PUBLIC COMMENTS RECEIVED

ON THE

MOBILE SOURCE STRATEGY DISCUSSION DRAFT

Mobile Source Strategy Discussion Draft (October 2015) Public Comments

Electronically-Submitted Comment Letters:

- Advanced Engine Systems Institute (AESI)
- CALSTART
- Manufacturers of Emission Controls Association (MECA)
- San Pedro Bay Ports Clean Air Action Plan: Port of Long Beach and Port of Los Angeles
- Santa Barbara County Air Pollution Control District (SBC APCD)
- Valley Clean Air Now (ValleyCAN)
- Western States Petroleum Association (WSPA)
- Doosan Infracore Co., Ltd.
- Volvo Group North America

Hand- Submitted Comment Letters:

- Jack Broadbent, APCO; Bay Area Air Quality Management District (BAAQMD)
- Paul Jablonski, CEO; San Diego Metropolitan Transit System (MTS)
- George Minter, Regional VP; SoCal Gas.
- Jerilyn Mendoza, Program Manager; SoCal Gas. Comments on ARB Advanced Clean Transit Regulation, with attachments:
  - E-3 Study Summary, Decarbonizing Pipeline Gas to Meet California's 2050 Greenhouse Gas Reduction Goal
  - Presentation for ARB Board Member de la Torre on Mobile Source Strategy
  - Nov 3, 2015 letter from SoCalGas to ARB
  - Presentation on South Coast Locomotive and OGV Natural Gas Opportunities
  - Presentation on Decarbonizing Pipeline Gas for 2050 Greenhouse Gas Reduction Goal
- Todd Campbell, Vice President; Clean Energy Fuels

WRITTEN COMMENTS OF THE
ADVANCED ENGINE SYSTEMS INSTITUTE
ON CALIFORNIA AIR RESOURCES BOARD'S
MOBILE SOURCE STRATEGY
DISCUSSION DRAFT

October 19, 2015

The Advanced Engine Systems Institute (AESI) is pleased to provide comments today in support of the Air Resources Board (ARB) Mobile Source Strategy Discussion Draft.

AESI represents emission control manufacturers in an industry employing more than 65,000 people in the U.S. We would like to extend our thanks and appreciation to ARB and to the ARB staff for their work in preparing this strategy and to express our strong support for an integrated approach to air quality and greenhouse gas reduction planning that decreases health risks, fights climate change and reduces petroleum consumption over the next 15 years. Such an approach will be essential for ARB, in cooperation with engine and vehicle manufactures, to achieve fully its multi-pollutant goals and benefits in the years ahead. We commend ARB for its longstanding leadership in this area and look forward to working with ARB in the future.

An integrated strategy is essential for California to continue making cost-effective progress in reducing the number of Californians that are living with unacceptable air quality. Such a strategy must be aimed at accelerating the statewide adoption of emission control and efficiency technologies that will save consumers money on their fuel bills, reduce pollution and improve energy and environmental security. AESI stands ready to work with ARB in achieving its goals through our innovative research and development programs and a decades-long commitment to delivering quality devices, products and systems.

Mobile sources continue to contribute approximately 80 percent of smog-forming nitrogen oxide (NOx) emissions, 95 percent of diesel particulate matter emissions, and 50 percent of GHG emissions. Obviously, there is more that can and should be done to reduce pollution from the transportation sector for both the on-road and the off-road sectors. In particular, heavy-duty vehicles represent the largest opportunity for achieving NOx reductions from the transportation sector and especially for off-road equipment. Such reductions could be cost-effectively achieved through national standards for heavy-duty on-road and off-road diesel engine applications.

With regard to the heavy duty on-road sector, AESI supports ARB's plan to strengthen the NOx standard. ARB is considering setting a standard of 0.02 grams/brakehorsepower-hour (g/bhp-hr), which AESI believes can be, working closely with our customers, both achievable and cost effective, particularly when compared to the costs of NOx reductions from other source categories. ARB's strategy calls for on-road engine technology approximately 90 percent cleaner than today's engines, and clean, renewable fuels for half the fuels burned. To demonstrate the feasibility of achieving these low NOx levels from various types of heavy-duty engines, ARB and MECA are partnering on a test program at Southwest Research Institute. The preliminary indications from this research are quite promising, but it is increasingly clear that

achieving this low level will require a variety of innovative strategies. These may include reducing NOx during low speed and cold-start conditions, use of advanced substrate and catalyst technologies and new thermal management technologies, using exhaust heat capture to activate catalytic controls, and a variety of heating and insulation strategies.

AESI believes that off road mobile sources represent a substantial opportunity for significant emission reductions. The ARB mobile source strategy includes off-road control measures designed to accelerate the penetration of zero and near-zero emissions equipment and to promote efficiency gains through the use of autonomous vehicles, worksite efficiencies and connected vehicles. However, the strategy does not include support for demonstration of low NOx control technologies on off-road sources or for petitioning EPA to tighten emission standards from off-road equipment beyond Tier 4.

In its 2012 Vision Document, ARB discussed the need to develop off-road engines meeting a 0.12 bhp-hr NOx limit. AESI suggests that ARB consider including this element in the mobile source strategy. Also, ARB could fund an off-road low-NOx demonstration program and consider requiring on-board diagnostics that are similar to the ARB heavy-duty highway requirements. Such in-use testing and OBD will ensure that the required emissions performance of off-road vehicles continues over the regulated life of the equipment or vehicle.

AESI would also like to suggest that cargo areas, including ports and their surrounding areas, provide one of the best opportunities to reduce emissions because of their high concentrations of mobile and stationary sources and because they are at the center of economic growth. Mobile source engines of all kinds, ranging from trucks and cranes, to marine vessels and locomotives, congregate in areas such as the port of Los Angeles, where they contribute significantly to non-attainment. It will be essential for any effective mobile source strategy to take the off-road sources at such ports fully into account and take actions to deploy and apply on-road control strategies and technologies to reduce emissions from those sources.

AESI urges ARB to specify NOx and PM reduction pathways in its final Mobile Source Strategy Report that demonstrate further emission reductions from off road engines and to petition U.S. EPA to consider tightening off-road NOx and PM emission standards beyond Tier 4.

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DATE: October 19, 2015

TO: California Air Resources Board

FROM: Ryan Schuchard, Policy Director, CALSTART

RE: Comments on 2030 Draft Mobile Source Strategy

CALSTART appreciates the opportunity to provide comments on the California Air Resources Board's (CARB) 2030 draft Mobile Source Strategy.[1] Following are comments which the board may wish to consider as it develops further plans. Several comments made here were also summarized orally during the workshop on October 16.

1. General Approach

CALSTART believes that general approach proposed in the draft Mobile Source Strategy ("strategy") is sound. We applaud CARB's continued leadership in developing policies that meet essential climate, health, and development objectives, while encouraging business investment that improves California's economic vitality.

In particular, we support the continued general effort to combine technology-forcing fleet average standards for new vehicles, cleaner-burning fuels, durability requirements and inspection programs to ensure clean in-use performance, sales requirements for advanced technologies, pilot programs to demonstrate technologies, and incentive programs to accelerate technology deployment.

We also are appreciative that the strategy represents a diversified approach with all "three legs of the stool" for sustainability of mobile sources: (1) increased technology efficiency; (2) reduced GHG/pollutant intensity of fuels, and (3) reduced vehicle miles traveled (or alternatively, increased system efficiency).

As CARB moves ahead to consider tradeoffs among specific activities, we propose that it considers prioritizing initiatives that advance the following key principles:

1. Maximize increased quantities of clean, low-carbon fuels, infrastructure vehicles, while bringing average costs down for the whole market;
2. Make targeted investments in overlapping product development cycles, in particular by encouraging demonstration projects to be connected to a wider arc of market study and commercialization activities;
3. Use performance-based incentives that give higher rewards for higher positive impacts;
4. Streamline permitting and certification processes in order reduce barriers to technology innovation and speed of introduction, noting that CARB needs industry to engage in aggressive, steady innovation to reduce carbon over next

[1] California Air Resources Board (October 2015). Draft Mobile Source Strategy: Discussion Draft. Available at http://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc_dd.pdf

35 years and current regulatory structure not suited to rapid innovation (Innovative Technology Regulation) is a good example of this); and

5. Build a sense of stability and consistency in order to encourage long-term, substantial investments of business capital.

In order to make the strategy successful, the private sector will need to make major investments. Fortunately, hundreds of companies already view this strategy as an area of opportunity. However, in order to generate substantial additional levels of investments, companies need to broadly perceive consistency and continuity among legislative and agency initiatives overall, especially in the face of low oil prices.

However, the current delay being experienced with allocations of 2015-16 GGRF funding is creating mixed messages that are causing some companies to express concern about whether or not there will be long term support. Therefore, we encourage CARB to consider ways to add enhancement of stability and consistency of incentive funding as a core component of the strategy.

2. Measures for On-Road (LDV and HDV)

Autonomous Vehicles. The discussion document references autonomous vehicles briefly. We agree that this technology demonstrate promise for increased efficiencies, but it also creates significant potential to increase VMT, both in consumer and commercial fleet sectors. Study on this topic should be added to the strategy.

Intelligent Logistics. It is widely understood that strategies for increasing system efficiency, such as platooning, show good promise for reducing GHG and pollution and reducing petroleum use. However, there remains a lack of good data on how this is working in practice, the size of the opportunity, and what activities should be incentivized. We would like to see California be a leader in research and planning on systems for freight and vehicle efficiency, and therefore suggest integrating this into the strategy.

Fleet Leadership. We believe that more can be done to accelerate investments by fleets, especially in the heavy duty sector, by more formally recognizing steps they are taking and encouraging them to take additional actions. Sustainable fleet accreditation systems exist that aim to create a so-called "race to the top," which and could be adopted or adapted.[2] We suggested adding this to the strategy.

3. Measure for Fuel

Importance of Fuels. It is vital to ramp up decarbonization of fuels, particularly in the HD/goods movement space, as vehicle efficiency improvement opportunities will become increasingly limited by 2035.We are generally supportive of additional measures in the fuels category (whereas there is currently only one outlined).

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[2] For example, NAFA and CALSTART have developed a Sustainable Fleet Accreditation program assesses fleet actions on energy, emissions and efficiency. More information is available at visit: http://www.nafa.org/about-nafa/nafa-sustainable-fleet/

Renewable Diesel. The requirement for 50% low emissions diesel for HDV by 2030 as proposed is important. We support this measure and in particular strongly favor the technology neutral aspect. We would also like to see this extended to gasoline and the LDV sector.

Investment Vehicles. In the stationary power sector, over 40 large companies have made voluntary commitments to being powered by 100% renewable energy, which is being done with long term voluntary PPAs (at least a half dozen doing 10-20 year PPAs of over 100 MW that is additional to RPS requirements.) We believe that it is worth considering lessons from this sector and using them to develop new measures for fuel that strengthen investment confidence and increase the attractiveness of long-term, collaborative financing across fuels as a broad category.

(end)

WRITTEN COMMENTS OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON CALIFORNIA AIR RESOURCES BOARD'S
MOBILE SOURCE STRATEGY
DISCUSSION DRAFT

October 19, 2015

The Manufacturers of Emission Controls Association (MECA) is pleased to respond to the California Air Resources Board's request for public comments on its Draft Mobile Source Strategy.

MECA is a non-profit association of the world's leading manufacturers of emission control technology for mobile sources. Our members have over 40 years of experience and a proven track record in developing and manufacturing emission control technology for a wide variety of on-road and off-road vehicles and equipment, including extensive experience in developing emission controls for gasoline and diesel engines and vehicles in all world markets. Our industry has played an important role in the emissions success story associated with mobile sources in the United States, and has continually supported efforts to develop innovative, technology-forcing, emissions programs to deal with air quality problems.

MECA commends ARB on its efforts to develop a comprehensive strategy to reduce criteria and GHG emissions from the mobile sector. As pointed out in the draft strategy document, cutting emissions of NOx, VOCs, PM and other pollutants from mobile on and off-road engines and vehicles provides a significant pathway for California to meet the state's future ozone and PM NAAQS attainment and GHG objectives while achieve the important health-related co-benefits of reducing pollution. The draft strategy document rightly points out California's impressive track record in reducing emissions from mobile sources over the past fifty years through the adoption of stringent emission standards for new vehicles and engines, and the implementation of emission reduction policies for existing diesel engines as part of ARB's Diesel Risk Reduction Plan. Mobile sources continue to contribute approximately 80 percent of smog-forming nitrogen oxide (NOx) emissions, 95 percent of diesel particulate matter emissions, and 50 percent of GHG emissions. We agree that more can be done to reduce emissions from the transportation sector and MECA is supporting several important demonstration programs to quantify these potential emission reduction opportunities. MECA's comments will focus on additional opportunities to reduce emissions from off-road mobile sources.

Combustion technology will continue to dominate heavy-duty powertrains in both on-road and off-road vehicles and equipment over the next 15 years. ARB's strategy calls for on-road engine technology that is effectively 90 percent cleaner than today's current standards, with clean, renewable fuels comprising half the fuels burned. To demonstrate the feasibility of achieving these low NOx levels from heavy-duty engines, ARB and MECA are partnering on a test program at Southwest Research Institute to demonstrate the achievable NOx reductions from a state-of-the-art, 13 L Euro VI certified engine as well as a 12 L stoichiometric natural gas engine. The program focuses on reducing NOx emissions from the low temperature portions of the test cycle including cold-start and low speed operation. MECA is providing several exhaust

system solutions for both engines that will deploy the most advanced substrate and catalyst combinations into novel system architectures focused on low temperature NOx reduction. Beyond catalyst advances, the next generation NOx reduction strategies will require careful attention to both active and passive thermal management strategies to retain the exhaust heat provided by the engine for activating catalytic controls, as well as, offering innovative approaches to actively heat the exhaust during low speed and low load operation of the engine when exhaust temperature is at a premium. An example of the types of thermal management strategies being considered under this program include dual wall and insulated exhaust pipes, dual wall stamped exhaust manifolds, active exhaust heating systems and thermally insulating substrate mounting materials along with other low thermal mass exhaust components. To achieve these very low NOx levels will require advanced reductant delivery systems and close attention to reductant dosing control strategies. To complete the system approach, SwRI engineers will optimize the engine calibration strategies to deliver the lowest possible engine-out emission levels in the exhaust. The goal of the program is to demonstrate the capabilities of next generation advanced NOx reduction technologies with no impact on the fuel efficiency of the diesel and natural gas engines. MECA is extremely confident that this program will deliver a successful result. Furthermore, we believe that similar low-NOx technologies could be deployed on off-road equipment to achieve a 60-70% reduction of NOx emissions beyond the Tier 4 final standards.

ARB staff has identified a Low NOx Engine Standard as one of the on-road, heavy-duty control measures in the draft mobile source strategy document. The mobile strategy includes an off-road control measure to deploy cleaner technologies by accelerating the penetration of zero and near-zero equipment and promoting in-use efficiency gains through use of connected and autonomous vehicles, and worksite efficiencies. The measure stops short of supporting the demonstration of low NOx technologies on off-road equipment and petitioning EPA to initiate a rulemaking effort to tighten emission standards from off-road equipment beyond Tier 4. In ARB's 2012 Vision Document, ARB discussed the need to develop reduced emission off-road engines that are 60% cleaner than Tier 4 final engines by meeting a 0.12 g/bhp-hr NOx emission limit. MECA believes that this component in the Vision Document should be carried over into the mobile strategy. It would be a lost opportunity not to build on the success of ARB's on-road low-NOx test program and fund a similar off-road low NOx demonstration test program. MECA would be interested in partnering with ARB on an off-road low NOx and low PM demonstration program.

To estimate the achievable level of NOx inventory reduction from off-road engines through the deployment of technologies similar to those being demonstrated in the on-road low NOx test program, MECA funded an independent emission inventory forecast study at ENVIRON, to better understand the full benefit of future national NOx tightening for off-road heavy-duty diesel engines beyond Tier 4. This analysis relied on EPA's NONROAD2008 emissions inventory model. The model was run to generate emissions inventories of NOx, VOC, CO and PM for off-road sources for calendar years 2025, 2030, 2040, and 2050. For the heavy-duty sector controls scenario, we selected NOx reduction and implementation timeline inputs for these sectors based on California ARB's June 28, 2012 Vision Document. For the heavy-duty off-road fleet, we assumed a nominal 70% NOx reduction from Tier 4 final levels for engine power ranges from 75-750 hp and an 80% NOx reduction from the small diesel off-road power

category from 25-75 hp. The NOx reductions from the off-road engines were phased in from 2025-2027 and staggered by power ranges analogous to those used to phase-in Tier 4 final off-road engine standards.

We estimated the NOx reduction potential of the fully implemented and phased-in regulations out to 2050. For the 47 contiguous states including the District of Columbia, but excluding California. The modeling results show that the off-road heavy-duty mobile sector has the potential of delivering over 215,000 tons/year of NOx reductions across the 47 lower United States plus D.C. in 2050 or nearly 600 tons per day. We believe that the heavy-duty mobile measures represent the largest opportunity for achieving NOx reductions from the mobile sector and especially for off-road equipment. These reductions would be best achieved through tighter national standards for both heavy-duty highway and off-road diesel engine applications.

To derive a cost effectiveness value, we estimated the incremental cost of the types of additional emission controls, discussed above, that would be necessary to achieve the target reductions from off-road equipment. The incremental cost of control varies widely for construction equipment due to the broad power range and equipment configurations that make up this sector. An average incremental cost of exhaust controls, beyond Tier 4 final, over the 25-750 hp power range is approximately $350 per engine. Because there are greater opportunities to reduce NOx from the off-road sector, we estimate that these reductions can be achieved within a range of costs from $1,000 - $1,500 per ton of NOx.

MECA believes that further reductions in NOx emissions from new off-road diesel engines beyond the Tier 4 off-road requirements will be possible through the combinations of more advanced diesel engines with advanced diesel exhaust emission control technologies. The types of future evolutionary technologies deployed, to achieve a future lower off-road NOx standard, will likely be similar to those being demonstrated in the SwRI on-road low NOx program discussed above. Future off-road emission standards could also take the opportunity to achieve further reductions of PM emissions from this sector. We believe that an indirect benefit from tighter-off-road NOx standards may be to force DPFs on unfiltered engines in order to meet these future standards while still achieving the currently established PM limits. There is further opportunity of reducing PM beyond Tier 4 final levels for the smallest power range of 25-75 hp engines by setting a tighter PM limit that would require the use of filters. ARB is funding a feasibility demonstration of installing emission control technologies on this small diesel engine sector that is being supported by MECA members.

Recent EPA certification information for off-road diesel engines certified in model year 2015 indicates that more than half of the engine families, for engines rated from 37-560 kW, were certified without DPFs. In some cases, OEMs are choosing to remove DPFs that were certified with engines for Tier 4 interim compliance in certifying their Tier 4 final configurations. MECA encourages ARB to characterize the regulated and unregulated exhaust emissions of similar Tier 4 final off-road diesel engines certified with and without DPFs to more completely understand the impacts of these alternative compliance pathways on public health and climate change. A Tier 5 off-road diesel engine regulation that forces the use of best available PM controls and state of the art NOx controls would provide additional public health, ozone and climate change benefits associated with further emission reductions of multiple pollutants from this sector. The European Union is due to finalize soon a Stage 5 off-road diesel

engine regulation that will likely include a particle number-based emission limit to force the use of filters on a large segment of off-road diesel engines. California (and the U.S.) needs to continue its leadership role on reducing emissions from diesel engines by putting policies in place that ensure that off-road diesel engines (including applications in agriculture, construction, locomotive, and marine) utilize both high efficiency filters and SCR controls. The advent of SCR catalyst-coated filters (now commercialized for light-duty diesel applications) allows for the design of compact diesel emission control systems that can simultaneously provide high reductions in PM/black carbon and NOx, pollutants important to both California's ambient air quality and climate change policy goals.

MECA is concerned about the PM emissions durability of off-road Tier 4 engines certified without DPFs. There is ample evidence that engine-based PM control strategies are prone to higher in-use emissions than DPF-equipped engines, due to factors such as cold starts, poor maintenance, and the large variety of duty cycles encountered in the off-road sector. Given the expected, relatively small compliance margins of off-road Tier 4 final engine designs that do not utilize DPFs, MECA believes that ARB should closely scrutinize Tier 4 final certification packages of non-DPF diesel engines and allocate extra compliance and enforcement resources to follow up with in-use emissions testing of any Tier 4 off-road engines certified without a DPF. MECA also believes that ARB and EPA should also strongly consider adoption of a manufacturer run, in-use emissions testing program in the off-road sector that utilizes the latest portable emissions measurement technology to ensure that Tier 4 final off-road engines are delivering the emission reductions associated with the Tier 4 off-road standards. The off-road sector could also benefit from the adoption of on-board diagnostic requirements that are similar in scope to the heavy-duty highway diesel on-board diagnostic requirements required by ARB. In-use testing and OBD ensure that the emissions performance of the engine/equipment is maintained over the regulated full useful life.

MECA encourages ARB to continue its leadership on reducing mobile source emissions by specifying NOx and PM reduction strategies in its upcoming, finalized Mobile Source Strategy report that include demonstrating further emission reductions from off-road engines and petitioning U.S. EPA to initiate a rulemaking to tighten off-road emission standards beyond Tier 4 final levels for both PM and NOx.

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SAN PEDRO BAY PORTS

CLEAN AIR ACTION PLAN

October 19, 2015

Submitted Electronically: http://www.arb.ca.gov/lispub/comm/bclist.php

Clerk of the Board
California Air Resources Board
1001 I Street
Sacramento, CA 95814

SUBJECT: COMMENTS ON CALIFORNIA AIR RESOURCES BOARD SOURCE STRATEGY (OCTOBER 2015 DISCUSSION DRAFT)

Dear Staff of the California Air Resources Board:

The City of Los Angeles Harbor Department and the City of Long Beach Harbor Department appreciate the opportunity to submit comments on the California Air Resources Board's (ARB) Mobile Source Strategy Discussion Draft (Discussion Draft) document which contains, in part, strategies for reducing air emissions from the major sources that move freight in and out of the Ports of Los Angeles and Long Beach (Ports). The Ports recognize the hard work that has gone into producing this Discussion Draft and applaud you for your efforts.

The Ports support the efforts of the ARB to work with the United States Environmental Protection Agency, South Coast Air Quality Management District, and International Maritime Organization to achieve emissions reductions from goods movement. Specifically, we support the proposed measure concepts identified in the Discussion Draft, including the development of low-NOx engine standards for on-road heavy-duty trucks; Tier 5 national locomotive emissions standards; and development of Tier 4 engine emissions standards and amendments to the At-Berth regulation for ocean-going vessels. Because the Ports do not possess the authority to regulate these sources, we believe that rulemaking at the national or state level is the most effective way to ensure emission reductions.

The development and advancement of transformative technologies, including zero-emission equipment, described in the Discussion Draft, will come at a significant price. The Ports support the use of monetary incentives and funding programs provided through the ARB to ensure successful deployment of these new technologies.

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The Green Port
Port of Long Beach | Environmental Planning
4801 Airport Plaza Drive | Long Beach, CA 90815
562.283.7100

THE PORT OF LOS ANGELES
Port of Los Angeles | Environmental Management
425 S. Palos Verdes Street | San Pedro, CA 90731
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The San Pedro Bay Ports Clean Air Action Plan was developed with the participation and cooperation of the staff of the US Environmental Protection Agency, California Air Resources Board and the South Coast Air Quality Management District.

We are also supportive of potential measures that include the use of strategies described in the Discussion Draft to increase operational efficiency at the Ports. We recommend that the ARB conduct detailed reviews or assessments of each efficiency strategy in order to ensure that the strategy will result in air pollution reductions.

We thank you again for the opportunity to comment and look forward to continuing our work with the ARB. If you have any questions or would like to discuss the comments raised in this letter please contact us.

Sincerely,

CHRISTOPHER CANNON
Director of Environmental Management
Port of Los Angeles

Matthew Arms for
HEATHER TOMLEY
Director of Environmental Planning
Port of Long Beach

POLA APP No.: 110128-840

Our Vision Clean Air

Santa Barbara County
Air Pollution Control District

October 19, 2015

California Air Resources Board
1001 I Street, PO Box 2815
Sacramento, CA 95812

Re: Comments on *Mobile Source Strategy*, Discussion Draft, October 2015

Dear California Air Resources Board:

The Santa Barbara County Air Pollution Control District is pleased to provide input on the above discussion draft document.

Ocean going vessels transiting offshore Santa Barbara County represent one of our largest sources of nitrogen oxides (NOx) emissions. As the onshore stationary sources we regulate have reduced their emissions, and as California rules have reduced emissions from cars and trucks, emissions from ships represent a key area of focus for us for NOx reductions. As stated in the *Mobile Source Strategy* (page 75), "Ocean going vessels, locomotives, and aircraft are sources that are primarily regulated by the federal government and international organizations... In contrast to the significant NOx emissions reductions in the on-road mobile sector, emission sources in this category are only forecasted to decrease by about 20 percent by 2031."

We support the actions identified in this Strategy to achieve additional reductions in NOx emissions from ships.

We urge California Air Resources Board to include vessel speed reduction (VSR) as a strategy to achieve near-term state-wide NOx emission reductions. Reducing ship speeds down to 12 knots along the California coast has the potential to achieve up to a 50 percent reduction in NOx emissions over the baseline, as we demonstrated in the 2014 VSR Trial, a voluntary incentive program in the Santa Barbara Channel, with seven global shipping companies participating. This was a partnership effort with the Channel Islands National Marine Sanctuary, Environmental Defense Center, National Marine Sanctuary Foundation, and the Ventura County Air Pollution Control District. The factsheet summarizing results from the program is attached here; the full report is available on our website at http://www.ourair.org/air-pollution-marine-shipping/.

Thank you for your consideration.

Sincerely,

Louis D. Van Mullem, Jr., Air Pollution Control Officer
Santa Barbara County Air Pollution Control District

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John Calambokidis – Cascadia Research

Protecting Blue Whales and Blue Skies

Report on the 2014 Vessel Speed Reduction Incentive Trial in the Santa Barbara Channel

In 2014, the Channel Islands National Marine Sanctuary, the Santa Barbara County Air Pollution Control District, and the Environmental Defense Center launched a trial incentive program to slow ships down in the Santa Barbara Channel to reduce air pollution and protect endangered whales. The trial was successfully completed November 30, 2014.

Highlights

- Seven global shipping companies participated
- Slowed 27 cargo ship transits to 12 knots or less from July through November for $2500 per trip incentive
- 50 percent reduction from baseline emissions for participating vessels:
  - 16 tons of ozone-forming nitrogen oxides (NOx)
  - 500 metric tons of regional greenhouse gases
- Ship strike on a whale up to 50 percent less likely to be fatal at speeds below 12 knots
- Most transits occurred July-October; benefits during peak ozone season and peak whale season
- Unique application of speed reduction in a non-port program

Issue

Each year, thousands of large container ships going to and from the Ports of Los Angeles and Long Beach travel in designated shipping lanes through the Santa Barbara Channel.

Air emissions

In Ventura and Santa Barbara counties, these vessels are a significant source of:

- ozone-forming nitrogen oxides
- sulfur dioxide
- greenhouse gases
- diesel particulate matter
- other toxic air pollutants hazardous to human health

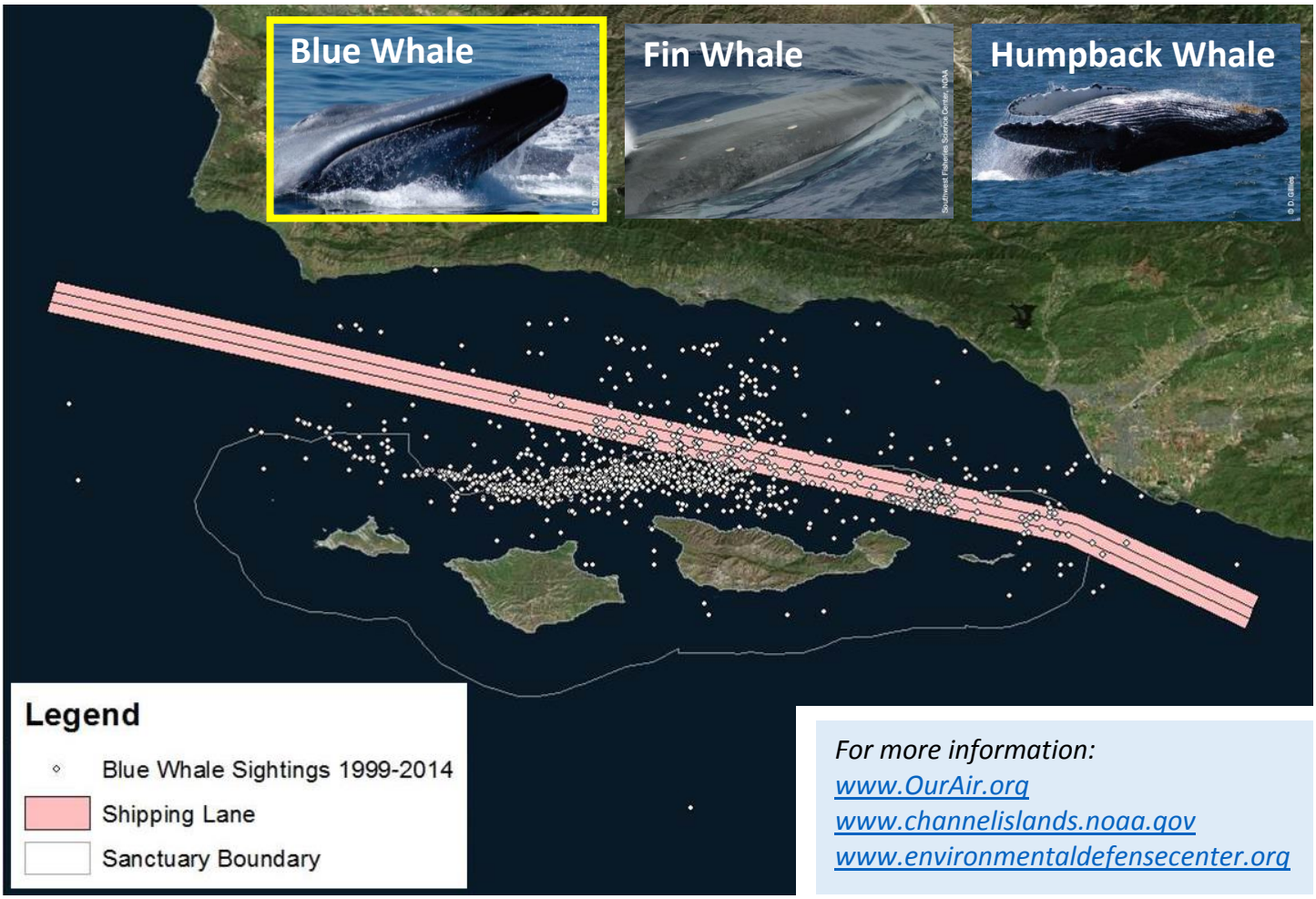
Fatal Ship Strikes

Endangered whale species feed and travel in and around the shipping lanes seasonally:

- Blues
- Fins
- Humpbacks

Increased Future Vessel Traffic

Within the Channel, pollution and endangered whale concerns from ship traffic may become more pronounced as the number of annual transits increases. There may also be changes in Channel traffic related to North American Emissions Control Area fuel requirements that took effect January 1, 2015.



For more information:
www.OurAir.org
www.channelislands.noaa.gov
www.environmentaldefensecenter.org

Goals for the Vessel Speed Reduction (VSR) Trial

- Assess potential air quality and whale protection benefits from a voluntary speed reduction program in the Santa Barbara Channel
- Test the shipping industry's willingness to participate in this kind of a program
- Refine data collection and tracking mechanisms
- Lay the foundation for establishing a larger-scale program in the future

Criteria for VSR Trial

- Vessel must have a documented speed of 14 knots or higher in previous trips through the Santa Barbara Channel
  - Ensures Trial achieves at least a 2 knot speed reduction
  - Previous baseline speeds ranged from 14 knots to 18.67 knots
- Vessels must be participating in one of the VSR programs at the Ports of Los Angeles/Long Beach
  - Prevents Trial from competing with Ports programs
  - Ensures a continuous slow-speed zone from Ports through Channel

Seven global shipping companies participated:

- COSCO
- Hapag-Lloyd
- K-Line
- Maersk Line
- Matson
- Mitsui O.S.K. Lines
- United Arab Shipping Company

Trial Implementation

The VSR Trial was developed and implemented by staff from the partner agencies and organizations:

- The National Marine Sanctuary Foundation served as a fiscal agent for receiving funds and making incentive payments.
- Funding was provided by:
  - Santa Barbara Foundation
  - Santa Barbara County Air Pollution Control District
  - Ventura County Air Pollution Control District

Speakers and Participants in a 9/10/14 forum on the Trial Program.

- More applications for eligible transits (40) than could be incentivized
- In total, 35 transits enrolled in the VSR Trial and 27 of these qualified for an incentive payment
- Ship speeds through the Channel were verified by using Automatic Identification System (receives vessel speed and location data from transponders on all ships)
- Total incentive payout amount of $67,500
- 5.1-knot average reduction from baseline speeds for the 27 eligible transits

Next Steps

The VSR Trial's design, enrollment process, and data collection/processing mechanisms were refined throughout, and a solid foundation is in place for establishing a larger-scale program.

Benefits of a Large-Scale Program in the Santa Barbara Channel

(Estimated 2,500-5,000 transits per year)

- 1,500-3,000 tons of NOx emissions reductions per year
- 47,500 -95,000 metric tons of regional GHG emissions reductions (expressed as carbon dioxide equivalent, or CO2e)
- Assuming similar incentive, cost approx. $6-12 million/year
- Immediate emission-reduction and whale-protection benefits
- Potential for a statewide program: benefits could be expanded along the California coastline

Urgency

- Proposed stricter federal ozone standard could put our region out of attainment; more important to reduce NOx emissions
- Projected increase in annual transits through the Channel to the Ports
- Possible changes in Channel traffic related to North American Emissions Control Area fuel requirements that took effect on January 1, 2015
- Ship strikes are one of the leading causes of whale mortality and may be affecting recovery

Valley Clean Air Now Comments on CARB Mobile Source Strategy Discussion Draft

Thank you for the opportunity to comment on the Mobile Source Strategy Discussion Draft. The draft document outlines the numerous programs to enforce current light duty emissions standards and to further reduce future fleet emissions. We commend CARB for their continued progress on this issue.

However, one significant source of criteria pollutants including ground-level ozone precursors is not mentioned in this document, namely light-duty vehicles in regular use that have fallen out of registration. **Acknowledging in the Mobile Source Plan this currently unregulated yet significant source would be a big step toward an eventual solution to this longstanding and well-known issue.**

<u>The Problem – The Dirtiest Cars Aren't Counted</u>

Given the recent global attention to emissions inconsistencies between laboratory testing and on-road results, there is a clear need to address this air quality issue which disproportionately affects disadvantaged communities where unregistered, high-emitting vehicles appear to be most prevalent. Revising the existing emissions models using direct testing of vehicles as opposed to calculations based on estimates could aid the state in creating large and immediate improvements in air quality for these communities. This quote from Thomas Cahill's recent Sacramento Bee op-ed "Vehicle testing has Achilles' heel" is a reminder of how long the air quality models have been skewed by the data imbalance caused by unregistered vehicles being excluded from the emissions inventory:

> "In 1987, a research team used a freeway tunnel in Van Nuys to compare the predicted auto emissions from ARB dynamometer laboratory tests to real-world conditions. The tunnel tests gave carbon monoxide and hydrocarbon emission values 300 percent and 400 percent higher than expected on the basis of dynamometer tests.
>
> The on-road tests identified a sad result – most California cars were clean, but a small number of "gross emitters" were generating two-thirds of all highway pollution. These cars are modified vehicles with bypassed catalytic converters, old throw-away cars, unregistered cars, some with fake smog-check clearances from shady service stations, and the like."

Based on Valley CAN's direct experience with nearly 40,000 vehicles in the San Joaquin Valley since 2011, we can demonstrate that there are significant numbers of light-duty vehicles concentrated in disadvantaged communities, where criteria pollutant levels are highest, that have dropped out of registration and are emitting ever-increasing levels of NOx, CO and HC. These cars are likely 1995 and older, with much higher criteria pollutant emissions than newer OBDII and LEVII vehicles.

Unregistered Cars Drive a Lot, and Emit a Lot

Valley Clean Air Now operates the Tune In & Tune Up (TI&TU) program on behalf of the San Joaquin Valley Air Pollution Control District. Recent TI&TU data illustrates the prevalence and impact of unregistered cars in the San Joaquin Valley. During CY 2014, 9,600 vehicles attended TI&TU, 46 percent of which were unregistered at the time of the event. Out of these unregistered vehicles, 2,931 failed a BAR-97 two-speed idle emissions screen and were given a voucher for up to $850 in smog repairs.

