ethanol producer (Genera Energy) regarding a switchgrass receiving facility suggests that these operations would cost about $0.40–0.50/gal ethanol (assuming a yield of 100 gal/ton). By contrast, USDA data indicate that the difference between the farm price of corn and the delivered price of corn (ready for processing) corresponds to about $0.15–0.20/gal ethanol.

- For reasons of feedstock supply economics and infrastructure, the most economic size for future cellulosic ethanol (and diesel) plants would tend to be ≈ 50–60 M gal/yr. vs. ≈ 100 M gal/yr. for corn ethanol plants. Hence, all else equal, cellulosic ethanol (and diesel) plants would not enjoy economy-of-scale in capital investment to the same degree as corn ethanol or sugar cane ethanol plants.

The NESCAUM analysis appears to reflect none of these considerations. NESCAUM is using estimates of future capital investment and production costs for cellulosic ethanol and bio-diesel that originally were published by EPA and CARB and subsequently adjusted by NESCAUM. (NESCAUM Tables 7A, 7B, and 8 [Slide 65]). EPA and CARB appear to have developed these estimates with commendable thoroughness and attention to detail. Indeed, the estimated capital investment costs quoted in Table 8 have nine significant figures—a truly noteworthy degree of precision. Unfortunately, this precision is unlikely to be matched by a corresponding degree of accuracy. As noted above, we consider the estimates cited by NESCAUM to be quite optimistic, and the future project economics they suggest are unlikely to be realized in practice during the NE/MA LCFS timeframe.

The prospective full investment and operating costs associated with the commercial production of cellulosic ethanol are highly uncertain at present. No cellulosic ethanol plants are in commercial operation in the U.S. or indeed anywhere else in the world, and no established commercial processes exist for cellulosic ethanol production. Critical technical problems remain to be solved in key components of all process pathways now under investigation or development before they can achieve commercial status. Moreover, each prospective biomass feed—corn stover (agricultural waste), switchgrass (on-purpose crop), wood waste, municipal solid waste—calls for a somewhat different processing scheme, poses unique technical challenges and constraints, has unique feedstock and infrastructure requirements, and has its own investment requirements and prospective costs of production.

These uncertainties make it risky to project either cellulosic ethanol's economics in future commercial operations or the time at which such operations might commence. The differences between the High and Low estimates of investment and per-gallon production costs shown in Tables 7A, 7B, and 8 fall well short of capturing the magnitude of these uncertainties. Indeed, the range mainly reflects *assumed* improvements in ethanol yield per unit of biomass between now (High estimates) and 2022 (Low estimates).

NESCAUM's presentation indicates no further acknowledgment of the uncertainty in the prospective economics of future cellulosic ethanol production.

Moreover, the production cost estimates presented by NESCAUM reflect some unrealistic and indeed inappropriate assumptions, as outlined below.

- In the EPA-generated estimates adopted by NESCAUM, the indicated capital charges reflect a cost of capital of 7% *before taxes*. This rate of return is consistent with the rate EPA uses in estimating the social cost of a new regulatory program. However, it is well short of the range of expected returns (≈ 10%–15% *after tax*) that private investors or lenders would demand before committing to a well-defined capital project in a process industry (e.g., refining, chemicals, etc.). It is reasonable to expect that investors would seek a higher return on investments in first-of-a-kind projects employing pioneering technologies and relying on subsidies or mandates for their economic viability. Applying a 15% after-tax return instead of the 7% pre-tax return (with a 20-year project life) would raise the capital costs shown in Tables 7A & 7B by about 60%, or about $0.25–0.45/gal (depending on the cellulosic feedstock), assuming no change in the underlying capital investment estimate.

- In preparing its capital investment estimates for future low-CI production facilities (Table 8), NESCAUM multiplied corresponding estimates published by EPA and CARB by a factor of 0.908 to convert $2007 (in which the EPA and CARB estimates are expressed) to $2010 dollars. This factor is the Producer Price Index for gasoline over the period. Use of this index—which has the effect of reducing the apparent investment required for low-C production facilities—is inappropriate for the purpose. The appropriate index for escalating 2007 cost estimates is the GDP deflator, which is about 1.06 for the period in question.

  Consequently, both the investment estimates in Table 8 and the corresponding per-gallon capital charge estimates in Tables 7A and 7B are understated by about 17% (= (1.06/0.908) – 1), with respect to the investment estimates quoted in the EPA and CARB references. Correcting this error adds about $0.05–$0.12/gal to the capital charges and total production costs of the cellulosic ethanol pathways and about $0.25/gal to the Fischer-Tropsch diesel pathway.

