Public workshops
on the development of the

Advanced Clean Transit Regulation

DISCUSSION DOCUMENT

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California Environmental Protection Agency
Air Resources Board

Advanced Clean Transit Proposal for May 2015 Workshops
Executive Summary

The Air Resources Board (ARB or Board) is developing strategies to transition the heavy-duty mobile source sector to zero and near-zero technologies to meet air quality, climate, and public health protection goals. The Advanced Clean Transit (ACT) program under development is focused on achieving this transition in all modes of public transit. This document describes the first step in ACT strategy development, a proposal to transition public transit bus fleets to zero emission technologies. We seek to develop this program in partnership with transit agencies, with a combination of incentives and regulatory approaches, while providing transit agencies the flexibility to continue to evolve to meet expanding needs for effective, efficient, and affordable regional transit services across California.

California faces challenging mandates to reduce air pollutant and greenhouse gas (GHG) emissions in order to meet federal air quality standards and State climate change goals, and protect public health. These goals require:

- A 90 percent reduction in oxides of nitrogen (NOx) emissions to attain federal ozone standards by 2031;
- An 80 percent reduction in GHG emissions below 1990 levels by 2050, and a 40 percent reduction from 1990 levels by 2030 to achieve California climate emission reduction targets;
- Significant improvements in efficiency and the use of renewable fuels to meet the Governor's 50 percent petroleum reduction target by 2030; and
- Continued reductions in diesel PM and air toxics to protect public health.

Staff is evaluating four potential broad elements to the Advanced Clean Transit regulation:

- **Require Zero Emission Bus Purchases** – mandate a modest fraction of bus purchases to be zero emission technology starting in 2018, and set a goal of complete transit fleet transition to zero emission technologies by 2040.
- **Minimize Emissions from Conventional Fleet** – require use of renewable fuels and the cleanest available engines as soon as feasible.
- **Provide Regional Flexibility for Zero Emission Buses** – allow fleets within a region the option to pool requirements and work together to achieve a zero emission bus fleet.
- **Innovative Transit Beyond Buses** – allow for transits to work with MPOs to develop and implement plans for increased efficiencies through the use of innovative transit technologies beyond conventional transit operations.

This paper provides background on the need for emissions reductions, identifies technologies that are available for reducing bus emissions, and describes a number of issues staff is seeking to address with stakeholder input. These issues include:

- How to phase-in requirements for zero emission bus purchases in a manner that is consistent with existing purchase patterns?
- How existing funding programs could be improved to provide more certainty about available funding and funding levels?
- Should smaller transit fleets be given more time to phase-in zero emission buses?
- How to encourage deployments of fuel cell buses to bring them closer to commercialization?
- How conventional and plug-in hybrid buses should be included in the strategy?
- What are potential new and creative approaches to meet climate goals with innovative transit solutions beyond buses?

All information will be discussed at the next workshop series to be held in May 2015. Additional information about the workshops is at: http://www.arb.ca.gov/msprog/mailouts/msc1511/msc1511.pdf.

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I. Overview

California has made substantial progress in reducing emissions from all mobile sources, with many vehicles sold today, including urban transit buses, being over 90 percent cleaner than those sold just a decade ago. However, despite this progress, these vehicles and equipment remain major contributors to statewide emissions of NOx, greenhouse gases (GHG), and diesel particulate matter (diesel PM). Compared to today's levels, a 90 percent reduction in NOx emissions by 2031 will be necessary to achieve compliance with the current federal ozone standards, and an 80 percent reduction in GHG emissions below 1990 levels by 2050 will be necessary to meet California climate targets. Significant improvements in efficiency and the use of renewable fuels are also needed to meet the Governor's 50 percent petroleum reduction and 40 percent greenhouse gas emission reduction target by 2030. Finally, continued reductions in diesel PM and air toxics are necessary to reduce localized health risks and protect public health. Achieving each of these goals will require a transition to zero and near-zero emission technologies in all mobile sources.

Public transit agencies have played, and will continue to play, an important role in meeting these goals.

II. The Importance of Public Transit in California

Public transit is an important part of the State's transportation system, providing a safe, reliable, and affordable mobility option for millions of Californians every day. Transit systems reduce congestion on roadways, dependence on cars, and emissions while improving air quality. Transit fleets were the first to adopt new technologies like compressed natural gas (CNG) engines and exhaust retrofits, and have been the first adopters of zero emission technologies in heavy duty applications, with multiple fleets already operating zero emission buses in regular revenue service. Transit fleets are also expanding, as new programs including The Sustainable Communities and Climate Protection Act of 2008 (SB 375) help encourage transit fleet growth and efficiency. The Advanced Clean Transit (ACT) proposal currently under development is designed to help assist fleets in the transition to zero emission technologies over time with incentive and other support. This document describes the current Advanced Clean Transit proposal to support development of public comment and input to the regulatory development process.

A. Transit Agencies' Role in Achieving SB 375 Goals

The Sustainable Communities and Climate Protection Act of 2008 (SB 375) supports the State's climate efforts to reduce GHG emissions through coordinated transportation and land-use planning with the goal of more sustainable communities. Under SB 375, ARB sets regional targets for GHG emissions reductions with the goal of reducing passenger vehicle use and improved transportation efficiencies. In 2010, ARB established targets for 2020 and 2035 for each region covered by one of the State's metropolitan planning organizations (MPOs). Transit agencies play a key role in taking steps to improve transit system efficiencies while reducing passenger car use, which will reduce GHG emissions. Staff is interested in discussing how regional planning efforts can be expanded to transform the transit system to zero emissions in all modes of public transportation, and to explore opportunities for transit agencies to work with MPOs to develop and implement plans for increased efficiencies and GHG reductions through the use of innovative transit technologies beyond conventional transit operations.

B. Current Transit Operations

Public transit is provided through a variety of modes. Urban buses generally operate on fixed-routes of short distances (less than 20 miles) with frequent stops and starts with low average speeds. They also return to a central base or facility at the end of the day. Urban buses primarily operate in densely populated areas; therefore, advanced technologies that reduce exhaust emissions at the tailpipe have an immediate advantage of reducing direct exposure to pollutants that have an adverse impact to human health. Urban buses typically range in length from 30 feet to 65 feet (articulated configurations) and most have a low-floor design. The most common bus configuration is 40 feet in length.