Valley CAN asked Jeffrey Williams, professor in the UC Davis Agriculture and Resource Economics Department to study the repair data from those unregistered vehicles that subsequently appeared at a STAR Test & Repair facility, and calculate how far these unregistered, high-emitting vehicles being driven as well as the emissions reductions resulting from the repairs. Dr. Williams provided the following in response:

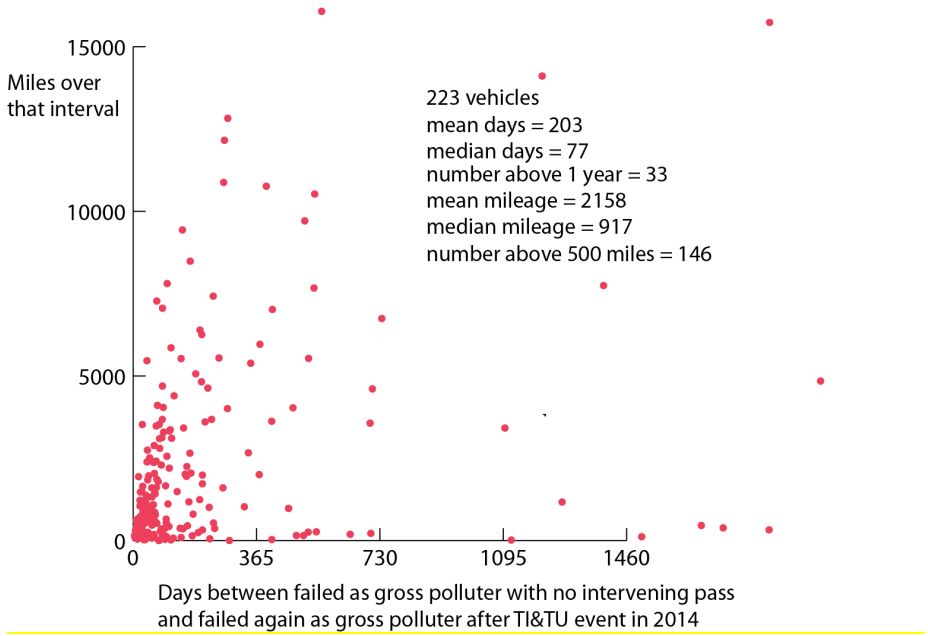
> "Among these 2,931 unregistered, high-emitting cars, 1,459 resulted in repairs in which the reduction in emissions can be easily measured. (Several hundred other vehicles were repaired, but the calculations are not easy, because the tests were not ASM or because several testing facilities were involved, including Test Only facilities.)
>
> "Mileage calculations could be made for 1,310 vehicles (another 25 had dubious odometer readings, principally because of the 5-digit odometers on the oldest vehicles). Of these 1,310 vehicles, 223 were classified as a Gross Polluter at the start of a sequence of Fails with no intervening Pass and again subsequent to the TI&TU event. These 223 vehicles are plotted in the first of the attached graphs. (The equivalent graph for all 1,310 vehicles with a fail before and after the TI&TU event looks very similar). Some of these gross-polluting vehicles had been driven very little, even over spans as long as three or four years, as would be hoped. However, two-thirds had been driven over 500 miles. Twenty-nine of the 223 (150 of the 1,310) had been driven at least 5,000 miles. The answer to the key question is thus: **Unregistered, high-emitting vehicles are on the road in substantial numbers for substantial miles.**
>
> "The calculation scrolls backwards in the smog check histories from the observation made subsequent to the TI&TU event. If the first of the previous smog checks was a Pass, it is ambiguous how long the vehicle has been out of compliance, anywhere from the day after that previous pass to the day before the TI&TU event. If the first of the previous smog checks was some type of fail, it can be presumed that the vehicle was out of compliance at least during that whole interval (if not from even earlier). That logic extends further backward through a sequence of failed tests until a pass is reached. The difference in the beginning and ending dates in this sequence, and more importantly, differences in odometer readings, reveals whether these vehicles have been driven.
>
> "The second of the attached graphs shows the reduction in emissions among the 408 Gross Polluters among the1,457 vehicles for which emissions can be readily computed; the third graph

shows the reductions among the 1,049 who simply failed. The reductions in emissions of the group of vehicles that failed but not at the Gross Polluter level are generally smaller but are still very substantial given the higher cut points for older vehicles. (Those few that show an increase in emissions due to the repair are mostly vehicles that failed because of tampering.)

"Summed across all these 1,457 vehicles, the reduction in the sum of NOx, HC, plus CO was 13,821 grams/mile. With application of the convention that vehicles travel 10,000 miles per year (27 miles/day), the reduction in emissions from these vehicles is 0.4 tons per day. (Because these are older vehicles, their miles/day average is less than the convention, although the average rate for the 223 unambiguous gross polluters is 21 miles/day.) Perhaps more relevant are the emissions of these vehicles before the repairs, which total 0.6 tons/day (0.1 ton/day if CO is not included). **These are significant emissions reductions – to provide some context, repairing these unregistered vehicles is roughly comparable to retiring newer vehicles.**

"None of these emissions from unregistered vehicles have been included in air quality models, but they are picked up by air quality monitoring stations because the vehicles are being driven. The percentage of unregistered vehicles has been consistently high at TI&TU events, with some individual events exceeding 55 percent unregistered. Why the owners of the vehicles come to a TI&TU event is itself an interesting subject for study, but the steady numbers over the years suggests that these owners represent only a small part of this hidden category of unregistered, high-emitting vehicles."

Miles driven by unregistered unambiguous gross polluters



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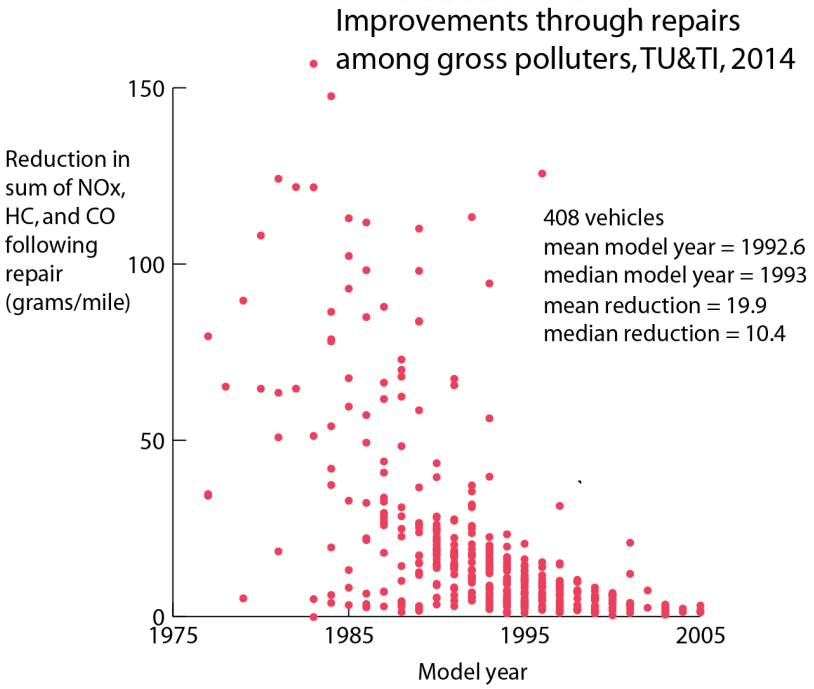
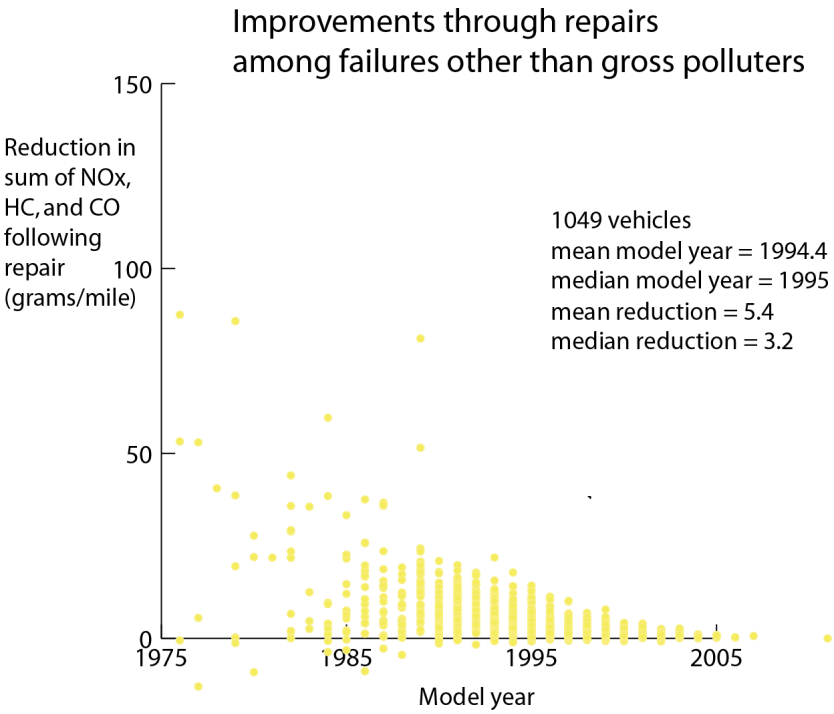
"clean air now"





The Source of Unregistered Cars

These results clearly demonstrate the predictable reaction to the inevitable emissions equipment failures in high-mileage older cars typically driven by low-income motorists. Breakdown of the catalytic converter and/or the O2 sensor results in a smog check failure, which necessitates expensive emissions repairs in order to reregister the car. Low-income individuals, often unable to pay for repairs, see no choice but to let their vehicle fall out of registration. Perhaps the owners hope to find the funds in a few months, but perhaps also, with time, they become accustomed to driving an unregistered vehicle. Once the vehicle drops out of the registration database, the state no longer accounts for the emissions of that vehicle, leaving a huge hole in the state's emissions tracking.

Based on the striking uniformity of the rate of unregistered cars throughout all eight Valley counties in both rural and urban areas, we predict a similar rate of unregistered cars with unreported emissions in disadvantaged communities statewide as defined by CalEnviroScreen 2.0 and SB535.

Better Understanding of Unregistered Cars Should Lead to Solutions

Determining the actual emissions status of California's entire vehicle fleet is an opportunity to find "new" sources of light duty criteria emissions reductions. We urge CARB staff to consider how to include in the Mobile Source Plan this significant source of criteria emissions from unregistered vehicles that are currently not addressed. It makes sense to go after these relatively cheap and easy emissions reductions first, which will create real-time improvements in disadvantaged communities. The districts that likely have the largest number of unregistered cars and thus the largest potential reductions are the districts with the majority of SB535 disadvantaged communities: South Coast AQMD, San Joaquin Valley APCD, Bay Area AQMD, Monterey Bay Unified APCD, Sacramento Metro AQMD, and San Diego County APCD.

Thank you for your consideration. We would also like to thank the San Joaquin Valley Air Pollution Control District for their ongoing support of Tune In & Tune Up, as well as Jeffrey Williams, Ph.D. for his time and unique expertise in analyzing vehicle emissions data. We are happy to further discuss our results and related conclusions. Please contact Tom Knox, Executive Director at tom.knox@valleycan.org or (916) 273-8886.

Western States Petroleum Association
Credible Solutions • Responsive Service • Since 1907

Catherine H. Reheis-Boyd
President

November 18, 2015

Carol Sutkus (carol.sutkus@arb.ca.gov)
Kirsten King (kirsten.king@arb.ca.gov)
Air Resources Board
1001 I street
Sacramento, CA 95814

RE: Comments on ARB Mobile Source Plan

Dear Ms. Sutkus and Ms. King:

The Western States Petroleum Association (WSPA) appreciates the opportunity to provide comment on the outline of the Air Resources Board (ARB) Mobile Source Strategy (MSS). Our members operate numerous facilities that explore for, develop, refine and transport petroleum and petroleum products and natural gas in California. We offer the following observations as input to ARB as they further develop plan elements.

Integration of Plan Elements

WSPA recognizes that the MSS is part of ARB's integrated planning effort where air quality and climate goals are being considered as an integrated effort. Such an approach, it is thought, can help ensure that efforts to control emissions are consistent, non-duplicative and cost-effective for all affected sources on a statewide basis. Finally, we understand that ARB expects to integrate plan elements within other plans such as the State Implementation Plan (SIP), AB32 Scoping Plan Update, the CA Sustainable Freight Strategy and the Short-Lived Climate Pollutant Plan. We agree that these efforts should be integrated to the extent legally required and appropriate.

However, we must stress the need for care in developing plan elements, because while some components of the MSS affect criteria pollutants (NOx, SOx, Ozone, PM) and, as such, will be submitted as part of the State Implementation Plan (SIP) and become federally enforceable, others could also result in reductions of GHG emissions. ***Plan elements addressing GHG reductions, that ARB asserts are in support of goals set in AB 32, should NOT be submitted within the SIP***. We

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note, specifically, that GHG reductions are not required elements of any SIP, nor is there any expectation that such requirements will be established. Hence, inclusion of GHG emissions within SIP submittals would be beyond the scope of the SIP and beyond EPA's authority to regulate.

Goals within Mobile Source Plan (MSS) are Unrealistic

The goals outlined in the MSS appear to mirror goals that, while initially proposed in 2015 legislation, were ultimately removed before passage. For example, the MSS calls for a 50% reduction in petroleum transportation fuels by 2030– a provision that was specifically removed by the California legislature from SB 350 (De Leon, 2015), thereby leaving ARB without regulatory authority to pursue such a reduction. Inclusion of this target within the Plan is problematic for several reasons.

First, and perhaps most importantly, the goals set by ARB that are to be met by 2030 appear to be grossly unrealistic and based more on wishful thinking than fact. For example, according to ARB, currently there are 100,000 Zero Emission and Plug-in Hybrid Electric Vehicles (ZEVs/PHEVs) on the road. Yet ARB's proposed Plan assumes a population of 4,300,000 such vehicles by 2030. A 40-fold-plus increase (4,200%) in penetration of such vehicles is virtually impossible when one considers the average life-span of vehicles in California approaches the 15-year timeframe that ARB is projecting for this transformation. The modeling results in the MSS document and workshop presentation do not account for this market penetration at such a profoundly rapid rate, and the raw and background data are not readily available for public review.

With respect to trucks, ARB notes that low NOx trucks are currently in demonstration or pilot stage testing – yet ARB projects a vehicle population by 2030 of 1,000,000. Again, as above, the rate of fleet turnover (more than 15 years as has been discussed in the past) required to achieve that level is entirely unrealistic. For both source categories, ARB should, instead, incorporate historic rates of fleet turnover as a benchmark for their analysis in the MSS.

We note ARB recognizes that achieving such targets will be a challenge that, in turn, will require innovative approaches, including funding and incentives, improved infrastructure, and increased consumer acceptance. This latter challenge may be the single biggest hurdle based on the high costs of new vehicle technologies. Given all these challenges and the uncertainty that accompanies them, it seems clear that the goals set forth in the MSS must be flexible and open to modification, as it is likely that the pace of implementation will not match ARB's optimistic projections. It is particularly important that this flexibility be maintained for any portion of this document that is inserted as a control measure into a SIP.

Please note also Scoping Plan comments we submitted (October 19, 2015) that discuss these issues.

Potential for Stranded Costs

The MSS, as outlined by ARB, is clearly ambitious, and even ARB would agree that there is uncertainty whether such goals are, indeed, achievable. Hence, those charged with implementation

will undertake innovative programs with a high degree of risk. It seems, again, given the uncertainty of the goals and the risks associated with implementation, that ARB should instead outline step-wise (or tiered) targets so that departures from the aspirational path set out by ARB can be documented and analyzed. Such an approach, including a cost-benefit analysis, would address concerns of stranded investments expressed by stakeholders at the last series of workshops.

Need for Cost-Effective Approach

WSPA has long supported, and will continue to support, measures that are cost-effective and technically feasible. The need for cost-effective approaches is even more important when evaluating elements of the MSS. We note that many stakeholders and ARB Board members echoed the requirement that implementation of the MSS must be cost-effective. Moreover, staff should be receptive to approaches that improve cost-effectiveness so that, as one Board member noted "we get the most reduction for the best expenditure."

Low Emissions Diesel (LED) concept

The proposal by ARB to impose dual diesel grades or "regional" diesel supply in California is problematic, as we previously noted in the ADF development period. The feasibility of implementing a distribution system for tracking and delivering separate diesel mixtures that somehow parallels the current system has not been documented - nor have the costs of such a system been noted (as stated above).

In advancing this concept, ARB has not even estimated the incremental emission reductions over the proposed next generation Heavy Duty Diesel engine controls. For example, in order to conduct such an analysis, ARB would need to forecast the market share of legacy (pre-2010) on-road diesel engines in 2025, as well as develop projections and outlook for "legacy" off-road fleet in 2025, factoring in ARB's parallel efforts to implement tighter engine standards for those engines by 2020 and the conversion of part of the sector to electricity. Once that forecast is accomplished, staff would need to convert the fleet estimates to diesel use (gallons) and also use EMFAC to predict criterial pollutant reductions for the LED measure. If that were done correctly, it seems likely that that such analysis would lead to the conclusion that the incremental engine emission standards targeted by CARB obviate the need for the parallel LED strategy they have just now put forward.

While this measure primarily targets criteria pollutant (NOx and PM) reductions, CARB is proposing to include a carbon intensity (CI) specification in LED and will likely attempt to represent the emissions impacts as also being beneficial on the GHG side. This is unreasonable. If ARB is interested in exploring a CI requirement, then ARB should document the need for this measure above and beyond what is already targeted by LCFS. We note that the reduction corresponding to a 50% replacement of the diesel pool with renewable diesel (or CI equivalent) represents a six-fold increase over corresponding LCFS 2020 figures for market penetration of such diesel alternatives. Any further targets (beyond the current LCFS regulation) to decrease CI in fuels should be covered only by the

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Low Carbon Fuel Standard, not in other rules or plans. Parceling out CI reductions among other plans and regulations is sleight of hand and cannot be engaged in by ARB to avoid critical review or legal scrutiny.

ARB assumptions re: Fuel Availability and Compatibility

Given the magnitude of the projected Renewable Diesel (RD) (or equivalent) volume increase outlined in LED (to 2400 MGY in 2030), a third-party evaluation of the feasibility of CARB's projections is needed. Furthermore, a critique of CARB's estimation methodology should be part of this segment and be based primarily on global, domestic and in-state bio-feedstock availability.

To address these critical issues, WSPA requests that CARB discuss the disposition and impacts of the displaced conventional diesel from the LED provision. To fully analyze this issue, ARB would need to document answers to critical questions. For example, what are the incremental criteria and GHG emissions resulting from the potentially displaced volume of diesel being exported from California? Where does CARB anticipate the additional renewable diesel will come from? Is it produced in-state? What are emissions from this production? If it is imported to California, where does it come from and how does it get here? What are the emissions from the transportation of the renewable diesel? What would be the Cap-and-Trade implications of the increase in renewable diesel imports? Would this cause emissions leakage and/or require border carbon adjustments?

Overlap with LCFS Requirements

More broadly, the ARB should consider the potential implications of the proposed LED measure vis-à-vis the existing LCFS requirements. How is a measure targeted at very specific geographical areas of the state (South Coast and San Joaquin) consistent with the broader targets of global GHG reductions? While ARB sees only synergies in the "integrated" multi-pollutant strategy approach, where are the unnecessary duplications and unforeseen contradictions in such a plan? WSPA has, on many occasions, expressed concern about the cost-ineffectiveness of the LCFS program as a regulatory overlay to the cap & trade program. CARB is now proposing a volumetric mandate as a regulatory overlay to the LCFS and to cap & trade. This underscores the need for CARB to provide incremental cost and emission benefit analysis for this proposal as an additional overlay of regulatory burden.

Next Steps

WSPA looks forward to working with the ARB in the continuing public process as it further develops the MSS. We anticipate more detail and substantiating documentation will be provided by ARB in the coming workshops. Should you have any questions, please feel free to call me at this office or Mike Wang of my staff (cell: 626-590-4905: mike@wspa.org).

Sincerely,

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From:	이서영(Seoyoung Lee) 과장 두산인프라코어
To:	Sutkus, Carol@ARB; King, Kirsten@ARB
Cc:	Sterling, Todd@ARB; Kato, John@ARB; 김효수(Hyosoo Kim) 부장 두산인프라코어
Subject:	[Question] 2016 Mobile Source Strategy - Off-Road Equipment Sources (Zero Emission Off-Road Forklift Phase 1)
Date:	Thursday, October 01, 2015 7:59:43 PM
Attachments:	(approved) Off-Road Zero Emission LSI Workshop_June 2015.pdf

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Dear Ms. Carol Sutkus and Ms. Kirsten King Cayabyab,

This is Seoyoung Lee from Doosan Infracore Homologation & Regulation Team.

Regarding the 2016 Mobile Source Strategy workshop on October,
Would you review our following questions regarding the "off-road" section especially forklift and reply to us?

1. Would you confirm the engine type of "Zero Emission Off-Road Forklift Phase 1" is either "SI (spark ignition)" or "CI (compression ignition)" engine for us?
   I found the attached document related with LSI workshop document on this June, but I could not find the relevant document of "CI"

2. If the "Zero Emission Off-Road" regulation will be for "SI" & below "8,000 lbs" forklift then Would you inform to us the other strategy
   (It will be the next emission standard of Tier4 final) concept (the emission limit and schedule) to reduce NOx and PM for following application for us?
   ⇨ The engine will be CI (compression ignition) and
   ⇨ The lift capacity will be above 8,000 lbs (and also includes below 8,000 lbs)

3. Would you inform to us about the "Zero Emission Off-Road Phase 2" regulation especially following points?
   1) Would you confirm the scope and expect implementation date of "Phase 2"?
      As according to following material,
      I think Phase 2 will be cover also larger, higher power construction and mining machine, but I am not clear the engine will be "SI" or both "SI" and "CI"
   2) If the Phase2 regulation will be cover large "CI" engine and the implementation date will be after 2025, then
      Would you inform to us current Tier4 Final emission regulation will be applied until at least MY2025
      without change emission limit number and nor add GHG/ Fuel consumption?

Measure Title: **Zero Emission Off-Road Emission Reduction Assessment**

Measure Overview:

The goal of this measure concept is to expand the use of zero emission technology in non-freight, off-road applications. This further-study measure concept would be a follow-up to off-road measures implemented in the 2023+ timeframe, such as the Zero Emission Off-Road Phase 1 Regulation, and through it ARB would identify opportunities to further expand the use of zero and near-zero emission technologies in off-road applications.

Type of Action:

ARB technology review

Timeframe:

ARB Board date: 2025+
Implementation schedule: --

Description of Measure and Commitment:

ARB would provide the Board with an informational update regarding the status of ZEVs in off-road applications, which would identify opportunities to further expand their use. The focus of this measure concept is on transferring zero and near-zero emission technologies to heavier pieces of off-road equipment, such as high lift-capacity forklifts or other equipment in the construction, industrial, and mining sectors, with the intent of expanding their application as technology matures and infrastructure grows. This evaluation would focus primarily on the scalability and transferability of zero emission technologies to larger, higher power-demand equipment types and would be used to inform the development of the Phase 2 regulation. The information obtained from this technology review would be used to inform the development of Phase 2 of the Zero Emission Off-Road Regulation. The Zero Emission Off-road Phase 2 Regulation would build upon the Phase 1 regulation and focus primarily on larger, higher power-demand equipment types, such as large forklifts, construction equipment, etc. The scope and timeframe of the regulation would depend upon advancements in technology and information obtained through the Advanced Off-Road Emission Reduction Assessment.

If you need additional discussion or information, please feel free to contact us.

Thank you and Best Regards,

Seoyoung Lee

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VOLVO

Volvo Group North America

Date: February 5, 2016

To: California Air Resources Board

From: Dawn Fenton
Director, Sustainability & Public Affairs

Subject: Volvo Group Comments on CARB Mobile Source Strategy Discussion Draft

The Volvo Group understands the challenges facing the state of California and applauds the extensive effort the California Air Resources Board (CARB) is taking to meet them. This document provides an important framework for the Sustainable Freight Action Plan and other actions by the state and we appreciate the opportunity to submit comments on this draft strategy.

Volvo Group is one of the world's leading manufacturers of trucks, buses, construction equipment and marine and industrial engines. The Group also provides complete solutions for financing and service. Volvo Group, which employs some 100,000 people worldwide, has production facilities in 19 countries and sells its products in more than 190 markets. In the United States, Volvo Group employs 12,000 people and has nine manufacturing plants in six states.

With regards to the strategy's focus on heavy-duty vehicles, we believe the challenge will be significant, with combustion technologies dominating far longer than the 15 years noted on page 2. While California's ultimate goal is the greater use of zero and near-zero emission vehicles (ZEVs), we recommend that the state focus on supporting complete vehicles rather than just the engines, to reduce emissions by 90 percent. Comments addressing specific points throughout the document are detailed below, however the main points we would like to highlight include:

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- The accelerated adoption of US2010 heavy-duty technology will provide more near-term GHG and criteria pollutant reduction for less cost than many advanced technologies. Both are important, but it is a question of emphasis and priority.
- Greater use of drop-in biofuels like renewable diesel can also bring cost-effective near-term impacts and could be more actively encouraged by the state.
- California should look very closely at metrics that take into account their economic impact when considering heavy-duty sector regulations; for instance, measuring emissions per ton-mile makes more sense to ensure positive, real-world impacts.
- Targeted emission reduction goals should be pursued rather than ones that are technology-focused.
- Significant positive environmental gains can be achieved by targeting increases in system efficiencies that utilize advanced technologies beyond the powertrain.
- Advanced and transformative technologies should be encouraged, but they should be evaluated in the context of their ultimate cost, commercial availability and their full impact on customer productivity.

(p.1-5) Executive Summary

It should be noted that Figure ES-1 shows the desired, rather than likely benefits of a proposed strategy to be achieved. Governor Brown's Executive Order (B-32-15) states that economic progress must continue while pursuing these environmental goals. However, economic factors have hardly been brought up in the report's executive summary, mentioned almost in passing on page 4. Economic considerations must be factored into the equation for success both from the perspective of the original equipment manufacturers (OEMs) relied upon to develop these new technologies and the California businesses and citizens who will face added costs to purchase them.

Although the strategy attempts to provide for these costs through R&D and purchase incentives, it fails to account for the larger environment and mitigating factors that technology, fuel and vehicle developers face. While actions listed in Table ES-1are proposed to help California achieve its state goals, they do not account for federal and global policy, fiscal, and competitive considerations that must be weighed by major national and multinational companies. In order to expedite the achievement of California's environmental goals, it will be important for state policymakers to focus on promoting national, harmonized standards rather than incentivizing specific technologies or solutions. In that way companies can achieve the most efficient solutions based on overall complex commercial and technology considerations.

In addition, the state must not only look at vehicles as an emissions source, but evaluate their role in commerce. If the goal were only to reduce emissions, this could be done. The challenge for heavy-duty vehicle manufacturers is that vehicle owners evaluate advanced technology vehicles on a range of factors. Overall productivity and total cost of ownership is equal, if not more important than purchase cost and emissions levels. As a result, OEMs must look beyond engine technologies and fuels to other system efficiencies and non-vehicle technology solutions such as platooning (Vehicle-to-vehicle/V2V and vehicle-to-infrastructure/V2I solutions) to deliver real-world reductions of greenhouse gas (GHG) and criteria pollutants as noted on p.3 of the executive summary. Some of these technologies are closer to deployment and more cost-effective than alternative propulsion technologies. The Volvo Group suggests using a less prescriptive approach, focusing on the end goal rather than specific technologies.

(p.6) Strategies:

With regards to engine performance standards, the Volvo Group suggests the state measure cost/benefit trade-offs. Pushing to the edge of current technology and beyond with new, unproven, expensive technology that is not ready for commercialization could be an expensive exercise that doesn't produce the intended results. Furthermore, for major heavy-duty truck OEMs, the size of the California market may not be sufficient to support the design, development, production and product support expenses related to complex engine

technologies. This could result in more limited product offerings in the state, reduced competition and higher product costs.

Ensuring durability: Stricter durability testing can dissuade the introduction of new, advanced technology if more onerous compliance demands raise the risk and cost of its introduction. There is no proven methodology to reliably accelerate durability testing for many vehicle sub-systems. Extending durability test requirements will necessarily extend the development time, thereby requiring extended lead time for any regulation implementation. Moreover, we question the added value of stricter durability testing in light of CARB's extensive on board diagnostics (OBD) testing requirements which are already focused on keeping trucks in compliance with regulations.

Incentive funding for cleanest engine technologies: The focus should not be limited to engine technologies. More importantly, greater effort should be given to accelerating US2010 and newer technology penetration in the market. Failure to do so significantly retards the achievement of the state's goals, leaving emissions on the table until some future time when more advanced technologies can compete in the market.

Renewable fuels: Other than the Low Carbon Fuel Standard (LCFS), what incentives are being given for the use of renewable fuels, which are given great prominence as part of the ongoing solutions? These fuels are available now and could, through expediting their availability and usage, provide significant GHG and criteria pollutant benefits.

(p.7) Blueprint

The Air Resources Board's (ARB) success of the past was predicated on potential improvements of existing technology and some new technology (mostly in the light-duty sector). Moving forward, the state appears to be focused almost entirely on new technology. This is a much bigger leap, particularly when it comes after decades of hard-fought and costly improvements.

Using the light duty sector as an example for heavy-duty vehicles (p7-9) is vastly overstated. Significant differences in duty cycles, purchasing factors, and the

volume of vehicles manufactured (among others) create different use and business cases that make the light-duty reference case deceiving and inaccurate.
Measure of success: The fact that 40% of ZEVs are in California does not necessarily indicate success. It indicates compliance with the ZEV Mandate since the volume is still extremely low and all of the vehicles are being sold at a loss. The reliance on financial support — for infrastructure, R&D and purchase incentives, props up an unsustainable market. Purchasing criteria for heavy-duty vehicles make it virtually impossible to replicate this penetration model with heavy-duty trucks and completely ignores consideration of customer return on investment.

(p.10) Advanced Transportation Technologies & Efficiency Improvements

Autonomous vehicle technology can and should be seen as not just for light-duty vehicles. In many ways its application to the freight sector and heavy-duty vehicles could be even more beneficial to efficiency and environmental improvements. V2V and connected vehicle technologies are important for the freight sector since efficiencies equal emissions improvements. Encouragement by the state can influence investment in these technologies and support progress.

(p.14) Air Quality Standards

In light of the regional and local challenges in meeting ozone and particulate matter (PM) standards, California should consider incentivizing the use of advanced technologies in areas with the worst air quality in order to target the greatest reductions where they are most needed rather than requiring a stricter statewide ozone standard that makes it exponentially more difficult and expensive for OEMs to meet multiple federal and state regulations.

(p.16) Nitrogen Oxide (NOx) reductions

Co-benefits from other programs: We believe the benefit from quicker adoption of US2010 engine technology, combined with requirements to expeditiously repair

emissions faults, would significantly accelerate the curve/trend of emissions reductions.

(p.16) *"Current health studies indicate that the largest share of air pollution-related health impacts occur from exposure to PM 2.5"* This significant statement seems buried in the document with most of the emphasis on GHG and NOx. Again accelerated 2007/2010 engine technology adoption would provide the quickest reduction of PM emissions.

(p.21) Assessing Coordinated Planning Needs

Technology Assessments: The Volvo Group is submitting more detailed comments on several of these technology assessments. In general, we have serious questions about the assumptions and conclusions of these assessments. Their role of "identifying the types of technologies that will be needed" and "describing available technologies" is not the same as "what is realistically possible" for implementing them in the complex world of the freight system. The technologies must not only address climate and criteria pollutant issues, but deliver equal or superior performance compared to existing technologies if commercial customers are going to buy them.

(p22) *"low-NOx diesel engines certified to the optional standard of either 0.05 or 0.1 g/bhp-hr available shortly thereafter."* We question the basis on which this statement is made. While current diesel engines test to NOx emission levels lower than the existing 0.20 g/bhp-hr, this does not account for compliance margins or deterioration factors which must be factored into any OEM calculus for making products commercially viable. In reality, further tightening of these margins require reductions far greater than publicly stated and beyond what can even be accurately measured. These compliance margins are of utmost importance to OEMs in this era of ever-tightening compliance confirmation actions by regulators, such as the recently introduced requirement for manufacturers to annually test OBD monitor compliance on high mileage heavy-duty vehicles.

"The development of heavy-duty zero emission technologies is also underway." It is true that these technologies are being developed; however, the bigger and

more important question is whether they can be made commercially viable, both for the OEM and the customer, and the extent to which they can penetrate the market considering duty cycle requirements.

(p.26) Introduction of Clean Technologies and Fuels

The Volvo Group supports the use of renewable diesel so increased use of that fuel should be encouraged to help California reach its petroleum and GHG reduction goals. The Volvo Group is also investigating other alternative fuels like di-methyl ether (DME) that holds promise for significant further reductions in NOx and PM emissions.

(p.28) *"The greatest NOx reductions result from actions associated with the turnover of the heavy-duty vehicles to cleaner technologies."* Based on this statement, shouldn't greater priority be given to policies and actions that incentivize quicker fleet turnover?

(p.32) Strategy Conclusions

The strategy sites policies, technology assessments and scenario evaluations as reasons to believe a transformation of the transportation sector is possible, yet it has completely overlooked the technical complexities and challenges that come from trying to meet multiple simultaneous regulations and the cost and risk factors that influence the commercial market. The technology assessments need to incorporate comments and reviews by peers/experts in the industry before they are presented as part of the roadmap for the state.

We firmly agree that California will need a mix of zero and near-zero emission technologies and increased use of renewable fuels, with the balance between them dependent on fleet characteristics and the pace of technology development. This is a key statement that needs to be very prominently presented as part of this strategy. As the state found in the light-duty sector, the pace of technology development can be stimulated by the state, but its results may not always be as prescribed.

While we agree with the importance of ensuring technology durability, these requirements have the impact of effectively lowering the prescribed standards to

account for compliance margins. While we do not oppose these goals, they "will take extensive time, effort and investments by OEMs to accomplish it.
(p.33) "Greater system efficiency" opportunities: Volvo believes the potential in this area is at least as large, and more cost-effective, than engine regulations alone.

(p. 35) Mobile Source Strategy & Measure Concepts

"The proposed SIP measure concepts reflect a combination of regulatory and programmatic actions to:

- *Establish more stringent engine performance standards for cleaner combustion technologies;*
- *Ensure that emissions control systems remain durable over the lifetime of the vehicle;*
- *Increase the penetration of the zero-emission technology across a broad range of applications;*
- *Expand the requirements for cleaner low carbon diesel fuels;*
- *Conduct pilot studies to demonstrate new technologies;*
- *Incentivize the turnover of equipment and fleets to the cleanest technologies; and,*
- *Increase system efficiencies."*

Volvo would order these differently based on their positive potential impact and on the emissions and timeline:

- Incentivize turnover
- Increase system efficiencies
- Expand requirement for cleaner low carbon diesel fuels
- Conduct pilot studies to demonstrate new technologies
- More stringent engine and vehicle emissions performance standards
- Ensure emission controls systems durability
- Increase penetration of zero-emission technology

(p.37) Increased efficiency is still low-hanging fruit in off-road and on-road sectors. That efficiency can apply to engine, vehicle and system improvements.

Incentive funding focus should be based on cost/ton of reduction over lifespan of technology implemented.

(p.55) On-Road Heavy-Duty Sector

"One-third of the trucks originating from out-of-state": That leaves two-thirds of the trucks as in-state vehicles and that population represents one of the lowest adoption rates of 2007/2010 engine technology in the heavy-duty sector in the nation.

(p.57) Federal Low-NOx Standard

The Volvo Group questions the supposition that failure to meet the federal ozone standard in the timeframe required through full fleet penetration of 2010-compliant engines necessitates a more stringent federal heavy-duty engine NOx emission standard. Such a standard would not only complicate (if not undermine) the GHG emission reductions anticipated in the federal Phase II regulation, but it would fail to bring the level of NOx emission reductions California policymakers are seeking because current certification duty cycles do not accurately reflect real world driving conditions. The result is lower emission reductions than anticipated.

Moreover, in light of the extremely low NOx emission levels in 2010 engines, more cost-effective reductions can come from higher penetration of post-2010 vehicles in the statewide truck fleet, requirements to expeditiously repair emissions faults, other advanced vehicle technologies or consideration of complete vehicle system efficiencies. As noted frequently above, Volvo believes the greatest gains in all emission reductions come through efficiencies and that the focus should be on improving efficiency of vehicle operation without dictating that reductions must come from engine technology.

