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Ms. Kim Heroy-Rogalski
Technology Assessment, Truck Sector Lead
California Air Resources Board
Submitted electronically to:
http://www.arb.ca.gov/msprog/tech/comments.htm

**Subject: Southern California Gas Company Comments on California Air Resources Board's (CARB) Sustainable Freight Strategy Technology Assessment—Truck and Bus Sector as presented at the September 2, 2014 workshop**

Dear Ms. Heroy-Rogalski:

The Southern California Gas Company (SoCalGas) appreciates the opportunity to comment on the Truck and Bus Sector Technology Assessments as presented in staff's ten presentations at the September 2nd workshop. We commend CARB for producing a thorough survey and assessment of technology with both near and longer term development potential across all significant transportation sectors.

SoCalGas understands that the intent of the Technology Assessments is to provide the technical foundation for the development of the Sustainable Freight Strategy (SFS) and upcoming State Implementation Plans. Given that both the South Coast Air Quality Management District (SCAQMD) and the San Joaquin Valley Air Pollution Control District (SJVAPCD) are federal extreme nonattainment areas for ozone, and oxides of nitrogen (NOx) are the primary pollutants of concern, we urge CARB to focus on the need for greater NOx emission reductions in all short-term freight strategies.

SoCalGas continues to pursue the technology potential of natural gas to reduce mobile-source emissions. Both the SCAQMD and the SJVAPCD need greater NOx emission reductions sooner than previously envisioned in some of CARB's planning documents (e.g., Vision for Clean Air: A Framework for Air Quality and Climate Planning, June 2012), which rely upon battery electric vehicles (BEV) and fuel-cell vehicles (FCV), and electrification of most other mobiles sources. To meet the 2023 deadline for attainment of the federal ambient ozone standard, our recommendation is that California, particularly the SCAQMD, SJVAPCD and CARB, pursue a multi-technology approach that builds on an early reliance of available, clean natural-gas vehicles focused on the heavy-duty truck market, locomotives and port activities including ocean-going vessels. Clean natural-gas technology is available now and moving us forward.

Our comments are structured with general comments and suggestions followed by specific comments and suggestions on the September 2nd individual presentation topics, which are labeled with the name of the specific presentation.

General Comments and Suggestions

1) Clarity is needed as to the benefit expected from each assessed technology. Specifically, the expected benefit for each technology should be identified for its emissions reductions of all criteria pollutants [NOx, particulate matter (PM), etc.] and greenhouse gases (GHG) including a discussion of the tradeoffs and challenges of attaining emission reductions for both types of pollutants, criteria and GHG.

   The goal of achieving near-zero emissions from new transportation technology in the 2050 timeframe is laudable. Nevertheless, SoCalGas believes that commercial success of these technologies, such as BEVs and FCVs, will be iterative and should be fostered by collaboration with other near-term technologies that are market ready today. Hence, we think CARB should include early reliance on clean natural-gas engines that will get more emission reductions sooner as many of today's natural gas engines have in use emissions below the 2010 heavy-duty engine NOx standard. This step is the starting point on the pathway to near-zero or "power-plant equivalent" transportation options that can achieve both federal ozone standards, and the state's 2050 GHG goals.

   In the final Technology Assessments, we request that CARB acknowledge that there will be commercially available natural-gas combustion engines that achieve 0.02 g/bhp-hr NOx certification and in-use performance levels in four to five years. We note that on slide 27 of the Lower NOx Heavy-Duty Diesel Engines presentation, CARB staff is "optimistic that diesel engines can meet very low NOx levels of 0.02 g/bhp-hr", and on slide 28 of the Lower NOx Heavy-Duty Natural Gas and Other Alternative Fuel Engines presentation that staff is "optimistic that natural gas engines can meet very a 0.02 g/bhp-hr standard, relatively quickly." In fact, staff further notes on slide 28, that natural gas engines have current NOx certification levels with conventional three-way catalyst that are 20% to 75% below 0.2 g/bhp-hr (the 2010 heavy-duty engines standard as noted above). Considering that currently CARB certified natural-gas engines are already 75% of the way to the 90% needed to go from 0.2 g/bhp-hr to 0.02 g/bhp-hr, we hope CARB starts to use the phrase "very quickly" when referring to the relative time frame for natural gas engines to meet CARB's lowest optional NOx standard of 0.02 g/bhp-hr.

