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Todd R. Campbell, MEM, MPP
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Clean Energy®

October 24, 2008

Mr. Floyd Vergara, Esq., P.E.
Manager, Industrial Section
California Air Resources Board
1001 I Street
Sacramento, CA 95814

Re: **Clean Energy's Comments on CARB's Draft Comparison of Greenhouse Gas Emissions from Natural Gas and Diesel Vehicles**

Dear Mr. Vergara:

Clean Energy appreciates the opportunity to offer additional comments on the California Air Resources Board's (CARB) draft Comparison of Greenhouse Gas Emissions from Natural Gas and Diesel Vehicles (noted as "Comparison Document" herein). Attached are written comments previously submitted by Clean Energy that we request also be included in the public record for this "Comparison Document":

- Appendix A – September 29, 2008 letter from Todd Campbell, Director of Public Policy for Clean Energy
- Appendix B – October 6, 2008 letter from Todd Campbell, Director of Public Policy for Clean Energy
- Appendix C – September 28, 2008 memorandum from Jennifer Pont, TIAX to Clean Energy entitled "Review of ARB's "Comparison of Greenhouse Gas Emissions from Natural Gas Vehicles and Diesel Vehicles"

Transparency:

Appendix C – the TIAX review of the Comparison Document vs. previous GREET modeling – highlights a number of issues regarding transparency of the process. On-line versions of GREET are not consistent with the version of GREET that CARB used for the Comparison Document. There is no documentation to explain the changes that CARB has made to GREET, nor is there buy-in that these changes are appropriate. Without documentation, there is absolutely no way for interested parties to critique the results in the Comparison Document.

CARB has published several pathway studies for fuels and has posted these on the CARB website. These reports go into extensive detail regarding input assumptions to the GREET model. No such documentation exists for the current GREET model CARB used for the Comparison Document. None of the currently published fuel pathways have been modified to reflect changes that CARB has made to the model.

LNG and CNG Pathways:

Appendix B defines what Clean Energy believes are the correct pathway assumptions for LNG fuel in California. These include the potential of producing LNG fuel from Canadian, Rocky Mountain, Permian Basin, San Juan Basin, out-of-state landfill gas, and in-state landfill gas. Clean Energy believes that the only viable pathway that includes off-shore import LNG will be through the LNG terminal in Baha – with truck transport of the fuel to the Southern California market. It is not realistic to expect that LNG from an import terminal will be gasified into a pipeline, conveyed to an LNG production facility, and re-liquefied.

Members of the California Natural Gas Vehicle Coalition (including Clean Energy) met with the CEC on Friday, October 10 to discuss our concerns with the LNG pathways represented in the Comparison Document. The CEC agreed with the NGV industry that LNG scenarios in the Comparison Document were unrealistic given the natural gas supply picture for the U.S. and the large finds of unconventional gas shale resources.

California's only LNG production plant feeds off the Kern pipeline (natural gas that comes from the Rockies) and cannot receive imported natural gas from any existing or proposed LNG import terminal. Furthermore, knowing that there would be certain regulatory liability for any proposed California LNG production facility under the LCFS that would require imported natural gas now or in the future, significantly diminishes the likelihood of this outcome based on the economics alone. Companies in the LNG business would more than likely build facilities that harness dedicated domestic sources of natural gas.

Even if LNG were to be imported at some point in the future to California, the markets that would receive imported natural gas would be constrained to the state's lower regions. Furthermore, any gas received from an LNG production facility or a CNG station would receive a mixture of domestic and imported natural gas with the domestic ratio significantly higher and the imported ratio marginal at best. Because of this reality, LNG and CNG pathways presented by CARB that use imported LNG should reflect a realistic domestic-import natural gas ratio and not assume that the facility would somehow use 100% imported natural gas for its production of LNG for vehicles.

Potential CNG pathways include all the natural gas sources listed above brought to California and compressed, in addition to LNG terminal gas in Baha being conveyed to Southern California markets and compressed.

All the pathways that CARB eventually uses for the LCFS need to be appropriately documented in thorough pathway reports as previously published and posted by CARB on their web site.

Marginal Sources of Natural Gas:

It is not stated in the Comparison Document, but it appears that the analyses in the Comparison Document define the carbon content of the marginal supply of natural gas (and diesel) – the next increment of gas (or diesel) added to the system. While the pathway assessments are required to perform an assessment of the marginal supply characteristics – this analysis is not complete without defining the percent contribution of each of the pathways in the total marginal mix. The Comparison Document infers

that the marginal supply will be 100% off-shore LNG. Given the rapidly expanding natural gas resource base of gas shale deposits in the U.S., it is doubtful that any significant amount of import LNG will be needed in an expansion of a California or national NGV market.

It is appropriate that CARB consult its sister agency, the CEC, to determine the mix of natural gas sources in a marginal supply scenario.

Comparison with a Low Carbon Diesel Fuel:

In the Comparison Document, CARB compares CNG and LNG with a low carbon diesel fuel that has yet to be defined. Conversely, CARB fails to include in its analysis of CNG and LNG the potential of low carbon renewable sources of natural gas such as those produced by landfills, waste water treatment facilities, and agricultural wastes.

A pathway analysis of landfill gas was conducted by TIAX under contract with the CEC in the spring of this year. This pathway analysis was reviewed by the CEC and sent to CARB for its review shortly afterward. CARB has yet to publish the pathway analysis of landfill gas – even though the NGV industry requested this pathway in late 2007. The NGV industry would like to see the landfill gas pathway published and future CARB analyses include landfill/renewable natural gas in comparisons with other fuels.

Conclusions:

Clean Energy appreciates the responsiveness of staff to our concerns as documented in Appendices A through C. We will continue to be a supporter in developing a comprehensive and meaningful Low Carbon Fuel Standard for California.

Sincerely,

Todd R. Campbell

cc: Dean Simeroth
Linda Lee

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September 29, 2008

Mr. Floyd Vergara, Esq., P.E.
Manager, Industrial Section
California Air Resources Board
1001 I Street
Sacramento, CA 95814

Re: Clean Energy's Comments on CARB's Draft Comparison of Greenhouse Gas Emissions from Natural Gas and Diesel Vehicles.

Dear Mr. Vergara:

Thank you for allowing the public to comment on the California Air Resources Board's (CARB) draft comparison of greenhouse gas emissions from natural gas and diesel vehicles (noted as "Comparison Document" herein).

Clean Energy has several comments and serious concerns pertaining to this document, including a complaint on process. This document appears to have been created August 10, 2008, distributed to a limited set of stakeholders on September 9, 2008 and does not appear to have been made publicly available. The document was not provided to Clean Energy despite the fact that we have previously submitted comments to CARB's Low Carbon Fuel Working Group. Clean Energy received no notification that this document was open for public comment from CARB. Further, as of September 19, this document could not be located on CARB's website nor is it marked "draft". Clean Energy only became aware of this draft document comparing natural gas vehicles to diesel vehicles from our colleagues in the industry. This lack of public process is both discouraging and troubling and we hope that future opportunities to comment on CARB's low carbon fuel evaluation efforts will be more open and transparent in the future. Finally, this document should be marked "draft" as it contains numerous assumptions that are subject to change and omissions that we believe must be corrected in order to achieve CARB's goals and the development of low carbon fuels. We view the current version of this document to be fatally flawed and it must be corrected before it is finalized or it may seriously impair the development of and utilization of viable low carbon fuels in the State of California.

The following are comments that we urge CARB staff to consider when they modify and update this comparison document:

First, it is very hard for anyone to adequately review, verify or question several values presented within the Comparison Document as pathways, methods and assumptions are not sourced, explained, or described. Here are a few examples:

- What assumptions and values were used to determine each pathway (LNG, CNG, CARB Diesel, and Low Carbon Diesel Pathway) presented in the Comparison Document?

    - The pathways that CARB published in April had detailed documentation on the assumptions used in the calculations. None of the assumptions are noted in the recent report. As noted in the current document, CARB has made many changes to previous assumptions but the changes are not noted.