Moreover, if California is interested in real-world emissions reductions, there should be an investigation of a change in the evaluation metric from NOx per g/bhp-hr to g/ton-mile. This would more accurately reflect real-world implications and help the state more appropriately channel its financial resources to

supporting technologies that will have the best chance of helping the state's air districts come into attainment with federal air quality standards.

(p.59) Role of Low-NOx Strategy

Since it appears that obligated fleet adoption of 2010 technology will not happen until 2023, it seems that accelerating this technology adoption should be a priority over new rules and new technology. The 400,000 low-NOx (0.02 g/bhp-hr) truck assumption (even over 15 years) seems very ambitious given the infancy of the only certified technology (natural gas & 3-way catalyst), its limited application, and the time to develop and certify additional low-NOx engines for various fuels and applications. Compared to the current adoption rate of natural gas technology, which has been highly incentivized, it would seem this is a very unrealistic assumption. An increased rate of adoption of renewable diesel fuel is more reasonable since this fuel is currently available and has been approved for use in existing Volvo and Mack Trucks.

(p.60) On-Road Heavy-Duty Proposed Measure Concepts

Building on past successes is a dangerous concept when it ignores physics and thermodynamics. Advances in engine emissions and related technology are limited by the potential of technology and thus, past successes do not assure additional future reductions.

"*Where commercial products are feasible and commercially available*" is a large loophole. As has been found with the ZEV Mandate in the light-duty sector, the feasibility and commercial availability of a technology is only one factor; customer acceptance is much more significant and that will be based on risk aversion, functionality of the technology, and cost. Furthermore, commercial availability in much of the heavy-duty truck market also requires an extensive nationwide network of service providers with diagnostic tools, training, and parts availability.

Technology migration and cost reductions across vehicle applications are not as great as commonly assumed, due in part to the low volume of heavy-duty vehicle technology and the highly specialized nature of many of the HD segments.

Acceleration of technology, while a valid concept, does not take into account the extensive time and cost needed to be invested by an OEM to bring a technology to market, with the key element being a market acceptance of a given technology. Incentives can help develop and deploy a technology in demonstration, but they cannot create a true market – the HVIP program could be seen as evidence of this. In fact the linkage between financial incentives and technology acceptance by customers is significantly weaker in heavy-duty vehicles than with light-duty vehicles since performance, fitness for duty, and the total cost of ownership calculus is more critical and less subjective than what most individuals consider for their personal vehicle choices.

"Investments that bring the cleanest technologies to market as quickly as possible are essential." We heartily agree, but that cost could be substantial.

(p.62) Lower In-Use Emission Performance Level measure

Many of the measures proposed are predicated on the assumption that heavy-duty vehicles have unfavorable reliability compared to their passenger car counterparts. Such a conclusion may be drawn if comparing emissions-related failures on a *per calendar year basis*. Volvo anticipates that if such an analysis were based on failures *per mile, per hour, or per ton-mile*, that heavy-duty vehicle emissions reliability would be superior. The proposed measures could amount to overkill, which will tend to disincentivize manufacturers' willingness to bring new technologies to market.

(pg.64) Low-NOx Engine Standard

Federal action: The limited impact of a California Low-NOx standard on emissions from Class 7 & 8 trucks in the absence of federal action seems to suggest that greater efforts to encourage higher penetration of 2010 technology trucks combined with incentives to encourage ZEV technology in Class 2b-6 trucks would enable the state to make quicker progress towards its goals. It would also allow large OEMs such as Volvo to dedicate more resources and expedite development of near-ZEV technologies with global application rather than focusing on developing technology with limited application and even less

likelihood of making a meaningful difference in reducing emission levels in California.

(pg.65) Heavy-Duty GHG Phase II:

Volvo cannot stress strongly enough the importance of regulatory harmonization and the negative impact of differing market regulations on product development decisions. CARB has expressed an interest in driving adoption of aerodynamic features on vocational vehicles over and above EPA's Phase 2 requirements. CARB must be very careful with any such consideration to be sure they are not forcing technology that brings little or no benefit depending upon the operational characteristics of the variety of applications involved. Furthermore, aero features that interfere with vehicle functionality must be avoided.

(p.68) Innovation Technology Certification Flexibility Measure:

This could be critical to bringing in new and innovative technologies, provided the flexibility provisions offer sufficient benefit to be utilized by OEMs.

(p.70) Incentive Funding to Achieve Further Emission Reductions from On-Road Heavy-Duty Vehicles: based on the time required to further develop and commercialize ZEV, near ZEV, and ultra-low NOx vehicles, it seems that there will be a lack of vehicles available for which this funding could be used. Instead, using such funds for fleet turnover to post-2010 technology vehicles would appear to provide most immediate, significant air quality benefits.

(p.75) Off-Road Sector:

Volvo believes the zero/near-zero focus does not recognize the potential advances through use of ITS and other connected vehicle technologies to maximize efficiencies and reduce emissions in this very diverse sector. It is further imperative that CARB not disrupt the tremendous work done to internationally harmonize non-road emissions standards. CARB should work with the international community on any future test protocols and limit values beyond the Tier IV final requirements in place today.

VOLVO

Volvo Group North America

(p.99) Fuels

Volvo is supportive of the increased use of drop-in renewable biofuels, with Volvo Trucks and Mack Trucks being the first and only major OEMs to approve of the use of renewable diesel in their vehicles. More state support for use of these fuels could accelerate the move to reduce petroleum use.

(P.113) Economic Impacts & Funding Mechanisms

We believe that, in addition to gasoline consumption vs GDP, the state should also plot diesel vs GDP to address true economic impact since diesel is such a critical component to the state's economy.

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Phone: (202) 536-1553

Off-Road Large Spark-Ignition (LSI) Equipment Regulation Proposed Amendments

Public Workshop

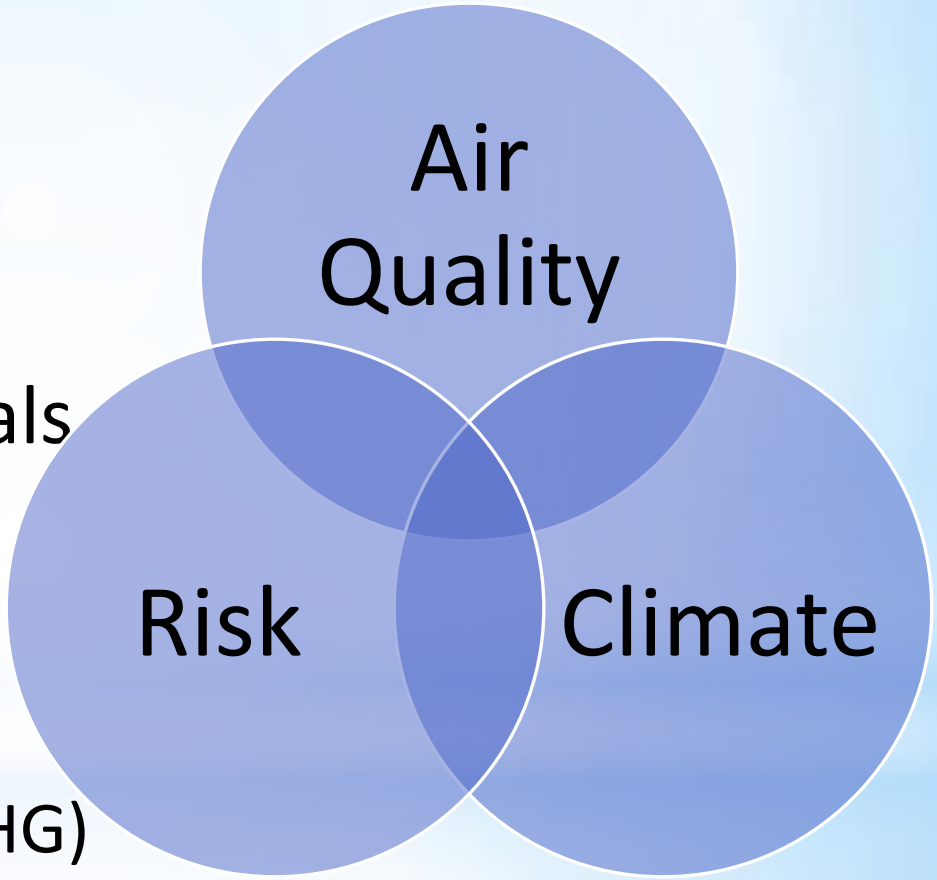
Date and Time	Location
June 8, 2015 – 10:00 am – 12:00 pm PDT	Cal EPA Building Byron Sher Auditorium Sacramento, CA 95812
June 10, 2015 – 10:00 am – 12:00 pm PDT	San Joaquin Valley Air Pollution Control District Auditorium 1990 E. Gettysburg Ave. Fresno, CA 93726
June 12, 2015 – 10:00 am – 12:00 pm PDT	South Coast Air Quality Management District Auditorium 21865 Copley Drive Diamond Bar, CA 91765

Overview

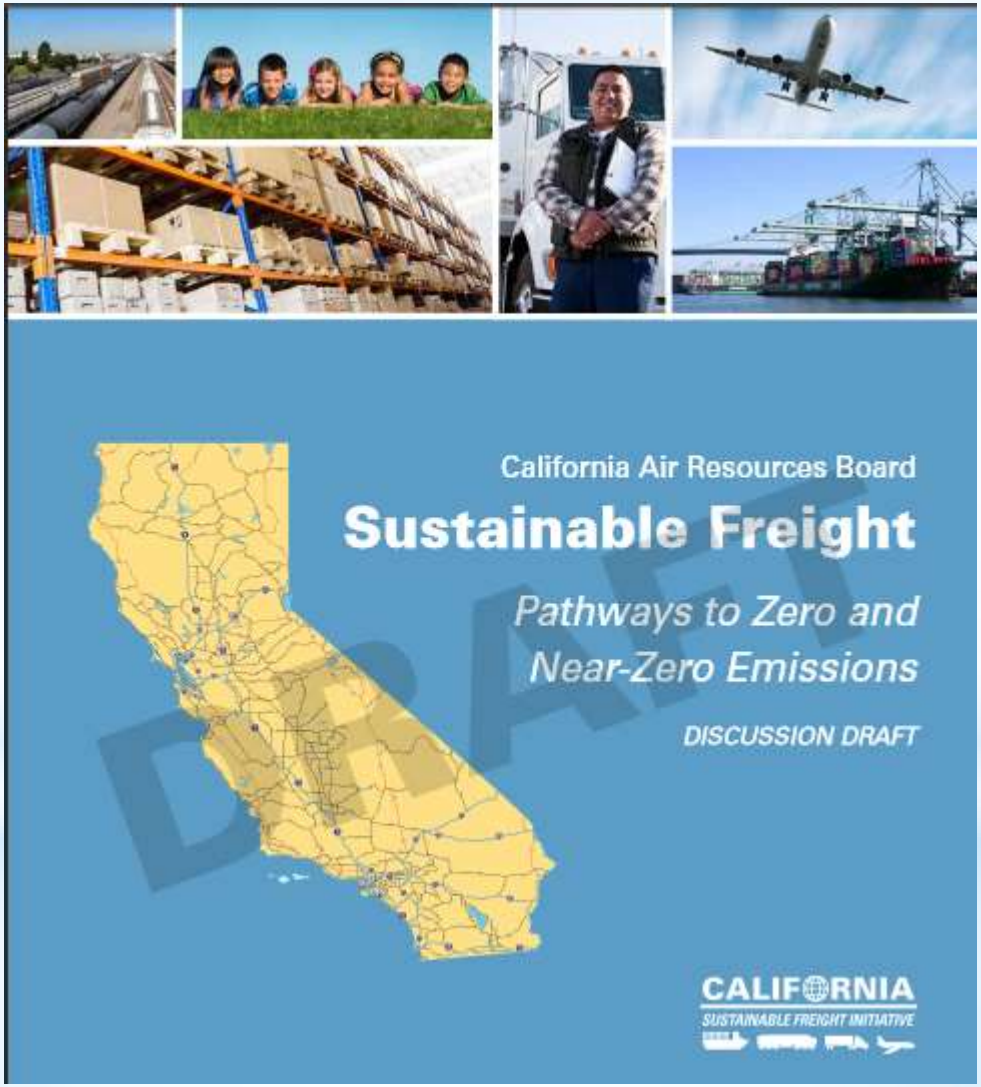
- Introductions
- Background
- Current LSI Regulation
- Proposed Amendment Concepts
- Important Dates/ Contact Information
- Discussion

Need for Emission Reductions

- Minimize Near-Source Health Risk
- Help Meet California Goals
  - 90% Oxides of Nitrogen (NOx) by 2032
  - 50% Petroleum by 2030
  - 80% Greenhouse Gas (GHG) by 2050



ARB Sustainable Freight Plan



Significant Opportunities for Zero-Emission Deployments

Long-term Goal: Expand zero emission, where feasible, in off-road sector through a coordinated incentive and regulatory approaches

- Roughly 50% of forklifts are already electrified
- 90-95% of forklifts with up to 8,000 lbs. lift capacity (~3/4 of market) can operate using today's zero-emission technology without significant change in workflow
- Fuel cell forklifts: ~5,000 in U.S.
  <1% zero–emission forklift market

Large Spark-Ignited (LSI) Regulation

LSI Engine Emission Standards

- Gasoline, Propane, CNG
- 25hp or greater, >1L displacement
- Self–propelled

Fleet Average Requirements

- Forklifts
- Industrial Tractors
- Sweepers/Scrubbers
- Airport Ground Support Equipment (GSE)

Estimated Statewide LSI Emissions

LSI Equipment Emissions Statewide Annual Average in tons per day (t/d)

Year	Population	HC	NOx
2004	87,687	15.4	54.8
2010	92,104	7.5	28.3
2020	96,964	4.4	19.0

LSI Equipment Emissions Top Three Equipment Categories (t/d)

Equipment Category	2004		2010		2020	
	HC	NOx	HC	NOx	HC	NOx
Industrial Forklifts	11.8	40.4	5.3	19.9	3.4	15.6
Airport GSE	0.6	3.3	0.3	1.5	0.2	1.0
Sweeper/Scrubbers	0.2	0.8	0.1	0.3	0.1	0.2

Controlling LSI Engine Emissions

- New Engine Emission Requirements
- Automotive – style controls
- Three-way catalytic converters
- Fuel/Air Control
- Retrofit kits available for older engines (Model Year (MY) 1980 – 2003)

LSI Fleet Average Requirements

- Forklifts
- Sweepers/Scrubbers
- Industrial Tow Tractors
- Airport GSE
- Powered by LSI Engine

Forklift

For the purposes of the LSI Fleet Regulation

"Forklift" means:

- Electric Class 1 or 2 rider truck
- LSI engine-powered Class 4 or 5 rider truck

"Forklift" does not mean:

- Electric Class 3 truck (e.g., pallet jacks & walkies)
- Man lifts, scissors lifts, and bucket/boom lifts

Sweeper/Scrubber

- “Sweeper/scrubber” means an electric motor powered or large spark-ignition engine-powered piece of industrial floor cleaning equipment

- Designed to vacuum up small debris (litter) and/or scrub and squeegee the floor

Industrial Tow Tractor

- "Industrial Tow Tractor" means an electric motor or LSI engine **Class 6** truck as defined by the Industrial Truck Association
- Designed primarily to push or pull non-powered trucks, trailers, or other mobile loads on roadways or improved surfaces
- Commonly referred to as tow motors or tugs
- Tow tractors used at airports are included in GSE Fleet definition

Airport Ground Support Equipment (GSE)

- LSI engine
- Some electric-powered equipment
- 23 subcategories

Air Conditioner	Cart	Lavatory Cart
Air Start	Catering Truck	Lavatory Truck
Aircraft Tractor	De-icer	Lift
Baggage Tractor	Fork Lift	Passenger Stand
Belt Loader	Fuel Truck	Service Truck
Bobtail	Generator	Sweeper
Cargo Loader	Ground Power Unit	Water Truck
Cargo Tractor	Hydrant Truck	

- Includes “On-Road Equivalent GSE,” those pieces of GSE designed for, but not licensed for on-road use

Exemptions to the LSI Fleet Regulation

- Small Fleets
  - 3 or fewer forklifts, and/or
  - 3 or fewer pieces of non-forklift LSI engine equipment
- In-field forklifts
- Rental or leased equipment operated 30 or fewer aggregated calendar days per year
- Tactical support equipment

Fleet Size/Type Considerations

- Two Separate fleets
  - Forklift
  - Non-forklift
  - For each, include electric equipment
- Forklift fleets
  - Medium (4-25)
  - Large (26+)
- Equipment must be added together into a single fleet if procurement decisions and/or budgeting for facility locations occur at a higher corporate level.

Fleet Average Emission Standards

Fleet Average Emission Level Standard in Grams HC+NOx per kilowatt-hour (g/kW-hr) (brake horsepower-hour)

LSI Fleet Type	Number of units	By 1/1/2009	By 1/1/2011	**By 1/1/2013**
Forklift – large fleet	26+	3.2 (2.4)	2.3 (1.7)	**1.5 (1.1)**
Forklift – mid-size fleet	4-25	3.5 (2.6)	2.7 (2.0)	**1.9 (1.4)**
Non-forklift – GSE, tow tractor, sweeper	4+	4.0 (3.0)	3.6 (2.7)	**3.4 (2.5)**

* **GSE forklifts must comply with the forklift standards**

Fleet Average Exclusions

- Limited Hours of Use
  - Less than 200 based on prior year
- Rental or lease equipment where:
  - Agreement is less than one year; and
  - Meets a 2.7 g/kW-hr standards; and
  - No more than 20 % of fleet (otherwise, the exclusion applies only to first 20%)
- Boneyard and Retired equipment

Calculating the Fleet Average

- Not based on hours of use, hp, or source test
- Straight average of HC+NOx certification/verification standards or a default value for uncontrolled engines

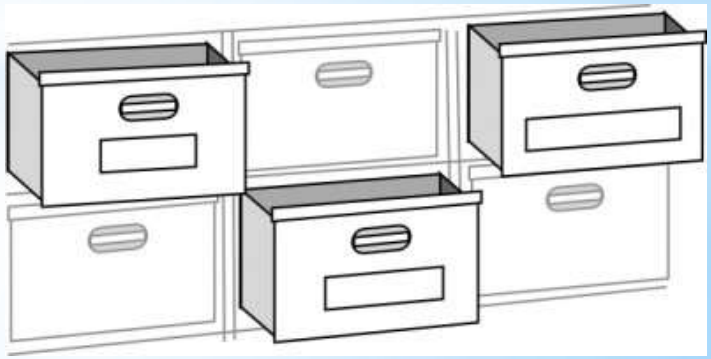
Engine Category	$HC+NO_x$ Emission Factor
Pre-2001 model years	16.0 g/kW-hr (12.0 g/bhp-hr)
Uncontrolled 2001-2003 MY	
Controlled 2001-2003 MY	4.0 g/kW-hr (3.0 g/bhp-hr)
2004 to 2006 MY	
2007 to 2009 MY	0.8 - 2.7 g/kW-hr (0.6 - 2.0 g/bhp-hr)
2010+ MY	0.8 g/kW-hr (0.6 g/bhp-hr)

Special Provisions

- Equipment Dealers Provisions
- Specialty Equipment Exemptions
- Agricultural Provisions
- GSE Provisions

Recordkeeping Requirements

- Current LSI regulation has no reporting requirements
  - Baseline inventory Nov. 2007
  - Contents: vehicle/engine make, model, serial number, certification, or verification level as shown on label
  - May be retained at a centralized location
- Records of fleet inventories through June 30, 2016



Near-Term Objective

- Provide needed State wide emission inventory updates
- Facilitating uniform compliance between all LSI fleets
- Identifying current zero emission incentive opportunities
- Open to alternatives to achieve the same goal
  - Agriculture
  - Airport GSE

Proposed LSI Regulatory Amendment Concepts

- Registration and Reporting
- Labeling
- Other Minor Regulatory changes
  - Improve clarity
  - Maintain incentive funding availability

Proposed LSI Registration and Reporting Requirements

- Maintain current applicability
  - Forklifts, GSE, sweepers/scrubbers, and industrial tow tractors
  - Large and Medium fleets
- Expand current recordkeeping to a reporting requirement
- Utilize Diesel Off-Road On-line Reporting System (DOORS)

Proposed LSI Labeling

- Propose labeling one label on back of LSI equipment
- Equipment Identification Number (EIN) is white with BLUE background
- Each character will be 3 inches high x 1.5 inches in width

Key
Activities and Contacts

- LSI Reporting Amendments
  - Workshops (Summer/Fall 2015)
  - Workgroups as requested
  - Board Item (May 2016)

- Todd Sterling – Staff Lead
  916-323-2397 Todd.Sterling@arb.ca.gov
- John Kato – Manager
  916-322-2891 John.Kato@arb.ca.gov

Discussion

BAY AREA
AIR QUALITY
MANAGEMENT
DISTRICT

October 21, 2015

Mary Nichols, Chair
Air Resources Board
1001 I Street
Sacramento, CA 95814

Dear Chair Nichols:

We appreciate the opportunity to comment on the discussion draft of the Mobile Source Strategy being presented to the Board at your October 22, 2015 meeting. We appreciate the effort your agency has put into cutting mobile source emissions, both to date and into the future as proposed in the discussion draft. We share the goal of cutting emissions from mobile sources, for both air quality and climate reasons.

These comments are not on the Strategy in general, but instead are on potentially significant emission reductions we would like to see included under the second light duty measure proposed concepts. This concept, titled 'Lower In-Use Emission Performance Assessment', is focused on trying to ensure that the vehicles in-use in California operate at the cleanest levels possible. We support using the Smog Check database and results from the Bureau of Automotive Repair's Random Roadside Inspection Program to better understand and address potential problems with the Smog Check program.

But we note that some motorists deliberately avoid the Smog Check program by either failing to register their vehicles, registering their vehicles in other states, or through other fraudulent registration schemes. We believe that these vehicles tend to have emissions far higher than the average on-road vehicle, and are likely to be significantly underrepresented in the inventory. While California does not have comprehensive data on the extent of these behaviors, anecdotal and academic information we have been collecting suggests that such vehicles are higher in numbers than previously believed. For example, 6% of fatal accidents in California involve an unregistered vehicle. Academic studies in the states of Oklahoma, Nevada, and Arizona (where registration and insurance costs are lower than California) found unregistered vehicles comprised 4.2%, 3.8%, and 3.6% of on-road vehicles, respectively. These behaviors not only have significant air quality implications, they also have fiscal costs to the state and local governments, and increase insurance costs to law-abiding motorists.

We urge you to consider incorporating some efforts to better understand and address these issues. We would welcome the opportunity to discuss them in more depth with your staff.

Sincerely,

Jack P. Broadbent, Executive Officer/Air Pollution Control Officer

cc: Richard Corey, Executive Officer

Metropolitan Transit System

Sharon Cooney
15-8-6

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San Diego, CA 92101-7490
(619) 231-1466 • FAX (619) 234-3407

October 22, 2015

Chairman Mary Nichols
California Air Resources Board
1001 I Street
Sacramento, CA 95814

SUBJECT: California Air Resources Board (CARB) Mobile Source Strategy Discussion Draft (Agenda Item 15-8-6)

Dear Chairman Nichols:

The San Diego Metropolitan Transit System (MTS) appreciates the opportunity to comment on the Mobile Source Strategy Discussion Draft. Our agency supports the State's efforts to pursue a comprehensive strategy to meet air quality standards and greenhouse gas and petroleum reduction targets, however we ask that the Board allow MTS and other transit agencies to continue to work with staff to propose a more effective urban bus strategy than the one included in the Draft.

The Discussion Draft (Chapter 6) provides a synopsis of the Advanced Clean Transit measure that would apply to urban bus service like ours. The proposal is to require a minimum purchase requirement for zero emission buses (ZEB) starting in 2018 with increases until the requirement reaches 100% in twelve years. MTS has appreciated CARB staff's willingness to discuss its proposal with our agency as it has refined it over the past several years, but we feel that the proposal needs significant modification.

While the proposed ZEB purchase requirements are intended to spur the market into creating technology that could be affordable and easily placed into revenue service by transit operators throughout the state, the technology is not yet ready for the proposed level of use in urban transit. The very limited and recent tests being conducted by California transit operators have not been sufficient to demonstrate that the technology is durable or reliable. There are only three manufacturers available to California agencies, and their charging technologies are all proprietary and therefore not interchangeable. It is not clear that these manufacturers could even accommodate a 15 percent purchase requirement in 2018, given that the 53 current ZEBs in California account for only .5 percent of all buses in California. The lack of competition in today's market diminishes the need for manufacturers to innovate or reduce cost. The limited battery storage capacity makes introduction on most urban routes impossible. All of these factors lead to the conclusion that implementation of a minimum purchase requirement is not yet feasible and would have detrimental consequences.

MTS requests that CARB consider overall performance goals for transit operators to achieve reductions, rather than prescribing a specific technology. Transit operators' investments in clean technologies to date are not extensively cataloged in the Discussion Draft, but they have

been considerable and effective. MTS operates transit service over 3,240 total square miles in San Diego County, and provides an environmentally-friendly transportation option to ten cities, the unincorporated County, and the international border. MTS has built and continues to expand an extensive electric powered, zero emission light rail network. Eighty-six percent of our 617 heavy duty buses have been replaced with Compressed Natural Gas (CNG) buses in keeping with our commitment to cleaner fuel technology. It is our goal to replace nearly 100 percent of the fleet by 2017. MTS has embraced CARB's commitment to CNG vehicles at a considerable cost to the transit system, a cost that we continue to absorb today. We are currently replacing an existing maintenance facility to allow it to accommodate CNG buses at a cost of $45 million.

In addition, MTS has begun to develop new technologies in our fleet, including the introduction of 12 electric hybrids, and the scheduled replacement of our 32 gasoline powered mini buses with cleaner propane powered vehicles. Our agency has also taken the significant step of ensuring that by 2016 we will be fueled entirely with renewable biogas. All of these actions have diminished MTS's emissions footprint and impact on air quality to near zero. We welcome the opportunity to work with CARB staff in creating a set of performance targets for our industry, with a tool kit of options for how to achieve those targets.

Rather than achieving the Mobile Source Strategy's goals, implementing staff's Advanced Clean Transit proposal will have significant adverse impacts on the environment due to the reduction in transit service it will cause. As the primary operator in San Diego County, MTS would be forced to expend funds it uses to provide transit service to pay for the higher capital and operating costs associated with ZEB technology. A 15% ZEB purchase requirement would equal an additional capital cost of $8 million for MTS in 2018, with unknown costs associated with facility and utility infrastructure modifications. Add to this additional operating expenses associated with the inflexible technology, along with the doubling of energy costs, and the estimated amount of service that would need to be cut in 2018 equates to three of our most urban bus routes which carry 16,000 passengers a day, 5.3 million passengers a year.

The trade-offs to accommodate the added cost to implement the Advanced Clean Transit proposal would have the greatest impact on low income, minority and disabled communities. MTS's customer base is 71 percent transit dependent, and 80 percent low income and/or minority. A full two thirds of passengers live in households with annual incomes less than $30,000. They rely on MTS to get to jobs, medical appointments, religious services and school. Reduced service, delayed light rail expansion and other cost offsets would have a compounded, quality of life impact on these populations.

The Discussion Draft indicates that increased federal funding could be relied on to help cover the additional expenses associated with implementation. Federal funding is applied based on long standing formulas and does not take into account increased expenses caused by state air regulations. While there have been discussions regarding more funding for transit, the federal government has yet to act. MTS asks the Board to reconsider near term implementation of a ZEB purchase requirement, and instead to create a funding coalition to seek federal assistance to implement a comprehensive air quality and greenhouse gas reduction strategy for California. We would encourage the Board to develop an outreach and education plan to work with the federal government on an expansion of federal funding for even cleaner transit bus funding options. We would view this as essential for your objectives to be realized.

MTS is committed to working with CARB staff to create a Mobile Source Strategy that will achieve the goals of improved air quality, reduced reliance on petroleum, and reduced

greenhouse emissions. We ask that you reconsider the Discussion Draft in light of our comments and appoint a transit advisory team to work through these essential issues and avoid unintentional consequences like transit service reductions impacting our most vulnerable riders.

Respectfully Submitted,

Paul Jablonski
Chief Executive Officer

cc: California Air Resources Board Members

George Minter
Regional Vice President
External Affairs & Environmental Strategy

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October 22, 2015

California Air Resource Board Members
California Air Resources Board
1001 I Street
Sacramento, California 95814
Via Hand Delivery at Board Meeting

Dear Chair Nichols, Vice-Chair Berg, and California Air Resources Board Members:

SoCalGas appreciates California Air Resources Board's ("CARB") focus on public health and addressing air pollution, and specifically the challenges of NOx reduction for Southern California, that is reflected in this Draft Mobile Source Strategy document.

At SoCalGas we remain focused on the end goal - which is emission reductions - whether it be reducing ozone for public health or reducing greenhouse gases ("GHGs") for global health. No one is asking for a change or a compromise in our end goals.

But we do think that CARB should take advantage of the best of what innovation can deliver, and shouldn't limit options, but instead welcome technology advancements that move us towards our goal.

We observe that CARB's Draft Mobile Source Strategy is focused on a NOx control strategy divided in two periods - from 2015 to 2030, and from 2031 to 2050. For the largest NOx contributor - the heavy-duty truck sector - CARB is relying upon a Low NOx Engine Strategy in the first period, but then pivots to a strategy that promotes zero emission tailpipe vehicles in the second.

We believe that a strategy that relies upon zero emission tailpipe vehicles that occurs nearly a decade before CARB's own technology assessment concludes these vehicles will be commercially available has significant technological and economic risk.

Importantly, the timeframe proposed undercuts the investment needed to deploy Low NOx trucks in the first phase - jeopardizing the success of CARB's NOx control strategy overall.

We see the same problem in CARB's Proposed Alternative Clean Transit ("ACT") rule - a mandate for an all-electric or fuel cell transit fleet by 2040 means that no natural gas near-zero

engine running on renewable natural gas ("RNG") can be purchased starting in 2028 (considering a 12-year capital life for the vehicle).

This essentially means that any investment in a .02 NOx engine - like the one already made and certified by Cummins Westport Innovations ("CWI") sized for the transit market (that actually certified at a .01 level – twice as clean!); or the one nearing completion and to be certified next year for the long haul goods movement sector - will become a stranded investment.
A more prudent plan would include an option that has a lower risk. CARB should include a Low Carbon Gas option which extends the Low NOx Strategy into the second period. Moving natural gas into heavy-duty transportation immediately reduces NOx. It also creates market pull for the development of RNG to displace traditional gas – which can achieve the same or even lower carbon intensities as electricity, given the state's renewable generation portfolio in the 2020 and 2030 timeframes.

As electric heavy-duty transportation options do become available over a later timeframe, then RNG can be redirected to traditional natural gas end uses, like cooking, space heating, and water heating, achieving our Governor's goal announced in this year's State of the State speech to "clean our heating fuels."

Results of E3's published analysis of an Electrification Scenario and a Low Carbon Gas Scenario demonstrates that a Low Carbon Gas Scenario can meet the 2050 GHG goals of the State, at less risk, and comparable or less cost.

Results of another E3 study indicate that with a 33% RNG factor, gas water heating, space heating, clothes drying and smaller commercial and industrial heat processes can have a lower GHG profile than their electric counterpart – a better outcome than electrification of these end uses.

We note that CARB is also requesting the Federal Environmental Protection Agency ("EPA") to establish a low NOx standard for heavy-duty trucks, implemented no later than 2024.

We support this request. But we also must note that in order to meet a 2023 goal, a substantial incentive program for the deployment of Low NOx heavy-duty trucks will be needed between 2016 and 2023. We see this deployment funding challenge as a critical component of any NOx control strategy; and critical for the success of the region's Air Quality Management Plan and the State's Implementation Plan ("SIP").

In sum, the reason it's important to establish a Low Carbon Gas pathway after 2030 is that it provides a continuous path forward for the Low NOx pathway to achieve 2023 *and* 2032 NOx reduction goals; as well as ensure investments made in RNG to address GHG reduction goals for 2030 and 2050 are not stranded investments, which would not be made.

While it is not explicit in the Draft Mobile Source Strategy (or the 2016 Scoping Plan Update slide presentation or CARB's "Vision 2.0"), it does seem to be fundamental to the emphasis on zero emission tailpipe vehicles, that there is a belief that fossil fuels and combustion together

must be eliminated. This approach is not fact-based, nor supported by science. And it will *not* lead to the goal – lower emissions.

The CWI truck engine tells us that from a criteria pollutant basis we can achieve electric equivalence. And utilization of RNG shows us (under CARB's own Low Carbon Fuel Standard program) that we can be lower in carbon intensity than electricity.

We need to re-think methane. First, methane emissions, primarily from agriculture, dairies, landfills, wastewater treatment, etc., will continue to be part of the GHG inventory, even with aggressive control technology applications. Second, capture and use of this methane as RNG takes the fossil out of the fuel.

In fact the Short Lived Climate Pollutant ("SLCP") plan depends on the capture of this methane and its delivery as an energy resource, mostly directed to transportation. Yet the Draft Mobile Source Strategy and the ACT rule would undermine the deployment of RNG to transportation by limiting its term of use, thus undermining the SLCP plan.

Today and out into the future, the most cost effective (and available) control technology for methane emissions is combustion, which converts methane (GWI = 25+) to CO_2, returning to the atmosphere the CO_2 that was sequestered by the organic matter originally – a net zero carbon loop.

The most efficient combustion of captured methane emissions, and the optimal end use applications, will be an important part of any long term plan to control GHG emissions. The Governor, in his State of the State speech, was right. We do need to clean our heating fuels. And the inclusion of a Low Carbon Gas pathway can accomplish this.

Sincerely,

George Minter
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September 11, 2015

Yachun Chow
Manager, Zero Emission Truck & Bus Section
Mobile Source Control Division
Sacramento, CA 95812
Via Email – yachun.chow@arb.ca.gov

Re: Comments on California Air Resources Board "Advanced Clean Transit Regulation Discussion Document" Released May 2015

Dear Ms. Chow:

The Southern California Gas Company ("SoCalGas") is pleased to submit these comments to the California Air Resources Board ("ARB") regarding the Advanced Clean Transit ("ACT") Regulation Discussion Document ("Discussion Document"). We recognize this is only the beginning of what will be a more formal, stakeholder-involved process. We wanted to take this opportunity to express some of our initial concerns and suggestions regarding the ACT Discussion Document and the ARB's proposed regulatory concepts.

The Analysis in the ARB Discussion Document Is Incomplete

Based upon our initial review of the Discussion Document, we believe ARB needs to provide additional, more comprehensive data to justify the proposed ACT regulation. In the Discussion Document, ARB provides no cost-effectiveness estimates identifying the air quality or greenhouse gas ("GHG") benefits of the proposed State's investment in this ACT approach. SoCalGas thinks much more information needs to be provided by ARB to justify what we believe will be a massive economic expense to the State, transit agencies and the public at large without a commensurate environmental outcome.

A. Acquisition Costs of New Zero Tailpipe Emission Buses Will Be Onerous

According to the most recent data available, thousands of transit buses would need to transition to zero tailpipe emission buses to comply with ARB's proposed regulatory concepts. Billions of dollars will be needed to purchase new buses, provide the necessary battery charging and hydrogen fueling infrastructure, and utility upgrades for 11,169 existing urban buses and transit fleet vehicles currently operating in California transit fleets.[1]

Our preliminary analysis[2] indicates that California transit agencies could be responsible for several billion dollars in new bus capital costs above business-as-usual natural gas or diesel operations to implement ARB's ACT plan over the course of the regulation (2018-4040). The projected increased costs do not account for any future infrastructure development costs or maintenance costs to the transit agencies, which SoCalGas anticipates will be significant. Transit agencies will also have to maintain higher ongoing annual expenditures following 2040 to continue purchasing compliant zero emission tailpipe buses, which could equal hundreds of millions in ongoing annual bus capital incremental costs.

ARB Projections of FTA Funding May Be Overly Optimistic

ARB assumes that Federal Transit Administration (FTA) funding will cover 82% of the expense for zero tailpipe emission bus costs, because FTA funding generally covers up to 80% of conventional fueled buses and up to 82% of CNG-fueled buses.[3] If these assumptions about FTA funding were correct, preliminary analysis indicates that California transit agencies would expend over a billion dollars in incremental costs to acquire compliant buses over the life of the regulation.[4]

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[1] See Discussion Document p. 5, Figure II-1.