Commuter buses typically are motor coaches that travel between urban areas on longer routes (typically more than 30 miles) and higher average speeds during peak times in the morning and evening, and are parked during the middle of the day. Vanpool and paratransit services are alternative modes of flexible passenger transportation that do not follow fixed-routes or schedules to serve individuals or groups of people who are not able to use traditional bus services such as people with disabilities. These special transportation services are often provided as a supplement to fixed-route bus and rail systems by public transit agencies.

Passenger rail is another transportation mode that transit agencies provide, most commonly in urban areas. California cities that currently provide passenger rail services include Los Angeles, Sacramento, San Diego, San Francisco, and San Jose. These cities use passenger rail and buses to create a structured network providing access to important destinations throughout the region. Passenger rail is often used as a backbone in these areas with buses used to transition between passenger rail lines and to access areas where the passenger rail lines do not go. Passenger rail expansions reduce vehicle miles traveled, decrease traffic congestion, displace buses, shorten commutes, and reduce commuter dependence on automobiles.

In addition to passenger transportation over land, some public entities also administer ferry services.[1] For example, Golden Gate Bridge Highway and Transportation District

[1] There are approximately 20 privately owned licensed operators that provide ferry services in California. See the California Public Utilities Commission (CPUC) at http://www.cpuc.ca.gov/puc/transportation/.

operates both Golden Gate Transit buses and Golden Gate Ferry.[2] The City of Vallejo administers the ferry service, Vallejo Baylink.[3]

C. Background on Existing Fleet Rule

Adopted in 2000, the Fleet Rule for Transit Agencies (Transit Fleet Rule) required reductions in criteria pollutant emissions from urban buses and transit fleet vehicles. Urban bus fleets were required to select either the diesel path or the alternative-fuel path, where agencies on the diesel path needed to meet the requirements sooner, while agencies on the alternative-fuel path had to ensure that 85 percent of urban bus purchases were alternative fueled. All agencies under the South Coast Air Quality Management District (SCAQMD) must follow the alternative-fuel path because these agencies are required to purchase alternative fuel buses per SCAQMD Rule 1192.[4]

California's transit agencies have been innovators and incubators for advanced technologies. To comply with the Transit Fleet Rule, transit agencies upgraded vehicles by retrofitting existing vehicles with particulate matter (PM) filters, replaced older vehicles with new ones that come equipped with exhaust after treatment or replaced with vehicles that have compressed natural gas engines. Many transit operators have installed natural gas refueling infrastructure at their facilities. Transit fleets have been instrumental in developing technologies, such as compressed natural gas buses, exhaust after treatment systems, battery electric buses, and fuel cell buses.

The Transit Fleet Rule was amended in 2006 to include an advanced demonstration from the diesel path transit agencies, and to temporarily postpone the 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 Advanced Clean Transit regulatory proposal, and a summary of work to date is provided in this document.

D. Existing Transit Fleet Vehicles

Transit agencies have been reporting fleet information to ARB for two separate categories – an urban bus fleet and all other transit fleet vehicles. Urban buses are buses that are primarily intended for intra-city operation while transit fleet vehicles are buses and other vehicles such as service trucks, paratransit vehicles, and commuter service buses (i.e., buses that make no more than ten scheduled stops per day).

[2] See Golden Gate Bridge Highway and Transportation District at http://goldengate.org/.
[3] See the Transportation Division of the City of Vallejo at http://66.161.26.67/govsite/default.asp?serviceID1=212&Frame=L1.
[4] SCAQMD Rule 1192. http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1192.pdf?sfvrsn=4.

Transit fleets reported about 9,900 buses and 1,600 other vehicles in California. These totals differ from California Department of Motor Vehicles registration data. We are interested in working with transit fleets in identifying where the differences are. Table II-1 lists the number of vehicles reported to ARB as of January 1, 2015, in the Transit Fleet reporting database for transit fleets with 50 or more vehicles.

Table II-1: Transit Fleet Size and Vehicle Type

(for fleets with 50 or more vehicles)

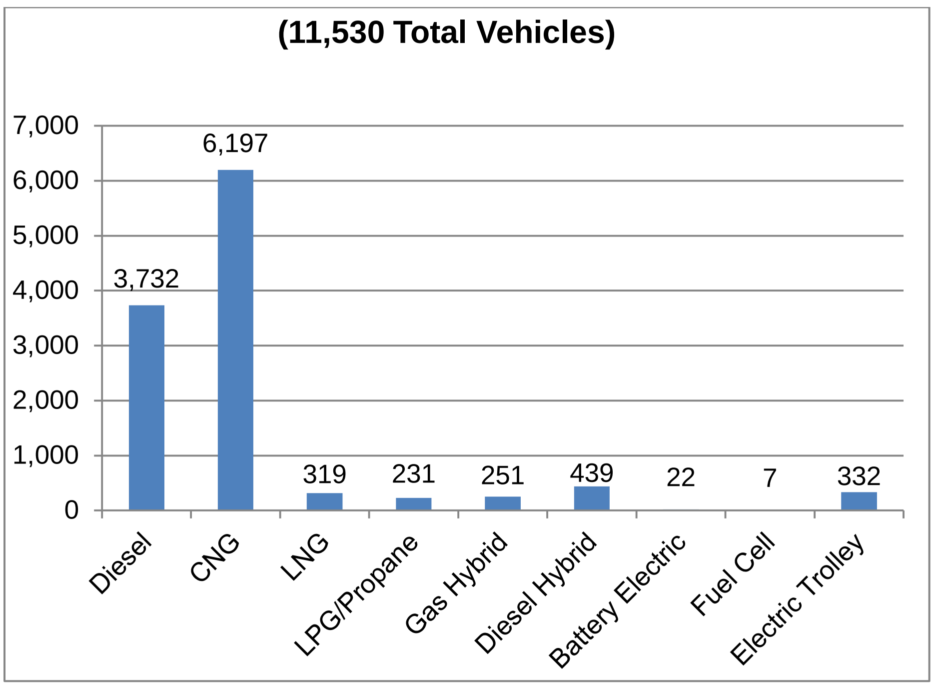
Transit Agency	Urban Buses	Other Vehicles	Grand Total
Los Angeles County Metropolitan Transportation Authority	2594		2594
San Francisco Municipal Railway	800		800
Orange County Transportation Authority	614	32	646
Alameda/Contra Costa Transit District	474	97	571
San Diego Metropolitan Transit System	551	15	566
Santa Clara Valley Transportation Authority	465	43	508
San Mateo County Transit District	319	10	329
Los Angeles - Department of Transportation	146	166	312
Foothill Transit	300		300
Long Beach Transit	249	2	251
Sacramento Regional Transit District	203	7	210
Santa Monica Big Blue Bus	194	4	198
Golden Gate Bridge, Highway and Transportation District	187	2	189
Omnitrans	177		177
North County San Diego Transit	127	16	143
Riverside Transit Agency	99	31	130
Santa Cruz Metropolitan Transit District	125		125
Golden Empire Transit	103	19	122
Central Contra Costa Transit Authority	121		121
Fresno Area Express	105	14	119
San Joaquin Regional Transit District	76	37	113
Santa Barbara Metropolitan Transit District	68	42	110
Santa Clarita Transit	90	14	104
SunLine Transit Agency	71	33	104
Monterey-Salinas Transit	80	15	95
Gold Coast Transit	54	24	78
Livermore/Amador Valley Transit Authority	52	24	76
Montebello Bus Lines	74		74
Gardena Municipal Bus Lines	66		66
Antelope Valley Transit Authority	65		65
Torrance Transit System	62		62
Eastern Contra Costa Transit Authority	62		62
Yolo County Transportation District	55	7	62
Modesto - Transit Division	51	4	55