    - Table 3 represents the first time that the industry has seen a pathway for LNG and the assumptions are not obvious. Liquefaction has two different carbon intensity values depending upon whether the LNG is liquefied off-shore or in Southern California. One needs to see the underlying assumptions before the industry can evaluate the results and their significance. We note that all of the LNG utilized in transportation in Southern California has historically been, and will for the foreseeable future continue to be, North American in origin. Utilizing foreign LNG sources to conduct this analysis is potentially very misleading.

- What assumptions and values are used in the "generalized diesel pathway" and how does this pathway vary from other diesel pathways that CARB has considered or developed?

    - In the ULSD pathway published by CARB in April, diesel had overall Wells-To-Wheels ("WTW") Greenhouse Gas ("GHG") emissions of 99.4 gmCO2e/MJ – now CARB is reporting a range of 95.9 – 96.8. What changed regarding diesel? In the April pathway, vehicle CH4 and NO2 emissions from combustion were noted as 5.2 gmCO2/MJ -- - whereas the current report says these are now zero. Please explain the basis for changing these numbers.

- Has CARB performed a "generalized CNG pathway" or a "generalized LNG pathway"? We note that there have been increases in the WTW pathway emissions for CNG – but these haven't been explained. CARB needs to publish a formal LNG pathway to reflect the same detail as was published in the April pathway reports.

    - Instead of publishing separate pathways for each fuel – then doing separate reports on the impact of vehicles, CARB has chosen to combine pathways with vehicle emissions as though they are absolute. TIAX in their AB1007 report for the California Energy Commission (CEC) made a similar mistake in combining the pathways with end-use emissions. The results are not reflective of reality or supported by facts. In the final TIAX report, the end-use emissions were reflective of the potential ratio of off-shore LNG to North American natural gas in California. CARB should use this same approach. If there was a demand for imported LNG in California – one would certainly not bring LNG into Gulf ports then

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try to cram it into a nearly full pipeline to California. ***If LNG is ever brought into California and put in the pipeline system – the GHG emissions will only be impacted by the ratio of North American gas to LNG gas – and not the full penalty subscribed to the entire pathway analysis. Moreover, it is extremely unlikely that any imported LNG will be used in transportation in California at any point in the foreseeable future given current market realities – a critical fact that is glaringly absent from the Comparison Document analysis.***

- Westport Innovations and Clean Energy commissioned TIAX earlier this year to do a Wells-To-Wheels assessment of LNG produced at Clean Energy's Boron plant and used in the Westport/Kenworth trucks at the Ports of Long Beach and Los Angeles. That assessment which modeled the performance of the Boron liquefaction plant and in-use emission of trucks showed that LNG reduced GHG emissions by 20% as compared to diesel trucks. The current CARB document we are reviewing says those GHG emission reductions would only be about 6% (using pathway #7 in the report). We respectfully believe that CARB's numbers are wrong –and in order to understand the discrepancy we must be provided the assumptions that were made by CARB in conducting their assessment.

- Why did CARB fail to consider a pathway that reflects the use of biomethane from landfills, dairy farms, or sanitation facilities? The NGV industry has been asking for this pathway assessment since the beginning of the year. We understand the study was completed by TIAX for the CEC (and CARB) in April, and still the report has not been released. Use of renewable natural gas as a transportation fuel would certainly have the impact of further reducing GHG emissions for NGVs. At Clean Energy we have recently invested in a landfill gas production facility that is currently producing substantial volumes of pipeline quality biomethane and has the potential of fueling thousands of vehicles, including heavy duty vehicles, daily with 100% renewable biomethane that reduces carbon emissions by 100% or more. This is not ten years away, or even two years away – it is happening today. Surely this is worth examination in the CARB report.

- What does "low carbon diesel" or "LCFS diesel" actually refer to in the Comparison Document? Does LCFS diesel fuel actually exist and, if so, why would the Petroleum Industry advocate for a delayed linear compliance pathway that only begins to achieve the 10% carbon reduction in years 2018-2020? If LCFS diesel does not currently exist, what is the purpose of this comparison? Further, why is biomethane, a fuel that does exist, not analyzed in the Comparison Document? Are there any scientific studies that demonstrate the carbon reduction that can be achieved through "low carbon diesel" – or does the analysis simply assume that a "low carbon diesel" will actually be produced and commercially available? It seems potentially very misleading to present data on a fuel that is not currently produced or commercially available in any quantities at present, particularly when the industry responsible for producing such a fuel has indicated that their ability

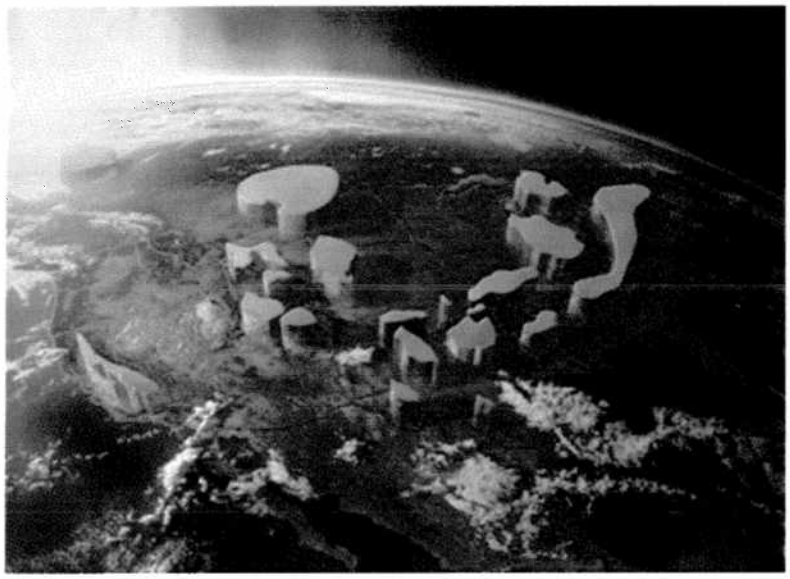
to achieve a 10% carbon reduction in diesel is at least 10 years away. As you are all too aware, California cannot wait that long for such minimal results in carbon reduction.

Second, we are also very concerned that none of the three LNG pathways represent how LNG will arrive at an LNG fueling pump in California. California does not import any LNG from overseas to meet its current natural gas demand nor will imported LNG be used to power LNG vehicles in the State of California. In fact, the only natural gas that is imported from overseas is limited to the Eastern seaboard where access to domestic natural gas supplies is constrained in certain areas. All other LNG terminals for the country are either mothballed or currently applying to become export terminals as the price of natural gas on the world market is significantly higher than what natural gas sells for here in the United States. This is largely due to the abundance of North American natural gas, complimented by recent findings of additional natural gas shale throughout the country. Advancements in technology now allow American gas producers, like Chesapeake and XTO, to capture this new natural gas resource, resulting in practically a doubling of natural gas supply.

Specifically, Clean Energy California, which is located in Boron, California, will pull its natural gas from the Colorado Rocky Mountains. Spectrum Energy Services, located in Ehrenberg, Arizona, will pull its natural gas from the Permian Basin in West Texas. Neither of these LNG producing facilities that intend to fuel California-based vehicles will draw their gas from any potential LNG import facilities nor could they as there are no pipelines that directly connect to LNG import terminals. Both terminals, however, could draw upon Clean Energy's recently acquired Dallas Clean Energy Landfill that has the capability of producing 20,000 gasoline gallon equivalents per day of pipeline quality biomethane. We therefore urge CARB to remove all three LNG pathways, as they are irrelevant and will never be utilized, and replace them with LNG producing pathways that actually reflect the reality of the marketplace. Further, we also request that CARB perform additional pathways that reflect biomethane benefits for both CNG and LNG pathways. Anything short of this would damage the LNG Fueling Industry, mislead the public as to the true benefits of LNG-powered vehicles, and quite possibly seriously and adversely impact CARB's own goal to reduce the carbon intensity in vehicle fuels.