[2] SoCalGas worked with our technical consultants, Gladstein, Neandross & Associates (GNA), to better determine the true cost of the proposed ACT plan for transit agencies and the state of California. Our preliminary analysis indicates that ARB's Federal Transit Agency ("FTA") assumptions underestimate the cost for CA transit agencies to comply with the ACT regulation by a factor of five, for bus capital alone. Although we recognize that there are many unanswered questions, such as the final phased-in purchase requirements for zero emission tailpipe buses, the breakdown between battery and fuel cell technology adoption, and long-term pricing for advanced technologies, the preliminary analysis indicates that the costs incurred by CA transit agencies will be several billion dollars more than what ARB's FTA assumptions would indicate, and demonstrate the sheer scale of the true investment to comply with the proposed rule. SoCalGas and GNA are continuing to work with FTA, transit agencies, and technology manufacturers to refine cost estimates and develop a similar infrastructure cost model.

[3] FTA 5307 funding for individual transit agencies is determined by a formula based on population, population density, number of low-income individuals, bus revenue vehicle miles, bus passenger miles, fixed guideway revenue vehicle miles, and fixed guideway route miles. This formula-determined allocation can then be used to fund capital, planning, job access and reverse commute projects, as well as operating expenses in certain circumstances. These funds constitute a core investment in the enhancement and revitalization of public transportation systems. Source: http://www.fta.dot.gov/documents/MAP-21_Fact_Sheet_-_Urbanized_Area_Formula_Grants.pdf.

[4] SoCalGas' preliminary analysis assumed that the state would replace the current transit fleet of 9,908 buses with 50% battery electric and 50% fuel cell electric buses to meet the zero tailpipe emission bus requirements.

However, this funding assumption is flawed because it ignores the fact that a transit agency's total allocations under section 5307 are determined by a complex mix of formula-based factors, and that this funding is intended to cover a range of capital assistance and operating costs. California transit fleets will not be automatically entitled to higher FTA allocations overall simply because they have more expensive in-state regulations. Although transit agencies would be able to request up to 82% in section 5307 funding from FTA to cover zero emission tailpipe bus purchases, such an allocation would come at the direct expense of funding other vital capital and operating costs also directly supported by 5307 funds.[5] Accordingly, ARB projections of FTA funds for zero tailpipe emission bus purchases should be based on a more probable assessment of overall FTA funding impacts for transit agencies under any ACT purchase requirement scenario.

Assuming that the bus costs listed in ARB's Discussion Document are accurate, a fleet that could normally purchase 15 natural gas buses with its FTA allocation would only be able to purchase 10 battery electric buses with that same FTA allocation. Alternatively, the agency would have to offset an additional four million dollars in operational or capital investments elsewhere to buy the 15 needed replacement buses while complying with zero emission tailpipe bus purchase requirements. In essence, the zero emission tailpipe bus purchase requirement would offset other critical transit investments to maintain the same number of buses on the road.

A more probable funding scenario assumes that FTA will continue funding total bus capital for California at approximately the same level as current allocations, after accounting for population growth and other factors that impact the formula-derived allocations. Therefore, it is reasonable to assume that California transit agencies will continue to receive FTA funding that is sufficient to cover approximately 82% of a conventional diesel or natural gas bus. Under this more probable FTA funding scenario, preliminary analysis indicates that ARB's FTA assumptions could underestimate the cost for California transit agencies to comply with the ACT regulation by a factor of five, for new bus capital alone. Therefore, the costs incurred by California transit agencies over the compliance timeframe could be several billion dollars more than what ARB's FTA assumption would indicate, not including charging or fueling infrastructure or maintenance costs. Incorporating new electric charging and hydrogen fueling infrastructure costs could add billions more to the shortfall.

B. ARB Should Adopt Fuel-Neutral, Performance-Based Policies

There are alternative approaches that could also accomplish critical state goals at a fraction of the price to transit agencies and taxpayers, such as near-zero emission engines coupled with renewable fuels. SoCalGas understands that Cummins Westport is currently certifying a near-zero emission natural gas engine (0.02 gram per brake horsepower-hour (g/bhp-hr)), and other natural gas and diesel engine manufacturers are working on short-term commercialization of

[5] Transit agencies will submit requests for up to their maximum formula-determined allocation, with federal cost share provided with the following limits by category: 80% for capital assistance (this includes buses), up to 82% for alternative fueled vehicles; 50% for operating assistance; and 80% for Americans with Disabilities Act non-fixed route paratransit service. Source: http://www.fta.dot.gov/documents/MAP-21_Fact_Sheet_-_Urbanized_Area_Formula_Grants.pdf.

similar near-zero emission products. If these technologies were used in conjunction with renewable fuels, transit agencies could achieve similar reductions in NOx, well-to-wheels GHGs, and petroleum displacement as with a 100% zero emission bus strategy.

For example, if transit agencies transitioned their entire fleet to 0.02 g/bhp-hr near-zero CNG buses using 100% renewable biomethane fuel from landfills, they could achieve 90% reductions in tailpipe NOx, up to 78% reduction in well-to-wheels GHGs, and 100% displacement of conventional petroleum. Under a 100% zero emission bus plan[6], transit agencies would achieve 100% reduction in tailpipe NOx, up to 55% reduction in GHGs, and a 100% displacement of conventional petroleum.[7]

If ARB set rigorous performance-based emission and petroleum reduction targets, each transit agency could choose the technology best suited to its individual operations, while still meeting goals that are in line with the state's ambitious emission and petroleum reduction targets.[8] This performance-based emission reduction approach could save transit agencies billions of dollars in anticipated compliance costs over the course of the regulation, versus the proposed ACT concepts identified in the Discussion Document.

C. ARB Should Provide More Robust Analysis on Infrastructure Charging and Fueling Costs

Battery Electric Charging Infrastructure: ARB charging infrastructure appears to be understated at $40,000 per fast charger and redundancy is not considered in calculation, such as number and location of chargers.[9] For example, Proterra's proprietary fast-charger costs $369,000[10], and can support depot charging for up to eight battery electric buses. As of September 2015, only two bus manufacturers, Proterra and New Flyer, offer a fast charge bus that has completed Altoona testing. Proterra's fast-charge bus technology offers only 30 miles per charge while its slow charge bus technology is capable of up to 100 miles per charge. With transit agencies providing services over a variety of route profiles, each transit agency will likely need a mix of slow and fast-charge options.

In SoCalGas discussions with local transit agencies, we have learned that en-route fast charging would certainly be necessary for many routes served by battery electric buses ("BEB"). Agencies are gaining some experience with electric buses and believe they currently have a range of ~150 miles and may extend that to ~200 in a year or two. However, agencies need

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[6] This scenario assumes 50% battery electric and 50% fuel cell bus deployments, with all fuel cell buses using 33% renewable hydrogen fuel.

[7] Well-to-wheels CO2e emissions are based on ARB's assumption that urban transit buses travel an average of 36,400 miles/year and calculated based on the number of zero tailpipe emissions and near-zero emissions buses deployed according to the purchase requirement. Well-to-wheels CO2e emissions are determined using estimated carbon intensity values for pathways under CA-GREET 2.0, as provided by ARB Staff in the document, "CA-GREET 1.8b versus 2.0 CI Comparison Table," April 1, 2015.

[8] The achievement of these goals is in line with the Performance Targets articulated by Governor Edmund G. Brown, Jr., and legislative requirements. Discussion Document, Executive Summary, p. i.

[9] Discussion Document, p. 21, which assumes the installed cost of a direct current fast-charging station at $40,000.

[10] "Electric Vehicles: Ex-Tesla Exec Moves on to Build Battery-Powered Buses," April 9, 2015, Greenwire, accessed from http://www.eenews.net/gw/2015/04/09.

buses capable of at least 275 miles range per day. Agencies do not believe that is possible given the weight issues (batteries are very heavy), logistics of charging, and other operational challenges. Further, there are limitations to the number of units that can use a charging station (eight units for Proterra's FC charger, for example). Each bus route may need its own en-route fast charge support, or may require operational (and labor-related) cost changes. Lifecycles of chargers should also be considered as part of ongoing operational costs, which is currently projected at six to eight years under heavy usage.

Calculated differently, BEB charging costs ($/kilowatt hour) appear low in the Discussion Document. ARB needs to complete additional analysis to cover peak demand en-route charging versus overnight fueling for more accurate cost impacts. Regarding BEBs, there are further significant questions about where this en-route infrastructure can be installed. Are there public facilities to support en-route charging? Who will own these chargers? Who will control the charging rates? How will peak-time en-route charging rates change cost calculations? What physical upgrades will be required to support increased grid demand for depot fueling at transit facilities? We respectfully request that these and other such questions about electric charging infrastructure be addressed by ARB as the ACT regulation proposal moves forward.

Hydrogen Fuel Infrastructure: ARB's Discussion Document makes no note of hydrogen fueling station costs, which are anticipated to be significant, particularly if fuel cell electric buses ("FCEB") are intended to support routes with operational challenges that cannot be met by BEBs, as is implied in the Discussion Document plan. Although we do not have information about what the infrastructure planning and costs might be for heavy-duty FCEB, we believe the recent California Energy Commission ("CEC") plan for light-duty fuel cell vehicles confirms that significant planning and investment is required for hydrogen fueling infrastructure. The CEC's 2015-2016 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program ("ARFVTP") notes hydrogen refueling stations are much less common than conventional gasoline stations or even other alternative fuel stations. As of March 2015, 11 hydrogen refueling stations in California were operational. By late 2015, the California network of operational hydrogen stations is projected to include up to 46 stations, with four additional stations scheduled to come on-line in the first quarter 2016, and a further four by second quarter 2016. These stations are designed to support consumer operations, and there is not currently an existing or planned network of heavy-duty transit-capable hydrogen fueling stations to support the ACT rollout.

ARB notes that the current price of hydrogen is approximately $6 to $9 per kilogram for a high capacity hydrogen station.[11] Prior analysis[12] of zero emission buses found that the anticipated

[11] Discussion Document, p. 13 (b). Although unstated, for purposes of this discussion, SoCalGas assumes the approximate price indicated in the Discussion Document is traditional hydrogen and not renewable hydrogen. Renewable hydrogen is expected to cost much more to produce.

[12] Gladstein, Neandross & Associates (GNA), "Equivalent Strategies for the ARB Zero Emission Bus (Z-Bus) Regulation," June 2014. The price of hydrogen varies greatly in various reports so GNA selected one of the lower reported prices, estimated to be $8.5 per kilogram for hydrogen produced via steam methane reformation. The price includes the cost of the natural gas, water, and the electricity used by the reformer and the compression equipment, and also includes the cost of amortized capital and maintenance. This price was sourced from "National Renewable Energy Laboratory. SunLine Transit Agency Advanced Technology Fuel Cell Bus Evaluation: Fourth Results Report. By L. Eudy and K. Chandler. NREL/TP-5600-57560. January 2013."

costs were at the higher end of this range ($8.5/kg). The price of traditional hydrogen per kilogram should be confirmed and updated with current fuel cost figures, and the projected cost of renewable hydrogen should be calculated with most current available data.

California Energy Commission funding, and therefore state infrastructure planning, is targeting light-duty consumer stations. The state infrastructure funding is based on previous average costs to the ARFVTP for the installation of new light-duty hydrogen refueling infrastructure (roughly $1.8 million–$2.1 million). The Energy Commission is also offering up to $100,000 in operation and maintenance funding per station, recognizing these needs are significant. Transit station development, operation, and maintenance costs can be expected to be much higher.

Thus, we believe there is a huge infrastructure and fuel cost from ARB's ACT approach, above and beyond the capital costs of purchasing new buses. We believe these total lifecycle impacts will be significant, for both BEB and FCEB implementation approaches, and that FTA and other grant funding may be inadequate to support the expense. As stated above, the total bus capital incremental cost increase for a zero tailpipe emission bus approach is in the multi-billion dollar range. Additionally, total charging and fueling infrastructure incremental cost for a zero tailipipe emission approach must also be factored into the overall cost of the proposed ACT transition. We respectfully request that ARB provide an infrastructure charging and fueling cost estimate for zero tailpipe emission vehicles in its next update on the ACT regulation.

Natural Gas Infrastructure: Fifty-seven percent of California's 11,530 transit fleet vehicles already use natural gas, and therefore have supporting infrastructure according to ARB's Discussion Document (p. 5, and Figure II-1.) Thus, in a fuel-neutral, performance-based alternative compliance scenario, the infrastructure transition cost would be significantly lower for fleets selecting a 0.02g/bhp-hr engine with renewable fuel compliance pathway than under a BEB/FCEB bus scenario. In addition, the natural gas fuel costs appear overstated in the Discussion Document as $2.55/diesel gallon equivalent for a transit agency operating its own fueling station. A natural gas fuel price of approximately $1.75/diesel gallon equivalent is more in line with transit agency CNG costs, based on recent discussions with local transit agencies. We respectfully request that ARB staff update the natural gas fuel costs with current and accurate fuel cost figures. By doing so, ARB will provide a cost estimate for transit fleets that better reflects natural gas fueling infrastructure costs and prevailing market conditions.

SoCalGas appreciates the hard work and effort exhibited by staff in developing the Discussion Document and the analyses contained therein. At the same time, we respectfully request that ARB re-evaluate its cost analysis as it relates to infrastructure and fuel for electric, hydrogen, and natural gas fueling in light of the information we have provided in these comments, as well as other sources of information available to ARB. ***Such informed analysis will provide the Board, elected officials and the public better data to appropriately evaluate the policy recommendations and implementation costs underlying the ACT regulation.***

D. The Discussion Document Emission Benefits Analysis Is Inconsistent

The Discussion Document notes the need to achieve the following performance goals:

- 90% reduction in NOx;
- 80% reduction in GHG emissions by 2050;
- Significant improvements in the use of renewable fuels and efficiency to meet 50% petroleum reduction by 2030; and
- Ongoing need to reduce diesel PM and air toxics to protect public health.[13]

The proposed ACT plan does not adequately demonstrate that the proposed proscriptive regulation (100% transition to battery and fuel cell buses) is the best solution for California, from a practical, technological, or cost perspective, to achieve the necessary emission reductions. Furthermore the performance data to date does not support that such a dramatic technology shift can deliver upon both the bus ridership demands, as well as the anticipated environmental outcome.

There is not an "apples-to-apples" comparison with hydrogen and other renewable fuels for GHG emissions. Although the Discussion Document assumes the 33% renewable hydrogen requirement, it also assumes that the natural gas bus market will utilize 100% conventional (not renewable) fuel, and does not include GHG impact calculations that include renewable natural gas alternatives, despite the fact that many California fleets are currently procuring renewable natural gas. Further, ARB assumes diesel is 100% conventional, and does not include GHG impact calculations that include renewable alternatives.

ARB also understates the emission reduction opportunity for near-zero emission engines with biomethane as anything other than an interim compliance method. The state has critical sustainability goals, including a 90% reduction in NOx, an 80% reduction in statewide GHGs, by 2050, and 50% petroleum reduction by 2030. In fact, ***ARB's own document*** notes that:

- Advanced low-NOx engines, that are anticipated to come into the marketplace by 2016, can achieve a 90% reduction in NOx (equal to ARB's emission reduction goal);
- Renewable fuels – including renewable NG – can achieve up to 78% reductions in GHGs when using landfill gas (which is approximately equal to the state's GHG goal);
- Renewable fuels entirely displace conventional petroleum (exceeding the state's petroleum reduction goal by 100%); and
- Near-term, lower-cost 0.02g/bhp-hr engine technologies plus renewable fuels distributed through existing fueling stations would enable transit agencies to achieve the state's goals using existing with minimal infrastructure and technology upgrade investments, and with no operational cost changes.[14]

As stated previously in these comments, SoCalGas and GNA are continuing to finalize our cost models to inform our analysis of the proposed ACT regulation. Yet, our initial cost-effectiveness

[13] Discussion Document, Executive Summary, p. i.
[14] Discussion Document, pp. 11-12.

calculations comparing possible BEB/FCEB rollout scenarios with a 100% renewable natural gas/near-zero engine alternative indicate that ***the more probable FTA funding levels will require Californians to spend approximately 30 times more per ton to achieve similar greenhouse gas reductions.***

At minimum, SoCalGas requests that ARB utilizes the carbon intensity values for alternative and renewable fuels as calculated using the most recent Low Carbon Fuel Standard analyses to demonstrate the potential GHG benefits to the state. In addition, we respectfully request that ARB include a full cost-benefit analysis of GHG and criteria pollutant reduction with all possible alternatives considered for advanced transit technologies, including the near-zero emission vehicles anticipated to be commercially available within the next two years. We also believe it would be beneficial to indicate transit's proportionate share of total NOx and GHG emissions to better assess the impact of this far-reaching regulatory proposal on statewide emission inventories.

As stated above, ARB must provide the best and more current data to support its proposed ACT regulation. ARB members, elected officials and the public will not be able to evaluate the efficacy of the proposed regulation without rigorous analysis to support the expenditure of billions of dollars on new, as yet untested BEBs and FCEBs and supportive infrastructure. ***Such informed analysis is necessary appropriately evaluate ARB's policy recommendation, its environmental benefits, and implementation costs.***

E. Serious Commercialization Concerns Persist Regarding Zero Emission Tailpipe Buses

ARB has postponed its 15% zero emission bus purchase requirement several times due to commercial readiness concerns. The Transit Fleet Rule was adopted in 2000 with zero emission bus purchase requirements that phased in for larger fleets starting in 2008. The Zero Emission Bus Rule was amended in 2006 to include an advanced demonstration from the diesel path transit agencies, and to temporarily postpone the zero emission bus purchase requirement. The Board in 2009 through Resolution 09-49 directed staff to report back to the Board with an assessment of zero emission technology and its progress towards commercialization, and to develop commercial readiness metrics to be used for purchase implementation criteria to initiate the zero emission bus purchase requirement. This work will be completed as part of development of the ACT regulatory proposal.

Transit agencies and the public have not had a chance to review or comment upon the feasibility of these commercialization metrics and implementation criteria. The current discussion draft admits to major data gaps, which is to be expected based on a sample size of 22 BEBs and 7 FCEVs currently on California's roads.[15] These buses are largely in the demonstration and data gathering phase efforts. A product's demonstration and early commercial availability is not equivalent to the large scale commercial readiness for across-the-board fleet-wide implementation. And yet, based on this paucity of data, ARB staff is still recommending overhauling California's entire system of transit bus operation at a total estimated investment – for bus capital incremental costs alone – of several billion dollars over the life of this rule. Very

[15] ARB Discussion Document, p. 5, Figure II-1.

few BEBs have received Altoona testing to-date. This does not provide enough commercial-scale availability for the true mix of transit operations throughout the state. Twelve years is a critical benchmark for transit agencies, because FTA support is contingent on twelve years of operation. However, existing data gives no insight into the durability or true lifecycle performance of these buses.

Given the paucity of data, it may be premature to claim that these buses are commercially ready for a 100% mandate. None of the lifecycle costs projected in the ARB Discussion Document is drawn from large-scale, comprehensive, longitudinal data sources. None of the projections include any reference to accurate infrastructure costs. The FTA funding projections may be greatly overestimated and could undercut the true transit agency impact by at least several billion dollars in bus capital costs alone. Therefore, none of the cost analysis provided even hints at the true scope of the taxpayer cost to implement a zero tailpipe emission bus plan, nor what the long-term maintenance, operational, and ongoing bus purchase costs might look like for such a significant, comprehensive technology shift.

These costs do not account for the significant infrastructure, bus redundancy, operational, and other costs that will likely accrue to transit agencies and taxpayers. SoCalGas believes much more data collection, analysis and financial estimates are necessary to move the State from an ongoing hesitation about a 15% BEB/FCEB implementation target for large fleets to a sudden 100% implementation requirements for all State transit fleets based on the data gathered from a few limited product options and trials.

Conclusion

Thank you for this opportunity to comment. We look forward to continuing to discuss this proposed regulation with ARB staff, and hope for a fruitful exchange of information and ideas leading to a meaningful and cost-effective reduction in air emissions.

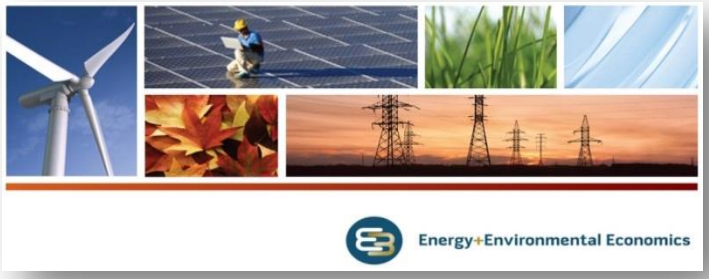
Sincerely,

Jerilyn López Mendoza

Jerilyn López Mendoza
Program Manager
Environmental Affairs

CC: Erik White, ARB
Craig Duehring, ARB
Patrick Chen, ARB
Lynsey Carmichael, ARB

Decarbonizing Pipeline Gas to Meet California's 2050 Greenhouse Gas Reduction Goal



E-3 Study Addresses Integration of new low/zero carbon options. Expands upon 2012 Science article.

CONCLUSIONS:

- The technology pathway for decarbonized gas to meet the state's GHG reduction goals may be easier to implement, less risky and less costly than a high electrification strategy.
- Technology pathways demonstrate that decarbonization of gas supply and use of pipeline infrastructure can balance electric generation, transmission and distribution infrastructures.

KEY FINDINGS:

- Decarbonized pipeline gas **reduces emissions in sectors that are otherwise difficult to electrify**, including **heavy duty vehicles** (HDVs); certain **residential and commercial end uses, such as cooking, and existing space and water heating**; and certain **industrial end uses, such as process heating**
- Decarbonized gas from electricity can play an important role **integrating renewable generation by producing gas, and then storing it in the pipeline distribution network** for when it is needed.
- Decarbonized gas technologies help **diversify technology risk** associated with heavy reliance on a limited number of decarbonized energy carriers, and would **allow consumers, businesses and policymakers greater flexibility and choice** in the transition to a low-carbon energy system.
- A transition to decarbonized pipeline gas to meet 2050 GHG targets would **eliminate the need for new energy delivery infrastructure** such as dedicated hydrogen pipelines or additional electric transmission and distribution capacity, enabling continued use of the state's existing pipeline distribution network.

A fully electrified end-use economy results in:

- Increased challenge to decarbonize electric generation sector
- Forced adoption and costly retrofit of existing energy end uses, and vastly expanded electricity grid
- New stranded costs and gas ratepayer risks

Key pipeline decarbonization pathways solve basic electrification issues:

- Biomethane development for short- to long-term can lower GHG profile for direct gas utilization, including transportation, limiting need for expand electric generation, transmission and distribution.
- Hydrogen and power-to-gas production from electricity can deliver storable decarbonized gas, for direct energy end uses over the mid- to long-term.

Presentation for Hector De La Torre CARB Board Member

October 21, 2015

SoCalGas

A Sempra Energy utility

CARB Mobile Source Strategy

- MSS acknowledges a Low NOx path for Heavy Duty trucks is superior to a zero tailpipe emission vehicle path in the period from 2015 to 2030.

  "In contrast, deployment of 350,000 electric trucks over the next 15 years would require technology development and cost that are well beyond what will be needed to deploy low-NOx trucks." (page 59)

- SCAQMD is also calling for Near Zero Emission vehicles:

  "In Southern California, clean, zero- and near-zero emission vehicle technologies are critical to meeting clean air standards." "Cummins Westport's new engine provides an important tool toward reaching that goal." Barry Wallerstein quoted in Cummins Westport press release (September 2015).

- SJVAPCD adopted Action Plan to promote the deployment of natural gas vehicles and infrastructure, noting "Heavy-duty natural gas vehicles provide fewer barriers to adoption than electric/hybrid." (May 2015)

SoCalGas A Sempra Energy utility

UPDATE: Near Zero Engine

- Cummins Westport 8.9 liter engine successfully certified below 0.02 g/bhp-hr by CARB and EPA in September 2015.
- Closed crankcase design has 70% lower methane emissions.
- This engine will be in commercial production by April 2016.
  - Used by transit fleets, waste haulers and regional goods movement
  - Power plant equivalent emissions years before HD EV available.
- New project funded by CEC, AQMD, Clean Energy and SoCalGas to apply NZE technology to 11.9 liter engine.
  - CWI investigating similar reductions for 6.7-liter NG engine.
- Potential to be used as a replacement for existing NG engine. An opportunity for older NG trucks to achieve further NOx reductions.

CARB Mobile Source Strategy

- After 2030, the Mobile Source Strategy pivots to a zero emission tail pipe strategy.
- We recommend that CARB include a Low Carbon Gas option, which would continue to use the same Low NOx technology path (from 2015 through 2030), adapted to meet the 2050 GHG goal.
- SoCalGas has investigated a Low Carbon Gas option
  - Attains the 2030 and 2050 goals
  - Shows comparable or less costs overall.

Low Carbon Gas Option

- Continues the Low NOx strategy adopted for 2015 to 2030.
- Reduces risk by including another option to attain GHG goals, using potentially less costly measures.
- Examples of vehicle populations and fuel profile in modeling of Low Carbon Gas Option (*preliminary results*):

	2015	2030 Electrification	2030 Low Carbon Gas
ZEVs (millions of vehicles)	0.1	9.4	9.3
CNG and LNG Vehicles (millions)	0.03	0.31	0.36
Biogas (% of final gas demand)	0%	2%	33%
Statewide GHG Reduction (% Reduction from 1990)	2%	**40%**	**40%**

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CARB Advanced Clean Transit Rule

- May 2015 Discussion Document requires transition of all transit fleets to zero tailpipe (BEV or FCEV) buses by 2040
  - Begins 2018; 100% of new purchases by 2026
- Staff analysis may not reflect total economics of this transition
  - Assumes increased federal funding for bus purchases
  - Does not account for fueling infrastructure costs
  - Provides no cost-effectiveness estimates for air quality, GHG benefits
- Near-zero NG engines with renewable fuels can achieve similar NOx and GHG reductions at a lower cost,
  - In southern California, a majority of the large transit fleets have already moved to CNG, many adding RNG to portfolio.
- Fuel-neutral, performance-based policy can accomplish state goals at a fraction of cost to transit agencies and bus riders

Mobile Source Strategy Delays Toxic Emission Relief for Communities

- In the next 15 years, the MSS seeks zero tailpipe technology penetration in only two sectors: transit buses and “last mile delivery vehicles.”
  - Negligible emission reduction substituting electric transit buses for natural gas buses
  - “Last mile delivery vehicles” have little impact in these communities.
- Substitution of NG for diesel in OGVs and locomotives will have a far greater impact in these port communities.

Natural Gas Can Be a Cost Effective Strategy to Reduce Cancer Risk

- OEHHA Guidance for calculating cancer risk revised March 2015
  - Cancer risk estimates for residential exposures increase.
- Higher cancer risk estimates affect public noticing, CEQA significance determinations, permitting, etc.
- Natural gas: **lower cancer risk opportunities**
  - Hypothetical Ocean Going Vessel example: Natural gas substituted for diesel results in **314 times lower cancer risk***.
  - Hypothetical Locomotive example: Natural gas substituted for diesel results in **107 times lower cancer risk***.

* Based on HRA Tier 2 screening level analysis

SoCalGas A Sempra Energy utility

Thank you for your time and attention

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November 3, 2015

Carol Sutkus
Kirsten King Cayabyab
Air Quality Planning and Science Division
California Air Resources Board
1001 I Street
Sacramento, California 95814

Re: California Air Resources Board Mobile Source Strategy Discussion Draft, Released September 30th, 2015

Dear Ms. Sutkus and Ms. Cayabyab:

SoCalGas welcomes the opportunity to comment on California Air Resources Board's ("ARB") Mobile Source Strategy Discussion Draft ("MSS"), released last month. This document will provide a road map for our entire State to follow to reduce greenhouse gases ("GHGs") and criteria pollutants from mobile sources, on and off our roads.

As a preliminary matter, SoCalGas appreciates ARB's ongoing focus on public health and addressing air pollution, and specifically the challenges of nitrogen oxides ("NOx") reduction for Southern California, that is reflected in the MSS. At SoCalGas we also remain focused on the end goal - emission reductions - whether it be reducing ozone for public health or reducing GHGs for global health. At the same time, we believe ARB should take advantage of the best of what innovation can deliver, and welcome technology advancements that move us towards our collective goals.

I. A Long-Term Low-NOx Pathway Accomplishes Many Objectives

We observe that ARB's MSS is focused on a NOx control strategy divided in two periods - from 2015 to 2030, and from 2031 to 2050.[1] For the largest NOx contributor, the heavy-duty truck sector, ARB is relying upon a low-NOx Engine Strategy in the first period, but then pivots to a

[1] "For heavy-duty vehicles, combustion technology will continue to dominate over the next 15 years. The strategy therefore calls for engine technology that is effectively 90 percent cleaner than today's current standards, with clean, renewable fuels comprising half the fuels burned. To position the heavy-duty sector for longer-term targets that extend beyond the timeframe of this strategy, actions to promote the use of clean-burning and near-zero emission vehicles must be complemented by targeted introduction of zero emission technologies in heavy-duty applications that are suited to early adoption of ZEV technologies." MSS, p. 2.

strategy that promotes zero emission tailpipe vehicles in the second. We believe that a strategy that relies upon zero emission tailpipe vehicles that occurs nearly a decade before ARB's own technology assessment concludes these vehicles will be commercially available is significant technological and economic risk.

Importantly, the timeframe proposed undercuts the investment needed to deploy low-NOx trucks in the first phase, jeopardizing the success of ARB's NOx control strategy overall. We see the same problem in ARB's Proposed Alternative Clean Transit ("ACT") rule - a mandate for an all-electric or fuel cell transit fleet by 2040 means that no natural gas near-zero engine running on renewable natural gas ("RNG") can be purchased starting in 2028 (considering a 12-year capital life for the vehicle).

The proposed 2031 technology "pivot," combined with ARB's proposed ACT, essentially means that any investment in a 0.02 gram of NOx per brake horsepower-hour ("g/bhp-hr NOx") engine - like the one already created by Cummins Westport Innovations ("CWI"), and certified by ARB, sized at 8.9 liters for the transit market (that actually certified at a 0.01 g/bhp-hr NOx level);[2] or the 11.9 liter engine nearing completion and to be certified next year for the long haul goods movement sector - will become a stranded investment.

The CWI truck engine tells us that from a criteria pollutant basis, we can achieve electric equivalence. And utilization of RNG shows us (under ARB's own Low Carbon Fuel Standard or "LCFS" program) that natural gas can have lower carbon intensity than electricity.[3]

A more prudent plan would include an option that has a lower risk. ARB should include a Low Carbon Gas option that extends the low-NOx Strategy into the second 2031-2050 time period. Moving natural gas into heavy-duty transportation immediately reduces NOx and reduces its negative health impacts on our most sensitive populations. It also creates market pull for the development of RNG to displace traditional natural gas, which can achieve the same or even lower carbon intensities as electricity, given the state's renewable generation portfolio in the 2020 and 2030 timeframes. As electric heavy-duty transportation options become available over a later timeframe, then RNG can be redirected to traditional natural gas uses, like cooking, space heating, and water heating, achieving our Governor's goal announced in this year's State of the State speech to "clean our heating fuels."

SoCalGas is in favor of a multi-technology and multi-fuel approach to emissions reduction. For example, Energy + Environmental Economics Inc., or E3, published an analysis of Electrification and Low Carbon Gas scenarios, demonstrating that a Low Carbon Gas scenario

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[2] Cummins Westport Innovations, Inc., Press Release, Oct. 5, 2015, *ISL G Near Zero Natural Gas Engine Certified to Near Zero Emissions, First MidRange engine in North America to reduce NOx emissions by 90% from EPA 2010,* "ISL G NZ meets the ARB certification 8 years in advance of the 2023 California Near Zero NOx schedule contributing to California Clean Air initiatives. ARB has defined this certified Near Zero emission level as equivalent to a 100% battery truck using electricity from a modern combined cycle natural gas power plant." http://www.cumminswestport.com/press-releases/2015/isl-g-near-zero-natural-gas-engine-certified-to-near-zero.

[3] http://www.arb.ca.gov/fuels/lcfs/reportingtool/registeredfacilityinfo.htm

can meet the 2050 GHG goals of the State, at less risk, and comparable or less cost.[4] According to the E3 report, "[b]y 2050 traditional uses of oil and natural gas, including transportation fuels, water and space heating, and industrial boilers and process heating, will need to be mostly, if not fully, decarbonized." SoCalGas is primarily concerned with the higher risk of developing the necessary zero emission tailpipe vehicles in the heavy-duty sector. Therefore the Low Carbon Gas scenario is not trying to replace zero emission tailpipe engines, but adds another option to reach the state's goals in the heavy-duty sector.

The most efficient combustion of captured methane emissions, and the optimal end use applications, will be an important part of any long term plan to control GHG emissions. The Governor, in his State of the State speech, was right. We do need to clean our heating fuels. And the inclusion of a Low Carbon Gas pathway can accomplish this.

II. Specific MSS Concerns

a. Advanced Clean Transit and Last Mile Delivery Control Measures

The objective of the ACT measure is to require the 100% purchase of zero emission tailpipe transit buses by 2030 and full zero emission tailpipe transit fleets by 2040.[5] As SoCalGas stated in our written comments in response to the ACT Discussion Document,[6] we are concerned about the lack of specific cost estimates both for capital to purchase zero emission tailpipe buses and for infrastructure to support the charging and fueling of such buses.

We are also concerned about such a strong technology mandate for the transit bus sector, a source that contributes only 2.0% of Statewide NOx mobile source emissions and 3.4% of South Coast Air Basin NOx emissions from mobile sources. Further, the transit bus sector contributes less than 1% of statewide GHG emissions from mobile sources (0.9%).[7]

The technology mandate contained in the ACT essentially means that any investment in a 0.02 g/bhp-hr NOx engine - like the CWI engine mentioned above; or the one nearing completion and to be certified next year for the long haul goods movement sector - will become a stranded investment. A more prudent plan would include an option that has a lower risk. ARB should include a Low Carbon Gas option extending the low-NOx Strategy into the 2050 timeframe. Moving more natural gas into the heavy-duty transportation immediately reduces NOx. It also creates market pull for the further development of in-state billion dollar RNG

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[4] http://biomassmagazine.com/articles/11519/e3-releases-report-on-decarbonizing-pipeline-gas-in-california. See also, *The Path to 2050: E3's Landmark Study of a Low-Carbon Future for California,* found at https://www.ethree.com/publications/index_2010.php.

[5] MSS, p. 66.

[6] Please see *SoCalGas Written Comments on the ACT Discussion Document,* submitted to Yachun Chow, Manager, ARB Zero Emission Truck & Bus Section, Mobile Source Control Division, September 9, 2015 (submitted in conjunction with these SoCalGas comments).

[7] See generally ARB Statewide GHG and Emissions Inventories. See also ARB's reported methodology for the Statewide GHG inventory applied to Urban Bus fuel consumption as reported in EMFAC2011, September 11, 2011 (updated January 2013).

market to displace traditional gas, which can achieve the same or even lower carbon intensities as electricity, given the state's renewable generation portfolio in the 2020 and 2030 timeframes.

We hope the board and staff provide a rigorous economic and cost benefit analysis to this particular MSS measure to determine if it is indeed the correct place to invest what may be millions or even billions of dollars for such a small reduction of NOx and GHG emissions.

ARB's MSS further justifies emphasis on zero tailpipe emission vehicles as a path to cutting toxics exposure: "Actions to promote [zero emission vehicles] in these heavy-duty applications are important to further reduce regional and near-source toxics exposure and foster the development of these technologies so they become suitable for broader use in the future." (MSS, page 2.)

However, SoCalGas is concerned with two specific aspects of this statement. In the next 15 years, ARB is focused on zero emission engines in two main heavy-duty sectors: transit buses and "last mile delivery vehicles." First, and as we discuss above, the substitution of zero tailpipe emission transit buses for natural gas transit buses (at 0.01 g/bhp-hr NOx) will do little to reduce diesel particulate emissions or NOx in disadvantaged communities adversely affected by freight movement and other sources of toxics exposure. In addition, "last mile delivery vehicles" have little impact on air toxic emissions in these disadvantaged communities. Those "last miles" are likely to take place close-in to port operations, and not on freeways, highways, or heavy arterial streets surrounding port and intermodal facilities. SoCalGas analysis shows that substitution of liquefied natural gas ("LNG") for diesel and bunker fuel in locomotives and ocean going vessels will have a far greater impact in communities impacted by ports and goods movement.[8] The presence of LNG fuel in the port communities would also encourage faster turnover of older diesel trucks to near zero emission natural gas heavy-duty trucks, especially if incentive funds were directed to reduce their payback period. Thus, our concern is, if ARB seeks to target its funding to its stated MSS preferences of transit buses and "last mile delivery vehicles," disadvantaged communities must wait until after 2030 to see significant reductions of air toxics and other pollutants.