Transit Agency	Urban Buses	Other Vehicles	Grand Total
Solano County Transit	54		54
Victor Valley Transit Authority	35	18	53
Culver City	52		52
Visalia Transit	36	15	51
Yuba-Sutter Transit Authority	17	34	51
Total (for fleets with 50 or more vehicles)	**9073**	**725**	**9798**

Source: ARB Transit Fleet Reporting Database, March 2015.

As shown in Figure II-1, approximately 32 percent of the heavy-duty transit vehicles operating in California are diesel-fueled. About 57 percent of the transit vehicles are operating on natural gas while six percent are hybrids. For agencies that are operating diesel buses, diesel hybrids represent about 50 percent of bus purchases, even though there is no purchase requirement.

Figure II-1 Transit Fleet Vehicle Count by Fuel Type



Source: ARB Transit Fleet Reporting Database, March 2015.

III. Technology Assessment

To support planning efforts, staff has been assessing the current state of technology in heavy-duty vehicles. More information on the ongoing technical assessments can be found at http://www.arb.ca.gov/msprog/tech/tech.htm. This section summarizes the findings as it relates to transit buses.

A. Feasibility to meet GHG and Efficiency Goals

Near-zero technologies are an important part of the overall strategy for heavy-duty trucks and buses; however, a transition to zero emission technologies in transit bus applications will be necessary to meet air quality and climate goals.

B. Advanced Technology for Transit Buses

Transit buses are generally a suitable early application for zero emission technology because they operate on fixed-routes over relatively short distances, perform frequent stop and start driving which enhances opportunities for regenerative braking, and have high idle time and low speeds. In addition, they are maintained and fueled at a central base or facility which enables overnight charging/fueling on site.

Early investments in advanced technologies for transit buses are expected to lead to additional technology improvements and cost reductions that will help enable a transition to zero emission technologies in other heavy-duty applications. At the same time, for the next 10-15 years, fleets will continue to purchase and use conventional buses. Near-zero engines and renewable fuels are coming to market and will play an important role in this interim period.

There are a number of technologies that lead to zero emission technology advancement or lower emissions compared to conventional technologies. Diesel hybrid electric transit buses are commercially available and are commonly purchased by transit fleets because of their fuel economy. Battery electric buses are commercially available, have no tailpipe emissions, and are being sold in California in small numbers. Fuel cell electric buses have been demonstrated for several years and are in early commercialization. Future low NOx engines have the potential to further reduce NOx by another 90 percent lower than the current engine standard, and renewable fuels are widely available and can displace conventional fuels to further reduce GHG emissions.

1. Hybrid Electric Buses

Hybrid electric buses use a conventional diesel engine in combination with an electric motor and a small energy storage system as an alternative motive power source. There are two primary configurations that can be used. In a parallel hybrid system, the combustion engine is coupled with the electric motor to both provide tractive power to move the vehicle. In a series hybrid system, the combustion engine acts like a generator to provide electrical energy to the electric motor, which provides the sole tractive power to move the vehicle. Hybrid transit buses are available both in parallel configuration (e.g., Allison's H 40/50 EP hybrid drive with Cummins ISB6.7 and ISL9 diesel engines) and series hybrid configuration (e.g., BAE Systems HybriDrive). Both systems have regenerative braking that recaptures energy while slowing the bus which improves fuel economy and reduces brake wear. Hybrid buses also rely on additional electrification of auxiliary systems or components like air conditioning, power steering, and braking systems that are necessary for battery electric or fuel cell electric buses. About 50 percent of diesel bus purchases in California are hybrid diesel buses. Hybrid configurations are currently not available with CNG engines; however, the primary power source in a hybrid design can be of any technology. The current upfront cost for a diesel hybrid bus is approximately $760,000, which is about $273,000 more per bus than a comparable conventional bus (see Table V-1). Table III-1 shows hybrid electric buses that are currently available by manufacturer and model.

Table III-1 Hybrid Electric Bus Manufacturers

Manufacturer	Model
Gillig	Standard, BRT, BRTPlus, commuter, trolley
Nova Bus	LFS HEV®
New Flyer	Xcelsior®
El Dorado National	XHF, Passport-HD, E-Z Rider II, and AXESS

Hybrid buses are able to achieve fuel economy improvements compared to conventional buses because of regenerative braking and improved efficiency. The amount of CO_2 emitted is also reduced. These CO_2 reductions or GHG emission benefits are typically in the range of 20-70 percent depending of the architecture of the hybrid system and the operational regimes. The fuel savings of a diesel hybrid bus compared to a diesel bus is approximately $9,000 per year with the following assumptions: fuel efficiency of a diesel hybrid bus is 30 percent higher than a diesel bus; diesel price is $3.9/gallon; and the annual mileage for a transit bus is 36,400.[5] Hybrid buses have lower brake replacement frequencies than conventional buses. However, staff currently does not have confirmed results for the maintenance cost difference between a conventional diesel bus and a diesel hybrid bus; therefore, this cost savings is not included in this analysis. After Federal Transit Administration (FTA)'s funding for bus purchase is taken into account, the incremental cost to transit agencies for bus purchase is approximately $49,000 (see Table V-1). The simple payback period for a diesel hybrid bus would be approximately 5.5 years if we only consider the fuel savings.