Third, Clean Energy urges CARB to remove the two CNG pathways that draw on Canada and the Gulf from the Comparison Document as they do not reflect reality. California does not currently draw natural gas from Canada or the Gulf. According to a June 2008 study by Navigant Consulting, North American has at least a 120-year supply of natural gas – contradicting the notion that America is running out. And as the technology comes on line to develop large reserves that five years ago weren't possible to develop, that supply is growing. "The assessments and estimates on natural gas supply are very impressive and have, frankly, caught industry forecasters off guard," shared Rick Smead, one of the study's co-authors and overall project manager for Navigant Consulting. The study found that while all three unconventional gas sources have increased production over the past decade, natural gas production from shale formations is growing exponentially, increasing from less than a billion cubic feet a day in 1998, to about 5 billion cubic feet a day now. That's a compound annual rate of growth of over 20%, which is over 600% for the time period. There are at least 22 shale basins located onshore in more than 20 states in the U.S. including Texas, Oklahoma, Arkansas, Louisiana, West Virginia, Wyoming, Colorado, New Mexico, West Virginia, Pennsylvania, New York and Michigan. In conclusion,

American producers can clearly supply enough natural gas to meet today's uses and become an economical source of transportation fuel in the form of CNG or greater supplies of electricity for plug-in hybrids for generations to come.



Fourth, Clean Energy is aware that CARB has performed WTW analysis for biomethane as early as April of this year with TIAX. Clean Energy is very curious as to why this analysis has yet to become public or incorporated into the Low Carbon Fuel Standard (LCFS) analysis. It would seem only fair to include this analysis, particularly for CNG and LNG applications, as the natural gas fueling industry will and already has acquired facilities for this exact purpose. Why has CARB performed WTW analysis for all other renewable biofuels other than what is perhaps the best biofuel in terms of GHG emissions reductions for motor vehicles: biomethane? We find that odd, irresponsible, and an action that could damage the CNG and LNG fueling industry. Clean Energy urges CARB to complete its natural gas v. diesel vehicle comparison with the inclusion of biomethane pathways for all CNG and LNG pathways. As the abundant natural gas supplies being developed in North America continue to bring down prices for natural gas, it is critical to demonstrate the GHG reduction value of utilizing biomethane as a transportation fuel in order to sustain investment in biomethane projects.

For the purpose of the LCFS it is important that CARB publish separate comprehensive fuel pathway reports for fuels and not try to combine the pathways with in-use emission modeling. The mix of fuel in the market (e.g. percent off-shore LNG to North American natural gas) can then be calculated in exactly the same way that CARB calculated the carbon content of RFG by using a ratio of 10% ethanol to 90% CARBOB. Had CARB used this approach in their current assessment of CNG and LNG, it would not have erroneously concluded that the carbon-intensity of imported LNG prevents NGVs from obtaining the LCFS, as natural gas imported from overseas will not constitute any of the LNG or CNG used for transportation in the State of California.

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Once the pathways are properly documented, CARB should publish guidelines on how to properly use the data to address a mix of CNG and LNG fuels that can consist of North American natural gas and renewable natural gas. Then conducting the in-use emissions modeling will give the correct assessment of natural gas as a transportation fuel.

In conclusion, the Comparison Document requires substantial disclosure for evaluation purposes, correction in accuracy for its proposed pathways, and inclusion of critical values that demonstrate CNG and LNG fuel pathways fairly and accurately. If done correctly, Clean Energy believes both CNG and LNG can demonstrate clear reductions of greenhouse gas emissions when compared to CARB diesel and forecasted fuels that are not currently in the marketplace like LCFS diesel. Failure to revise the Comparison Document as proposed will undeniably harm the public and the natural gas fueling industry as well as misrepresent the true benefits of utilizing domestic natural gas as a vehicle fuel to the public and both current and future customers. Understating the GHG reduction benefits of utilizing natural gas as a transportation fuel will result in continuing dependence on petroleum fuels and seriously impair California's ambitious goals with respect to GHG reductions and the expansion of alternative fuels. Quite frankly, we believe that utilizing domestic natural gas and biomethane in transportation is the single best way to achieve substantial GHG reductions in the transportation section utilizing available technology and resources and that a thorough and complete study based on actual market realities will support this conclusion. CARB's apparent failure to utilize appropriate inputs for LNG sourcing, disregard of biomethane production, and inclusion of a hypothetical petroleum based fuel (Low Carbon Diesel) that could be a decade from commercial production and achieves only a 10% carbon reduction constitutes a total abdication of CARB's responsibility to the citizens of the State of California. Liquified biomethane can be utilized today (not in a decade) to fuel heavy duty vehicles while reducing GHG emissions by 100% or more, not 10%. We can't afford to wait 10 years to achieve 10% reductions in GHG, particularly when the technology is currently available to do so much more.

We request that CARB (1) disclose the values and assumptions used to justify each pathway analysis it provides in the Comparison Document, (2) re-draft the pathways to reflect real conditions of the market for CNG and LNG (in particular the source of CNG and LNG used in transportation), (3) include biomethane pathways (which serve as natural gas' renewable pathway) in its Comparison Document analysis and (4) schedule a face-to-face meeting to discuss these items in full. Finally, we also question the inclusion of LCFS diesel in the Comparison Document as the regulation doesn't call for such a comparison, nor is it clear if such a fuel will ever exist in the marketplace. We look forward to your response.

Sincerely,

Todd R. Campbell
Director of Public Policy

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October 6, 2008

Mr. Dean C. Simeroth
Criteria Pollutants Branch, Chief
California Air Resources Board
Stationary Source Division
1001 I Street
P.O. Box 2815
Sacramento, CA 95812

Re: Meeting on CARB's Comparison Document of Natural Gas vs. Diesel (August 10, 2008)

Dear Mr. Simeroth:

Clean Energy would like to thank you and your staff for your collective time spent with us to discuss the draft Comparison Document, dated August 10, 2008, estimating the lifecycle greenhouse gas emissions of natural gas and diesel as a transportation fuel. During this meeting, Clean Energy staff and our consultants gained a better understanding of CARB's approach in drafting this preliminary document and we have collectively identified areas within the analysis where we can help CARB staff refine its analysis to better reflect our industry's current and future operations.

You have asked us to identify pathways that would best reflect the operations of both compressed natural gas (CNG) and liquefied natural gas (LNG) vehicle fueling for the natural gas vehicle industry. Based on our knowledge and experience in the industry, we recommend that CARB incorporate the following CNG pathways for the final document:

(1) CNG (using Canada as a source);
(2) CNG (using the Rocky Mountains as a source)
(3) CNG (using the Permian Basin/San Juan as a source)
(4) CNG (using California landfill gas)
(5) CNG (using out-of-state landfill gas)
(6) CNG (using remote LNG shipped to Baja, re-gasified, pipelined to CA, then compressed).

We also recommend that CARB incorporate six LNG pathways to be analyzed for the final document:

(1) LNG (using Canada as a source);
(2) LNG (using the Rocky Mountains as a source);
(3) LNG (using the Permian Basin/San Juan as a source);
(4) LNG (using California landfill gas)
(5) LNG (using out-of-state landfill gas); and,
(6) LNG (using remote LNG shipped to Baja as a source and trucked to the station).

Clean Energy believes that the first five CNG and LNG pathways recommended above are the most reflective of the natural gas vehicle industry today and will continue to be well into the future. We continue to submit that Option 6 (Baja) for LNG is an unlikely LNG pathway for vehicle refueling as the country is flush with natural gas (new natural gas shale discoveries in North America are projected to extend proven natural gas reserves from 83 to 120 years, increased renewable portfolios should displace natural gas use in power generation, and the rise of biomethane use provides additional resources) and existing LNG production facilities for vehicles are not physically connected to the Baja terminal's pipelines. That said, we have included it based on CARB staff's desire to be thorough in its analysis and to cover the unexpected. We strongly recommend that CARB alter the mechanics of Option 6 in that we believe any LNG fuel purchased by Clean Energy from the Baja import terminal would be trucked directly to fueling stations, not gasified into existing pipelines and then re-liquefied at a California-based LNG production facility. Such an operational practice would be pre-empted by economics and presumably an increasingly tightened low carbon fuel standard by CARB over time.