   A component of the development of these engines is to achieve or surpass the efficiency associated with diesel fueled engines, and provide much-needed GHG emissions reductions. Another important consideration is the role that natural gas can and should play in the build-out of hydrogen infrastructure to support the market expansion of hydrogen FCV. While hydrogen and renewables may play a significant long term role in the transportation arena, natural gas can be a catalyst for development (e.g., on-board compressed gas storage and fuel systems, as well as technological advancements in gaseous fueling systems) of and increasing the demand for FCVs, thereby benefiting their

long term potential. We request that the role of natural gas in the growth in the number of FCVs be given greater recognition in the final technology assessment.

SoCalGas respectfully points out that CARB has articulated conflicting perspectives regarding the future role of internal combustion engines and the respective use of diesel and natural gas fuels. On the one hand, during the presentations and verbal replies to questions, CARB staff clearly states that heavy-duty diesel engines will still be dominant players in California's goods movement sector for many years to come. But then underscores the challenges of introducing ultra-clean diesel engines, while also noting that key tradeoffs (e.g., reducing NOx versus GHGs) are "solvable." On the other hand, CARB staff seems to be making the opposite point for heavy-duty natural gas engines: despite the fact that they will quickly meet CARB's lowest optional NOx standard of 0.02 g/bhp-hr, they are not likely to be key players in California's future transportation sector because they do not meet the standard zero emission vehicle (ZEV) definition like BEVs and FCVs.

2) We request that CARB state unequivocally that both diesel and natural gas combustion vehicles play important roles now, and both will continue towards the ultimate goal: near-zero emissions with very low fuel-cycle GHG emissions. CARB can then follow this general introduction to the future of internal combustion engines with details about the prospects for both fuels, and advanced technologies to achieve such objectives.

3) We support CARB's continued effort to remain technology neutral in its assessments.

4) CARB's discussion and inclusion of in use emissions and onboard diagnostic systems in the truck sector is an important component of the Technology Assessment. We suggest that CARB consider all of the technologies discussed, including natural gas, and the benefit that each of them may represent relative to improved long term in-use performance. Accordingly, the design of requirements for onboard diagnostic systems and their eventual utilization in inspection and maintenance programs should be assessed relative to the new and advanced technologies discussed, the intent being to not put forth requirements that might inadvertently discriminate against technologies that might have significant in-use performance benefits.

5) We would like CARB to characterize clearly the major opportunities that exist to reduce NOx emissions in California's legacy heavy-duty fleet by replacing diesel trucks with those powered by inherently cleaner natural gas engines. The off-cycle in-use NOx emissions from diesel trucks are strong reminders that we should not rely on one fuel and technology. The more California can complement deployments of selective catalytic reduction (SCR) equipped heavy-duty vehicles (across all goods movement sectors) with very low NOx natural gas engines (throughout their useful lives), the better hedge we have to meet the various critical state goals laid out for CARB's Technology Assessments.

Truck Sector Overview Presentation

1. The introductory presentation set the tone for the first workshop relative to truck technology potential and progress including technologies that are still in the research and development phase accompanied by high projected cost, such as homogenous charge compression ignition (HCCI), camless engine, opposed piston and free piston engine. These technologies require significant "break-through" milestones before reaching field demonstration, let alone commercialization. Absent from the introduction was discussion of more near-term advanced technologies such as natural gas based powertrains with dedicated or direct-injected natural gas engines (including hybridized systems) that can achieve near-zero emissions (NOx and PM). Development of these systems is well underway, and all have greater near-term commercialization potential than heavy-duty BEVs or FCVs. While alternative fuels are presented and discussed in a later section of the workshop (Lower NOx Heavy Duty Natural Gas and other Alternative Fuel Engines presentation), we believe there would have been significant merit if natural gas as a technology enabler had been discussed from both the perspectives of near zero emissions and low GHG emissions. SoCalGas requests that CARB include this topic in the final Technology Assessments.

2. In the Engine Powerplant and Drivetrain Optimization-Vehicle/Trailer Efficiency presentation, reducing tractor/trailer mass or light-weighting is identified as a key technology under evaluation. We suggest that this evaluation include in a discussion of light-weighting that might be complemented or offset by application of alternative powertrain technologies such as those used with natural gas fuels, engine downsizing, and fuel cells.