In addition, the Last Mile Delivery Control Measure provides for flexibility that is not provided in the proposed ACT regulation. "**One option** for this regulation would be to require that 10 percent of purchases of new last mile delivery trucks are zero emission trucks starting in 2020 and 75 percent of purchases of new last mile delivery trucks are zero emission trucks starting in 2030. **Under a less aggressive option**, 4 percent of purchases of new last mile delivery trucks

[8] See, e.g., Ramboll/Environ Presentation, California Natural Gas Vehicle Partnership Presentation, September 2015 (finding that converting locomotives and ocean going vessels from diesel and bunker fuels to liquefied natural gas by 2023 can result in almost 5 tons per day of NOx emission reductions) (submitted in conjunction with these SoCalGas written comments).

must be zero emission trucks starting in 2020 and 40 percent of sale of new last mile delivery trucks must be zero emission trucks starting in 2030." (MSS, p. 67, emphasis added.)

SoCalGas questions why the proposed ACT rule sets forth such a strict technology mandate and requisite timeline for transit operators, while the Last Mile Delivery measure provides for different options and compliance timelines for truck operators. SoCalGas requests that ARB staff clarify why such a stark contrast exists between the flexibility of these two proposed measures.

b. Locomotives and Ocean Going Vessels

As part of the MSS, ARB describes a variety of mobile source scenarios to explain their various suggestions of measures to reduce GHG and criteria pollutant emissions. For example, the MSS states, "[f]urther emission reductions beyond current engine standards for locomotives and ocean going vessels are feasible with the use of after treatment technologies such as oxidation or three-way catalysts, diesel particulate filters, or selective catalytic reduction." (MSS, p. 22.) However, no mention is made of switching from diesel and bunker fuels to LNG, and the potential for emissions reductions, if such a fuel switch is evaluated for locomotive and ocean going vessels. Large non-road engines such as these could provide air quality benefits of over 4.8 tons per day ("TPD") of NOx emissions reductions in the South Coast Basin by 2023, and an additional reduction of 8.6 TPD of NOx by 2032.[9] SoCalGas requests that staff consider inclusion of the use of LNG as a method of reducing NOx, GHGs, and other pollutants from these freight sectors.

c. Incentive Funding and Other Financial Concerns

The MSS projects that by 2031, "nearly two-thirds of the heavy-duty truck fleet operating in the State would consist of vehicles meeting the Phase 2 or low-NOx standards, with similar proportions in the South Coast." (MSS, p. 28.) At the same time, achieving such a large conversion of the truck fleet would require significant incentives. Even ARB acknowledges such incentives will be necessary a few pages later in the MSS, "[n]evertheless, the 2023 deadline to meet the 80 ppb standard will require significantly earlier penetration of the cleanest technologies. Given the timing and the overlay of current regulatory programs, **technology deployment by 2023 must come primarily through incentive mechanisms**." (MSS, p. 31, emphasis added.) Yet ARB provides no in-depth discussion of a Low Carbon Gas approach, nor an increased incentive program to help convert the State and South Coast fleets to lower NOx trucks. SoCalGas asks that such incentives be considered by ARB staff to achieve the low-NOx truck conversions it projects for 2031.[10]

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[9] Ramboll/Environ Presentation, California Natural Gas Vehicle Partnership Presentation, September 2015, slide 3 (submitted in conjunction with these SoCalGas written comments).

[10] See also MSS, p. 33, "Although establishing cleaner engine and fuel standards will provide ongoing reductions, actions to further accelerate penetration of the cleanest technologies by 2023 will be needed. This will require

In addition, Table 3-1 of the MSS shows both a decreasing use of petroleum-based fuels such as gasoline and diesel, and increasing use of "cleaner energy sources, including biofuels, electricity, and hydrogen." Again, there is no mention of LNG or compressed natural gas ("CNG") as a cleaner energy source and transportation fuel for mobile sources, particularly in the heavy-duty transportation sector. As SoCalGas has discussed in a variety of venues that the ARB Low Carbon Fuel Standard has shown the use of conventional LNG and CNG can immediately reduce GHGs and NOx emissions from heavy-duty engines.[11] The use of renewable natural gas ("RNG") has an even more dramatic reduction.[12] SoCalGas requests that natural gas, especially RNG, be included in the discussion of the future energy and fuel mix for State mobile sources.

Looking at the Table 4-3 titled "South Coast NOx Reduction from Measure Concepts," the "Incentive Funding to Achieve Further Emission Reductions from Heavy-Duty Vehicles" measure only accounts for 3 TPD reduction of NOx by 2023 and another 3 TPD reduction of NOx by 2031. Additionally, in pages 71-74, ARB sets forth an air pollution reduction measure specifically targeting "Further Deployment of Cleaner Technology: On-Road Heavy-Duty Vehicles." SoCalGas agrees in principle with the goal of this measure, which is described by ARB as the following: "[t]his measure concept is designed to achieve further emission reductions for South Coast attainment in 2023 and 2031 through a suite of additional actions, including early penetration of zero and near-zero technologies... To achieve the further reductions associated with early penetration of these cleaner heavy-duty technologies, ARB and South Coast staff estimate that by 2023, approximately 100,000 to 150,000 trucks would need to have engine technologies equivalent to emissions represented by a 0.02 g/bhp-hr NOx standard." (MSS, p. 71.)

However, a more zealous reduction of NOx can be accomplished much sooner with the use of increased incentive funding. Ramboll/Environ and Gladstein, Neandross & Associates conducted an exhaustive study demonstrating that an aggressive incentive program for low-NOx natural gas light, medium-, and heavy-duty trucks has the potential to put over 200,000 vehicles on the road by 2023, achieve 17 TBD reduction of NOx by 2023, and another 18 TBD reduction of NOx by 2031.[13] Indeed, ARB acknowledges the need for funding of low-NOx heavy-duty trucks will yield positive air quality results in the short term: "ARB's Low Carbon

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strategic investments and development of a comprehensive funding plan to identify funding needs and financing and incentive options will be a necessary first step."

[11] Where ultra-low sulfur diesel fuel has a carbon intensity of 102.01, conventional CNG's carbon intensity is 87.06 and conventional LNG is 93.92. Calculated using data and scenarios shared by ARB staff at ARB Board Meeting, LCFS Hearing, September 24-25.

[12] Where ultra-low sulfur diesel fuel has a carbon intensity of 102.01, CNG from landfill gas has a carbon intensity of 20.46 and LNG from landfill gas carbon intensity is 48.02. Calculated using data and scenarios shared by ARB staff at ARB Board Meeting, LCFS Hearing, September 24-25.

[13] Please see *Near-Zero Emission (NOx) Natural Gas Opportunities in the South Coast Basin*, Environ International Corp. and Gladstein, Neandross & Associates, December 2014, p. 9-10, Sections 3.2 and 3.3 (submitted in conjunction with these SoCalGas written comments).

Transportation and AQIP funds can be apportioned from 2015 through 2020 with approximately $7 million per year allocated for low-NOx trucks using renewable fuels in South Coast. Additionally, up to $28 million per year of District funds from AB 923 and Carl Moyer funds could be allocated for cleaner trucks in the 2015-2020 timeframe. The combination of available State and local funds in this measure concept could potentially achieve between 2.4 to 5.9 tons per day of NOx emission reductions in the short term." (MSS, p. 70.)

SoCalGas requests that ARB staff carefully review the *Natural Gas Opportunities* study completed by Ramboll/Environ and Gladstein, Neandross & Associates to determine the cost-effectiveness and increased public health benefits of accelerating and increasing incentive funding for low-NOx heavy-duty trucks statewide.

d. Renewable Natural Gas and Transportation

SoCalGas supports ARB's inclusion of RNG as a transportation fuel as part of the Short-Lived Climate Pollutant reduction strategy. Reducing emissions and petroleum use within the transportation sector is critical to meeting both air quality and climate change policy goals for California. We believe supporting the development and deployment of RNG in the transportation sector should be included as a key strategy to achieve emission reduction goals.

The transportation sector is responsible for 37% of statewide greenhouse gas emissions and over 80% of NOx emissions in South Coast Air Quality Management District ("SCAQMD") and San Joaquin Valley Air Pollution Control District ("SJVAPCD").[14] Meeting the federal ozone and particulate matter standards in Southern and Central California are the most significant air quality challenges for the state. Natural gas vehicles ("NGVs") that can meet the optional low-NOx standard and run on renewable fuels can help the California meet its GHG reduction and petroleum displacement goals, and should be included as a pathway, particularly in the heavy-duty vehicles sector.

The transportation sector can also be an important catalyst for building an RNG market and encouraging the utilization of methane sources. The LCFS identifies RNG from existing organic sources, such as dairy waste, landfills, and waste water treatment as the lowest carbon intensity standard pathway available, even lower than the current electricity mix and hydrogen. Today, due largely to this policy, RNG is already being used in California's transportation sector. For example, Waste Management, Inc., uses RNG produced at its Altamont Landfill and Resource Recovery Facility to fuel its waste hauling fleet in that region. Clean Energy Fuels Corporation offers RNG at their CNG and LNG stations throughout California. A review of the ARB LCFS

[14] 37% figure: California Air Resources Board (CARB). *2000-2012 California Greenhouse Gas Emission Inventory.* CARB, May 2014. http://www.arb.ca.gov/cc/inventory/inventory_current.htm; 80% figure: South Coast Air Quality Management District (SCAQMD). *Final 2012 Air Quality Management Plan,* SCAQMD, February 2013, p. ES-9. http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2012-air-quality-management-plan/final-2012-aqmp-(february-2013)/main-document-final-2012.pdf.

reporting tool shows that RNG, as a percentage of total natural gas used in the transportation sector, has increased from approximately 10% to 40-60% in the past year. The State needs to look at policies and incentives to promote more development of RNG in the State. Support for heavy-duty natural gas vehicles is a key to this development. The transportation sector can be an important catalyst for building the renewable natural gas market.

In the long term, and as transportation options evolve, more RNG can be injected into the pipeline and redirected to traditional natural gas end-uses, like cooking, space and water heating, achieving our Governor's goal announced in this year's State of the State speech to "clean our heating fuels."

When ARB references fuel options from renewable feedstocks in the MSS and accompanying meetings and workshops, there seems to be a preference for liquid biofuels and renewable diesel with very little mention of renewable natural gas options. We urge ARB to remain open regarding the use of biological feedstocks and not prematurely dictate where these resources should be specifically used.

III. SoCalGas Agrees on the Importance of a Low-NOx National Standard

We note that ARB is also requesting the Federal Environmental Protection Agency ("EPA") to establish a low-NOx standard for heavy-duty trucks, implemented no later than 2024.[15] We support this request. We also agree with ARB that the most successful path to NOx emission reduction goals includes an emphasis low-NOx trucks:

> Based on ARB staff's technology assessment, the most viable approach to meeting the 2031 and 2030 goals is low-NOx trucks. The pathway therefore assumed approximately 400,000 internal combustion trucks with NOx emissions 90 percent cleaner than today's standards and equipped with highly efficient particulate filters would be required. To meet the GHG emissions and the petroleum use reductions targets it was further assumed that approximately 55 percent of the truck fuel demand is met with renewable fuel. (MSS, p. 59.)

But we also must note that to meet a 2023 goal, a substantial incentive program for the deployment of low-NOx heavy-duty trucks will be needed between 2016 and 2023. SoCalGas sees this deployment funding challenge as a critical component of any NOx control strategy, and critical for the success of the South Coast Air Quality Management Plan and the State's Implementation Plan ("SIP"). Further, as noted above, utilizing LNG in locomotives and ocean going vessels, and the use of RNG in low-NOx heavy-duty engines, can reduce NOx and GHGs from mobile sources throughout the State in the short and long term. We urge ARB staff to evaluate and include such low-NOx options and pathways in their MSS moving forward.

[15] "While the Cleaner Technology and Fuels scenario discussed in Chapter 3 assumed U.S. EPA action by 2024, delaying implementation until 2027 would result in a significant loss in overall emission benefits." MSS, p. 57.

Conclusion

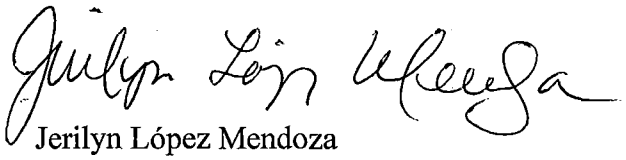
While it is not explicit in the Draft Mobile Source Strategy (or the 2016 Scoping Plan Update slide presentation or ARB's "Vision 2.0"), it seems that the emphasis on zero emission tailpipe vehicles is fundamental and that there is a belief that fossil fuels and combustion together must be eliminated. And it will *not* lead to the goal – lower emissions.

We need to re-think methane. Capture and management of methane emissions (primarily from agriculture, dairies, landfills, etc.) will have a proportionately greater impact than efforts to control CO2 emissions because of the higher global warming potential of methane. Combustion of methane, i.e. conversion to CO2, reduces its global warming potential by a factor of greater than 20 times. Other management techniques, e.g. sequestration, are untested and still have significant issues to resolve, e.g. the ability to sequester the methane for long periods without leakage. Therefore combustion of captured or recovered methane emissions will play an important role in current and future plans to reduce global warming.

In the MSS, it's important to establish a Low Carbon Gas pathway after 2030 because it provides a continuous path forward for the low-NOx pathway to achieve 2023 *and* 2032 NOx reduction goals; as well as ensure investments made in RNG to address GHG reduction goals for 2030 and 2050 are not stranded investments, which would not be made.

Please contact me if you have any questions or concerns about these comments.

Sincerely,



Jerilyn López Mendoza
Program Manager
Environmental Affairs

Attachments (submitted as separate documents with these comments):

(1) SoCalGas Comments on ARB Advanced Clean Transit Regulation Discussion Document, 9/9/2015.
(2) CARB Mobile Source Strategy Letter from George Minter of SoCalGas, 10/22/2015.
(3) E-3 Study Summary, *Decarbonizing Pipeline Gas to Meet California's 2050 Greenhouse Gas Reduction Goal.*
(4) ARB Board Member Presentation on MSS from SoCalGas, 10/21/2015.
(5) Ramboll/Environ Presentation, California Natural Gas Vehicle Partnership Presentation, September 2015.
(6) *Near-Zero Emission (NOx) Natural Gas Opportunities in the South Coast Basin*, Environ International Corp. and Gladstein, Neandross & Associates, December 2014.

South Coast Air Basin Locomotive & Ocean Going Vessel Opportunities

Southern California Gas Company

A Sempra Energy utility®

9/2015

Locomotive and OGV Sector Insights

Freight Rail

- Class 1 railroad companies are investigating NG feasibility as prime power
- A positive decision to change primary fuel would permeate all Class 1 railroad companies simultaneously
- The change would be swift (~20 years for full fleet turnover nationally)
- NG will likely be deployed transcontinentally on a line-by-line basis

Ocean Going Vessels

- IMO fuel sulphur reduction requirements is disrupting bunker fuel economics
- LNG is actively being adopted in the Global OGV fleet
- Current LNG technology surpasses IMO Tier 3 NOx emission requirements
- LNG bunkering has potential to attract the cleanest vessels
- Pacific coast LNG bunkering would facilitate LNG powered coastal trade

- NG enables ultra-low NOx emission engine technology
- Renewable NG has potential for significant GHG reductions

Rail and OGV Pathways Key Findings

Year	SC Air Basin Freight Rail[2] & OGV[1] NOx Reduction Potential	Total Freight Rail & OGV Inventory
2023	4.8 tpd	42 tpd
2032	8.6 tpd	36 tpd

1. OGV includes non-hotelling main and auxiliary engine emissions; 2. Freight rail includes long-haul and switch locomotive emissions

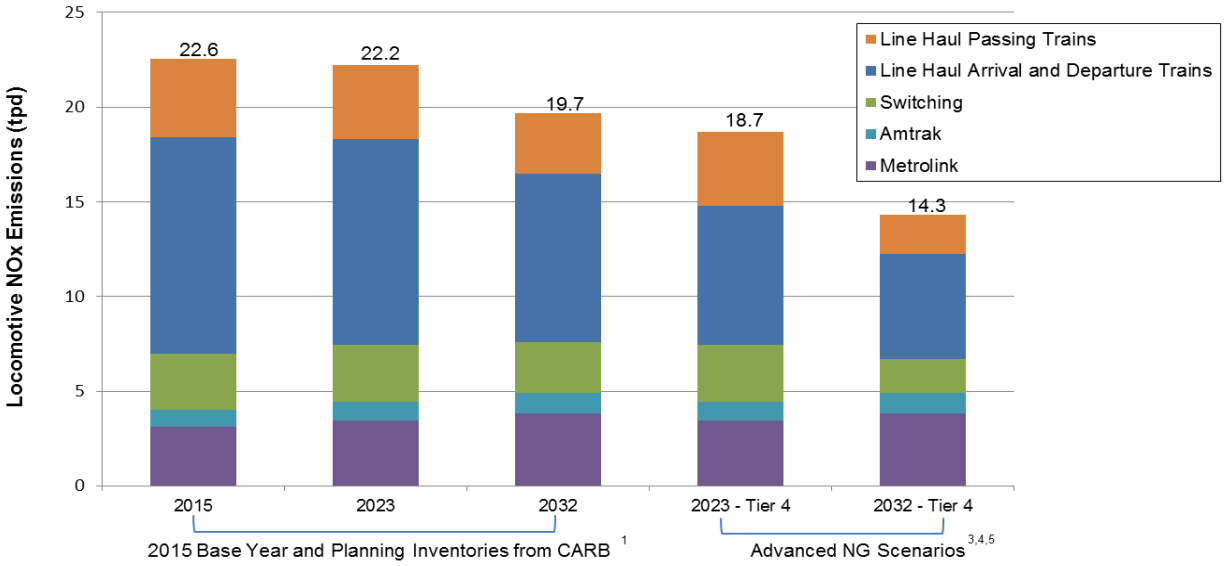
- Based on domestic and global trends, natural gas in and Locomotive and Ocean Going Vessel (OGV) sectors are potential key NOx reduction opportunities
- Southern California natural gas (NG) fuelling infrastructure could attract early implementation of NG in transcontinental railroad lines serving the region
- A Class 1 Railroad shift to NG would accelerate the uptake of Tier 4 engine technologies
- Port terminal liquefied natural gas (LNG) fuel bunkering appears to be a critical pathway for attracting newest technology OGV to Southern California
- A healthy and expanding NG engine market could signal manufacturer confidence and in turn encourage R&D in ultra-low NOx emission engine technology
- Other nonroad sectors can benefit from the availability of natural gas

Historic Opportunity to Collaborate with Railroad Companies

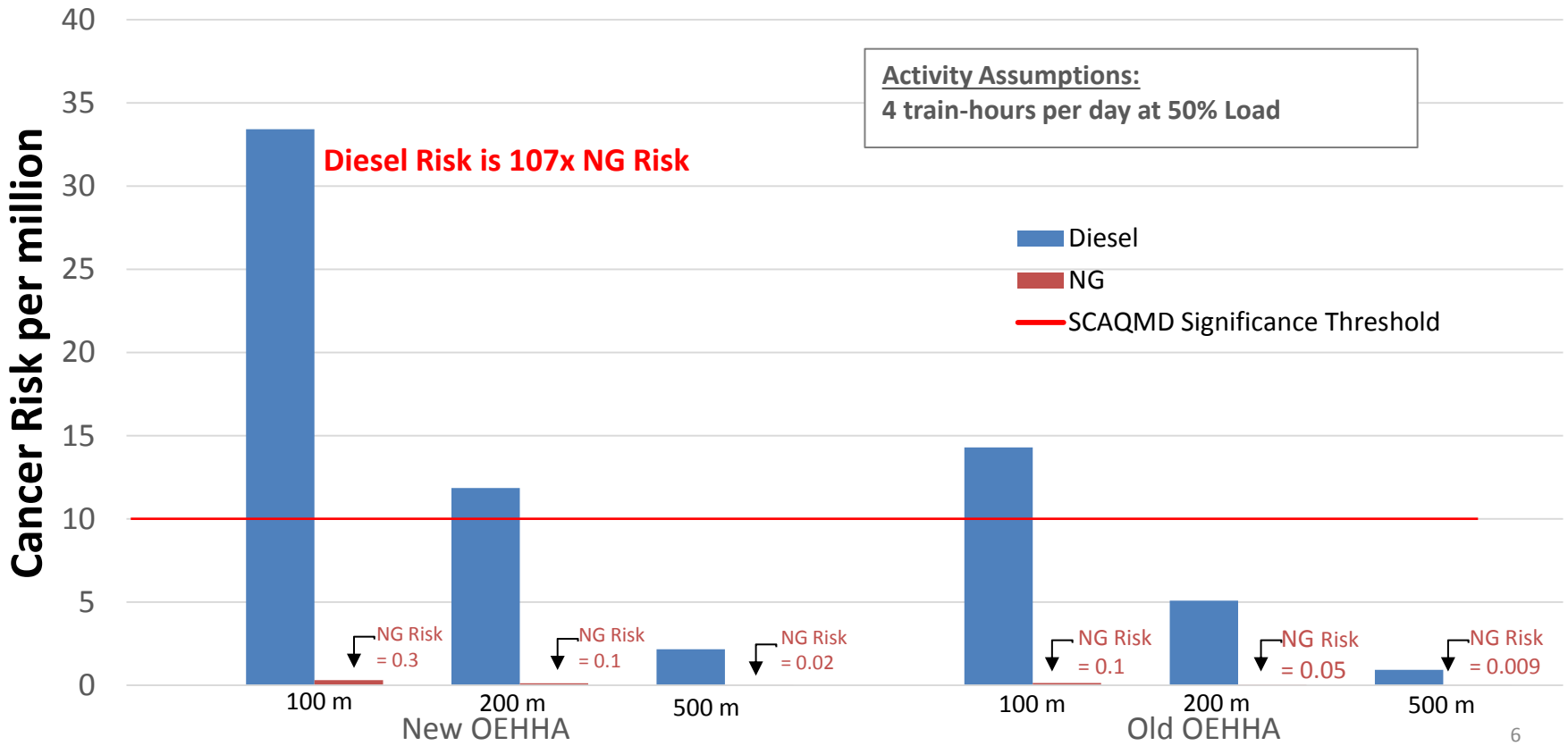
- Class 1 Railroad companies are currently evaluating NG fuelling economics & logistics
- NG would likely be deployed transcontinentally on a line-by-line basis
- NG bunkering availability could attract early NG conversion of Southern California transcontinental lines
- Conversion of these lines would bring a higher proportion of Tier 4 locomotives to the region

South Coast Air Basin Locomotive NOx Emissions Advantaged by NG Conversion

- A fuel switch to NG will accelerate modernization of Class 1 line haul locomotives to Tier 3+ and Tier 4 significantly faster than natural turnover on those lines
- NG implementation of Southern California transcontinental lines first could result in complete Class 1 fleet modernization as early as 2027, contingent on fuelling infrastructure and economics



Locomotive Absolute Residential Cancer Risk- Diesel vs. NG
Hypothetical Example: Arrival and Departure Trains

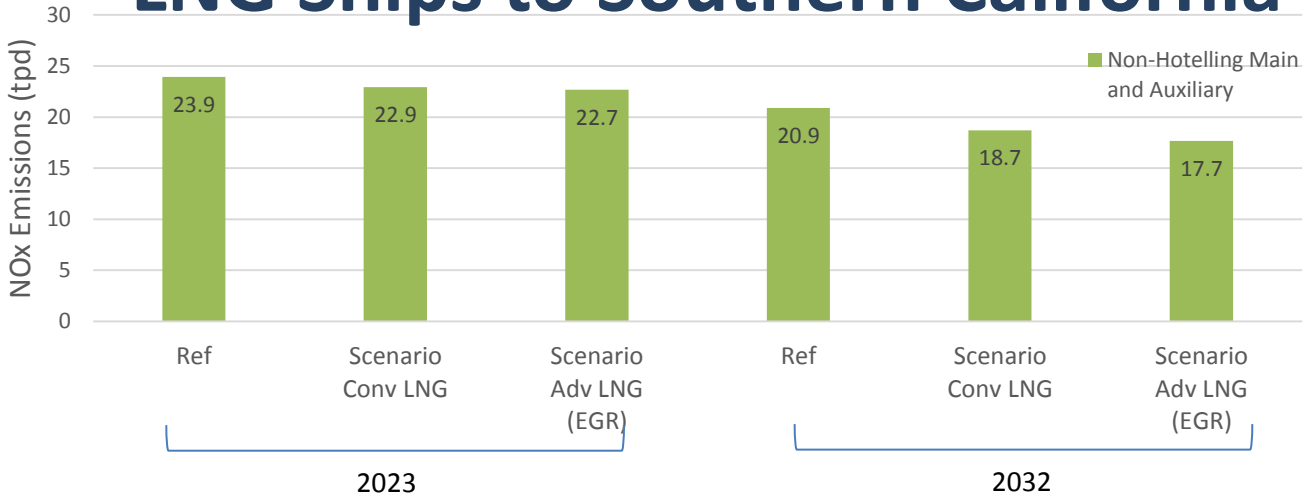


Ship Market is Signalling for LNG Infrastructure

- 63 LNG vessels in operation worldwide and increasing
- 76 LNG vessels on order worldwide and increasing
- Puget Sound LNG bunkering project precipitated by Totem Trailer Ocean Express, Matson & Pasha Hawaii move to LNG
- Vancouver LNG bunkering project precipitated by an order of 3 LNG ferries
- Carnival Cruises orders 4 LNG Mega-cruise ships “undeterred by lack of LNG infrastructure”

"I think the early adopters can drive forward LNG infrastructure…"
Roger Frizzell, Carnival Cruise, June 18, 2015

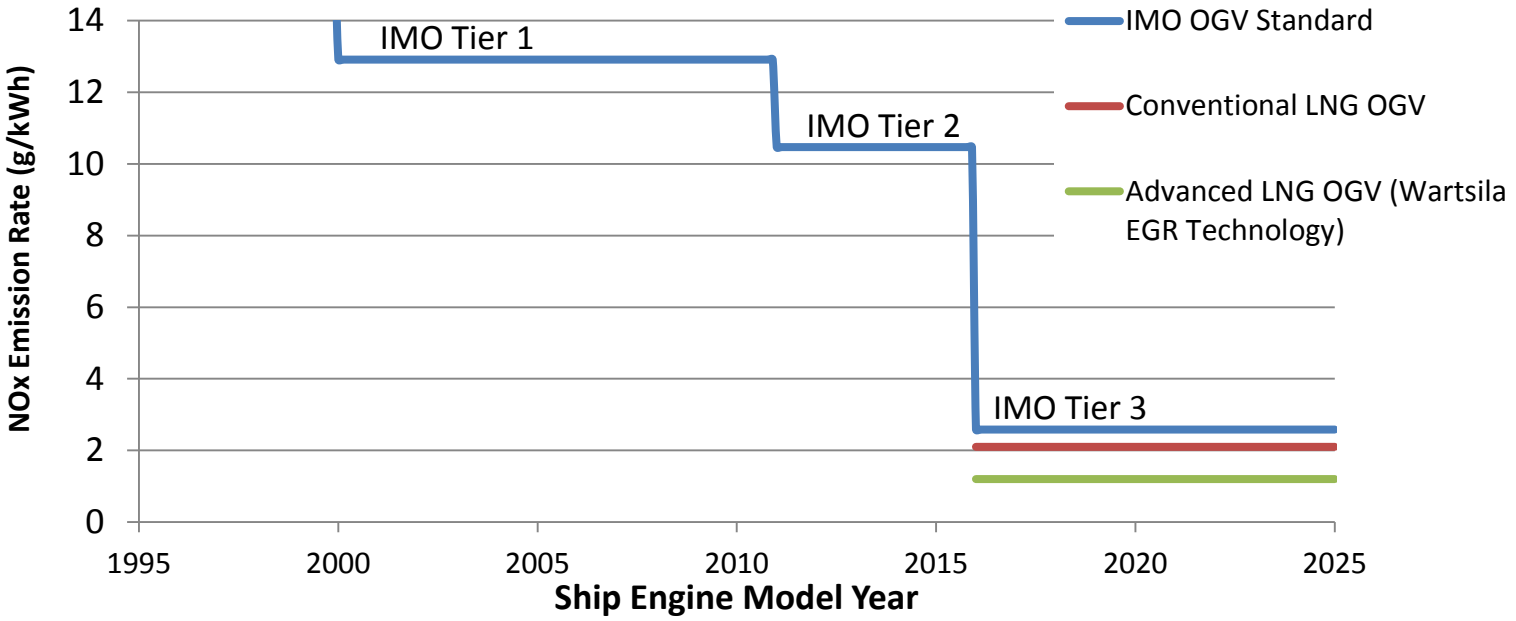
LNG Bunkering Can Attract Modern LNG Ships to Southern California



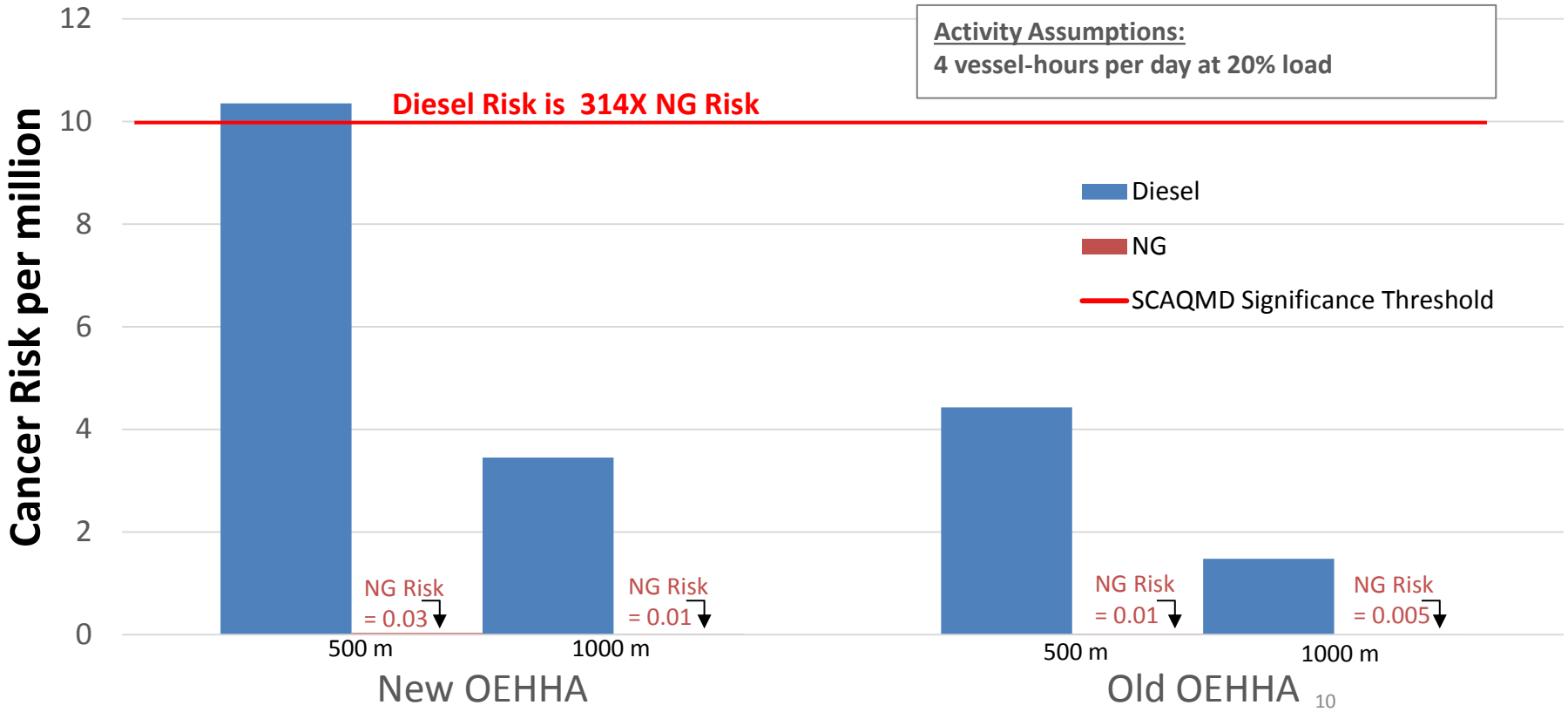
- NOx emission reductions could be possible by 2023 and 2032
- These meaningful ship-related NOx reductions require LNG fuelling availability at Southern California ports
- Domestic LNG ocean trade routes will benefit the entire State
- LNG is consistent with ocean cargo transport business models
  - A major advantage is no rulemaking is necessary to achieve these reductions

LNG OGV Outperforming IMO Tier 3 NOx

- "Advanced LNG"- LNG enables a NOx emission rate up to 54% below IMO Tier 3
  - Wartsila 4-stroke LNG with exhaust gas recirculation; Commercially available

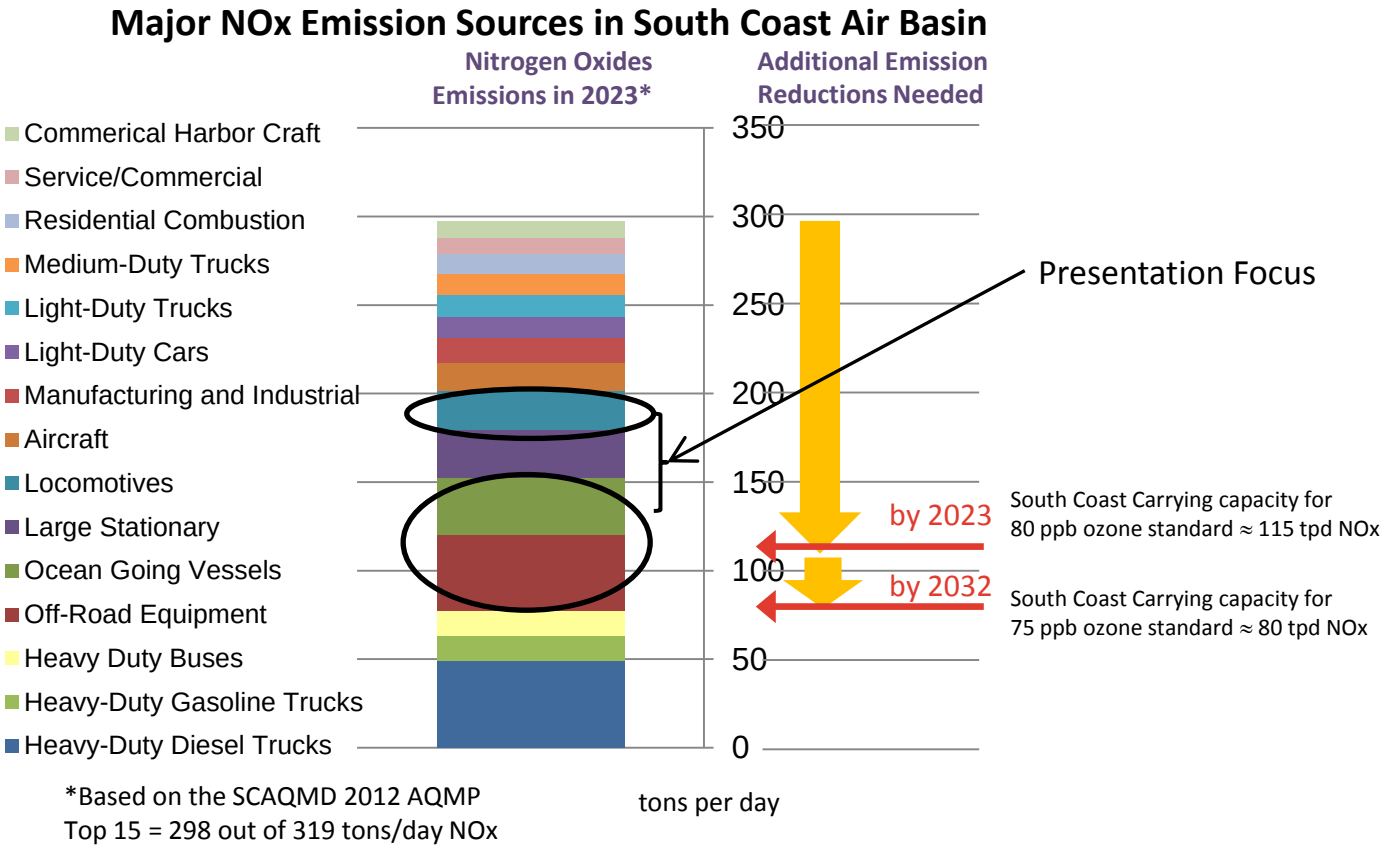


Marine Engine Absolute Residential Cancer Risk- Diesel vs. NG
Hypothetical Example: Transiting Near Port Terminal