Both hybrid and conventional diesel engines meet the same NOx emissions standard. Because engine manufacturers are held to the certification standard over the life of the engine, emissions benefits are realized when an engine certifies to a lower emissions

[5] See Average Annual Vehicle Miles Traveled of Major Vehicle Categories at http://www.afdc.energy.gov/data/10309.

standard. In-use chassis dynamometer and on-road portable emissions measurements both suggest NO_x emissions from a parallel hybrid vehicle in-use can be higher compared to an equivalent conventional vehicle;[6] however, one study of a series hybrid bus showed lower in-use emissions[7]. The conflicting results are, in part, due to the fact that current certification test methods separately evaluate the engine and the drivetrain, and do not assure that NOx reductions will occur. ARB has developed an optional test method to certify hybrid systems, but no hybrid systems have yet been certified to that method. Staff is continuing to work with engine manufacturers to ensure compliance with emissions standards and low in-use NOx emissions from hybrid and conventional technologies.

Figure III-1 Gillig Diesel Hybrid Electric Bus

Plug-in hybrid electric vehicles (PHEV) differ from conventional hybrids in that they typically have larger batteries with the ability to be recharged from an external charger that is connected to the power grid which allows for extended all-electric driving range. Nova Bus is currently demonstrating a PHEV.

2. Battery Electric Buses

Battery electric transit buses utilize an electric drive powertrain powered solely by an onboard battery storage system and features regenerative braking along with other electric components such as inverters and electric motors that are common to other medium- and heavy-duty battery electric trucks and buses. Most components in a battery electric bus are similar or, in some cases, identical to those used in existing hybrid buses. Battery electric buses are commercially available from several manufacturers and in several configurations. The capital cost for a base forty-foot battery electric bus not including infrastructure is approximately $800,000, which is about

[6] (NREL, 2014) *Data Collection, Testing, and Analysis of Hybrid Electric Trucks and Buses Operating in California Fleets, Final Draft*; May 2014.

[7] (Kittelson, 2014) David Kittelson. *On-Road Evaluation of Energy Flows and Emissions from New Technology Conventional and Hybrid Transit Buses*; 24thCRC Real World Emissions Workshop, San Diego, California.

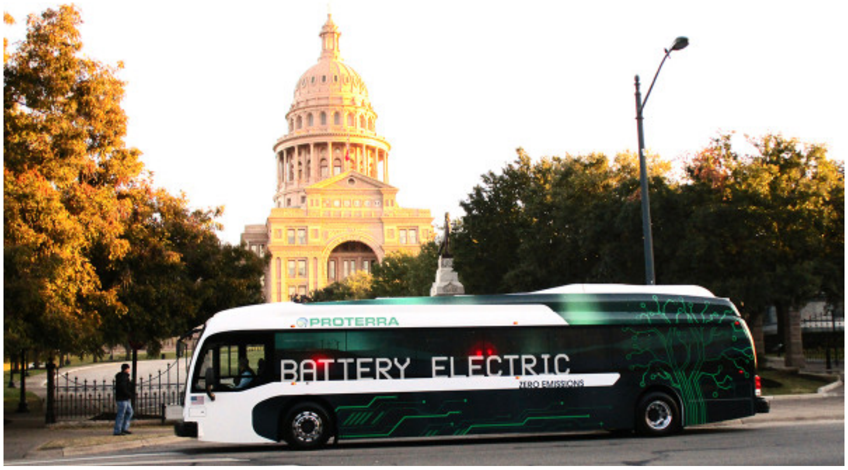
$315,000 more than a diesel bus and about $275,000 more than a natural gas bus. Table III-2 lists battery electric buses that are available by manufacturer, model, type, and the charging method.

Table III-2: Available Battery Electric Buses

Manufacturer	Model	Bus Type	Charging Options*
BYD	K7M	30’	Slow charge
BYD	K9S	35’	Slow charge
BYD	K11M	40’	Slow charge
BYD	K9M	60’ (Articulated)	Slow charge
Nova Bus	LFSe	40’	Fast charge
New Flyer	Xcelsior	40’	Slow or fast charge
Proterra	BE35	35’	Slow or fast charge
Proterra	Catalyst	40’	Slow or fast charge

Battery electric buses are currently charged conductively, wherein a physical contact is made between the electricity source and the vehicle (i.e., it is “plugged in”). Slow charge buses are charged by plugging into a wall mounted AC charger for several hours, and currently can travel up to 160 miles per charge. Fast charge buses, on the other hand, typically use small battery packs that commonly can travel about 30 miles per charge where the bus is charged in four to six minutes at a time at the end of each route or at strategic points throughout the day. Currently, bus manufacturers predominately use an overhead conductive charging approach that is unique to the bus manufacturer. Battery bus manufacturers are also beginning to offer a variety of charging strategies, by optimizing the size of the battery to meet the needs of the transit fleet. Some battery electric buses are also beginning to demonstrate wireless (or inductive) charging between vehicle and roadway. Staff is currently in the process of collecting data on Foothill Transit’s battery all-electric buses through a recent contract with the National Renewable Energy Laboratory (NREL) for data collection. Although upfront capital costs are higher for a battery electric bus, the total cost of ownership is expected to be lower than a diesel or natural gas bus due to high efficiencies, lower fuel cost, and reduced maintenance.

Figure III-2 Proterra Battery Electric Bus



3. Fuel Cell Electric Bus

Current fuel cell electric transit bus models that are currently being demonstrated are designed with a series hybrid configuration. The fuel cell electric vehicle drivetrain is similar to a conventional internal combustion hybrid drivetrain, where the fuel cell system takes the place of the engine and the hydrogen tank replaces the conventional fuel tank. The battery system, electrical propulsion, and other electrical sub-components are a part of the hybrid drivetrain. Fuel cells and other energy storage systems power the vehicle concurrently, which allows for the fuel cell to operate in more efficient regimes. Table III-3 lists current manufacturers of fuel cell buses for the US market.