3. As we have previously stated, SoCalGas believes it is critical for the state to focus on emission reductions needed for attainment in the SCAQMD and SJVAPCD air basins. Thus, it would be beneficial to understand CARB's priorities and the potential for how each of the technology assessments relate to emissions reductions of NOx, PM, and GHG. We suggest that CARB include a technology matrix with the benefit/merit of each the technology to put the technology pathways in perspective.

4. As a complement to Slide 9, we suggest that there would be added benefit from inclusion of information on what portion of the NOx and PM emissions by truck classification are attributable to centrally fueled and regionally based truck fleets.

5. As a complement to Slide 13, we suggest that a table be added that summarizes the CARB Fleet Rules including of implementation timing, emission requirements, and applicable vehicle definitions.

6. Slide 14 presents tends in emissions of NOx and particulate matter less than or equal to 2.5 microns in diameter (PM2.5) from on-road heavy duty trucks thru 2035. We suggest CARB evaluate and present one or two more scenarios including forecasts of penetration

rates of some of the most promising advanced technologies, including increased penetration of advanced natural-gas engines and hybrid-electric combinations.

7. We agree that there is significant opportunity for penetration of alternative fuels for heavy duty trucks in the marketplace, but we believe CARB is remiss in not including natural gas along with hybrids, FCVs and BEVs in the list of alternatives that can be effective in drayage, waste (refuse) and bus applications in both the near and longer term for dedicated fueling platforms and as complementary to the other three listed technologies. It is our understanding that broad market penetration of commercially ready hybrids, FCVs, and BEVs may not occur in the near term, whereas, market availability of low-emission energy-efficient natural gas engines for these applications will occur much sooner—within the next five years. Accordingly, we strongly suggest that natural gas be included in the assessment for drayage, refuse, and bus applications.

8. To complement the used truck purchasing patterns presented on Slide 23, SoCalGas requests that CARB evaluate the purchasing patterns and residual values of trucks as they will be impacted by greater penetration of advanced technology and alternative fuels such as natural gas, hybrids and FCVs. Furthermore, such evaluation will benefit neighboring state fleets and interstate transport from growth of advanced technology markets in California.

9. Regarding Slide 38, we request that CARB provide background and/or reference sources for the statement that industry typically looks to an 18 month payback for fuel economy technologies in respect to long-haul fleets. We believe that this is not necessarily typical, particularly when it comes to advanced technologies that have individual merits, including natural gas.

<u>Truck Sector In-Use Emissions Presentation</u>

1) We believe that CARB staff under emphasizes a *critical advantage* for manufacturers of heavy-duty natural gas engines with respect to minimizing in-use emission levels. Unlike diesel engines, dedicated natural gas engines do not need complex exhaust aftertreatment systems that appear to readily fail in real-world use under certain duty cycles. The good news for diesel is that diesel particulate filter (DPF) technology seems to be generally robust and very successful at durably reducing DPM emissions. However, it seems very clear that the jury is still out on the real-world NOx-reduction performance of SCR under low-speed, low-load conditions. The latest data from two key new reports (cited below) clearly indicate that in real-world use, diesel vehicles with SCR require sustained vehicle speeds and higher operating loads to achieve lower NOx emissions.

   We commend CARB for noting that controlling SCR performance under this part of the duty cycle is "essential for NOx control." We fully understand that CARB does not want to convey alarm about the in-use performance of widely deployed SCR systems. However, we think it should be made very clear by CARB (as the graph on Slide 10, potential excess NOx emissions, clearly shows) that heavy-duty natural gas engines DO

NOT require such SCR systems that are underperforming for diesel engines in real-world use. In two different recent emissions testing programs, which are two of sources for Slide 10, the following findings are highlighted:

**University of West Virginia emissions testing report to SCAQMD, July 2014**

This study presents a comprehensive analysis of current emissions rates of heavy-duty diesel, natural gas, and dual-fuel engines while operating under different vocations. The overall results of the study indicate **orders of magnitude lower emission rates of NOx from stoichiometric natural gas engines when compared to heavy-duty diesel engines** (emphasis added). The study clearly illustrates the differences in emission rates of diesel engines equipped with SCR while operating in and out of conditions favoring SCR activity.