Clean Energy would like to reiterate the critical importance of displaying the recommended pathways in the final document over the pathways drafted in the current CARB document. For example, the current document contains pathways that are not reflective of how the LNG industry currently operates or plans to produce vehicle fuel. While we appreciate CARB's efforts to provide a model that will allow each fuel provider to calculate the carbon intensity of its product using its own special circumstances, maintaining three LNG pathways that will never be implemented in a finalized CARB document could harm the LNG refueling industry irreparably and mislead potential customers, adversely impacting the state's low carbon fuel goals.

During our meeting, we also questioned the comparison of a low carbon diesel fuel that achieved a ten percent reduction in carbon. We have confirmed with CARB staff that this was a hypothetical analysis and that no such fuel existed in the market place to date. When asked why this comparison was performed for natural gas and not for any other fuel under consideration, CARB staff explained that it was done for internal purposes only but would likely not be in the final version of the Comparison Document. We, therefore, would ask that hypothetical fuels not be included in the final version of the analysis as such a comparison could harm or unfairly stunt the growth opportunities of a vital and existing low carbon fuel, such as domestic or renewable LNG.

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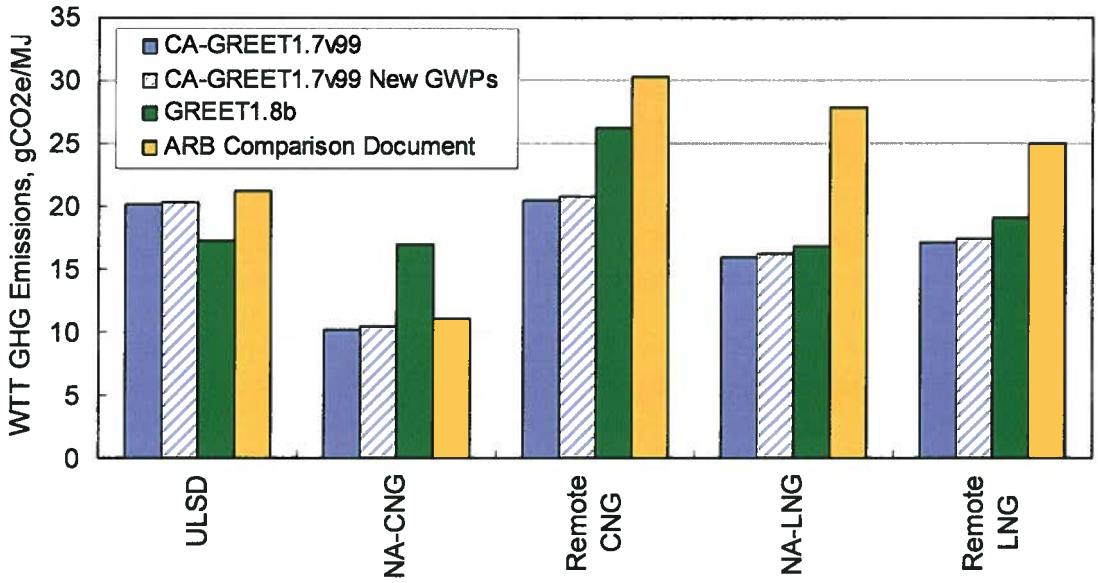
Clean Energy is also concerned that the values presented in the ARB Comparison document are significantly different than the values resulting from the AB1007 analysis and from the ULSD and CNG pathway documents posted on the LCFS website. We understand that the first CA-GREET model posted on the LCFS website is based on GREET1.7 while the soon to be released ARB version of the CA-GREET model is based on GREET1.8b. However, the only change for natural gas fuels in the new version of the GREET model is the global warming potential (GWP) factors for CH4 and N2O. Figure 1 below compares the WTT values produced by CA-GREET1.7 v99 with the old and new GWP values. The updated GWP factors minimally impact the results for NG fuels.



Also shown in the figure are the values generated by GREET1.8b with all Argonne National Lab default values, including the U.S. average electricity mix. The ULSD values are markedly lower because of the increased refining efficiency values. The CNG values are higher than the CA-GREET values, mainly because of the higher pipeline leak rate assumption. The LNG values are higher than the CA-GREET values largely due to poorer boil-off recovery efficiencies.

Finally, the values presented in the ARB Comparison document are shown. The ULSD and NA-NG CNG values are higher than those in the pathway documents posted on the LCFS website. The remote CNG values and the LNG values are substantially higher than the CA-GREET and GREET1.8b values. To better understand the underlying assumptions in the ARB analysis, Clean Energy requests that ARB provide the version of GREET utilized to generate the results presented in the Comparison document. If this level of transparency is not feasible, at a minimum we request the following:

- Electricity Mix for each case
- ULSD Case
    - Crude recovery efficiency
    - Crude transport modes and miles for each mode
    - ULSD refining efficiency
    - Refining non-combustion emissions
    - ULSD transport modes and miles for each mode
- For all NG Fuels:
    - NG Recovery efficiency
    - Vented methane in recovery %
    - Processing efficiency
    - Vented methane in processing %
    - Non-combustion emission in processing step
- CNG from California NG
    - Pipeline transport distance
    - Pipeline leak rate %/mile
- CNG Remote Baja Case
    - Pipeline transport distance to liquefaction
    - Pipeline leak rate %/mile
    - Liquefaction efficiency
    - Storage losses
    - Storage days
    - Boil-off recovery efficiency
    - LNG transport modes and distances
    - Boil-off assumptions during transport
    - Boil-off assumptions during terminal storage
    - Regasification efficiency
    - Pipeline transport distance and leakrate
    - Compression efficiency
- LNG Canada NG Case
    - Pipeline transport distance
    - Pipeline leak rate %
    - Liquefaction efficiency
    - Boil-off assumptions at the liquefaction plant
    - Heavy duty truck transport distance and boil-off assumptions
    - Station storage boil-off assumptions (days, loss rate, recovery)
- LNG Remote LA Case
    - Pipeline transport distance to liquefaction
    - Pipeline leak rate %
    - Liquefaction efficiency
    - Boil-off assumptions at liquefaction plant
    - LNG transport modes and distances
    - Boil-off assumptions during transport
    - Boil-off assumptions during storage at terminal
    - Distribution distances and boil-off assumptions

Finally, you mentioned during the meeting that CARB is currently engaged in internal discussions regarding which entities that are involved in the LNG and CNG vehicle fuel production cycle should be the "regulated entity" responsible for compliance with the LCFS. You indicated that CARB was currently contemplating regulation of the

entity that holds title to the natural gas at the border of the State of California. We strongly believe this is the wrong approach, and that in order to effectively regulate and incentivize participants in the LNG and CNG vehicle fuel market the regulated entity for purposes of LCFS compliance must be the CNG or LNG fuel provider. Gas marketing firms and utilities that purchase gas at the California border are commodities businesses (not fuel businesses) that sell that gas downstream to a multitude of customers for a wide variety of end uses. Vehicle fuel providers like Clean Energy currently constitute a tiny fraction of the utility and/or gas marketing firms' natural gas customers, and the commodity supplier has no visibility or control over the fuel creation and sales process. In order for natural gas to be used as a low-carbon fuel alternative, it must be either compressed or liquefied and trucked to the end customer. It is the fuel providers that compress, liquefy ***and sell natural gas as a vehicle fuel*** that should be regulated under the LCFS.[1] It is the fuel providers, like Clean Energy, that make the decisions regarding gas sourcing and CNG and LNG production methods that are critical to determining the carbon intensity of the fuel production process. The fuel providers, like Clean Energy, enter into long-term natural gas vehicle fuel supply agreements with fuel consumers and make the capital investments necessary to build natural gas fueling infrastructure. Ultimately, it is the fuel providers that must be the regulated entity under the LCFS. Attempting to regulate the commodity provider that holds title to the gas at the border would presumably require highly inefficient and complicated supervision by the commodity provider of a certain portion of their downstream customers that compress or liquefy natural gas for use as a vehicle fuel. This presents numerous significant practical and logistical problems that may prove highly detrimental to the natural gas fueling industry as a whole and result in an ineffective regulation. We would welcome the opportunity to speak in greater detail with CARB regarding the "regulated entity" decision. We believe that it is a critical decision that must be made correctly if the LCFS is going to effectively regulate and incentivize the low carbon natural gas fueling industry.