Table III-3: Fuel Cell Buses

Manufacturer	Model	Bus Type
El Dorado	American Fuel Cell Bus	41'
New Flyer	Xcelsior® XE40 (in development)	40'
New Flyer	Xcelsior® XE60 (in development)	60' (Articulated)

Existing fuel cell electric bus fleets utilize hydrogen fueling stations built on-site and the cost of the station is shared by the fleet. Society of Automotive Engineers (SAE) published the SAE J2601-2 Surface Vehicle Technical Information Report "Fueling Protocol for Gaseous Hydrogen Powered Heavy-Duty Vehicles" on September 24, 2014. This protocol establishes safety limits and performance requirements for heavy-duty vehicle fueling. The station equipment for heavy-duty vehicles is essentially identical for light-duty applications, so any advances in station technology are applied across all sectors.

Data from reports generated by NREL on fuel cell electric buses are showing similar availability and durability to conventional buses. Fuel cell electric buses currently have a higher capital cost than battery electric buses. The current capital cost of a fuel cell bus is approximately $1.3 million,[8] which is significantly higher than for other bus technologies. We expect prices to come down with higher sales. Fuel cell technology may be necessary to meet service needs for trucks and buses in the future where battery electric vehicles may not be a practical option. We believe it is important to continue advancing fuel cell technology and are interested in discussing how to encourage additional deployments of fuel cell buses in the strategy to ensure market diversity.

Figure III-3: El Dorado American Fuel Cell Bus

4. Low NOx Engines

There have been major advances in heavy-duty engine technology to meet the current 0.2 g/bhp-hr standard (such as NOx exhaust after-treatment and use of natural gas engines. ARB recently adopted optional low NOx standards for heavy-duty engines specified to 0.1 g/bhp-hr, 0.05 g/bhp-hr, and 0.02 g/bhp-hr. A number of current projects are underway to demonstrate meeting a 0.02 g/bhp-hr standard, including SCAQMD's low NOx engine demonstration research project which focuses on engine and after-treatment technology that has the potential to meet a 0.02 g/bhp-hr NOx emission level, and that can be in commercial service soon after completion of the project by the end of 2016. We expect low NOx engines certified to optional low NOx standards to come to market in both diesel and natural gas engines over the next several years. While too early to assess, we estimate the cost of a bus with a low NOx engine will be several thousand dollars higher than a current engine.

[8] New Flyer has provided ARB with a letter dated, May 29, 2014, stating that $900,000 price per bus would be feasible with an order of 40 or more buses to be delivered over a 3 year period. Sunline Transit recently purchased 10 fuel cell buses that were custom built for $1.8 million each.

5. Renewable Fuels

Renewable fuels can provide substantial reductions in depletable resources (including petroleum) and GHG emissions, and will be a critical part of the portfolio of technologies and fuels that will be used to meet California's GHG emissions and air quality goals. The ARB has estimated the lifecycle GHG emissions of various renewable fuels and fuel feedstocks. Lifecycle GHG emissions are the aggregate quantity of GHGs related to the full fuel cycle, from feedstock production and extraction through distribution, delivery, and end use of the fuel. Renewable fuel supplies are expected to continue to increase for compliance with the Low Carbon Fuel Standard (LCFS) regulation.[9]

a) Renewable Natural Gas[10]

Renewable natural gas (RNG), or biomethane, is produced from biogas. Biogas is the gaseous product produced from the decaying processes of organic matter. When processed to a higher purity standard, biogas is called RNG and can be used as an alternative fuel for natural gas vehicles.[11] Biogas is produced from various biomass resources, such as landfills, wastewater treatment facilities, agricultural livestock operation, and food and organic waste. Biomethane can reduce GHG emissions by up to 87 percent compared to conventional petroleum-based fuels.[12] The transportation sector in California consumed 89 million diesel gallon equivalent (DGE) of fossil natural gas and 11 million DGE of RNG in 2013.[13] Total transportation natural gas consumption in 2020 is expected to be 600 to 1,200 million DGE. Of that, RNG consumption is expected to be 250 to 500 million DGE.[14] The majority of the supply of RNG is expected to come from out of state. The cost of RNG depends on many factors, including biomass availability and cost, conversion processes, conversion yield, the costs of capital, delivery, and distribution infrastructure, but after LCFS and federal Renewable Identification Number (RIN) credits, staff expects consumer prices to be comparable to conventional fuels.[15]

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[9] ARB Public Workshop on the discussion of low-carbon-intensity fuel availability. http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/092514_lcfs_fuels_availability_presenation_color.pdf.

[10] See the definitions of renewable natural gas (biomethane) and biogas at U.S. Department of Energy's Alternative Fuels Data Center at http://www.afdc.energy.gov/fuels/emerging_biogas.html and California Energy Commission at http://www.energy.ca.gov/drive/technology/biofuels.html.

[11] See U.S. Department of Energy's Alternative Fuels Data Center at http://www.afdc.energy.gov/fuels/emerging_biogas.html.

[12] California Energy Commission, http://www.energy.ca.gov/drive/technology/biofuels.html.

[13] ARB Public Workshop on the discussion of low-carbon-intensity fuel availability. http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/092514_lcfs_fuels_availability_presenation_color.pdf.

[14] ARB Public Workshop on the discussion of low-carbon-intensity fuel availability, September 25, 2014. http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/092514_lcfs_fuels_availability_presenation_color.pdf.

[15] The National Petroleum Council. 2012. Renewable Natural Gas for Transportation: An Overview of the Feedstock Capacity, Economics, and GHG Emission Reduction Benefits of RNG as a Low-Carbon Fuel. http://www.npc.org/FTF_Topic_papers/22-RNG.pdf.