*"Results of this study show that NOx emissions from natural gas vehicles with TWC and the dual-fuel HPDI equipped with DPF and SCR to be significantly lower both in distance-specific and brake-specific emissions metric than US-EPA 2010 compliant diesel engines "*

**University of California, Riverside emissions testing report to SCAQMD, July 2014**

*"In summary, the data from this study suggests that 2010 compliant SCR-equipped HDD vehicles are exhibiting high in-use NOx emissions that can be as high as 2 g/bhp-hr under low load conditions represented by short trips or frequent stops The cause of the high NOx emissions appears to be low load exhaust temperatures and, thus, low SCR aftertreatment temperatures For SCR-equipped diesel engines, some accounting of vehicle duty cycle and SCR exhaust temperature is needed to properly characterize NOx inventories Additionally, there were differences in SCR performance that varied between manufacturers, suggesting future performance will continue to vary "*

These two new reports highlight a very important advantage and air quality benefit regarding the long-term viability of natural gas (and possibly other low-carbon alternative fuels) in California's heavy-duty sector. Beyond the tested on-road heavy duty vehicles, these benefits can translate to a plethora of high-horsepower off-road applications (e.g., locomotives, marine, cargo handling equipment, etc.) if they use natural gas instead of diesel with SCR as aftertreatment. This bodes extremely well for keeping in-use NOx emissions levels from off-road vehicles and vessels at or below their already very low-NOx design levels—thus helping to more expeditiously attain the federal ozone standard.

2) On slide 10, there is a clear difference in the graphical presentation of off-cycle emissions for diesel, hybrid diesel and natural gas trucks. We request that CARB include in the technology assessment a description of the three technologies/applications and discussion of the difference in performance characteristics between the three.

Engine/Powerplant and Drivetrain Optimization Presentation

1) For Slide 5, please provide a specific reference source for the National Academy of Sciences report that is cited.

2) Regarding Slides 43 and 44, SoCalGas requests that evaluations of all technologies that have significant potential for NOx reductions are included in this technology assessment, including natural gas. This is particularly relevant to the potential for natural gas to contribute to both NOx and GHG emission reductions.

Lower NOx Heavy-Duty Diesel Engines Presentation

1) We believe that opportunities exist within the evaluation of heavy-duty diesel engines to discuss the merits of use of natural gas for quicker NOx and PM reductions, and highlight this achievement with minimal exhaust gas aftertreatment. Recognizing the focus of this presentation is diesel, we request that in the final technology assessments and analysis, CARB not silo the individual fuels and technology types, rather combine the assessments such that benefits from each for specific good movements sectors are recognizable.

Lower NOx Heavy-Duty Natural Gas and Other Alternative Fuel Engines Presentation

1. Regarding Slide 14, we request that CARB discuss the potential for optimization of GHG and NOx reductions in natural gas engine applications just as this opportunity exists for diesel engines. Also, please provide a source of the 10-15% reduction in fuel economy cited on this slide.

2. On Slide 18, please provide a reference for the citation that methane emissions from natural gas engines are much higher than those from diesel engines. It is also worth noting that N2O emissions, another significant GHG, from diesel engines employing SCR are typically much higher than those emissions from natural gas engines.

   SoCalGas explains in detail in our separate comment letter on the fuels technology assessment and methane leakage, that there are several efforts currently underway to provide greater transparency on the factors that contribute to overall methane leakage rates. These new technical studies with updated information on methane emissions will be available after January 2015 and will add much needed clarity to this issue.

   SoCalGas believes the findings from the recent and new studies will not only better ground CARB in its efforts to develop sound policies for addressing methane emissions from the natural gas supply chain, but also foster a more accurate public understanding of methane leakage rates. SoCalGas, therefore, urges CARB to consult these studies and programs as well as review their findings and results before finalizing the SFS Technology Assessments.

3. There are applications for natural gas engines in all sectors of the medium and heavy (Class 3-8) truck markets, yet some application sectors have potentially promise for NOx and PM emission reductions and cost implications (vehicle and infrastructure related) than others. CARB should fully evaluate and discuss these applications relevant to their particular duty cycles and emission reduction contributions. For example, application of natural gas to drayage trucks, either in dedicated engines or hybrid applications in and around ports in the South Coast Air Basin have unique and potentially greater air quality benefits than long haul over-the-road trucks. Discussing these benefits and the research programs needed to move these technologies toward commercialization is necessary.