Again, Clean Energy would like to thank you and your staff for your time and consideration of our comments, input and analysis. We hope that you will continue to view us as a resource and ally in developing and implementing the state's Low Carbon Fuel standard.

Most sincerely,

Todd R. Campbell
Director of Public Policy

Cc: Floyd V. Vergara, Esq., P.E.
Linda Lee, P.E.

[1] Properly defining the "fuel provider" under the LCFS will be of critical importance. For CNG, we would propose that the fuel provider be defined as the owner of the compression infrastructure utilized to compress the gas for use as a vehicle fuel. For LNG, we would propose the fuel provider be defined as the entity supplying the LNG to the end-user for use as a vehicle fuel.

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Memorandum

Date: September 28, 2008
To: Todd Campbell and Mike Eaves, Clean Energy Fuels
Cc: Michael Jackson, Michael Chan, Jeff Rosenfeld

From: Jennifer Pont
Loc: Cupertino Office
Phone: 408.517.1573

Subject: Review of ARB's "Comparison of Greenhouse Gas Emissions from Natural Gas and Diesel Vehicles"

Recently, ARB distributed a document[1] comparing Well to Wheel (WTW) GHG emissions from NG vehicles to diesel vehicles (both current and "LCFS compliant"). ARB used the CA-GREET model to estimate WTT GHG emissions for eight natural gas pathways (5 CNG and 3 LNG) and diesel.

At present, there are several versions of CA-GREET. CA-GREET1.7v98 is currently posted on the ARB LCFS website and was utilized in development of the State Alternative Transportation Fuels Plan. Under funding from the Energy Commission, TIAX recently added two new pathways: landfill gas to CNG and landfill gas to LNG. We also provided, at ARB's request, a detailed documentation of the LFG to CNG pathway for posting on the LCFS website. The version of the model with the LFG pathways is CA-GREET1.7v99; it has not yet been posted to the ARB or CEC websites. This version of the model includes three feedstocks (North American NG, Remote NG, and Landfill Gas) and two fuels (CNG, LNG) for a total of six NG pathways.

Argonne National Laboratory (ANL) has recently released a new version of GREET (GREET1.8b) which is essentially the same as version 1.7 for the natural gas based fuels, but has not been tailored to California conditions. ARB is working on modifications to GREET1.8b to reflect California conditions, and it appears this was used to generate this natural gas document out for limited comment. ARB now refers to this model as CA-GREET1.8b, but it has not been posted to the ARB website for review.

This memo compares the GHG emissions estimated with CA-GREET1.7 v99 to the emission estimates presented in the ARB Comparison document. Underlying assumptions for the CA-GREET1.7 v99 results are also provided.

[1] "Comparison of Greenhouse Gas Emissions From Natural Gas and Diesel Vehicles", Simeroth, CARB, September 9, 2008.

Well To Tank Emission Estimates

Table 1 presents the WTT emission estimates from the CA-GREET1.7 v99 model. Note that the values shown for cases D3 and C1 match the values in the detailed pathway descriptions on the ARB LCFS website. The underlying assumptions for each pathway are listed in Tables 2-6.

Table 1. Breakdown of WTT GHG Emissions Estimates from CA-GREET1.7 v99

Pathway #	D3	C1	C2	C4	L1	L3	L4
Fuel	ULSD	CNG	CNG	CNG	LNG	LNG	LNG
Feedstock	CA Avg Crude	NA-NG	Remote NG	Landfill Gas	NA-NG	Remote NG	Landfill Gas
Recovery	6.60	3.30	3.42	0.49	3.33	3.41	0.50
Transport to Processing	2.20			0.00			0.00
Processing/Refining	11.00	3.59	3.75	15.03	3.62	3.74	20.50
Pipeline Transport		1.16	0.06	0.06	1.23	0.06	
Compression/Liquefaction		2.10	7.08	2.10	6.85	7.04	
LNG Transport			1.29		0.31	2.34	0.03
LNG Storage			0.24		0.53	0.53	0.03
LNG Regasification			0.89				
Pipeline Transport			0.24				
Compression/Liquefaction			3.42				
Final Transport	0.30						
Flaring Credit				-64.38			-75.67
WTT Total	20.10	10.15	20.40	-46.69	15.87	17.11	-54.62
NA-NG refers to North American Natural Gas							
Remote NG refers to NG from overseas, shipped to the LNG facility in Baja California, Mexico.							

Table 2. Main Assumptions for ULSD Pathway

Parameter		Units	Value
Electricity Mix	California Average		
Recovery	Efficiency	%	93.9%
	Vented Methane	g/mmBtu	2.3
Crude Transport	Ocean Tanker	miles	3,550
	Tanker payload	tons	250,000
	Tanker fuel consumption	Btu/hp-hr	4620
	Tanker speed	mph	19
	Pipeline	miles	266
	Vented Methane	g/mmBtu	69.5
Refining	Efficiency	%	86.70%
	Non-combustion CO2	g/mmBtu	1117
Transport	Pipeline	miles	40
	HD Truck	miles	50
	Terminal/station VOC losses	g/mmBtu	3.57

Table 3. Main Assumptions for CNG From North American Natural Gas

Parameter		Units	Value
Electricity Mix	California Marginal		
Recovery	Efficiency	%	97.2%
	Methane vented	%	0.35%
Processing	Efficiency	%	97.20%
	Methane vented	%	0.15%
	Non-combustion CO2	g/mmBtu	1,237
Pipeline Transport	Pipeline distance	miles	1000
	Leak rate	%/mile	0.08% / 600 miles
Compression	Efficiency	%	98%

Table 4. Main Assumptions for CNG From Remote Natural Gas

Parameter		Units	Value
Electricity Mix	Overseas Mix		
Recovery	Efficiency	%	97.2%
	Methane vented	%	0.35%
Processing	Efficiency	%	97.20%
	Methane vented	%	0.15%
	Non-combustion CO2	g/mmBtu	1,237
Pipeline Transport	Pipeline distance	miles	50
	Leak rate	%/mile	0.08% / 600 miles
Liquefaction	Efficiency	%	91%
	Storage Losses	%/day	0.10%
	Storage Days	days	5 days
	Boil-off recovery	%	80%
LNG Transport	Ocean Tanker Distance	miles	7200
	Fuel Type		NG/Residual Oil
	Tanker payload	tons	65,000
	Tanker fuel consumption	Btu/hp-hr	4620
	Tanker speed	mph	19
	Boil-off recovery	%	100%
LNG Storage	Storage Losses	%/day	0.10%
	Storage Days	days	5 days
	Boil-off recovery	%	90%
Regasification	Efficiency	%	99.40%
	Storage Losses	%/day	0.10%
	Storage Days	days	5 days
	Boil-off recovery	%	80%
Pipeline Transport	Pipeline distance	miles	200
	Leak rate	%/mile	0.08% / 600 miles
Compression	Efficiency	%	98%

Table 5. Main Assumptions for LNG From North American Natural Gas

Parameter		Units	Value
Electricity Mix	California Marginal		
Recovery	Efficiency	%	97.2%
	Methane vented	%	0.35%
Processing	Efficiency	%	97.20%
	Methane vented	%	0.15%
	Non-combustion CO2	g/mmBtu	1,237
Pipeline Transport	Pipeline distance	miles	1000
	Leak rate	%/mile	0.08% / 600 miles
Liquefaction	Efficiency	%	91%
	Storage Losses	%/day	0.10%
	Storage Days	days	5 days
	Boil-off recovery	%	80%
LNG Distribution	Heavy Duty Truck Distance	Miles	50
	Payload	tons	15
	Fuel Economy	mpg	5
	Fuel Type		Natural Gas
	Boil-off	g/mmBtu	0
LNG Storage	Storage Losses	%/day	0.10%
	Storage Days	days	5 days
	Boil-off recovery	%	90%