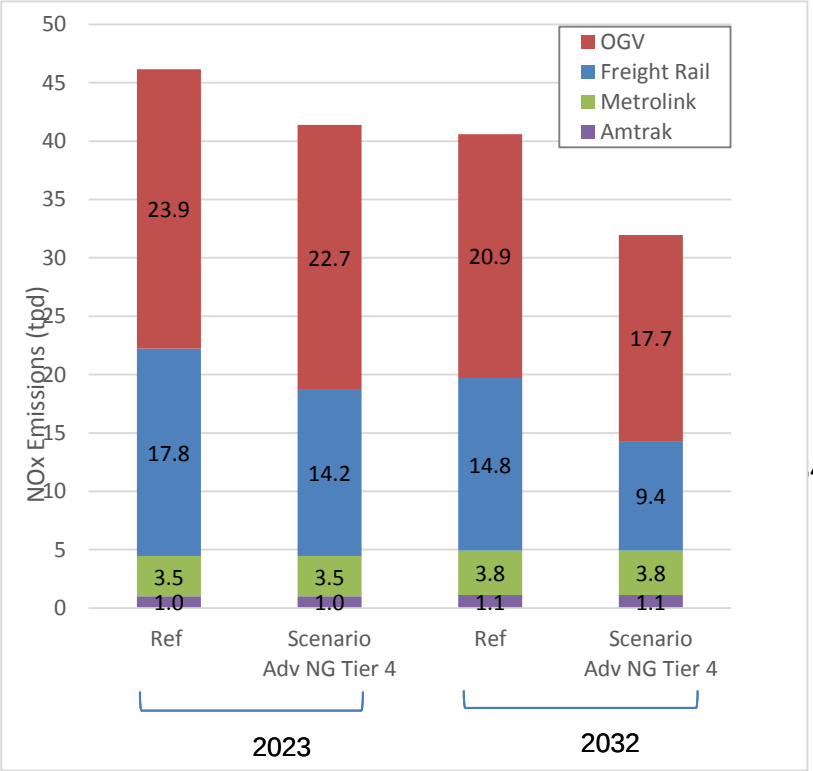


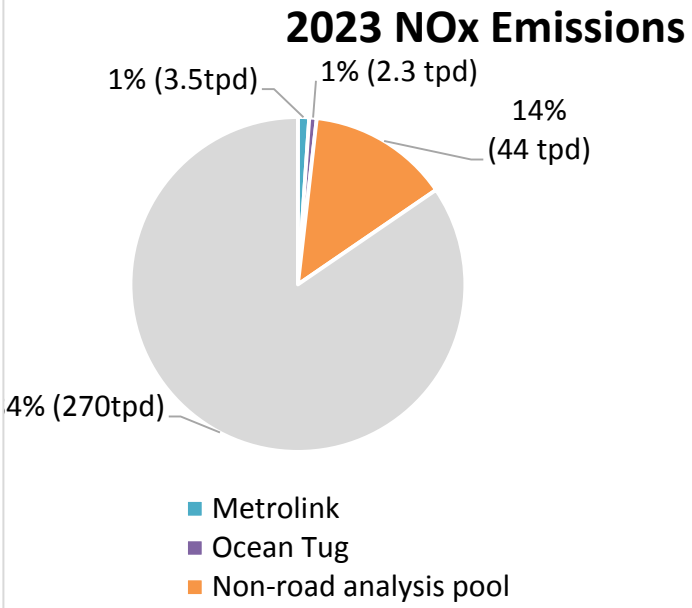
ADDITIONAL MATERIALS

South Coast Air Basin Attainment Goals

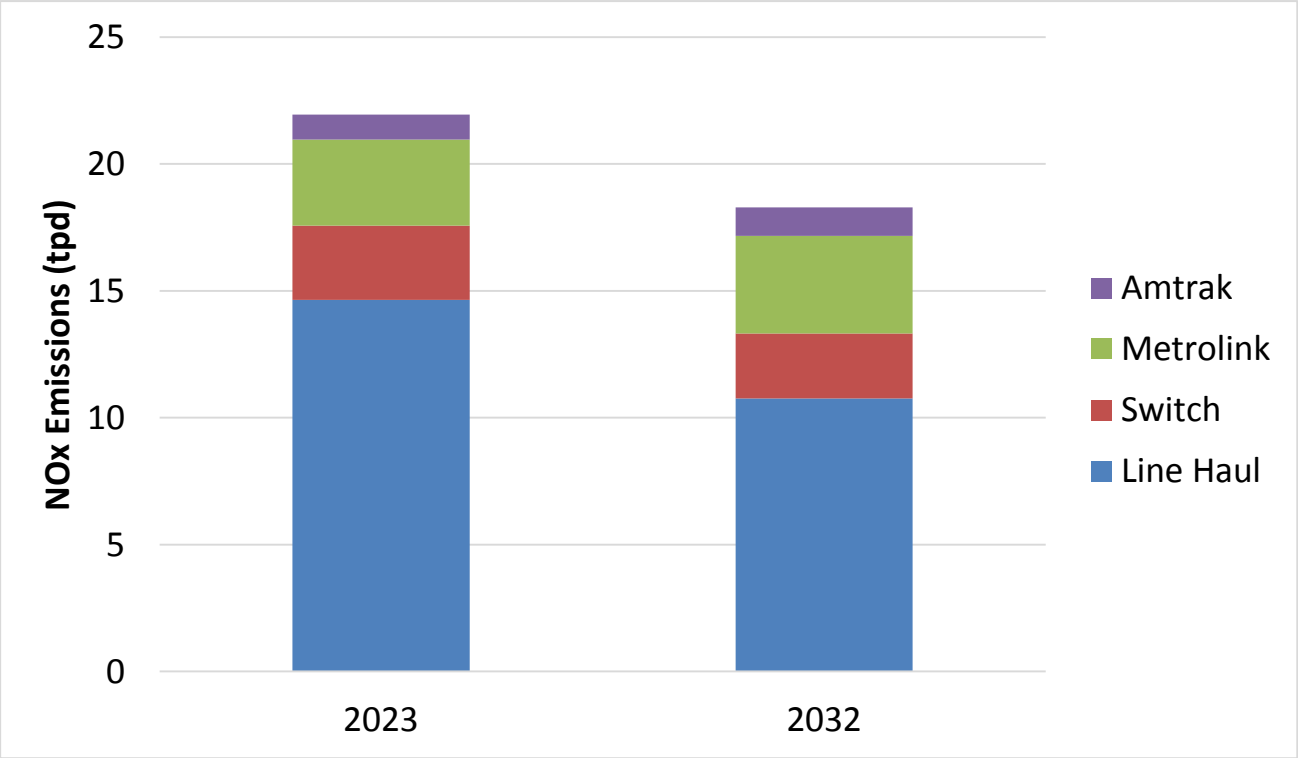


SC Air Basin Locomotive and OGV Summary Results

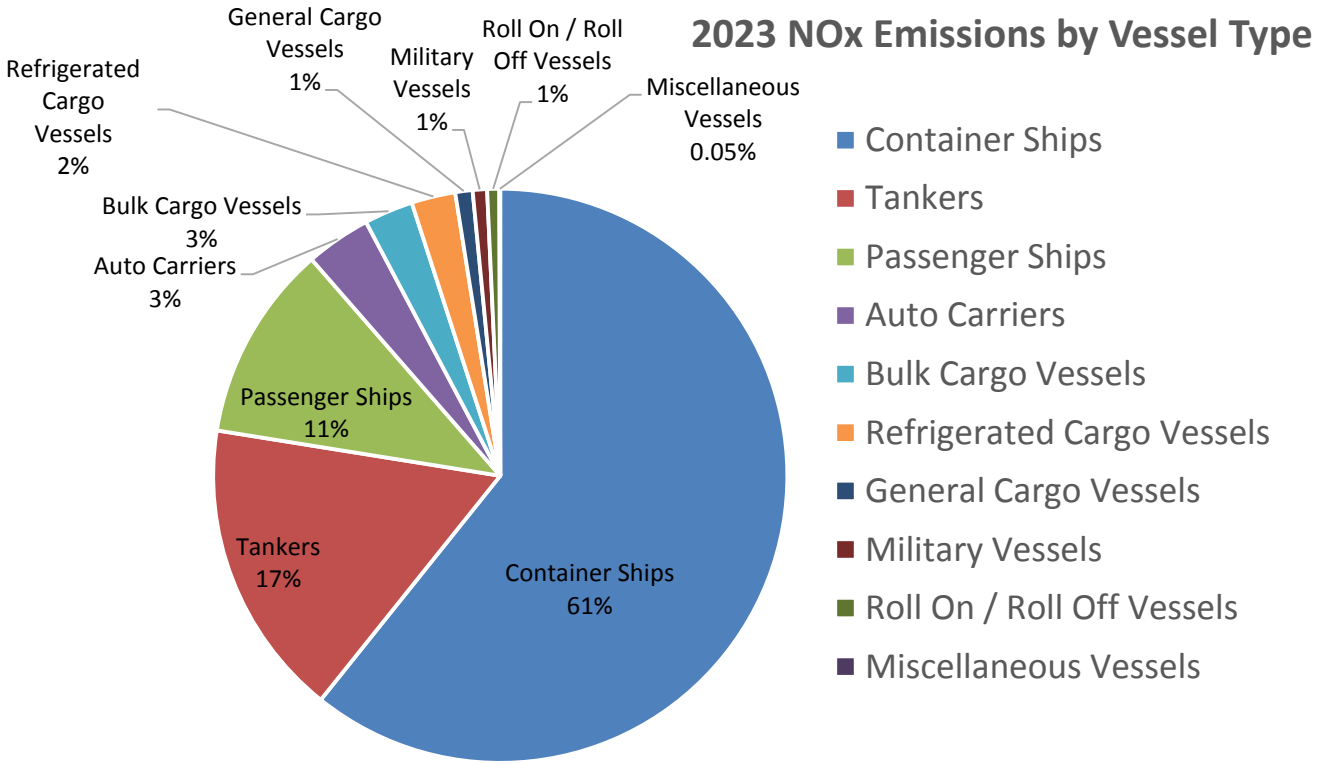




Locomotive Sector Analysis: Reference Inventory



OGV Sector Analysis: Inventory Composition



Decarbonizing Pipeline Gas to Help Meet California's 2050 Greenhouse Gas Reduction Goal

November 2014

(Revised from June 2014 draft)

Energy+Environmental Economics

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Executive Summary

This study examines the potential role of decarbonized pipeline gas fuels, and the existing gas pipeline infrastructure, to help meet California's long-term climate goals. The term "decarbonized gas" is used to refer to gaseous fuels with a net-zero, or very low, greenhouse gas impact on the climate. These include fuels such as biogas, hydrogen and renewable synthetic gases produced with low lifecycle GHG emission approaches. The term "pipeline gas" means any gaseous fuel that is transported and delivered through the natural gas distribution pipelines. Using a bottom-up model of California's infrastructure and energy systems between today and 2050 known as PATHWAYS (v.2.1), we examine two "technology pathway" scenarios for meeting the state's goal of reducing greenhouse gas (GHG) emissions to 80 percent below 1990 levels by 2050:

- **Electrification scenario**, where all energy end uses, to the extent feasible, are electrified and powered by renewable electricity by 2050;
- **Mixed scenario**, where both electricity and decarbonized gas play significant roles in California's energy supply by 2050.

Both scenarios meet California's 2020 and 2050 GHG goals, to the extent feasible, accounting for constraints on energy resources, conversion efficiency, delivery systems, and end-use technology adoption. Across scenarios, we

compare total GHG emissions, costs, and gas pipeline utilization over time relative to a Reference scenario, which does not meet the 2050 GHG target.

The study concludes that a technology pathway for decarbonized gas could feasibly meet the state's GHG reduction goals and may be easier to implement in some sectors than a high electrification strategy. We find that the total costs of the decarbonized gas and electrification pathways to be comparable and within the range of uncertainty. A significant program of research and development, covering a range of areas from basic materials science to regulatory standards, would be needed to make decarbonized gas a reality.

The results also suggest that decarbonized gases distributed through the state's existing pipeline network are complementary with a low-carbon electrification strategy by addressing four critical challenges to California's transition to a decarbonized energy supply.

- First, decarbonized pipeline gas can help to reduce emissions in sectors that are otherwise difficult to electrify, either for technical or customer-acceptance reasons. These sectors include: (1) certain industrial end uses, such as process heating, (2) heavy duty vehicles (HDVs), and (3) certain residential and commercial end uses, such as cooking, and existing space and water heating.
- Second, the production of decarbonized gas from electricity could play an important role in integrating variable renewable generation by producing gas when renewables are generating power, and then storing the gas in the pipeline distribution network for when it is needed.
- Third, a transition to decarbonized pipeline gas would enable continued use of the state's existing gas pipeline distribution network, eliminating

the need for new energy delivery infrastructure to meet 2050 GHG targets, such as dedicated hydrogen pipelines or additional electric transmission and distribution capacity.

- Fourth, pursuit of decarbonized gas technologies would help diversify the technology risk associated with heavy reliance on a limited number of decarbonized energy carriers, and would allow consumers, businesses and policymakers greater flexibility and choice in the transition to a low-carbon energy system.

1 Introduction

California has embarked on a path to dramatically reduce its GHG emissions over the next four decades. In the nearer term, Assembly Bill 32 (AB 32) requires the state to reduce GHG emissions to 1990 levels by 2020. The state appears to be on track to meet this goal. In the longer term, Executive Order S-3-05 sets a target for California to reduce GHG emissions by 80% relative to 1990 levels by 2050. Achieving this target will require significant changes in the state's energy systems over the coming decades; the state's energy supply will need to be almost entirely carbon free by mid-century.

Natural gas and other gaseous fuels face an uncertain future in California's energy supply mix. The need to reduce the carbon intensity of the state's transportation fuels and industrial output to meet near- to medium-term GHG goals opens up opportunities for natural gas as a substitute for more carbon-intensive oil and coal. However, natural gas from traditional fossil fuel sources cannot represent a significant share of energy use by 2050 if the state is to meet its long-term GHG goal. By 2050, traditional uses of oil and natural gas, including transportation fuels, water and space heating, and industrial boilers and process heating, will need to be mostly, if not fully, decarbonized.

Solutions for achieving a deep decarbonization of California's energy supply have focused on extensive electrification using renewable energy sources, with

some liquid biofuel and hydrogen fuel use in the transportation sector. However, there are three principal challenges associated with this decarbonization "pathway." First, there are practical limits to electrifying some energy end uses, such as HDVs and industrial process heating. Second, there are physical limits on sustainable biomass resources, which limit the amount of biomass that can be used as a primary energy source. Third, very high levels of renewable penetration require large-scale energy storage solutions, to integrate wind and solar generation on daily and seasonal timescales. Decarbonized[1] gas fuels distributed through the state's extensive existing gas pipeline network offer a little-explored strategy for overcoming some of these challenges and meeting the state's GHG goals.

To examine the roles of gas fuels in California and utilization of the state's existing gas pipeline infrastructure from now until 2050, Southern California Gas Company (SCG) retained Energy and Environmental Economics (E3) to address four main questions:

1. Are there feasible technology pathways for achieving California's nearer- and longer-term GHG targets where gaseous fuels continue to play a significant role?
2. If yes, how do these pathways compare against a reference case and a "high electrification" strategy in terms of GHG emissions and costs?How does the use of the state's gas pipeline infrastructure differ under scenarios where more and less of the state's energy supply is electrified?
3. In what key areas would research, development, and demonstration (RD&D) be needed to produce decarbonized gas on a commercial scale?

[1] Throughout this report, the term "decarbonized gas" refers to gases that have a net-zero, or very low, impact on the climate, accounting for both fuel production and combustion.

To provide an analytical framework for addressing these questions, we develop two "technology pathway" scenarios that represent different points along a spectrum between higher and lower levels of electrification of energy end uses by 2050:

(1) "Electrification" scenario, where most of the state's energy consumption is powered with renewable electricity by 2050;

(2) "Mixed" scenario where decarbonized gas replaces existing natural gas demand and fuels HDVs, but renewable energy is used to produce electricity and to power most light-duty vehicles (LDVs).

The decarbonized gas technologies examined in this study were selected to represent a range of different options, but are not intended to be exhaustive. The focus in this study is on more generally examining the role of gas fuels over the longer term in a low-carbon energy system, not on comparing different emerging decarbonized gas options.[2] These scenarios are compared to a Reference scenario where current policies are unchanged through 2050 and the state's GHG target is unmet. Table 1 shows a high-level summary of key differences among these three scenarios.

[2] A number of emerging technology options for low-carbon gas, such as artificial photosynthesis, are thus not included in the list of technology options examined in this study. Including these technologies would likely reinforce many of the main conclusions in this study.

Table 1. High-level summary of key differences among the three scenarios examined in this analysis

Scenario	Source of residential, commercial, industrial energy end uses	Source of transportation fuels	Source of electricity supply	Source and amount of decarbonized pipeline gas[3]
Electrification	Mostly electric	Mostly electric LDVs, mostly hydrogen fuel cell HDVs	Renewable energy, some natural gas with CCS	Small amount of biogas
Mixed	Decarbonized gas for existing gas market share of end uses	Electric LDVs, Decarbonized gas in HDVs	Renewable energy, some natural gas with CCS	Large amount of biogas, smaller amounts of SNG, hydrogen, natural gas
Reference	Natural gas	Gasoline, diesel	Mostly natural gas	None

Both the Electrification and Mixed scenarios were designed to meet California's 2020 and 2050 GHG targets. For each scenario we analyzed its technical feasibility and technology costs using a bottom-up model of the California economy. This model (California PATHWAYS v2.1), which includes a detailed "stock-rollover" representation of the state's building, transportation, and energy infrastructure, allows for realistic depiction of infrastructure turnover and technology adoption; sector- and technology-based matching of energy demand and supply; and detailed energy system representation and technology coordination. The model includes hourly power system dispatch and realistic

[3] Throughout this report, the term "pipeline gas" is used to encompass different mixes of gas in the pipeline, including conventional natural gas, gasified biomass, hydrogen (initially limited to 4% of pipeline gas volume, with up to 20% allowed by 2050), and gas produced from P2G methanation.

operating constraints. An earlier version of the model was peer reviewed as part of an article published in the journal *Science*.[4]

The identification of realistic sources of decarbonized gas is a critical piece of this analysis. We considered three energy carriers for decarbonized gas, each with different potential primary energy sources:

- **Biogas**, which includes gas produced through biomass gasification (biomass synthetic gas) and anaerobic digestion of biomass;
- **Hydrogen**, produced through electrolysis; and
- **Synthetic natural gas (SNG)**, produced through electrolysis with renewables (mostly wind and solar "over-generation") and further methanated into SNG in a process referred to as power-to-gas (P2G) throughout this report.[5]

By 2050, there are a limited number of primary energy sources available to supply decarbonized energy: renewable electricity, biomass, nuclear, or fossil fuels with carbon capture and sequestration (CCS). Each has different scaling constraints. For instance, wind and solar energy are intermittent and require energy storage at high penetration levels. Hydropower and geothermal energy are constrained by land and water use impacts and the availability of suitable

[4] James H. Williams, Andrew DeBenedictis, Rebecca Ghanadan, Amber Mahone, Jack Moore, William R. Morrow III, Snuller Price, Margaret S. Torn, "The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity," *Science* 335: 53-59.

[5] P2G, though often used generically to refer to any process that converts electricity to gas, refers specifically to electrolysis and hydrogen methanation in this report. The methanation reaction requires a source of CO_2, which we assume to be air capture in this study, although carbon capture from seawater is another promising, emerging technology. This extra methanation step, and the costs of seawater carbon capture, or air capture, makes P2G relatively expensive. We examined this technology in this study primarily for its electricity storage benefits. Other potential low-carbon gas production technologies, such as synthetic photosynthesis, are not examined within the scope of this study.

sites for development. Bioenergy is limited by the amount of feedstock that can be sustainably harvested. Nuclear is limited by public acceptance and the lack of long-term storage and disposal of spent fuel. Carbon capture and sequestration is also limited by public acceptance and generates higher emissions than the other options due to partial capture rates of CO_2. Choices of primary energy sources for a decarbonized energy supply require tradeoffs in costs, reliability, externalities, and public acceptance.

Similar limits and tradeoffs exist with conversion pathways from primary energy to secondary energy carriers, often with multiple interrelated options. Biomass, for instance, can be converted into a number of different energy carriers (e.g., liquid biofuels, biogas, hydrogen, electricity) through multiple energy conversion processes. P2G is only cost-effective from an energy system perspective when there is significant renewable over-generation. Fossil fuels can be converted into partially decarbonized energy with carbon capture and sequestration (CCS). Evaluating different decarbonized gas technology options — primary energy sources, energy conversion pathways, and energy carriers — thus requires realistic scaling constraints, an integrated energy system perspective, and strategies for managing uncertainty and complexity.

Our modeling framework addresses these requirements by: consistently constraining physical resources (e.g., biomass availability), conversion efficiencies (e.g., gasification efficiency), and gas distribution (e.g., limits on hydrogen gas volumes in pipelines); allowing for interrelationships among energy sources (e.g., electricity and gas); accounting for system costs and GHG emissions across a range of technologies; and exploring different potential options under a range of inputs and avoiding over-reliance on point estimate

assumptions as the driver of technology adoption. The results of this study confirm that the electricity sector will be pivotal to achieving a low-carbon future in California — in both the Electrification and Mixed scenarios the need for low-carbon electricity increases substantially. The results also suggest that decarbonized gases distributed through the state's existing pipeline network are complementary with a low-carbon electrification strategy by addressing four critical challenges to California's transition to a decarbonized energy supply.

- First, decarbonized pipeline gas can help to reduce emissions in sectors that are otherwise difficult to electrify, either for technical or customer-acceptance reasons. These sectors include: (1) certain industrial end uses, such as process heating, (2) HDVs, and (3) certain residential and commercial end uses, such as cooking, existing space heating, and existing water heating.
- Second, the production of decarbonized gas from electricity could play an important role in integrating variable renewable generation by producing gas when renewables are generating power, and then storing the gas in the pipeline distribution network for when it is needed. At high penetrations of variable renewable generation, long-term, seasonal electricity storage may be needed to balance demand and supply, in addition to daily storage. On these longer timescales, gas "storage" may be a more realistic and cost-effective load-resource balancing strategy than flexible loads and long-duration batteries.[6]
- Third, a transition to decarbonized pipeline gas would enable continued use of the state's existing gas pipeline distribution network, reducing or

[6] In this scenario, we assume that electrolysis for hydrogen production, powered by renewable electricity, can be ramped up and down on a daily basis as a dispatchable load in the medium-term. In the long-term, P2G methanation with air capture, or carbon capture from seawater to produce SNG could provide both a source of low-carbon gas and a grid balancing service.

eliminating the need for new energy delivery infrastructure to meet 2050 GHG targets, such as dedicated hydrogen delivery pipelines or additional electric transmission and distribution lines. Increased use of decarbonized gas in the coming decades would preserve the option of continued use of existing gas pipelines as a low-carbon energy delivery system over the longer term.

- Fourth, pursuit of decarbonized gas technologies would help diversify the technology risk associated with heavy reliance on a limited number of decarbonized energy carriers, and would allow consumers, businesses and policymakers greater flexibility and choice in the transition to a decarbonized energy system.

All of the decarbonized gas energy carriers in this study make use of proven energy conversion processes — none require fundamental breakthroughs in science. Nonetheless, these processes remain relatively inefficient and expensive, and would need significant improvements in conversion efficiency and reductions in costs to be competitive in the medium- to long-term. Additionally, existing gas pipelines and end use equipment were not designed to transport and utilize hydrogen gas, and would require operational changes as the blend of decarbonized gas shifts over time.

Developing a supply of sustainably sourced biomass presents an additional challenge. Biomass resources have competing uses — food, fodder, and fiber — which may limit the amount of sustainably-sourced biomass available for energy production. The Electrification and Mixed scenarios both assume that a limited quantity of sustainably sourced biomass would be available to California in the 2030 and 2050 timeframe. The same quantity of biomass is assumed to produce electricity in the Electrification scenario, and biogas in the Mixed scenario.

However, it remains uncertain whether it will be possible to increase the production of biomass fuels to this scale, as would be needed to significantly reduce fossil fuel use, without negatively impacting food supply or increasing GHG emissions from changes in land use.

Furthermore, current RD&D efforts and policy initiatives have prioritized the production of liquid biofuels, particularly ethanol, over the production of biogas. More generally, the state does not appear to have a comprehensive decarbonized gas strategy, in contrast to low-carbon electricity which is promoted through the state's Renewables Portfolio Standard (RPS) and the decarbonized transportation fuels are encouraged through the state's Low Carbon Fuel Standard (LCFS). Overcoming these challenges would require prompt shifts in policy priorities and significant amounts of RD&D if biofuels, and particularly biogas, are to become an important part of the state's future energy mix.

The results suggest priority areas and time frames, outlined in Table 2, for a RD&D agenda that would be needed if California is to pursue decarbonized pipeline gas as a strategy to help meet the state's GHG reduction goals.

Table 2. RD&D timescales, priorities, and challenges for decarbonized gas fuels

Timeframe of RD&D payoff	RD&D Area	Challenge
Near-term	Energy efficiency	Achieving greater customer adoption and acceptance
	Reduction in methane leakage	Cost-effectively identifying and repairing methane leaks in natural gas mining, processing, and distribution
	Use of anaerobic digestion gas in the pipeline and pilot biomass gasification	Quality control on gas produced via anaerobic digestion for pipeline delivery
Medium-term	Agronomic and supply chain innovation for biomass feedstocks	Competition with liquid fuels, food, fodder, fiber may limit amount of biomass available as a source of decarbonized gas
	Pilot decarbonized SNG technology to improve conversion efficiency and cost	Gasification, electrolysis, and methanation need efficiency improvements, reductions in cost to be competitive; safety, scale, and location challenges must be addressed
	Limits on hydrogen volumes in existing pipelines	Need pipeline and operational changes to accommodate higher volumes
Long-term	Emerging technologies (e.g., P2G, artificial photosynthesis, CO_2 capture from seawater for fuel production)	P2G must be scalable and available as a renewable resource balancing technology; in general, emerging technologies still require innovations in material science

The organization of the report is as follows: Section 2 develops the Reference case and two afore-mentioned scenarios. Section 3 describes the modeling approach and elaborates on the technology pathways for decarbonized gases. Section 4 presents the results. The final section, Section 5, distills key conclusions and discusses their policy and regulatory implications. Further details on methods and assumptions are provided in an appendix.

1.1 About this study

This study was commissioned by SCG to help the company consider their long-term business outlook under a low-carbon future, and to fill a gap in the existing literature regarding long-term GHG reduction strategies that include the use of decarbonized gas in the pipeline distribution network.

A number of studies have evaluated the options for states, countries and the world to achieve deep reductions in GHG emissions by 2050.[7] These studies each make different assumptions about plausible technology pathways to achieve GHG reductions, with varying amounts of conservation and efficiency, CCS, hydrogen fuel cells, nuclear energy, and biofuel availability, to name a few key variables. However, few studies have undertaken an in-depth investigation of the role that decarbonized pipeline gas could play in achieving a decarbonized future.[8]

In our prior work, we highlighted the pivotal role of the electricity sector in achieving a low-carbon future for California.[9] This study for SCG uses an

[7] See for example: "Reducing Greenhouse Gas Emissions by 2050: California's Energy Future," California Council on Science and Technology, September 2012; "Roadmap 2050: A practical guide to a prosperous, low-carbon Europe," European Climate Foundation, April 2010; "EU Transport GHG: Road to 2050?," funded by the European Commission, June 2010; "EPA Preliminary Analysis of the Waxman-Markey Discussion Draft," U.S. EPA, April 2009; "Energy Technology Perspectives, 2008: Scenarios & Strategies to 2050," International Energy Agency, 2008; "The Power to Reduce CO_2 Emissions: The Full Portfolio: 2008 Economic Sensitivity Studies," EPRI, Palo Alto, CA: 2008. 1018431; "Building a Low Carbon Economy: The U.K.'s Contribution to Tackling Climate Change," The First Report of the Committee on Climate Change, December 2008; "Making the Transition to a Secure and Low-Carbon Energy System: Synthesis Report," UK Energy Research Center, 2009.

[8] For an example of a deep decarbonization study from Germany that employs both electrolysis and P2G (Sabatier), see Palzer, A. and Hans-Martin Henning, "A Future Germany Energy System with a Dominating Contribution from Renewable Energies: A Holistic Model Based on Hourly Simulation," Energy Technol. 2014, 2, 13 – 28.

[9] James H. Williams, Andrew DeBenedictis, Rebecca Ghanadan, Amber Mahone, Jack Moore, William R. Morrow III, Snuller Price, Margaret S. Torn, "The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity," *Science* 335: 53-59.

updated version of the model (California PATHWAYS 2.1) employed in that prior work, relying on the same fundamental infrastructure-based stock roll-over modeling approach, and many of the same underlying input assumptions, such as energy efficiency potential. However, important updates to the analysis include:

- Updated forecasts of macroeconomic drivers including population and economic growth;
- Updated technology cost assumptions where new information has become available, including for solar photovoltaic (PV) and energy storage costs;
- A more sophisticated treatment of electricity resource balancing, moving from a four time period model (summer/winter & high-load/low-load), to an hourly resource balancing exercise; and
- Slightly higher biomass resource potential estimates, based on new data from the U.S. Department of Energy (DOE).[10]

The model results are driven by exogenous, scenario-defined technology adoption assumptions. Costs of technologies and fuels are exogenous, independent inputs which are tabulated to track total costs. The model does not use costs as an internal decision variable to drive the model results, rather the model is designed to evaluate technology-driven, user-defined scenarios.

[10] U.S. Department of Energy, "U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry," August 2011.

2 Scenarios

2.1 Low-carbon scenarios

Two distinct low-carbon scenarios are developed and compared within this study. Both of these scenarios result in lower GHG emissions than required by California's mandate of reducing emissions to 1990 levels by 2020, and are designed to meet the 2050 goal of reducing GHG emissions 80% below 1990 levels. Each scenario is further constrained to achieve an approximately linear path in GHG reductions between today's emissions and the 2050 goal. The differences between the two scenarios are not in GHG reduction achievements, but between technology pathways, implied RD&D priorities, technology risks, and costs.

The two low-carbon scenarios evaluated include:

- **Electrification Scenario: This scenario meets the 2050 GHG reduction goal by electrifying most end-uses,** including industrial end uses, space heating, hot water heating, cooking and a high proportion of light-duty vehicles. Low-carbon electricity is produced mostly from renewable generation, primarily solar PV and wind, combined with a limited amount of natural gas with carbon capture and storage (CCS) and 20 GW of electricity storage used for renewable integration. Low-carbon electricity is also used to produce hydrogen fuel for heavy-duty vehicles. California's limited supply of biomass is used largely to generate

renewable electricity in the form of biomass generation. In this scenario, the gas distribution pipeline network is effectively un-used by 2050. With very few remaining sales by 2050 and significant remaining fixed distribution costs, it seems unlikely that gas distribution companies would continue to operate under this scenario.

+ **Mixed Scenario: This scenario meets the 2050 GHG reduction goal with a blend of low-carbon electricity and decarbonized pipeline gas.** Existing uses for natural gas in California, such as industrial end uses (i.e. boilers and process heat), space heating, hot water heating and cooking are assumed to be supplied with decarbonized pipeline gas, such that the current market share for pipeline gas is maintained over time. California's limited supply of biomass is used to produce biogas which is injected into the pipeline. Over time, this scenario assumes that an increasing share of hydrogen is blended into the pipeline gas, which is assumed to be produced from renewable power (mostly solar and wind) using electrolysis. This scenario includes a significant increase in electric light-duty vehicles, while most heavy-duty vehicles are assumed to be powered with compressed or liquefied decarbonized gas and liquid hydrogen fuel. Electricity is produced mostly from renewable generation, primarily solar PV and wind, with a limited amount of natural gas with CCS and 5 GW of electricity storage used for renewable integration. Load balancing services are primarily provided by cycling the production of decarbonized gas to match the renewable generation profiles. In this way, the decarbonized pipeline gas provides both daily and seasonal energy storage. The Mixed scenario represents neither a significant expansion nor contraction of the gas pipeline distribution system. In this scenario, both the gas pipeline network and the electricity transmission and distribution system operate as conveyors of decarbonized energy.

The key parameters of these scenarios are summarized in Table 3 below.

Table 3. Summary of Low-Carbon Scenarios Based on Key Parameters in 2050

Scenario	Source of residential, commercial, industrial energy end uses	Source of transportation fuels	Source of electricity supply & resource balancing	Uses of biomass
Electrification	Mostly electric	Mostly electric light-duty vehicles, mostly hydrogen HDVs	Renewable energy, limited natural gas with CCS, 5 GW of pumped hydro energy storage and 15 GW of battery energy storage, some hydrogen production	Electricity generation, small amount of biogas
Mixed	Decarbonized gas (biogas, SNG & hydrogen) for existing gas market share of end uses	Decarbonized gas in HDVs; electric light duty vehicles (LDVs)	Renewable energy, limited natural gas with CCS, 5 GW of pumped hydro energy storage, plus P2G and hydrogen production assumed to provide resource balancing services	Biogas

Both of the low-carbon scenarios evaluated here entail different assumptions about the future feasibility and commercialization of key technologies to achieve an 80 percent reduction in GHGs relative to 1990. For the Electrification scenario to be viable, significant amounts of long-term electricity storage must be available on a daily and seasonal basis to balance intermittent renewable generation. The Electrification scenario also relies significantly on the production of low carbon liquid biofuels and hydrogen fuel cell vehicles in the transportation sector, for vehicles that are otherwise difficult to electrify. For the Mixed scenario to succeed, it must be possible to produce large quantities of biogas using sustainably-sourced biomass. Furthermore, the Mixed scenario

depends on eventual adoption of P2G methanation with carbon capture from sea water or air capture to produce SNG. All of the technologies that are applied in these scenarios are technically feasible; the science exists today. The challenge is commercializing and scaling these technologies to provide a significant energy service to California before 2050. In Table 4 below, the emerging technologies applied in the low-carbon scenarios are ranked based on their "risk" to the scenario's success. Risk is determined by ranking the amount of energy that passes through each technology in 2050 for a given scenario (higher energy use implies higher reliance on the technology), combined with a measure of the technology's current commercialization stage (lower availability implies higher risk).

Table 4. Ranking of emerging technology's criticality to the Electrification and Mixed scenarios

Emerging Technologies	Overall Ranking of Technology Criticality by 2050 (maximum = 9 for most critical, minimum = 0 for least critical)	
	Electrification	Mixed
Availability of sustainably-sourced biomass	6	9
Power-to-gas methanation using carbon capture from seawater or air	0	6
Battery storage for load balancing	9	0
Carbon capture and storage	3	3
Cellulosic ethanol	6	0
Hydrogen production	4	4
Use of hydrogen in the distribution pipeline	0	4
Gasification to produce biogas	1	3
Fuel cells in transportation (HDVs)	6	3
Electrification of industrial end uses	2	0

2.2 Common strategies and assumptions across all low-carbon scenarios

Both of the low-carbon scenarios described above include a number of other carbon reduction efforts that must be implemented to achieve the state's long-

term GHG reduction goal. These other assumptions do not vary between scenarios, and include low-carbon measures such as:

- Significant levels of energy efficiency in all sectors, including transportation efficiency, industrial and building efficiency;
- Significant reductions in non-CO_2 and non-energy GHG emissions, such as methane emissions and other high-global warming potential gases such as refrigerant gases;
- Improvements in "smart growth" planning as per Senate Bill 375,[11] leading to reductions in vehicle miles traveled (VMT) and increased urban density leading to lower building square footage needs per person;
- All scenarios include the use of sustainably-sourced biomass to produce decarbonized energy. The scenarios differ in how the biomass is used, to produce electricity, liquid or gas fuels.
- All scenarios include an increase in electrification relative to today; the scenarios differ in how much additional electrification is assumed relative to other sources of low-carbon energy;
- Flexible loads for renewable resource balancing, including limited use of controlled charging of electric vehicles and a limited share of certain residential and commercial electric thermal end uses.[12] Hydrogen and P2G production are assumed to provide fully dispatchable, perfectly flexible load-following services, helping to integrate variable renewable generation in the low-carbon scenarios.

[11] The Sustainable Communities and Climate Protection Act of 2008

[12] Up to 40 percent of electric vehicle charging load is assumed to be flexible within a 24-hour period to provide load-resource balancing services. Electric vehicles are not assumed to provide energy back to the electric grid, in a "vehicle-to-grid" configuration.

- Imports of power over existing transmission lines are limited to a historical average and are assumed to maintain the same emissions intensity throughout the study period. New, dedicated transmission lines for out-of-state renewable resources are also tracked. Exports of electricity from California of up to 1500 MW are allowed.