Heavy-Duty Hybrid Vehicles Presentation

1) On Slide 48, we strongly suggest that CARB add natural gas engines as a potential contributor to hybrid truck applications, particularly with their potential for near-zero NOx emissions not only at certification but also in-use. This is true particularly when the focus is on near-zero emissions and extended range needed in hybrid applications.

2) We commend CARB for noting on slide 28, that emissions from hybrid-electric vehicles must be "carefully scrutinized" (in fact, NOx can increase with hybridization), largely due to duty-cycle dependent issues and system integration complexities. CARB also notes that heavy-duty hybrids are integral to California's goods movement roadmap, but NOx issues need to be addressed. Here again the point should be made here that heavy-duty natural gas hybrids would need less-complex exhaust gas aftertreatment systems (i.e., no SCR) that are no doubt part of the integration issues with diesel hybrid vehicles.

Medium and Heavy-Duty Battery Electric Vehicles

1) To complement Slide 24, we suggest CARB include a discussion in the technology assessment of ultra-fast charging infrastructure development for trucks. For example, port drayage trucks that might be limited to a ten to fifteen mile all-electric range, ultra-fast charging could be beneficial and relevant to cost-savings thru reduced battery pack size and for specific duty cycles.

2) Regarding Slides 45-46, we would like CARB include a discussion of the need for focused research on vehicles that have reduced all electric range demands with the intent of reducing the overall costs of battery electric trucks. There may be more realistic applications of battery packs to trucks that are more centralized in operation than over-the-road vehicles that in the longer term may be the best application for battery technology.

Medium- and Heavy-Duty Fuel Cell Electric Vehicles Presentation

1) Complementary to the schematic presented on Slide 37, we suggest co-location of natural-gas refueling dispensers, along with on-site generation of hydrogen via steam reformation of natural gas. There are multiple synergies in infrastructure for light-,

medium- and heavy-duty vehicle fueling, including natural gas, and hydrogen for FCVs that would be supported by a demonstration fueling station of this type.

2) SoCalGas is collaborating and co-funding with the CA Energy Commission and other technology partners on development of medium- and heavy-duty port and drayage vehicles utilizing natural gas fuel and various forms of hybridization. Detailed technical information on these projects will be provided under separate cover to CARB in mid-October 2014.

3) We also believe there is significant merit in discussing the potential for renewable natural gas as a feedstock for hydrogen production. This should be included in this Technology Assessment as it is important relative to the current effort to increase refueling infrastructure to support market expansion of hydrogen FCVs. There are important synergies between natural gas and hydrogen that need further consideration and development that can facilitate the growth of hydrogen as a vehicle fuel, accordingly.

Wrap-Up Truck Technology Assessment Presentation

1) Supported by our earlier comments, we suggest adding under Advanced Technology on Slide 3: Near-Zero Emission Natural Gas Engines. It should be emphasized that numerous projects are underway with engine manufacturers to achieve this goal. Inherently, there appears to be advantages for maintaining low in-use NOx emissions by using natural gas and avoiding the need for SCR aftertreatment.

2) On Slide 16, we suggest adding the need for further research to ensure that both NOx and GHG reductions can be realized through lower emission natural gas engines. This should include mention of advanced, direct-injection natural gas engines (e.g., based on Cummins Westport's high pressure direct injection technology) that can evolve from already-commercialized engines in the on-road trucking sector. This type of technology has potential to achieve diesel-equivalent fuel efficiency (low tailpipe carbon dioxide) while also achieving very low NOx and fuel cycle GHG emissions. While it's possible that some aftertreatment might be necessary (SCR and/or a DPF), these systems could be scaled down to the minimum to help ensure low in-use emissions.

3) On Slide 22, the merits of co-benefits from electric hybridization matched with near-zero emission natural gas engines should be added.

SoCalGas is very appreciative for the opportunity to provide these comments. We look forward to working closely with CARB as work to complete the Sustainable Freight Strategy Technology Assessments continues.

If you have any questions on these comments, please contact me directly at (213) 244-5554 or tpeacock@semprautilities.com.

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