Table 6. Main Assumptions for LNG From Remote Natural Gas

Parameter		Units	Value
Electricity Mix	Overseas Mix		
Recovery	Efficiency	%	97.2%
	Methane vented	%	0.35%
Processing	Efficiency	%	97.20%
	Methane vented	%	0.15%
	Non-combustion CO2	g/mmBtu	1,237
Pipeline Transport	Pipeline distance	miles	50
	Leak rate	%/mile	0.08% / 600 miles
Liquefaction	Efficiency	%	91%
	Storage Losses	%/day	0.10%
	Storage Days	days	5 days
	Boil-off recovery	%	80%
LNG Transport	Ocean Tanker Distance	miles	7200
	Fuel Type		NG / Residual Oil
	Tanker payload	tons	65,000
	Tanker fuel consumption	Btu/hp-hr	4620
	Tanker speed	mph	19
	Boil-off recovery	%	100%
Terminal Storage	Storage Losses	%/day	0.10%
	Storage Days at Terminal	days	5 days
	Boil-off recovery	%	90%
LNG Distribution	Heavy Duty Truck Distance	Miles	170
	Payload	tons	15
	Fuel Economy	mpg	5
	Fuel Type		Natural Gas
Station Storage	Storage Losses	%/day	0.10%
	Storage Days	days	3 days
	Boil-off recovery	%	80%

The WTT values for these five pathways are compared to the values in the ARB Comparison Document in Figures 1-5. There are significant differences for several of the pathways. Because the underlying assumptions for the ARB cases are not provided in the Comparison document, the causes for the differences can not yet be identified. However, it is likely that assumptions regarding pipeline leakage and boil-off recovery are not consistent. Additionally, the global warming potential (GWP) factors have been slightly increased in GREET1.8b.