2.3 Reference case

In addition to the low-carbon scenarios evaluated here, a Reference case is developed as a comparison point. The Reference case assumes a continuation of current policies and trends through the 2050 timeframe with no incremental effort beyond 2014 policies to reduce GHG emissions. This scenario is not constrained to achieve specific GHG reduction goals. As a result, this scenario misses the state's GHG reduction targets in 2050 by a wide margin, with 2050 emissions 9% above 1990 levels. In the Reference case current natural gas end uses, such as space heating and hot water heating, continue to be supplied with natural gas through 2050. With no future efforts, California achieves a 33% RPS by 2020 and maintains this share of renewable energy going forward. The transportation sector continues to be dominated by the use of fossil-fueled vehicles in the Reference case.

3 Analysis Approach

3.1 PATHWAYS model overview

This analysis employs a physical infrastructure model of California's energy economy through 2050. The model, known as PATHWAYS (v2.1), was developed by E3 to assess the GHG impacts of California's energy demand and supply choices over time. The model tracks energy service demand (i.e. VMT) to develop a projection of energy demand and the physical infrastructure stock utilized to provide that service (i.e. types and efficiency of different vehicles). End uses in the building sector, vehicles in the transportation sector, and power plants in the electricity sector are tracked by age and vintage, such that new technologies are adopted as older technologies and are replaced in a stock roll-over representation of market adoption rates.

Technology lifetimes, efficiency assumptions and cost data are generally drawn from the U.S. DOE National Energy Modeling System (NEMS), used to support development of the Annual Energy Outlook 2013. Assumptions about new technology adoption are highly uncertain, and are defined by E3 for each scenario. New technology adoption rate assumptions are selected to ensure that the low-carbon scenarios meet the state's 2050 GHG reduction goal.

The model can contextualize the impacts of different individual energy technology choices on energy supply systems (electricity grid, gas pipeline) and

energy demand sectors (residential, commercial, industrial) as well as more broadly examine disparate strategies designed to achieve deep de-carbonization targets. Below, Figure 1 details the basic modeling framework utilized in PATHWAYS to project results for energy demand, statewide GHG emissions, and costs for each scenario.

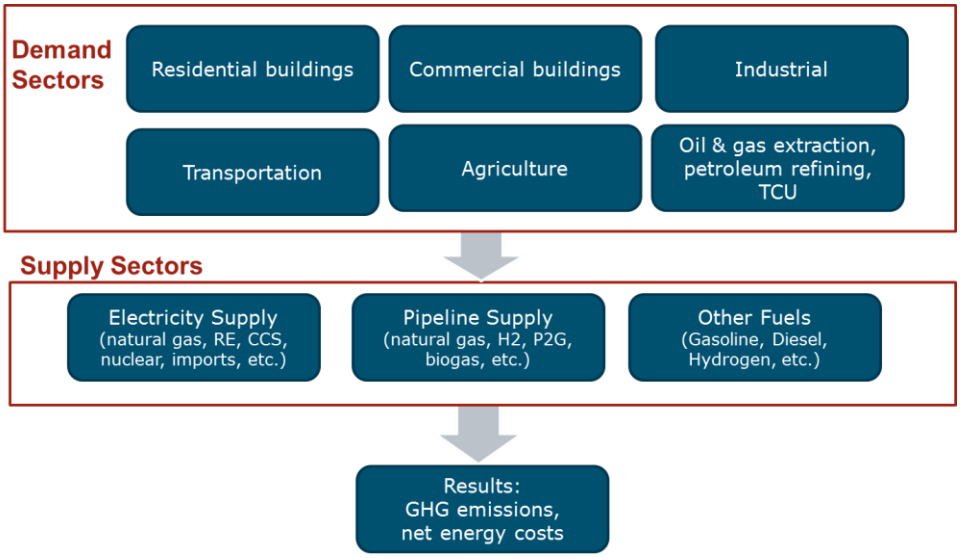

Figure 1. Basic PATHWAYS modeling framework

- **Energy Demand:** projection of energy demand for ten final energy types. Projected either through stock roll-over or regression approach.
- **Energy Supply:** informed by energy demand projections. Final energy supply can be provided by either conventional primary energy types (oil; natural gas; coal) or by decarbonized sources and processes (renewable electricity generation; biomass conversion processes; CCS). The energy supply module includes projections of costs and GHG emissions of all energy types.

- **Summary Outputs:** calculation of total GHG emissions and costs (end-use stocks as well as energy costs). These summary outputs are used to compare economic and environmental impacts of scenarios.

PATHWAYS V2.1 projects energy demand in eight sectors, and eighty sub-sectors, as shown below in Table 5.

Table 5. PATHWAYS Energy Demand Sectors and Subsectors

Sector	Subsector
Residential	Water Heating, Space Heating, Central AC, Room AC, Lighting, Clothes Washing, Dish Washing, Freezers, Refrigeration, Misc: Electricity Only, Clothes Drying, Cooking, Pool Heating, Misc: Gas Only
Commercial	Water Heating, Space Heating, Space Cooling, Lighting, Cooking, Refrigeration, Office Equipment, Ventilation
Transportation	Light Duty Vehicles (LDVs), Medium Duty Trucking, Heavy Duty Trucking, Buses, Passenger Rail, Freight Rail, Commercial Passenger Aviation, Commercial Freight Aviation, General Aviation, Ocean Going Vessels, Harborcraft
Industrial	Mining, Construction, Food & Beverage, Food Processing, Textile Mills, Textile Product Mills, Apparel & Leather, Logging & Wood, Paper, Pulp & Paperboard Mills, Printing, Petroleum and Coal, Chemical Manufacturing, Plastics and Rubber, Nonmetallic Mineral, Glass, Cement, Primary Metal, Fabricated Metal, Machinery, Computer and Electronic, Semiconductor, Electrical Equipment & Appliance, Transportation Equipment, Furniture, Miscellaneous, Publishing
Agricultural	Sector-Level Only
Utilities (TCU)	Domestic Water Pumping, Streetlight, Electric and Gas Services Steam Supply, Local Transportation, National Security and International Affairs, Pipeline, Post Office, Radio and Television, Sanitary Service, Telephone, Water Transportation, Trucking and Warehousing, Transportation Service, Air Transportation
Petroleum Refining	Sector-Level Only
Oil & Gas Extraction	Sector-Level Only

For those sectors that can be represented at the stock level – residential, commercial, and transportation – we compute stock roll-over by individual subsector (i.e. air conditioners, LDVs, etc.). For all other sectors, a forecast of energy demand out to 2050 is developed based on historical trends using regression analysis. These two approaches are utilized to project eleven distinct final energy types (Table 6).

Table 6. PATHWAYS Final Energy Types and Sources of Energy

Final Energy Type	
Electricity • many types of renewables, CCS, nuclear, fossil, large hydro.	Gasoline • ethanol & fossil gasoline
Pipeline Gas • natural gas, hydrogen, biogas, SNG	Liquefied petroleum gas (LPG)
Compressed Pipeline Gas • natural gas, hydrogen, biogas, SNG	Refinery and Process Gas
Liquefied Pipeline Gas • natural gas, hydrogen, biogas, SNG	Petroleum coke
Diesel • biodiesel & fossil diesel	Waste Heat
Kerosene-Jet Fuel	

These final energy types can be supplied by a variety of different resources. For example, pipeline gas can be supplied with combinations of natural gas, biogas, hydrogen, and SNG (produced through P2G processes). Electricity can be supplied by hydroelectric, nuclear, coal, natural gas combined cycles and combustion turbines, and a variety of renewable resources including utility-scale & distributed solar PV, wind, geothermal, biomass, etc. These supply composition choices affect the cost and emissions profile of each final energy type. Further methodology description can be found in the Technical Appendix.

3.2 Modeled energy delivery pathways

A decarbonized technology pathway can be thought of as consisting of three stages: (1) the provision of the primary energy itself, (2) the conversion of primary energy into the energy carrier, and (3) the delivery of an energy carrier

for final end use. In practice, there can be many variations on this theme, including multiple conversion process steps and the use of CCS. The primary decarbonized energy sources are biomass, renewable and nuclear generated electricity, and natural gas with CCS. The main options for energy carriers in a decarbonized system are electricity, liquid biofuels such as ethanol and biodiesel, and decarbonized gases including biogas, SNG, and hydrogen and decarbonized electricity.

Figure 2 illustrates the main decarbonized technology pathways for delivering energy to end uses represented in the model. In the remainder of this section, we sketch briefly the main low-carbon pathways considered in this study and how they are modeled.

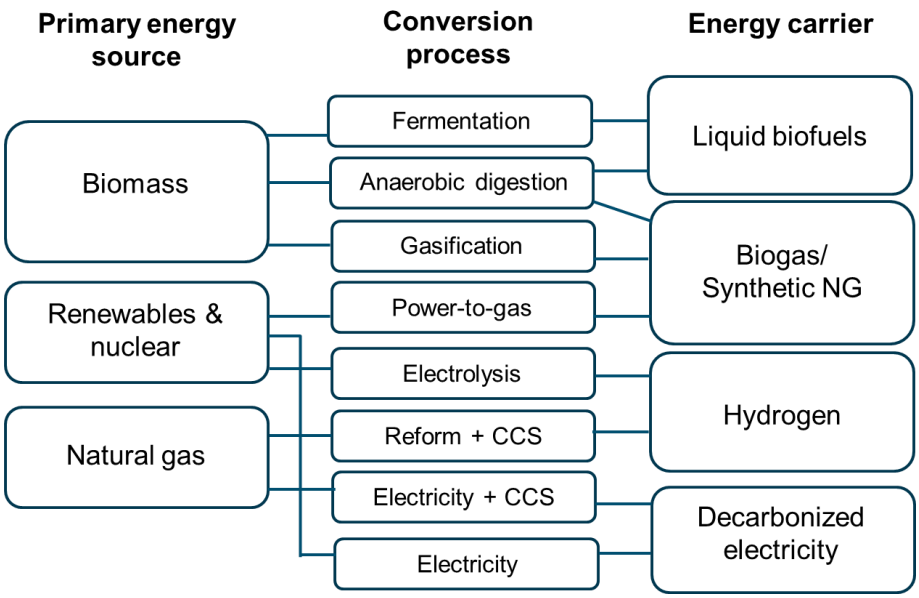

Figure 2. Major low-carbon pathways for delivered energy, from primary energy to conversion process to energy carriers

The technical opportunity for the gas distribution industry lies in providing an alternative to widespread electrification of end uses as an approach to deep decarbonization. The decarbonized gas technologies included in the Mixed scenario have been well-understood and some have been used in commercial applications for decades. For example, synthesized town gas, not natural gas, was the prevalent energy carrier for the first gas distribution companies over a century ago.

However, improvements in cost and efficiency will be required for decarbonized pipeline gas supplies to outcompete other forms of low-carbon delivered energy, such as electricity and liquid biofuels, and other issues require careful consideration and research, such as long-term biomass resource potential and carbon benefits. It is difficult at present to predict which pathways are the most

likely to take root and become the dominant forms of energy delivery in a deeply decarbonized world.

3.2.1 BIOMASS RESOURCE ASSUMPTIONS

The principal data source for biofuel feedstocks in our model is the DOE's *Billion Ton Study Update: Biomass Supply for a Bioenergy and Bioproducts Industry* led by Oak Ridge National Laboratory, the most comprehensive available study of long-term biomass potential in the U.S.[13] This study, sometimes referred to as the BT2, updates the cost and potential estimates in the landmark 2005 *Billion Ton Study*, assessing dozens of potential biomass feedstocks in the U.S. out to the year 2030 at the county level (Figure 3).[14]

The estimated future supply of California produced biomass stocks is relatively small compared to the resource potential in the Eastern portion of the U.S., as shown in Figure 3. In this study, we have assumed that California can import up to its population-weighted proportional share of the U.S.-wide biomass feedstock resource potential, or 142 million tons per year by 2030. In the case of the Mixed scenario, where nearly all biomass is assumed to be gasified into biogas, this could be accomplished through production of biogas near the source of of the feedstock, which would then be distributed through the national gas pipeline network. California would not necessarily need to physically import the biomass feedstock into the state in order to utilize, or purchase credits for, the biogas fuel. Under the emissions accounting

[13] U.S. Department of Energy, "U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry," August 2011.
[14] U.S. Department of Energy, "Biomass as a Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply," April 2005.

framework employed in this study, California would take credit for assumed emissions reductions associated with these biofuels, regardless of where the fuel is actually produced. This assumption may not reflect California's long-term emissions accounting strategy. Furthermore, there remains significant uncertainty around the long-term GHG emissions impacts of land-use change associated with biofuels production.

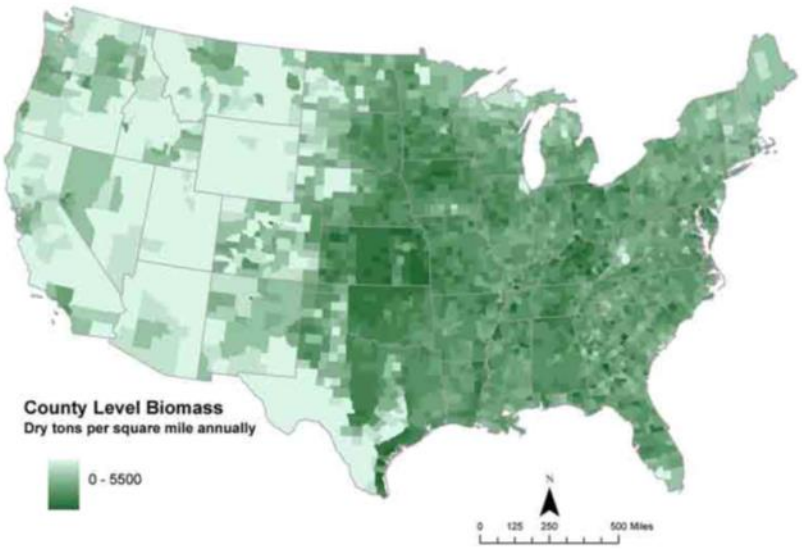

Figure 3. DOE Billions Tons Study Update Biomass Resource Potential (Source: DOE, 2011)

3.2.2 PIPELINE GAS AND LIQUID FUELS FROM BIOMASS

Biomass feedstocks ranging from purpose-grown fuel crops to a variety of agricultural, forestry, and municipal waste products can be converted into decarbonized gas. The main conversion method that is assumed in the Mixed

scenario is gasification, including thermal and biochemical variants, which break down complex biomass molecules through a series of steps into a stream of SNG, consisting primarily of hydrogen and carbon monoxide. In the modeled pathway, the SNG is cleaned, shifted, and methanated to produce a pipeline-ready biogas with a high methane content. The other main method for biomass conversion represented in the model is anaerobic digestion. In anaerobic digestion bacterial digestion of biomass in a low-oxygen environment produces a methane-rich biogas which, after the removal of impurities, can be injected into the pipeline. In addition to gas fuels, biomass can be turned into liquid fuels directly through fermentation and distillation, as in the case of ethanol, or through the transesterification of fats such as waste cooking oil to produce biodiesel. Biogas from gasification can also be turned into liquid fuels, for example through the Fischer-Tropsch process.

3.2.3 PIPELINE GAS AND LIQUID FUELS FROM ELECTRICITY AND NATURAL GAS

Renewable energy, fossil generation with CCS and nuclear energy produce low-carbon electricity that can either directly power end uses or be used to produce pipeline gas or liquefied gases for transportation fuels. There are two P2G pathways in the model. One pathway uses electricity for electrolysis to split water and produce hydrogen, which can be injected into the pipeline for distribution up to a certain mixing ratio, or can be compressed or liquefied for use in hydrogen fuel cell vehicles. The other pathway modeled also begins with electrolysis, followed by methanation to produce SNG, which is injected into the pipeline. The SNG pathway requires a source of CO_2, which can come from carbon capture from sea water, air capture or biomass, or under some

circumstances from CCS (e.g. situations in which the use of CCS implies no additional net carbon emissions, such as biomass power generation with CCS). The CO_2 and hydrogen are combined into methane through the Sabatier or related process.

Continued use of natural gas under a stringent carbon constraint requires that carbon be captured and stored. The low-carbon scenarios evaluated in this study assume a limited amount of natural gas with CCS is used for electricity generation in both of the low-carbon scenarios. There are two main types of CCS: (1) post-combustion capture of CO_2, and (2) pre-combustion capture of CO_2. In one pathway, CCS occurs after the natural gas has been combusted for electricity generation in a combined cycle gas turbine (CCGT), and the delivered energy remains in the form of decarbonized electricity. In the other pathway, natural gas is subjected to a reformation process to produce hydrogen and CO_2 streams. The CO_2 is captured and sequestered, and the hydrogen can be injected into the pipeline, liquefied for use in fuel cells, or combusted in a combustion turbine.

3.3 Modeling Technology and Energy Costs

3.3.1 GENERAL DESCRIPTION OF APPROACH

For long-term energy pathways scenarios, future costs are particularly uncertain. As a result, the PATHWAYS model does not use technology or energy cost estimates to drive energy demand or resource selection choices. Rather, total capital costs and variable costs of technologies are treated as input variables, which are summed up for each scenario as an indicator of the

scenario's total cost. The model does not include a least-cost optimization, nor does the model include price elasticity effects or feedback to macroeconomic outcomes. As such, the model should be understood as primarily a technology and infrastructure-driven model of energy use in California.

The model includes more resolution on cost for two key types of energy delivery: pipeline gas and electricity. These approaches are described in more detail below.

3.3.2 PIPELINE GAS DELIVERY COSTS

We model the California system of delivering pipeline gas as well as compressed pipeline gas, and liquefied pipeline gas for transportation uses. We model these together in order to assess the capital cost implications of changing pipeline throughput volumes. Delivery costs of pipeline gas are a function of capital investments at the transmission and distribution-levels and delivery rates, which can be broadly separated into core (usually residential and small commercial) and non-core (large commercial, industrial, and electricity generation) categories.

Core service traditionally provides reliable bundled services of transportation and natural gas compared to non-core customers with sufficient volumes to justify transportation-only service. The difference in delivery charges can be significant. In September 2013 the average U.S. delivered price of gas to an industrial customer was $4.39/thousand cubic feet compared to

$15.65/thousand cubic feet for residential customers.[15] This difference is driven primarily by the difference in delivery costs and delivery charges for different customer classes at different pipeline pressures.

To model the potential implications of large changes in gas throughput on delivery costs, we use a simple revenue requirement model for each California investor owned utility (IOU). This model includes total revenue requirements by core and non-core customer designations, an estimate of the real escalation of costs of delivery services (to account for increasing prices of materials, labor, engineering, etc.), an estimate of the remaining capital asset life of utility assets, and the percent of the delivery rate related to capital investments.[16]

3.3.3 ELECTRICITY SECTOR AVERAGE RATES AND REVENUE REQUIREMENT

Electricity sector costs are built-up from estimates of the annual fixed costs associated with generation, transmission, and distribution infrastructure as well as the annual variable costs that are calculated in the System Operations Module. These costs are used to calculate an annual revenue requirement of total annualized electric utility investment in each year. These costs are then divided by total retail sales in order to estimate a statewide average electricity retail rates. These average electricity rates are applied to the annual electricity demand by subsector to allocate electricity costs between subsectors.

[15] United States Energy Information Administration, 2013.

[16] We assume that 50% of the revenue requirement of a gas utility is related to throughput growth and that capital assets have an average 30-year remaining financial life. This means that the revenue requirement at most could decline approximately 1.7% per year without resulting in escalating delivery charges for remaining customers.

Transmission and distribution costs are also estimated in the model. Transmission costs are broken into three components: renewable procurement-driven transmission costs, sustaining transmission costs, and reliability upgrade costs. Distribution costs are broken into distributed renewable-driven costs and non-renewable costs. The revenue requirement also includes other electric utility costs which are escalated over time using simple growth assumptions, ("other" costs include nuclear decommissioning costs, energy efficiency program costs and customer incentives, and overhead and administration costs). These costs are approximated by calibrating to historical data. The methodology for calculating fixed generation costs in each year is described below, more details are provided in the Technical Appendix.

3.3.3.1 Generation

Fixed costs for each generator are calculated in each year depending on the vintage of the generator and assumed capital cost and fixed operations and maintenance (O&M) cost inputs by vintage for the generator technology. Throughout the financial lifetime of each generator, the annual fixed costs are equal to the capital cost (which can vary by vintage year) times a levelization factor plus the vintage fixed O&M costs, plus taxes and insurance. This methodology is also used to cost energy storage infrastructure and combined heat and power (CHP) infrastructure. Input cost assumptions for generation technologies are summarized below.[17]

[17] Cost assumptions were informed by E3, "Cost and Performance Review of Generation Technologies: Recommendations for WECC 10- and 20-Year Study Process," Prepared for the Western Electric Coordinating Council, Oct. 9, 2012.
<http://www.wecc.biz/committees/BOD/TEPPC/External/E3_WECC_GenerationCostReport_Final.pdf>

In general, cost assumptions for generation technologies, as for all technology assumptions in the model, are designed to be conservative, and avoid making uncertain predictions about how the relative costs of different technologies may change over the analysis period. Generation capital cost changes are driven by assumptions about technology learning. As a result, the cost of newer, less commercialized technologies are assumed to fall in real terms, while the costs of technologies that are widely commercialized are assumed to remain constant or to increase.

Table 7. Generation capital cost assumptions

Technology	Capital Cost from present - 2026 (2012$/kW)	Assumed change in real capital cost by 2050 % change	Capital Cost from 2027 - 2050 (2012$/kW)
Nuclear	9,406	0%	9,406
CHP	1,809	0%	1,809
Coal	4,209	0%	4,209
Combined Cycle Gas (CCGT)	1,243	16%	1,441
CCGT with CCS	3,860	-3%	3,750
Steam Turbine	1,245	0%	1,245
Combustion Turbine	996	44%	1,431
Conventional Hydro	3,709	0%	3,709
Geothermal	6,726	0%	6,726
Biomass	5,219	0%	5,219
Biogas	3,189	0%	3,189
Small Hydro	4,448	0%	4,448
Wind	2,236	-9%	2,045
Centralized PV	3,210	-31%	2,230
Distributed PV	5,912	-30%	4,110
CSP	5,811	-25%	4,358
CSP with Storage	7,100	-30%	5,000

3.3.4 COST ASSUMPTIONS FOR ENERGY STORAGE, DECARBONIZED GAS AND BIOMASS DERIVED FUELS

Cost and financing assumptions for energy storage technologies are summarized below. For this analysis, these costs are assumed to remain fixed in real terms over the analysis period.

Table 8. Capital cost inputs for energy storage technologies

Technology	Capital Cost (2012$/kW)	Financing Lifetime (yrs)	Useful Life (yrs)
Pumped Hydro	2,230	30	30
Batteries	4,300	15	15
Flow Batteries	4,300	15	15

The modeling assumptions for hydrogen production and SNG production are described in detail in Technical Appendix Sections 2.2.3 and 2.2.4, respectively. Below, Table 9 shows final product cost ranges, levelized capital costs, and conversion efficiencies for hydrogen and SNG pathways in the model.

Table 9. Renewable electricity-based pipeline gas final product cost, levelized capital cost, and conversion efficiencies in model

Product	Process	Levelized Capital Cost ($/kg-year for hydrogen; $/mmBTU-year for SNG)	Conversion Efficiency	Product Cost Range ($/GJ)
SNG	Electrolysis plus methanation	$7.60-$18.50	52%-63%	$30-$138
Hydrogen	Electrolysis	$0.65-$1.53	65%-77%	$24-$112

The modeling assumptions for biofuels are described in detail in Technical Appendix Section 3. Below, Table 10 shows final product cost ranges, feedstock

and conversion cost ranges, and conversion efficiencies for all biomass conversion pathways in the model.

Table 10. Biomass final product cost, feedstock and conversion costs, and conversion efficiencies in model

Product	Process	Feedstock Cost Range ($/ton)	Conversion Cost ($/ton)	Conversion Efficiency (GJ/ton)	Product Cost Range ($/GJ)
Biogas Electricity	Anaerobic digestion	$40-$80	$96	6.5	$21-$27
Pipeline Biogas	Gasification	$40-$80	$155	9.5	$20-$25
Ethanol	Fermentation	$40-$80	$111	6.7	$23-$29
Diesel	Trans-Esterification	$1000	$160	36.4	$32

4 Results

4.1 Summary of results

The two low-carbon scenarios evaluated in this study present unique technology pathways to achieve California's 2050 GHG reduction goals. Each scenario represents a different technically feasible, plausible strategy to decarbonize the state's energy system, resulting in different levels of energy consumption and different mixes of fuels providing energy services. This section presents energy demand by scenario and fuel type in 2050 for the Reference case and the two low-carbon scenarios. Energy system cost projections for each scenario are provided. The cost trajectories are highly uncertain and cannot be interpreted as definitive at this point in time. Each of the low-carbon scenarios shows a similar statewide GHG reduction trajectory.

4.2 Final energy demand

Figure 4 shows final energy demand by fuel type for each scenario in the year 2050. Of note, both the low-carbon scenarios have significantly lower total energy demand than the Reference case due to the impact of energy efficiency and conservation in the low-carbon scenarios.

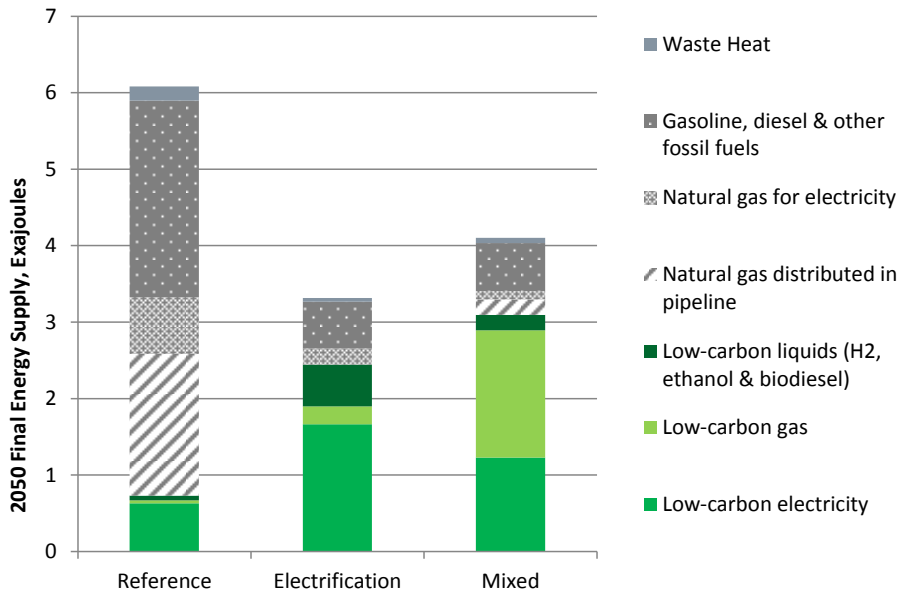

Figure 4. 2050 California economy-wide final energy demand by scenario and fuel type

Final energy consumption in 2050 is lower in the Electrification scenario than the Mixed Scenario due to the higher conversion efficiencies of electric batteries and motors compared to combustion engines and fuel cell vehicles.[18]

Low-carbon electricity is also used as an upstream energy source to produce decarbonized gas and liquid hydrogen, so it plays a larger role in meeting the state's GHG reduction goals in the Mixed scenario than indicated by final energy demand alone. To gain a more complete picture of energy supply by fuel type, the next sections discuss the composition of the pipeline gas by scenario, the sources of electricity in each scenario, and the composition of the

[18] Note that upstream efficiency losses associated with energy production: i.e. P2G methanation, hydrogen production and CCS, do not appear in the final energy supply numbers.

transportation vehicle fleet energy consumption. These results are not meant to be an exhaustive description of each assumption in each sector of the economy, but rather are selected to provide some insights into the biggest differences in energy use between the two low-carbon scenarios and the Reference case.

4.2.1 PIPELINE GAS FINAL ENERGY DEMAND

There are important differences between the two low-carbon scenarios. Pipeline infrastructure continues to be used extensively in the Mixed scenario, with decarbonized gas substituting for the natural gas that would otherwise be used in the pipeline. In the Electrification scenario, pipeline infrastructure is nearly unutilized by 2050. This corresponds to much more widespread electrification of industrial processes, vehicles, space heating, water heating, and cooking. The limited demand for pipeline gas in this scenario is assumed to be met with biogas (Figure 5).

The Mixed scenario includes a higher quantity of biogas, based on the assumption that all of the available sustainably sourced biomass are used to produce biogas. The remaining demand for decarbonized pipeline gas in this scenario is met with a mix of two technologies: 1) SNG produced using P2G methanation with air capture of CO_2[19] and 2) hydrogen produced using electrolysis with renewable electricity.

[19] Methanation using CO_2 capture from seawater is an alternative, potentially more efficient method to creating produced gases that have a net-carbon neutral climate impact.

In the Mixed Scenario, hydrogen use in the gas pipeline is limited by estimates of technical constraints. By 2050, the share of hydrogen gas in the pipeline is assumed to be limited to 20 percent of pipeline volume for reasons of safety as well as compatibility with end-use equipment.[20]

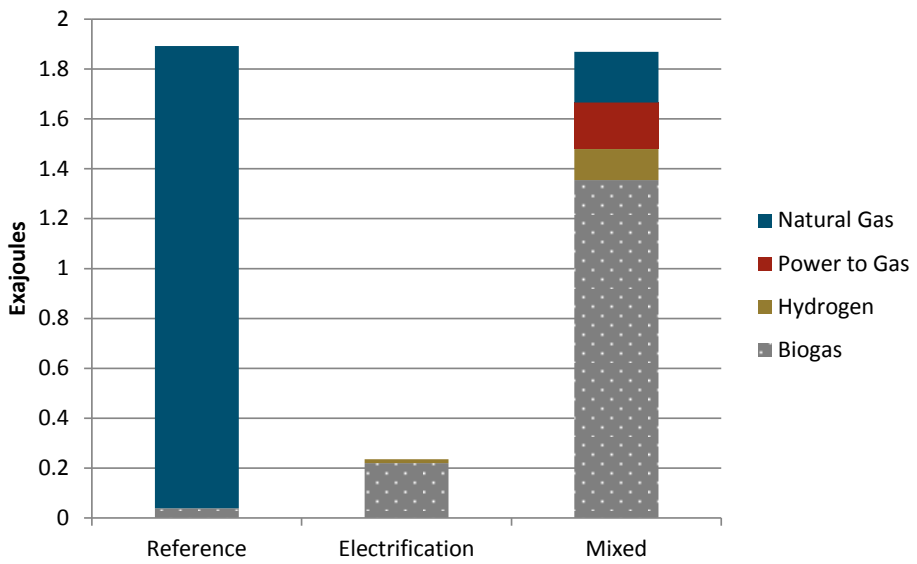

Figure 5. California pipeline gas final energy demand by fuel type by scenario, 2050

4.2.2 ELECTRICITY DEMAND

The 2050 electricity demand in each scenario tells a different part of the energy supply story. In the low-carbon scenarios, 2050 electricity demand is significantly higher in the Reference case due to the impact of electrification, particularly electric LDVs, and the electricity needs associated with P2G and

[20] Note that this limit is only a rough estimate of technical feasibility limits and the actual limit may be lower; additional research is needed to determine an appropriate limit for hydrogen gas in the pipeline.

hydrogen production. The expanding role of the electricity sector in achieving a low-carbon future is evident in each of these scenarios. Figure 6 shows the generation mix by fuel type utilized in each of the scenarios in 2050.

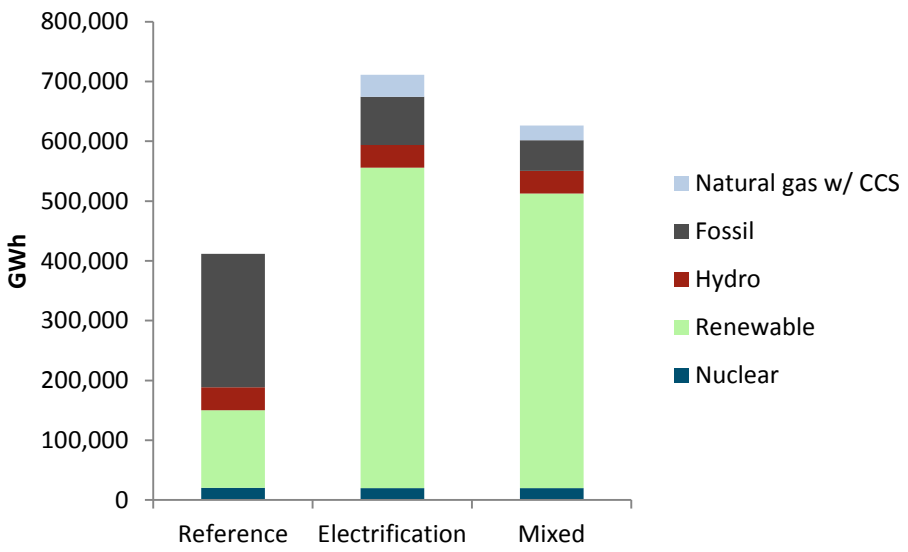

Figure 6. 2050 electricity sector energy demand by scenario and fuel type, GWh

4.2.2.1 Load resource balancing

Both of the low-carbon scenarios reflect a significant increase in intermittent wind and solar PV renewable generation by 2050 (Table 11). This results in new challenges that the grid faces to achieve load-resource balance.

Table 11. Share of 2050 California electricity generation provided by wind and solar PV

	Reference	Low-Carbon Scenarios
Intermittent renewables share of total electricity generation in 2050 (wind and solar PV)	30%	60 -70%

In the model, electricity supply and demand must be equal in each hour of each year. This load-resource balance is achieved using different strategies in each scenario, which contributes to the differences in technology costs and risks. As Table 12 indicates, the Electrification scenario relies heavily on the use of electric energy storage, in the form of flow batteries and pumped hydroelectric storage resources, while the Mixed scenario relies more heavily on P2G production as a load-following resource. Natural gas with CCS is assumed to be a load-following resource in both scenarios. Furthermore, both scenarios assume electric vehicles can provide limited load-resource balancing services through flexible charging of EVs over a 24-hour period, and that hydrogen production for fuel cell vehicles can be operated as a fully-dispatchable, flexible load.

Table 12. 2050 Load Resource Balancing Assumptions by Scenario

Load-resource balancing tool	Electrification	Mixed
Electric energy storage capacity	**20 GW** 75% 6-hour flow batteries, 25% 12-hour pumped hydro energy storage	**5 GW** 100% 12-hour pumped hydro energy storage
P2G capacity	**None**	**40 GW** P2G production cycles on during the daylight hours to utilize solar generation and cycles off at night, significant variation in production by season for load balancing
Electric vehicles & other flexible loads	**40%** of electric vehicle loads are considered "flexible" in both scenarios and can be shifted within a 24-hour period. Vehicle batteries are not assumed to provide power back onto the grid. Certain thermal electric commercial and residential end uses are also assumed to provide limited amounts of flexible loads to the grid. In both scenarios, hydrogen production is assumed to be a fully dispatchable, flexible load.	

4.2.3 ON-ROAD VEHICLE ENERGY CONSUMPTION BY FUEL TYPE

The decarbonization strategy pursed in the transportation sector differs by scenario, as illustrated in Figure 7 (LDV vehicle energy use) and Figure 8 (HDV energy use). Both of the low-carbon scenarios assume a significant reduction in VMT and vehicle efficiency improvements in the LDV fleet compared to the Reference scenario. This leads to a significant reduction in total energy demand by LDVs by 2050 in these scenarios. Among the HDV vehicle fleet, VMT reductions and vehicle efficiency improvements are assumed to be more difficult to achieve than in the LDV fleet. Furthermore, the Mixed scenario relies on a high proportion of fuel cell vehicles using hydrogen or liquefied pipeline gas, which have less efficient energy conversion processes than conventional

diesel engines, leading to higher energy demand. As a result, the HDV sector does not show a significant reduction in energy consumption by 2050 relative to the Reference case, although total carbon emissions are significantly lower.

Electricity is the largest source of fuel for the transportation sector among LDVs in both the Electrification and the Mixed scenarios. The HDV fleet is harder to electrify, so the Electrification scenario assumes HDV energy demand is largely met with hydrogen fuel and fuel cells. In the Mixed scenario, the majority of HDV energy demand is assumed to be met with liquefied pipeline gas (an equivalent to decarbonized LPG), with some compressed pipeline gas (the equivalent to decarbonized compressed natural gas), electrification and hydrogen fuel cell vehicles.