Natural gas can also be generated by using renewable electricity. Power-to-gas is a process that uses excess electricity to electrolyze water to produce hydrogen in order to help balance the electrical grid. The hydrogen generated in this process can be used for methane production.

b) Renewable Hydrogen

Senate Bill 1505 requires ARB to adopt a regulation to mandate that one-third of hydrogen to be produced from renewable sources for transportation. Various methods can be used to produce renewable hydrogen.[16] First, renewable hydrogen can be generated by using excess renewable electricity to electrolyze water to balance over-generation on the electrical grid. This process is called power-to-gas and is discussed above. Second, it can be produced by using biogas. Steam-methane reformation is a process that uses high-temperature steam and methane to produce hydrogen. Third, the tri-generation process co-produces hydrogen in addition to electricity and heat by using biogas as the feedstock. The price of hydrogen depends on the capacity and use of the hydrogen station. The current price of hydrogen is approximately $6 to $9 per kilogram for a high capacity hydrogen station, which is typical for transit applications. Power-to-gas and vehicle-grid integration strategies can be part of an integrated solution to achieve a sustainable and renewable electrical grid, transportation and freight system.

c) Biodiesel

Biodiesel is a diesel substitute made from vegetable oils, animal fats, or used cooking oil. These products can be used in its pure form (B100) or blended with petroleum diesel at various levels: B2 (2% biodiesel), B5 (5% biodiesel), or B20 (20% biodiesel). Currently, there are about 50 public biodiesel stations in California that supply biodiesel (B20 or above).[17] The plant feedstock used in the production of biodiesel captures CO_2 as the plant grows. This can offset the CO_2 released from fuel combustion. Biodiesel can reduce CO_2 emissions by approximately 50 to 88 percent depending on the feedstock used.[18] However, biodiesel has slightly higher NOx emissions than conventional diesel fuel in heavy-duty legacy engines. The proposed Alternative Diesel Fuel regulation will ensure that is minimized and eliminated over time. Biodiesel cannot be used in retrofit engines, unless specified by the retrofit manufacturers. The domestic biodiesel (B100) production in the U.S. was about 1.3 billion gallons in 2014.[19] The

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[16] See ARB Fact Sheet on Environmental and Energy Standards for Hydrogen Production (SB 1505) at http://www.arb.ca.gov/msprog/hydprod/hydprod_fs.pdf.
[17] U.S. Department of Energy, Alternative Fuels Data Center, Biofuel Fueling Station Locations: http://www.afdc.energy.gov/fuels/biodiesel_locations.html.
[18] California Energy Commission, http://www.energy.ca.gov/drive/technology/biofuels.html.
[19] U.S. Energy Information Administration. Monthly Biodiesel Production Report. http://www.eia.gov/biofuels/biodiesel/production/table1.pdf.

national average price for biodiesel (B20) and biodiesel (B99-B100) in January 2015 were $3.18/gallon and $4.02/gallon respectively.[20]

d) Renewable Diesel

Renewable diesel is derived from non-petroleum renewable resources, such as animal fats and wastes, municipal solid waste, or plant and algae oils. Renewable diesel, chemically indistinguishable from conventional diesel, uses similar feedstock as in the production of biodiesel, but they have different processing methods, and are chemically different products. Renewable diesel is compatible with existing diesel engines and distribution infrastructure and has lower NOx emissions in heavy-duty legacy engines than conventional diesel. The total stocks in the U.S. were about 4.5 million barrels in 2013.[21] The projected national renewable diesel supply for year 2020 ranges from 900 to 1,500 million gallons,[22] and is expected to increase through the implementation of the Low Carbon Fuel Standard regulation.

e) Renewable Electricity

California's RPS calls for a target of 33 percent of electricity retail sales served by renewable energy resources by 2020.[23] Renewable energy sources include solar, wind, geothermal, ocean tides, and other thermal energy sources. Some of these sources, especially solar and wind, provide energy periodically, and can create a mismatch between electricity supply and demand on the electrical grid as the renewable portfolio increases. Zero emission technologies in the mobile source sector represent a growing electricity demand on the grid. Vehicle-grid integration technology aims at creating a mutually beneficial relationship between electric vehicles and the electrical grid by providing a two-way power flow that allows vehicles to both accept a charge from the grid, and supply a charge to the grid when necessary to maintain balance between electricity supply and demand. The California average electricity price in February 2015 was $0.145/kWh.[24] The electricity price depends on the utilities and the time of usage.

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[20] U.S. Department of Energy, Alternative Fuels Data Center, http://www.afdc.energy.gov/fuels/prices.html.

[21] U.S. Energy Information Administration. Stocks by Type. http://www.eia.gov/dnav/pet/pet_stoc_typ_c_nus_EPOORD_mbbl_a.htm.

[22] ARB Public Workshop on the discussion of low-carbon-intensity fuel availability. http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/092514_lcfs_fuels_availability_presenation_color.pdf.

[23] See Senate Bill X1-2 at http://www.energy.ca.gov/portfolio/documents/sbx1_2_bill_20110412_chaptered.pdf, and California Energy Commission at http://www.energy.ca.gov/portfolio/.

[24] U.S. Department of Energy, Alternative Fuels Data Center, http://www.afdc.energy.gov/fuels/prices.html.

C. Emissions Comparison for Advanced Technologies

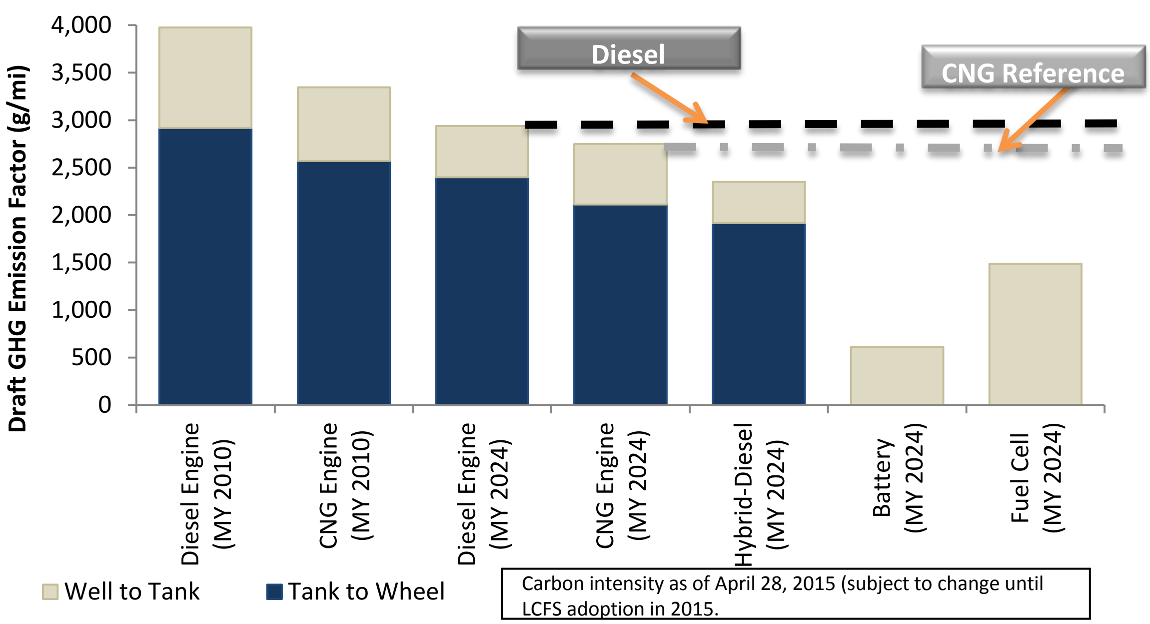
Advanced technologies can affect NOx emissions, GHG emissions, or both. NOx emissions contribute to smog formation at the regional level and have a direct and immediate impact on those who are exposed to the emissions from the exhaust of a vehicle. GHG emissions must be compared with a well-to-wheel analysis where the emissions associated with the vehicle use and fuel consumed is determined regardless of where the activity occurs.