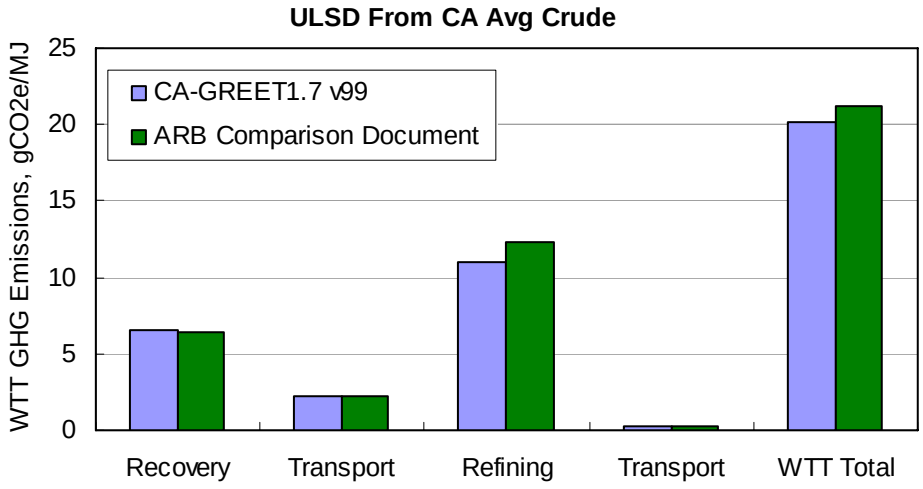

Figure 1. Comparison of WTT GHG Emissions for CA Avg ULSD

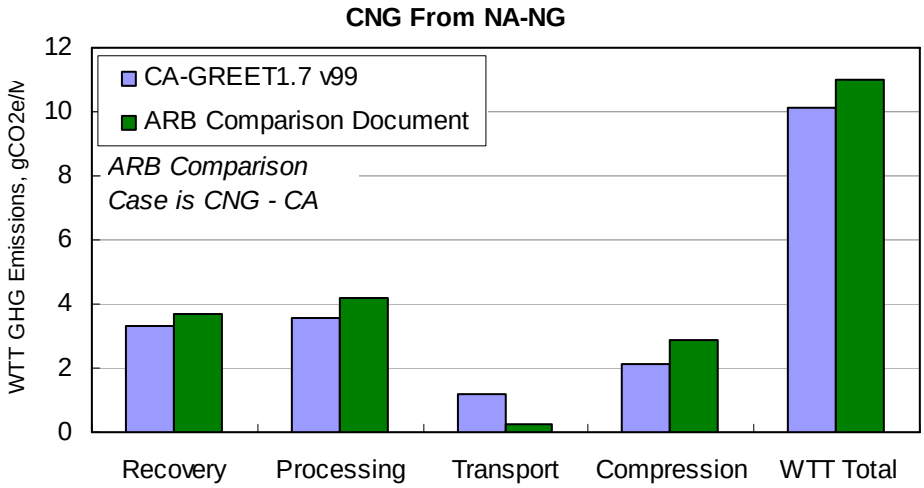

Figure 2. Comparison of WTT GHG Emissions for CNG From NA-NG

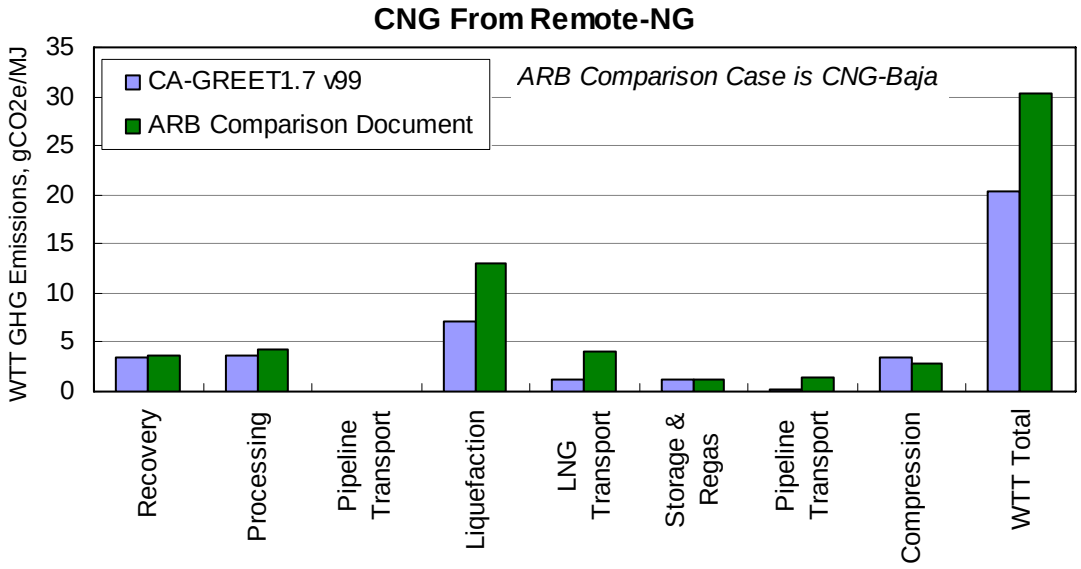

Figure 3. Comparison of WTT GHG Emissions for CNG From Remote NG

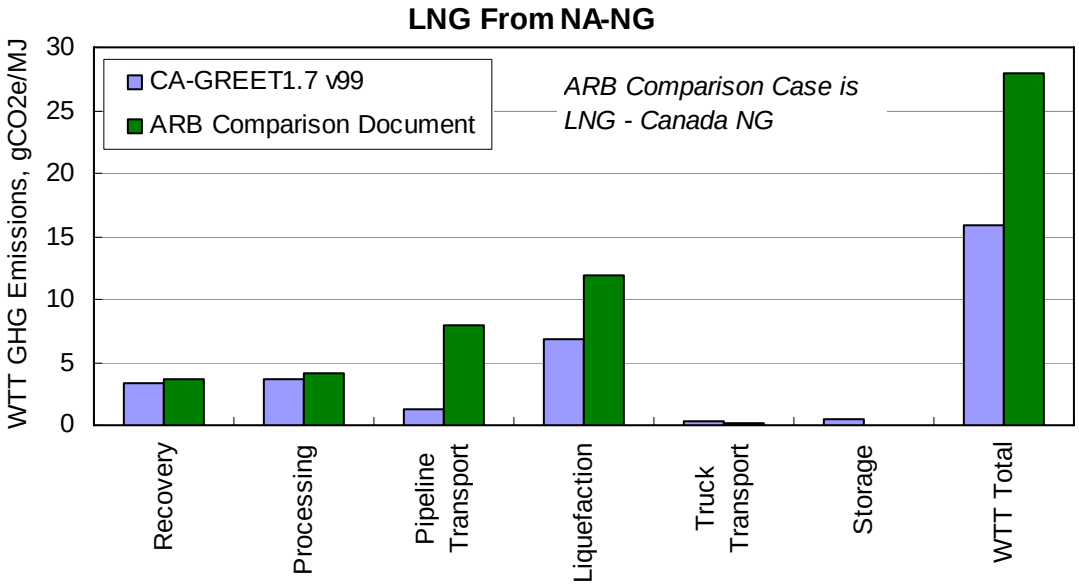

Figure 4. Comparison of WTT GHG Emissions for LNG From NA-NG

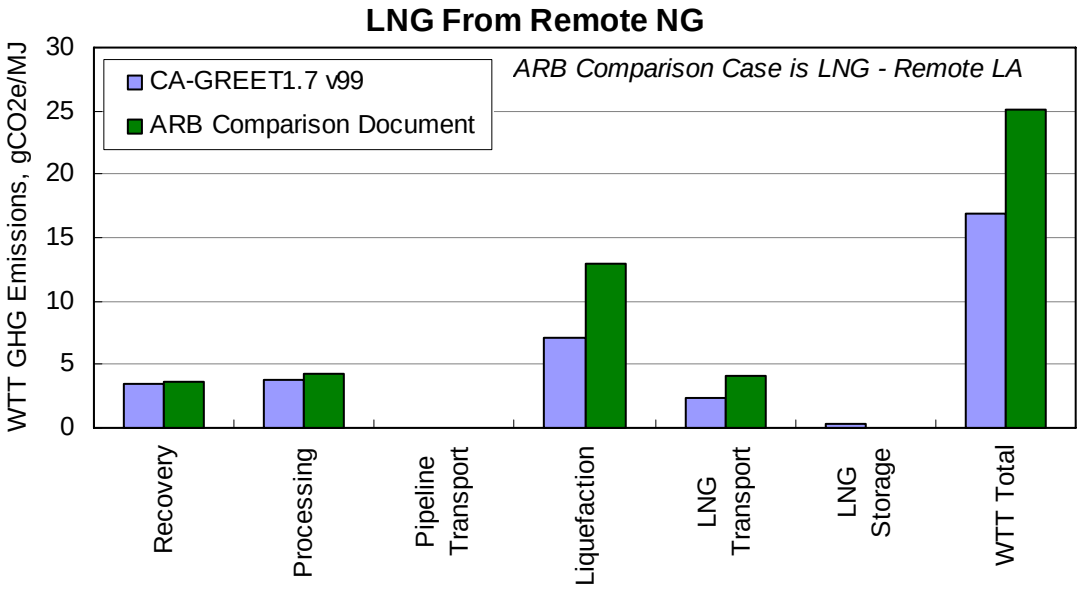

Figure 5. Comparison of WTT GHG Emissions for LNG From Remote NG

Tank-To-Wheel Emission Estimates

The TTW estimates include CO2 from combustion of the carbon in the fuel and the vehicle N2O and CH4 emissions. Since the completion of the AB1007 analysis, ARB has revisited vehicle fuel economy values, and the California Climate Action Registry (CCAR) has updated the vehicle emission factors for CH4 and N2O in the general reporting protocol. The CH4 and N2O emission factors are provided on a g/mi basis for diesel and LNG/CNG light duty and heavy duty vehicles. The citation in the CCAR protocol is the California Greenhouse Gas Inventory: 1990-1999. This report has a substantial discussion of CH4 and N2O emission factors for gasoline and diesel vehicles, but no reference to NG vehicle emissions was found.

At any rate, Table 7 provides TTW emissions utilizing CCAR emission factors for N2O and CH4 along with fuel economies from the ARB Comparison document. These TTW emission estimates are compared to those from the ARB Comparison Document in Figure 7. The main differences are that the TIAX values include vehicle CH4 and N2O values, and the GWP factors are consistent with GREET1.7 rather than GREET1.8b.

Table 7. Tank-To-Wheel GHG Emissions

		ULSD	CNG	CNG	CNG	LNG	LNG	LNG
		CA Avg Crude	NA-NG	Remote NG	Landfill Gas	NA-NG	Remote NG	Landfill Gas
Fuel C Content	wt %	86.50%	72.40%	72.40%	72.40%	75%	75%	75%
Density	g/gal or g/scf	3,142	20.4	20.4	20.4	1,621	1,621	1,621
LHV	Btu/gal or /scf	127,464	930	930	930	74,720	74,720	74,720
Vehicle CO2	g CO2/MJ	74.11	55.20	55.20	55.20	56.55	56.55	56.55
LDV CH4	g/mi	0.01	0.04	0.04	0.04			
LDV N2O	g/mi	0.02	0.04	0.04	0.04			
HDV CH4	g/mi	0.06	3.48	3.48	3.48	3.48	3.48	3.48
HDV N2O	g/mi	0.05	0.05	0.05	0.05	0.05	0.05	0.05
LDV Fuel Economy	MJ/mi	5.38	5.49	5.49	5.49	5.49	5.49	5.49
HDV Fuel Economy	MJ/mi	25.25	26.86	26.86	26.86	26.86	26.86	26.86
LDV TTW CO2	gCO2e/mi	398.7	303.0	303.0	303.0			
LDV TTW CH4	gCO2e/mi	0.2	0.9	0.9	0.9			
LDV TTW N2O	gCO2e/mi	5.9	11.8	11.8	11.8			
LDV TTW Total	gCO2e/mi	404.8	315.8	315.8	315.8			
LDV TTW Total	gCO2e/MJ	75.2	57.5	57.5	57.5			
HDV TTW CO2	gCO2e/mi	1,871	1,483	1,483	1,483	1,519	1,519	1,519
HDV TTW CH4	gCO2e/mi	1	80	80	80	80	80	80
HDV TTW N2O	gCO2e/mi	15	15	15	15	15	15	15
HDV TTW Total	gCO2e/mi	1,887	1,577	1,577	1,577	1,614	1,614	1,614
HDV TTW Total	gCO2e/MJ	74.7	58.7	58.7	58.7	60.1	60.1	60.1
CH4 and N2O Emissions from California Climate Action Registry General Reporting Protocol, March 2008.								
Vehicle Fuel Economy from ARB's Comparison Document								

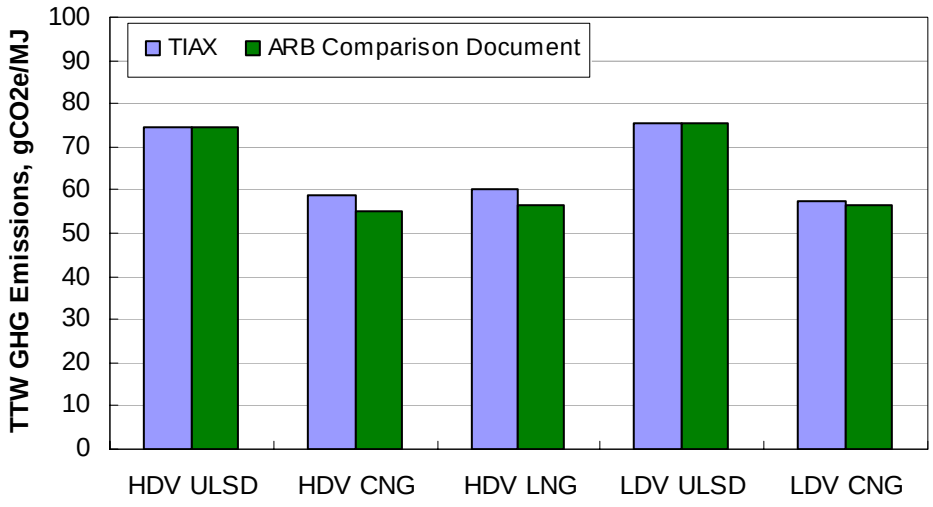

Figure 6. Comparison of TTW emissions.