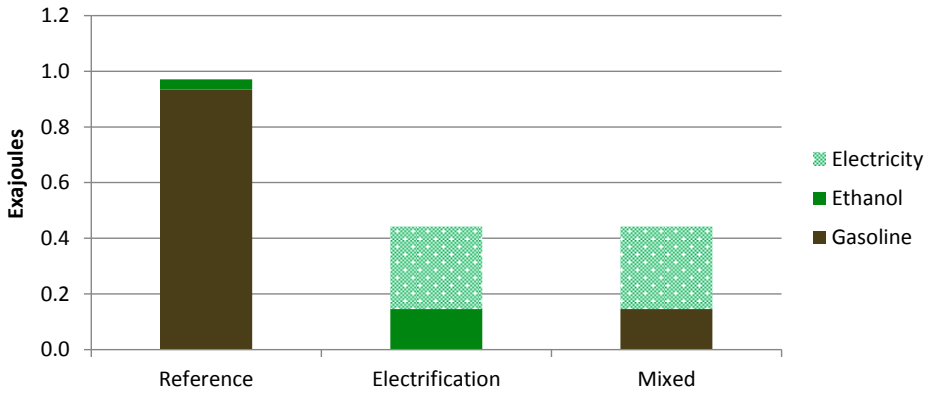

Figure 7. 2050 LDV energy share by fuel type by scenario

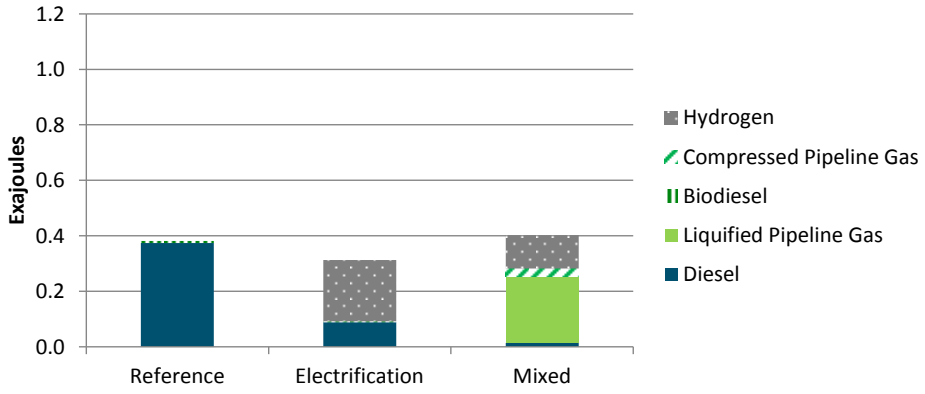

Figure 8. 2050 HDV energy share by fuel type by scenario

4.3 Greenhouse gas emissions

The Reference case shows GHG emissions that are relatively flat through 2030 before slightly increasing in the outer years through 2050. This increase occurs because population growth and increasing energy demand overwhelm the

emissions savings generated by current policies. The result is a 9 percent increase in Reference case emissions relative to 1990 levels by 2050.

The GHG emissions trajectories for the two low-carbon scenarios evaluated in this report are essentially the same. Both scenarios achieve the target of 80% reduction in GHG emissions by 2050 relative to 1990 levels, and both scenarios reflect a similar, approximately straight-line trajectory of emissions reductions between current emissions levels and 2050.

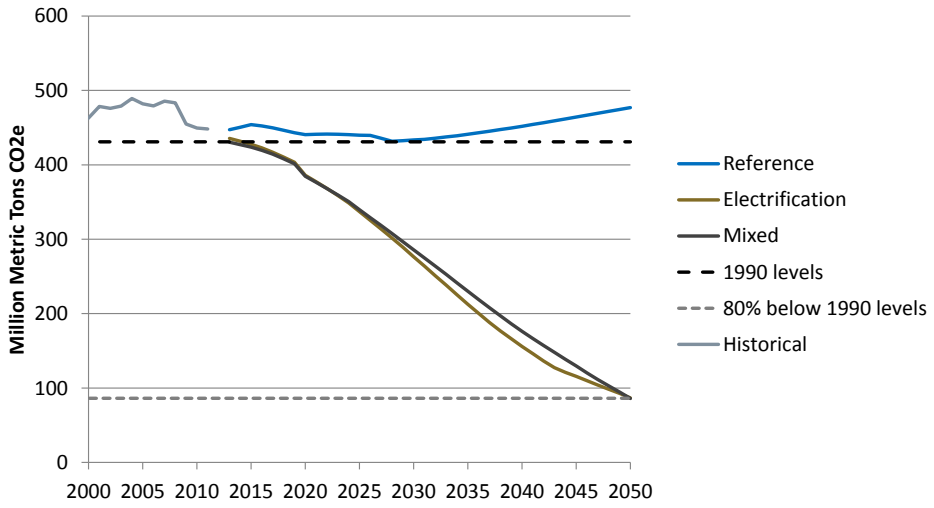

Figure 9. California GHG emissions by scenario, including historical emissions and policy targets (2000 – 2050)

4.4 Energy system cost comparison

The total energy system cost of each of the scenarios analyzed is one metric by which to evaluate different GHG scenarios. Total energy system cost is defined here as the annual statewide cost of fossil fuels and biofuels, plus the levelized cost of electricity and natural gas infrastructure, plus the cost of most energy-consuming customer products (e.g., clean vehicles in the transportation sector and energy efficiency and fuel-switching equipment in the buildings sector). The total energy system cost is calculated on a levelized basis in each analysis year, from 2015 – 2050. Further detail on cost assumptions and how costs are treated in the model is provided in the Technical Appendix.

While the Reference case is the lowest total cost scenario from an energy system perspective, it also does not succeed in meeting the state's GHG reduction goals. Of the two low-carbon scenarios, the Mixed scenario has approximately 10 percent lower cost than the Electrification scenario in 2050 using our base case assumptions. This difference is well within the range of uncertainty of projecting technology costs to 2050, and either scenario could be lower cost.

It is, however, useful to examine the differences in base case scenario costs that result from the modeling assumptions made in this analysis to identify the key drivers. Using the base case assumptions, the Mixed case results in lower total energy system costs in 2050 than the Electrification scenario for two main reasons (Figure 10). First, using the assumptions in this study, adding decarbonized gas in the Mixed case has a lower cost than adding the low-carbon electricity and end-use equipment necessary to electrify certain end-uses in the Electrification case. Therefore, the reduction of electricity-related capital costs between the Electrification and the Mixed scenario shown in Figure 10 is greater than the increase in pipeline gas capital costs and biogas fuel costs between these scenarios. Second, seasonal electricity storage needs are lower in the Mixed scenario than in the Electrification scenario. As a result, the electricity storage that is built in the Mixed scenario is utilized at a higher capacity factor than the electricity storage in the Electrification scenario. This means that the unit cost of electricity storage ($/MWh) is higher in the Electrification scenario than in the Mixed scenario.

In order to evaluate the range of uncertainty, we define high and low cost Scenarios for the key input assumptions. These do not reflect the range of all of

the uncertainties in energy demands, population, or other key drivers embedded in the analysis, but serve to provide a boundary of possible high and low total costs given the same assumptions across the three cases. We then evaluate the total costs of each of the cases; Reference, Electrification Case, and Mixed Case with each cost scenario. Table 13, below, shows the range of the cost uncertainties in the analysis. Scenario 1 is purposefully designed to advantage the Mixed Case, and Scenario 2 is designed to advantage the Electrification Case.

Table 13 Cost sensitivity parameters

Cost Assumption	Scenario 1	Scenario 2
Renewable generation capital	+25%	-25%
Electrolysis capital equipment	-50%	+50%
SNG capital equipment	-50%	+50%
Fuel cell HDVs	+50%	-50%
Building electrification cost[21]	+50%	-50%
Natural Gas Costs	-50%	+50%
Other Fossil Fuel Costs	+50%	-50%
Electricity storage costs	+50%	-50%
Biomass Availability[22]	+0%	-50%

The 2050 cost results shown below indicate that there are conditions under which either case is preferable from a cost standpoint. Given that, and given the

[21] Costs of electrified water and space heating equipment
[22] Biomass is replaced with addition P2G to maintain emissions levels +- 5MMT from base case.

additional uncertainties not analyzed in terms of other technology costs, energy demand drivers, etc., the preference for pursuing one mitigation case over the other should come down to other factors than narrow cost advantages displayed over these long term forecasts.

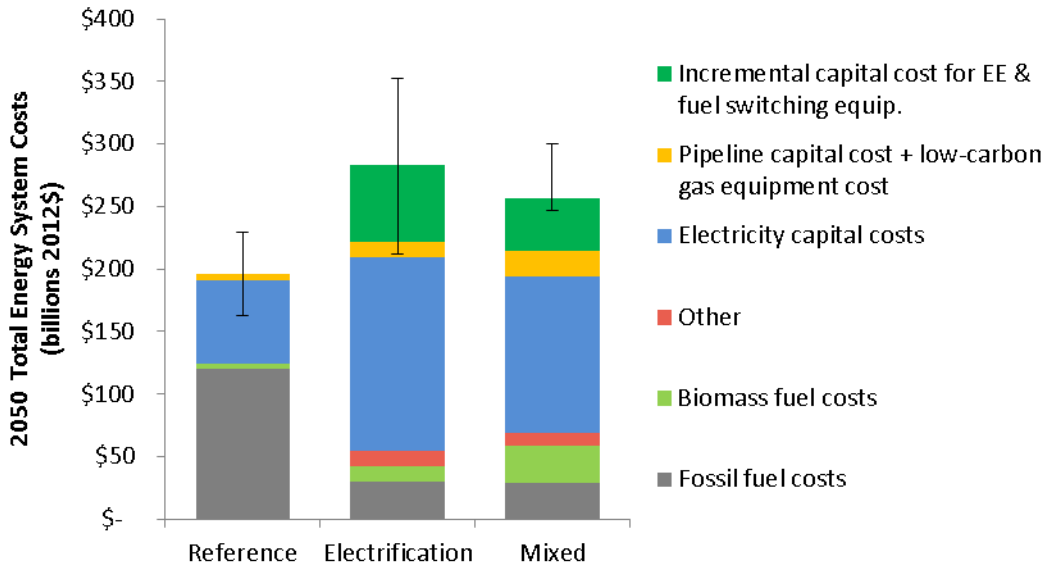

Figure 10. 2050 total energy system cost by scenario (levelized cost of fuel and levelized capital cost of energy infrastructure)

Figure 11, below, shows the base case total levelized energy system capital investment and fuel costs for each scenario along with the uncertainty range. Given the uncertainties associated with forecasting technology and commodity costs out to 2050, a difference in costs of approximately 10% ($27 billion) between the two scenarios is not definitive.

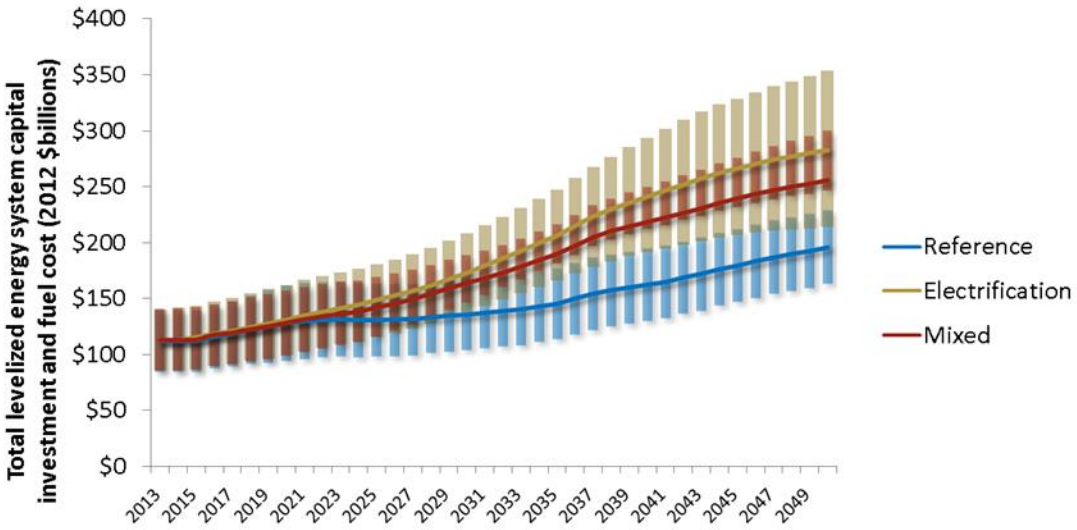

Figure 11. Total energy system cost by scenario, 2013 – 2050 (levelized cost of fuel and levelized capital cost of energy infrastructure, billions, 2012$)

Figure 12, below, shows total electricity sector costs on an annualized basis, or equivalently, the statewide electricity sector revenue requirement, in 2050. Electricity costs are higher in the Electrification scenario both because total electricity demand is higher, and because the unit cost of electricity is higher. The cost of energy storage is highest in the Electrification scenario because more storage is needed to balance intermittent renewables, and because batteries are the primary means of storage. In the Mixed scenario, less energy storage is needed because the production of decarbonized gases (hydrogen and SNG) is dispatched to balance the grid, and because gas is a more cost-effective form of seasonal energy storage, given the assumptions here, than batteries. Again, however, cost forecasts for 2050 are highly uncertain and should be interpreted with caution.

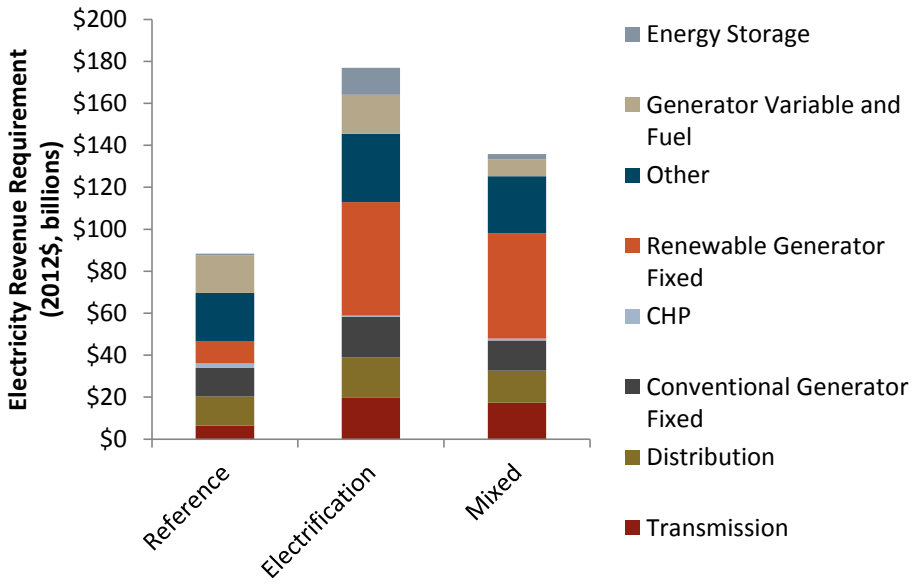

Figure 12. 2050 California total electricity sector revenue requirement by component and scenario (billions, 2012$)

5 Discussion & Conclusions

California is committed to deeply reducing CO_2 and other GHG emissions across all sectors over the next several decades, as well as to sharply reducing ground-level ozone and particulate matter to protect public health. Both of these policies imply a dramatic transition of California's economy away from fossil fuel combustion as we know it, and indeed this transition is already underway. In some places where coal is the dominant form of energy supply, natural gas is often seen as a key transition fuel to a lower carbon system. In California, however, natural gas is the main incumbent fossil fuel in electricity generation, the building sector, and many industries, and is therefore the target of transition to a lower carbon economy rather than its vehicle; the problem of methane leakage in the natural gas production and supply chain, though not modeled in this analysis, only increases the policy pressure to hasten this transition.

It is possible for SCG and other gas distribution companies to be a contributor rather than an impediment to California's transition to a low carbon economy. This path of decarbonizing pipeline gas will require a major technological transformation in the coming years. On the demand side, the transition requires reducing demand in many existing applications and improving combustion processes to increase efficiency. On the supply side, it requires

developing decarbonized alternatives to conventional natural gas for delivering energy to end uses.

This study examined the role of gas fuels in California's energy supply from 2013 to 2050, using a bottom-up model of the California economy and its energy systems. We examined the feasibility andcost associated with two distinct technology pathways for achieving the state's 2050 GHG targets: (1) Electrification, and (2) Mixed (electricity and decarbonized gas).

To date, much of the literature on low-carbon strategies and policy strategies for achieving deep reductions in GHG emissions in California by 2050 has focused on extensive electrification. This study's results support our prior conclusions that the electricity sector must play an expanded and important role in achieving a low-carbon future in California. In both of the low-carbon scenarios, the need for low-carbon electricity increases significantly beyond the Reference case level: to power electric vehicles, electrification in buildings and as a fuel to produce decarbonized gases. We also demonstrate that, under reasonable assumptions, there are feasible technology pathways where gas continues to play an important role in California's energy supply.

The costs of technologies in the 2050 timeframe are highly uncertain, making it impossible to reach a definitive conclusion as to which of the low-carbon pathways evaluated here would be the lowest cost. However, we show that the Mixed scenario, where decarbonized gas meets existing natural gas market share in residential, commercial, and industrial end uses, and is used to power the heavy-duty vehicle fleet, could potentially be higher or lower cost depending on the technology and market transformation. A key driver of this

result is the ability to use the existing gas pipeline distribution network to store and distribute decarbonized gas, and to use the production of decarbonized gas as a means to integrate intermittent renewable energy production. Excess renewable energy in the middle of the day is absorbed by P2G production of SNG and hydrogen production in the Mixed scenario. The Electrification scenario, which does not utilize the P2G technology to produce decarbonized gas, decreases gas pipeline use out to 2050 (shown for SCG, Figure 13) and requires more relatively high-cost, long-duration batteries for energy storage.[23]

[23] In Figure 13 the slight increase in natural gas used for electricity generation observed in 2020 is due to an existing coal generation contract being partially replaced with natural gas generation.

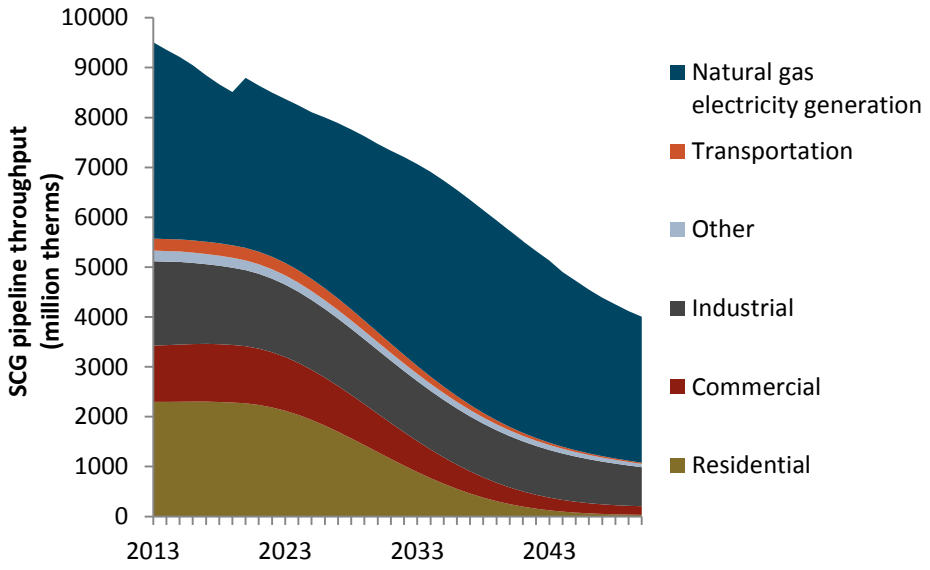

Figure 13. Electrification Scenario, SCG pipeline gas throughput (2013 – 2050)

Strategic use of decarbonized gas would additionally help to overcome four potential obstacles in California's transition to a decarbonized energy system.

First, a number of current uses of natural gas and oil are difficult to electrify. These include certain industrial processes such as process heat, HDVs and certain end uses in the residential and commercial sectors such as cooking, where customers have historically preferred gas fuels. Using decarbonized gas for these end uses could avoid the need for economically and politically costly electrification strategies.

Second, under a high renewable generation future, long-term, seasonal load balancing may be needed in addition to daily load balancing. However, meeting these seasonal balancing needs under the Electrification scenario requires

uncertain technical progress in energy storage. Using the production of decarbonized gas to provide daily and seasonal load balancing services may be a more realistic and cost-effective strategy than flexible loads and long-duration batteries for electricity storage.

Third, using decarbonized gas takes advantage of the state's existing gas pipeline distribution system, and reduces the need for other low-carbon energy infrastructure such as transmission lines or a dedicated hydrogen pipeline network.

Fourth, and finally, the Mixed scenario, by employing a range of energy technologies, including electricity and decarbonized gas technologies, diversifies the risk that any one particular technology may not achieve commercial successes.

All of the decarbonized gas energy carriers examined in this analysis rely on century-old conversion processes; none require fusion-like innovations in science. However, these conversion processes — anaerobic digestion, gasification, electrolysis, and methanation — require improvements in efficiency and reductions in cost to be more competitive. Furthermore, existing pipelines were not designed to transport hydrogen, and innovations in pipeline materials and operations would be needed to accommodate a changing gas blend.

Sustainably-sourced biomass feedstock availability is another large source of uncertainty in both of the low-carbon strategies evaluated here. In the Mixed scenario, biogas plays a particularly important role in achieving the GHG emission

target. In the Electrification scenario, biomass is used to produce low-carbon electricity. However, biomass feedstocks are constrained by competing uses with energy supply, including food, fodder and fiber. The amount of biomass resources available as a feedstock for fuels, or for biogas production specifically, will depend on innovations in biosciences, biomass resource management, and supply chains. None of the above three challenges — conversion technology efficiency and cost, pipeline transport limits, and biomass feedstock availability — is inherently insurmountable. For decarbonized gas to begin to play an expanded role in California's energy supply in the coming decades, however, a program of RD&D to overcome these challenges would need to begin very soon. This report identifies research priorities with near-term, medium-term and long-term payoff.

As a whole, California policy currently explicitly encourages the production of low-carbon electricity, through initiatives such as the RPS, and the production of decarbonized transportation fuels, through initiatives such as the LCFS. Biogas from landfill capture and dairy farms are encouraged, however, the state does not currently have a comprehensive policy around decarbonized gas production and distribution. This analysis has demonstrated that a technologically diverse, "mixed" strategy of electrification and decarbonized gas may be a promising route to explore on the pathway to a long-term, low-carbon future in California.

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Clean Energy

The Honorable Mary Nichols
Chairman, California Air Resources Board
Post Office Box 2815
Sacramento, CA 95812

November 6, 2015

RE: MOBILE SOURCE STRATEGY DISCUSSION DRAFT COMMENTS

Dear Chairman Nichols:

Clean Energy would like to submit the following comments concerning the Mobile Source Strategy Discussion Draft. Our comments strongly support the air quality, climate and petroleum reductions goals that the Mobile Source Strategy Discussion Draft sets out to achieve as we believe they are critical to attaining public health goals, improving conditions for disadvantaged communities, and transforming our current economy into a modern one. Our comments also encourage staff to take a more technology neutral approach well beyond 2030. By doing so, all advanced clean technologies can play a role in helping the state meet its federal air quality attainment requirements and the state's petroleum reduction and greenhouse gas targets.

As North America's largest provider of natural gas transportation fuel with over eighteen years of leading industry experience, we provide construction, operation and maintenance services for refueling stations. We have a deep understanding of the growing marketplace, and our portfolio includes over 550 stations in 43 states, including a significant presence of 154 stations in California, of which 65 are public. All 65 public stations deliver renewable natural gas (RNG) as compressed natural gas (CNG) or liquefied natural gas (LNG) vehicle fuel.

Already used as a clean, low carbon source of energy around the world, natural gas is abundant and proven to be a cost-saving alternative fuel to diesel and gasoline. Natural gas for transportation fuel strengthens our economy with lower fuel costs, increases our energy security, and significantly benefits our environment by reducing carbon emissions and smog-forming NOx emissions by up to 23% and 35%, respectively, relative to diesel fuel. Carbon emissions are reduced even further – approximately 80% to 90% - when RNG is used instead of diesel.

AIR RESOURCES BOARD MEMBER COMMENTS

At the October 22, 2015 California Air Resources Board's (ARB) Governing Board meeting, there were many comments from Board members which we fully support. These include:

- Several board members encouraged staff to modify the Discussion Draft's so that it embraced all advanced technologies (i.e., both low-NOx and electrification strategies). Some expressed worry over neglecting the importance of biomethane or the full potential of low-NOx strategies beyond 2030. The majority of the members appeared to support the setting of goals over picking winners when it comes to technologies;
- One board member expressed relief that the board was not voting on the Mobile Source Strategy document that day as it needed to be more goal-oriented than technology-oriented. The member further added that it was important not to make bio-derived methane unattractive and that the plan needs to be careful about unintended consequences;
- Several board members expressed sympathy for transit agencies that moved to CNG after ARB asked them to do so. They also expressed concern over costs and reliability issues associated with electrification (vehicles and infrastructure) and what those immense costs could do to ridership with only marginal or even negative air quality improvement from this sector;
- Many expressed support for Cummins Westport's 8.9L natural gas engine and praised the ARB-certified 0.02g NOx value, pointing to it as evidence that ARB really cannot accurately predict what transit might look like in 15-20 years;
- We appreciated Mr. Corey's acknowledgement of the board's concerns by stating staff will further "drill down" on the specifics of the plan, that there would be several more future workshops, and that the plan would not re-emerge for a board vote until mid-2016.
- Chair Nichols also stated that the "framing" of the report is important and may need further work. We could not agree more as the current draft should embrace all technologies that can help California reach attainment of federal clean air attainment standards and the state's petroleum reduction and greenhouse gas targets over the next several decades and beyond.

NOx AND PM2.5 EMISSIONS REDUCTIONS FOR HEAVY-DUTY FLEETS ARE MISSION CRITICAL TO MEET EPA DEADLINES AND TO PROTECT DISADVANTAGED COMMUNITIES

At the October 16th workshop, staff stated that the South Coast Air Basin's emissions reduction needs are the "primary driver" for ARB's Mobile Source Strategy. Although similar modeling appears to be absent for the San Joaquin Valley, there is no doubt that both of these air basins require urgent and significant NOx emissions reductions given their designations as the two most extreme non-attainment zones in the nation for the 8-hour ozone standard. Additionally, both the South Coast and the San Joaquin Valley's air pollution control districts have each independently identified heavy-duty class 7 and 8 trucks to be the number one source for NOx pollution. Further, through the South Coast Air Quality Management District's MATES-III efforts, diesel particulate matter (DPM) makes up almost 70% of the air toxics in the basin. Fortunately, applying a low-NOx strategy with a renewable fuels component will also support deeper PM and air toxics reductions as staff states on page 16 of the Discussion Draft that "NOx reductions will also provide benefits for PM 2.5 by reducing ammonium nitrate formed from interactions between NOx and ammonia...providing significant regional health benefits, coupled with reductions in diesel PM to reduce near-source exposure." DPM was listed as a toxic air contaminant known to cause cancer and reproductive harm by the State of

California in 2001. We also agree strongly agree with the conclusion made by staff on page 59 that, "Based on ARB staff's technology assessment, the most viable approach to meeting the 2031 and 2030 goals is low-NOx trucks."

ALL STRATEGIES OUTLINED ARE "NEAR ZERO" EMISSION STRATEGIES AND WILL REMAIN SO POST-2030

Battery and fuel cell vehicles are often referred to as zero emission vehicles but their capability of being truly zero in emissions largely depends upon whether or not the vehicle's power source is emissions free. Even with a 50 percent renewable portfolio by 2030, the state is still likely to draw at least half of its power from sources of energy that emit some form of pollution. Meanwhile, low-NOx strategies combined with renewable fuels can demonstrate far superior emissions benefits for NOx and GHG emissions today as neither depends upon the composition of the grid. In fact, the penetration of renewable natural gas volumes at natural gas vehicle stations in California is quickly approaching 50% based on ARB's LCFS reports for the 3rd quarter of this year.

We would recommend providing the readership of the final Mobile Source Strategy with a more transparent framing of the pollution benefits associated with each technology strategy versus statements that are vague or unclear. For example, the statement that "light-duty BEV technologies provide co-benefits across all pollutants and decrease petroleum use" on page 23 of the Discussion Draft could also apply to a low-NOx heavy-duty truck that is powered by renewable diesel or renewable natural gas. We therefore encourage staff to look at the lifecycle benefits of all near-zero strategies (i.e., 90% low-NOx strategies that harness renewable strategies, electrification via the grid, and hydrogen) and fuel displacement based on cost-effectiveness and commercial readiness of the technology.

Additionally, according to the draft staff report, the October 16th workshop and a recent SWRI presentation in Illinois on October 27th, there are no diesel engines in development that are capable of certifying to the 90% low-NOx target. At best, these engines are expected to meet a 0.05 g NOx target or a 75% NOx reduction compared to current standards. Despite these observations regarding the state of diesel technology, and despite numerous statements throughout the Mobile Source Strategy Discussion Draft that a 90% low-NOx strategy must succeed to reach attainment with the 2023 federal 8-hour ozone standard, the document's narrative on page 30 forecasts that low-NOx engines will be "powered by liquid fuels blended with increasing levels of clean, renewable fuels." This statement unintentionally overlooks the fact that natural gas engines certified to the 0.02 g low-NOx value can run on both liquid and gaseous forms of renewable natural gas blends. In order to embrace and support the state's desire to significantly transform the heavy-duty market to all forms of advanced renewable fuels, the final Mobile Source Strategy should avoid forward looking statements for specific fuels that may compliment a technology. If the document's narrative is open to all fuel types, it will be much easier to build business confidence behind advanced technology strategies required by the state to meet federal attainment standards and state petroleum and carbon targets.

VISION MODEL MUST REFLECT BOTH ADVANCED TECHNOLOGY ADOPTION RATES AND COST-EFFECTIVENESS

It is not clear if the Vision Model used historical adoption rates of advanced technologies to forecast emission scenarios that support the conclusions in the Mobile Source Strategy Discussion Draft. Further, the Vision Model does not appear to consider the cost-effectiveness of each advanced technology strategy which will be crucial to understand when it comes to making strategic investments with limited financial resources. Surely, the state must make a strong case to EPA that its forecasts are both realistic and achievable to validate the State Implementation Plan. Perhaps more importantly, it will be critical to make certain that the funds expended by various state programs not only maximize emissions benefits required to meet both federal and state air quality targets, but also to ensure the protection of disadvantaged communities.

ARB's FOCUS TO IMPLEMENT ZERO EMISSION VEHICLE TECHNOLOGY STRATEGIES IN TARGETED FLEETS COULD IMPAIR THE STATE'S ABILITY TO SUCCEED

ARB's proposal to require transit properties to transition all zero emission vehicle technologies by 2040 appears premature and ignores the significant public health and cost savings that are already being realized using natural gas vehicle strategies. Further, with the certification of the Cummins Westport 8.9L engine at 0.01 g NOx and the availability of renewable natural gas to the California fuels market, it appears to be unreasonable to expect transit properties who have already invested tens, if not hundreds of millions of dollars into a near-zero bus strategy to now transition their fleets to very expensive electric or fuel cell bus and infrastructure strategy that may not be commercially ready for the market. Even the executive director of the California Transit Association, Joshua Shaw, challenged ARB staff's suggestion that transit buses are a significant contributor to air quality and climate change issues by stating in a July 6th letter to ARB that, "According to the United States Department of Energy (DOE), roughly 1/5 of 1 percent of energy-related GHG emissions in the United States is attributable to transit buses." In that same letter, Mr. Shaw expresses concern over the lack of funding sources identified in the Advanced Clean Transit proposal regulation beyond a few relatively small discretionary incentive programs. Mr. Shaw goes on to state that, "This is problematic, as a recent assessment of California's unmet transit funding needs found a $72 billion shortfall for transit capital expansion and preservation over the next ten years without the added bus capital costs of this regulation." The fact that a low-NOx bus can actually be a very cost-effective alternative to a ZEV requirement and deliver power plant equivalent NOx emissions and greater GHG benefits using a renewable natural gas blend should cause one to pause.

ZERO EMISSION TAILPIPE 2030+ PHASE-IN STRATEGY MAY COMPLICATE SLCP GOALS AND HURT BUSINESS CONFIDENCE FOR LOW-NOX STRATEGIES

The Executive Summary of the September 2015 *Short-lived Climate Pollutant Reduction Strategy* includes the statement, "The science unequivocally underscores the need to immediately reduce SLCPs which include black carbon, methane, and fluorinated gases." To

achieve this goal for methane, it must be captured, not flared or vented, and put to productive use and the "highest and best use" in transportation as stated by NRDC's former Executive Director Peter Lehner at the Rethink Methane conference earlier this year. However, this is contradicted by the *Draft Mobile Source Strategy* - which proposes a strategy that promotes zero emission tailpipe vehicles from 2031-2050 – and the *Advanced Clean Transit Regulation* – which would result in ceasing purchases of natural gas near-zero engines running on RNG starting in 2028 (because those purchased after would not have a long enough financially viable lifespan before the 2040 deadline.) Both programs would undermine the use of Renewable Natural Gas (RNG) for transportation, by limiting its long-term use, thus undermining the SLCP plan. Further, limiting low-NOx strategies starting in 2030 would essentially make these stranded investments by OEMs that are investing heavily to help us comply with air quality, carbon, and petroleum reduction goals. We therefore urge ARB to work internally across all departments to support the use of RNG as a transportation fuel and to reframe the narrative to be inclusive of all strategies that achieve the 2030 and 2031 goals and beyond.

ADVANCED HEAVY-DUTY TRUCK FUNDING MUST INCLUDE LOW-NOX STRATEGIES

Not only does usiness confidence require certainty and clarity for years into the future, it will be critical for the Mobile Source Strategy to insure that both low-NOx near zero emission strategies and zero tailpipe emission strategies have a long-term role in the State's clean air mobile source strategy and enjoy equal funding opportunities. Specifically, the role for low-NOx strategies certainly should be longer than 15 years if California wants to attract the necessary investments required to implement a substantial transformation of the medium- and heavy-duty vehicle fleets. Further, California's Funding for Advanced Heavy-Duty Trucks must go beyond hybrid and zero tailpipe emission truck and buses as currently proposed under the voucher incentive project.

Failure to encourage and meaningfully incentivize near zero low-NOx strategies on a long-term basis with meaningful incentives will only worsen California's ability further to meet clean air standards. It is important to remember that out-of-state trucks do not need to comply with California's strict standards and the failure to successfully penetrate California's market will low-NOx trucks and renewable fuels will continue to deteriorate the state's clean air efforts. It is even made clear within the Discussion Draft that successful penetration of low-NOx near zero strategies must succeed but to do so they must be clearly encouraged.

FINAL MOBILE SOURCE STRATEGY DOCUMENT SHOULD MODIFY NARRATIVE ON TECHNOLOGY TO SUPPORT ALL STRATEGIES

Page 22 of the Discussion Draft uses a narrative that various low-NOx engine technologies are either certified for natural gas or anticipated to be certified for both natural gas and/or diesel fuel applications. We believe this is how the entire document should read as it has a technology and fuel neutral tone. However, this section lacks a discussion on the commercial readiness and emissions distinction between the various low-NOx strategies by fuel type.

Specifically, natural gas vehicles – an alternative to diesel – are in wide use throughout the heavy- and medium-duty sector today, and a fleet owner could immediately deploy a certified low-NOx engine meeting the 90% NOx reduction target set by ARB for numerous heavy- and medium-duty applications.

Further addressing the need for technology and fuel neutrality throughout the document, it is important to also point out that the following paragraph on page 22 that discusses zero emission technologies in the heavy-duty space outlines the various stages of development for various zero emission vehicle applications (i.e., "Zero emission vehicles are already available in a number of applications such as forklifts and airport ground support equipment"). We believe that the final Mobile Source Strategy document should also point out that natural gas strategies are successfully being used in ports, transit, refuse, airport, and shuttle services.

By doing so, ARB will be providing a level playing field for all advanced technology strategies that address NOx, greenhouse gasses, DPM, and petroleum reduction. While it is true that the Cummins Westport 8.9L engine certified at 0.02 g/bhp-hr NOx has yet to be fully deployed in all of these markets, there is no reason why these advanced low-NOx engines cannot be placed into immediate service today in port drayage, transit, refuse, airport, and other shuttle services. Thus, the document should reflect this opportunity to encourage state, county and city decision makers and fleet owners who want to act now and reduce emissions to be aware of such an opportunity. After all, we are in an urgent race to reduce NOx emissions in many parts of the state, but most especially in both the South Coast and San Joaquin Valley.

CORRECTION NEEDED

Page 15 of the Discussion Draft states that "US EPA is also expected to finalize a more stringent ozone standard in October of this year at a level between 65 and 70 ppb." This should be updated to reflect the 70 ppb standard that was adopted in October.

Thank you for considering our views. We look forward to continuing being part of the process and discussion.

Sincerely,

Todd R. Campbell
Vice-President, Public Policy & Regulatory Affairs
Clean Energy

CC: Members, California Air Resources Board