1. Greenhouse Gas Emissions Comparison

The well-to-wheel analysis compares the emissions of a typical vehicle and fuel on a per mile basis. A well to wheel analysis can be subdivided into to two components, well-to-tank emissions and tank-to-wheel emissions. Tank-to-wheel emissions are characterized by the emissions produced by the vehicle. Well-to-tank emissions are associated with extracting, producing, transporting and distributing the fuel or energy.

GHG emissions for seven urban buses were analyzed for comparison as shown in Figure III-3. The two bars on the left show emissions associated with a conventional bus having a 2010 California certified diesel and CNG engine. The remaining bars on the graph reflect improved efficiencies and emissions expected by 2024 for conventional and advanced technologies. The next three bars reflect improved efficiencies from future buses with diesel engines, CNG engines, and hybrid-diesel buses, respectively. On the far right are the emissions associated with battery electric and fuel cell electric buses. Low NOx engines are not shown in the graph because they are not expected to impact GHG emissions.

Figure III-3: Urban Bus GHG Emission Comparison

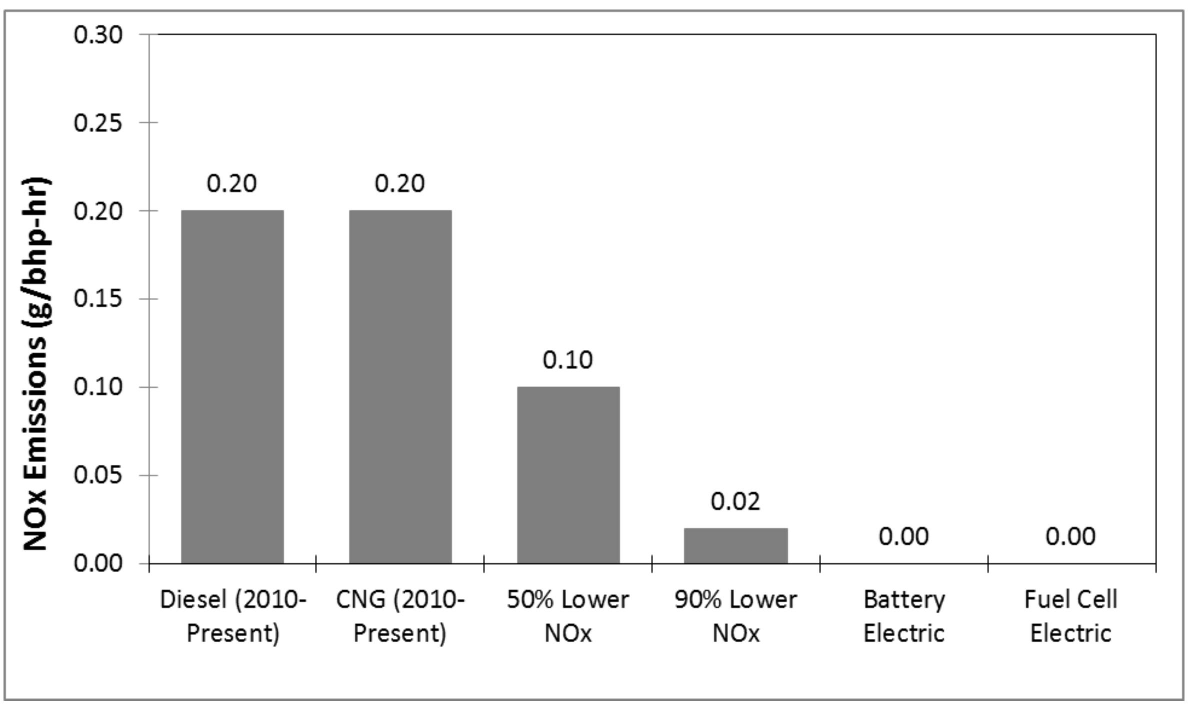


The GHG emissions from conventional buses are expected to decline modestly by 2024 primarily because of improved vehicle efficiencies associated with the U.S. Environmental Protection Agency and National Highway Traffic Safety Administration Phase 2 Fuel Efficiency and Greenhouse Gas Standards for heavy-duty vehicles, and from lower carbon intensity from conventional fuels associated with the Low Carbon Fuel Standards. Battery and fuel cell electric buses have the lowest GHG emissions associated with their use than the other vehicles analyzed. Emissions from electricity reflect the California renewable energy mix as required by the renewable portfolio standard (RPS). Hydrogen used in fuel cell buses reflects the 33 percent renewable hydrogen requirement in Senate Bill 1505.[25] All conventional and advanced technologies can have significantly lower GHG emissions than shown when using renewable fuels.

1. NOx Emissions Comparison

NOx emissions from different technologies are compared based on the engine certification standard on a gram per brake horsepower-hour basis. As shown on the left two bars in Figure III-I, diesel and natural gas engines are certified to the same NOx emission standard of 0.2 g/bhp-hr regardless of fuel type. The optional low NOx standards of 50 and 90 percent below the current standard are shown in the middle. On the right, the zero emission technologies are shown with zero NOx emission from the vehicle.