Well-to-Wheel Results

Combining the GREET1.7 v99 WTT estimates with the TIAX TTW estimates above results in the WTW values shown in Table 8 and Figures 7 and 8. As indicated NG light duty vehicles result in a 17% to 88% reduction relative to diesel; heavy duty NG vehicles yield from 11% to 94% percent reduction.

Table 8. TIAX Estimates of WTW GHG Emissions

	Units	ULSD CA Avg Crude	CNG NA-NG	CNG Remote NG	CNG Landfill Gas	LNG NA-NG	LNG Remote NG	LNG Landfill Gas
WTT	gCO2e/MJ	20.10	10.15	20.40	-46.69	15.87	17.11	-54.62
LDV F.E.	MJ/mi	5.38	5.49	5.49	5.49			
HDV F.E.	MJ/mi	25.25	26.86	26.86	26.86	26.86	26.86	26.86
Light Duty								
WTT	gCO2e/mi	108	56	112	-256			
TTW	gCO2e/mi	405	316	316	316			
WTW	gCO2e/mi	513	371	428	59			
% change			-28%	-17%	-88%			
Heavy Duty								
WTT	gCO2e/mi	508	273	548	-1,254	426	460	-1,467
TTW	gCO2e/mi	1,887	1,577	1,577	1,577	1,614	1,614	1,614
WTW	gCO2e/mi	2,395	1,850	2,125	323	2,040	2,074	147
% change			-23%	-11%	-86%	-15%	-13%	-94%

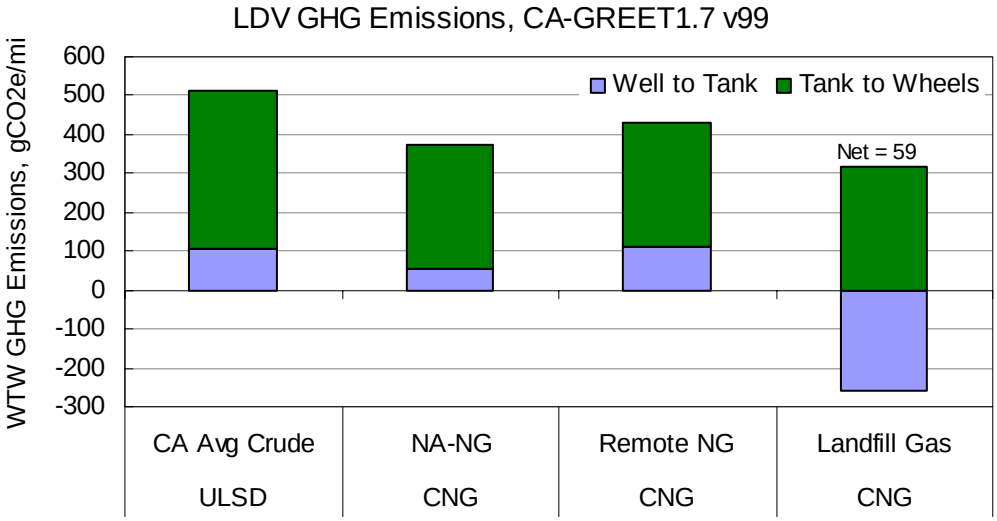

Figure 7. Light Duty WTW GHG Emissions

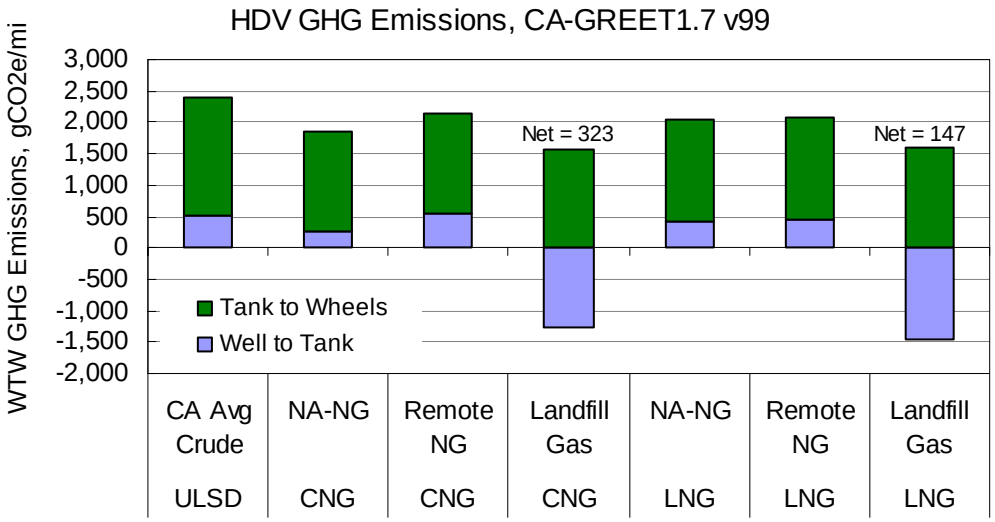

Figure 8. Heavy Duty WTW GHG Emissions

Finally, Figure 9 provides a comparison of the TIAX estimated WTW emissions and the ARB Comparison Document estimates. Except for the CNG from NA-NG, the ARB estimates are much less favorable than the TIAX estimates based on GREET1.7 v99. For the CNG from NA-NG case, ARB's California NG case is utilized. The ARB estimate is more favorable, likely because of the reduced pipeline transport distances (the TIAX estimate assumes 1000 miles of pipeline travel). For the LNG case from NA-NG, the ARB case utilizing NG from Canada is utilized. For the CNG case from remote NG, the ARB case assuming LNG imported to Baja is utilized. For the LNG case from remote NG, the ARB case assuming receipt in Los Angeles and direct distribution from the shipping terminal is utilized.

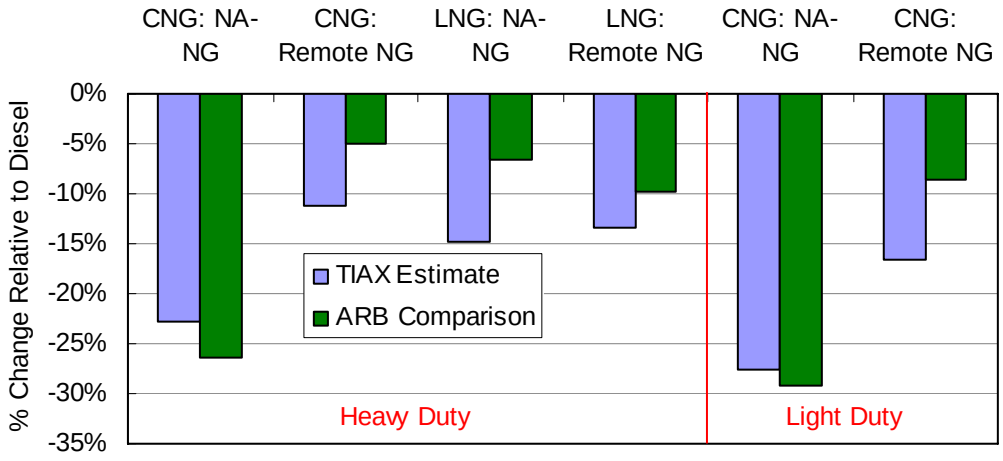

Figure 9. TIAX WTW Estimates and the ARB Comparison Document Estimates