- As noted above, cellulosic ethanol plants using agricultural feeds (waste products or on-purpose crops) would require facilities to receive a year's worth of feedstock in a short time and then to store, dry, preserve, pre-process, and convey the feed ratably to the process plant over a year's operation. Building and operating these facilities would add about $0.40–0.50/gal to the production cost of cellulosic ethanol produced from agricultural feeds. The cost estimates for the relevant pathways in Tables 7A & 7B do not appear to include this cost element.

Advanced Biofuels Production in the NE/MA Region – The Biofuels Future scenario assumes that "the low-C fuels produced as a direct result of the LCFS incentives are likely to be produced in the NE/MA region" (Slide 32). This assumption is crucial to NESCAUM's estimation of the prospective benefits to the NE/MA region under each in each scenario, especially the Biofuels Future scenario.

At present, the NE/MA states are home to just three of the nearly 150 corn ethanol plants in the U.S. These three account for just over 1% of U.S. corn ethanol production. Consequently, the region's physical and commercial infrastructure for moving corn to market is sparse. Most U.S. ethanol production is concentrated in the agricultural heartland between the Appalachians and the Rockies. Unlike NE/MA, this heartland is rich in the physical, commercial, and human resources (including the EPC companies that specialize in designing and building biofuels plants) that are needed to support rapid expansion in biofuels production.

NESCAUM's assumption that the low CI fuels produced as a direct result of the LCFS incentives are likely to be produced in the NE/MA region appears implausible on its face. NESCAUM offers no rationale for this assumption other than a suggestion of large municipal solid waste availability. NESCAUM remedy this omission to facilitate stakeholders' assessments of the results of the study.

3.4 CNG Future

The CNG Future Scenario is Not Plausible – The CNG future scenario assumes that increased use of natural gas will reduce the CI of transportation fuels by 6% and that the incremental cost of the vehicles operating on that fuel will be zero.

This scenario is simply not plausible. NESCAUM should eliminate it from the analysis, and should modify the other two scenarios to eliminate the 2% CI reduction attributable to CNG vehicles

At present, only a limited number of models of light-duty natural gas vehicles are available and those have significant incremental costs associated with the need for high-pressure gas storage tanks, vehicle design changes, and other factors. These vehicles, which are generally dedicated to operation only on natural gas, have significant range limitations and are generally used in fleet operations that can accommodate their limited range and provide centralized refueling facilities. Viable applications include taxi and utility fleets. Given the nature of natural gas vehicles, their current production status, and lead-time requirements for both vehicle production and refueling infrastructure, it is highly unlikely that significant volumes of light-duty CNG vehicles will come into operation between now and 2023.

The situation is similar for heavy-duty natural gas vehicles and engines. At present, there are only a limited number of engine manufacturers, and vehicle applications are generally restricted to fleet operations such as transit buses and garbage collection vehicles. Obviously, given the long-distance nature of most trucking operations, using natural gas to fuel over-the-road vehicles would not be feasible unless there were a nationwide public refueling infrastructure.

In addition to the above, while the incremental costs of $7,000 and $40,000 per vehicle for light- and heavy-duty CNG vehicles appear to be reasonable, it is completely unreasonable to assume that they will become $0 per vehicle under the CNG future scenario. These costs are mainly associated with the high-pressure storage tanks required for CNG and other hardware that is specific to CNG vehicles that are not likely to change significantly even with high-volume CNG vehicle production.

As noted above, the creation of a widespread refueling infrastructure is also a key factor with respect to public acceptance of CNG vehicles. This infrastructure will be very expensive to create and could pose serious logistical challenges if NESCAUM expects CNG refueling facilities to be co-located with existing vehicle refueling stations. These facts must be appropriately accounted for in the CNG future scenario.

Finally, NESCAUM needs to reconsider its assumption that imposing LCFS requirements on existing fuel producers will be an economically efficient means of forcing the introduction of CNG vehicles and refueling infrastructure into the region. These current fuel producers obviously do not have any control over the types of vehicles that auto manufacturers produce and are generally not involved in the distribution of natural gas in the region. If the goal of the northeast LCFS is to achieve a “CNG future,” it seems much more appropriate to impose the necessary requirements and to provide incentives to vehicle manufacturers and current distributors of natural gas.

<u>Biogas Quality, Cost, and Volumes</u> – It is well known that the quality of natural gas produced from landfills or gasification of biomass may be of inferior quality to pipeline gas. This is significant for at least two reasons. First, the use of natural gas that falls outside of certain quality ranges as a transportation fuel can cause either increases in criteria pollutant emissions from vehicles and/or problems with vehicle operability and engine damage. Second, improvement of biogas quality will increase its cost of production. NESCAUM needs to clearly indicate what the assumptions are regarding biogas quality and cost and ensure that those assumptions are consistent. Finally, it is not clear that NESCAUM’s assumptions regarding feasibility and costs associated with developing the required biogas production capability in the northeast are reasonable.

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