Figure III-I: Urban Bus Engine Certification Standards for NOx Emissions



[25] See ARB Fact Sheet on Environmental and Energy Standards for Hydrogen Production (SB 1505) at http://www.arb.ca.gov/msprog/hydprod/hydprod_fs.pdf.

In-use emission measurements are a useful way to evaluate NOx emissions from vehicles. Although new engines are certified to the same standard, there are common engine emissions control technology characteristics that differ depending on the fuel or vehicle design that can effect real world emissions. Studies are suggesting that some CNG engines may have lower NOx emissions than diesel engines in some applications, and as discussed earlier, hybrid vehicle NOx emissions comparisons in-use are showing widely varying results. Because engine manufacturers are held to the certification standard over the life of the engine, emissions benefits are realized when an engine certifies to a lower emissions standard.

D. Axle Weight Limits

Axle weight limits for buses sold in the United States (U.S.) are an issue that is unique to transit buses. The federal axle weight limit is 24,000 lbs. /axle; however, transit buses sold in the U.S. regularly exceed the allowable limit. California Law (enacted in 1975) prohibits transit operators from procuring buses over the weight limit of 20,500 lbs./axle. To date, a majority of transit buses do not meet the California weight limit as documented in the California Transit Association (CTA) letter[26] that states "Our research shows that at least as many as half of the transit buses in California operating at peak commute times may exceed the state weight limit of 20,500 lbs. per axle." AB 1720 (Bloom), approved by the Governor on August 22, 2014 provided a temporary solution to this situation by allowing transit agencies to continue procuring buses that do not meet the weight limit through January 1, 2016. Further, AB 1706 also mandates new regulations to consider vehicle weight impacts and the ability of vehicle manufacturers or vehicle operators to comply with laws limiting the weight of vehicles.[27] This law requires ARB to take into account vehicle operator's weight limit requirements when developing new regulations such as the Advanced Clean Transit proposal currently under development. The American Public Transportation Association (APTA) has published "An analysis of transit bus axle weight issues" in November 2014, which suggests twenty-three possible solutions to addressing transit bus weight issues.[28] Staff will continue to follow the situation as both CTA and APTA work to find a solution.

IV. Advanced Clean Transit Framework

The ARB is developing strategies to transition the heavy-duty mobile source sector to zero and near-zero technologies to meet air quality, climate, and public health

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[26] California Transit Association, September 6, 2012, letter to Governor Brown.

[27] CGC 11343.3. Notwithstanding any other law, a state agency that is required to promulgate administrative regulations, including, but not limited to, the State Air Resources Board, the California Environmental Protection Agency, the State Energy Resources Conservation and Development Commission, and the Department of Motor Vehicles, shall take into account vehicle weight impacts and the ability of vehicle manufacturers or vehicle operators to comply with laws limiting the weight of vehicles.

[28] http://www.apta.com/resources/reportsandpublications/Documents/An-Analysis-of-Transit-Bus-Axle-Weight-Issues-TCRP-J11-T20.pdf

protection goals. The ACT program under development is focused on achieving this transition in all modes of public transit. This document describes the first step in ACT strategy development, a proposal to transition public transit bus fleets to zero emission technologies. We seek to develop this program in partnership with transit agencies, with a combination of incentives and regulatory approaches, while providing transit agencies the flexibility to continue to evolve to meet expanding needs for effective, efficient, and affordable regional transit services across California.

A. Require Zero Emission Bus Purchases

We are proposing modest zero emission bus (battery all-electric or fuel cell electric) purchase requirements starting in 2018. As fleets become more familiar with the technology, and as the technology evolves, purchase requirements will increase. Ultimately, the Advanced Clean Transit program will require all transit buses operating in California to be zero emission by 2040.

Purchase requirements would be phased in every few years to meet percentage of fleet milestones that would establish the minimum number of zero emission buses in the fleet. Establishing periodic milestones is expected to provide flexibility for transit fleets to incorporate zero emission bus purchases in their normal procurement process. Bus replacements are commonly made through a public competitive bidding process in three to five-year increments, and must meet certain criteria depending on the sources of funding. Transit fleets may also work with MPO's or other transits to pool their orders to save staff time in preparing solicitations and to get lower prices. Staff is interested in discussing how to phase in requirements for zero emission bus purchases in a manner consistent with existing purchase patterns, and to provide a review process to ensure zero emission technologies are compatible with transit bus fleet operational needs.

Smaller transit fleets may face relatively higher initial costs per bus because of fixed infrastructure, maintenance facility and training costs. Staff is interested in discussing if approaches to address this issue, which might include providing a longer period for small fleets to meet requirements, providing flexibility for small fleets to pool resources on a regional basis, or other approaches, are necessary. For comparison, the San Joaquin Regional Transit District will soon be operating seven zero emission buses out of a total bus fleet size of 76 buses (nearly ten percent of the fleet).

B. Minimize Emissions from Conventional Fleet

We are proposing to require use of renewable fuels and the cleanest available engines as soon as they are available for transit applications. These proposed requirements will provide near-term NOx, particulate matter, and GHG emissions reductions to help meet nearer term air quality, climate, and petroleum targets.

C. Provide Regional Flexibility for Zero Emission Buses

We are proposing an option to allow transit fleets within a region to pool zero emission bus purchase requirements and work together to achieve a zero emission bus fleet. This allows for flexibility for transit agencies to plan for expanding a zero emission bus fleet and associated infrastructure in a more cost effective manner. This would also result in larger concentrations of zero emission buses that may allow for a more robust program with pooled resources and for strategic bus placements where the technology can be most effective and successful in current transit operations.

D. Innovative Transit beyond Buses

We are exploring a strategy that would encourage transit fleets to work with metropolitan planning organizations (MPOs), regional Transportation Planning Agencies (RTPAs) or The California Department of Transportation (Caltrans) to develop regional plans for innovative transit beyond conventional transit operations as part of implementing Sustainable Communities Strategies (under SB 375) beyond improving bus efficiencies. Innovative transit technologies are new and emerging technologies, such as intelligent transportation systems, that improve transit system efficiencies and would not include conventional transportation systems and methods. Innovative transit technologies that improve efficiency and result in additional GHG reduction would potentially be recognized in implementing regional Sustainable Communities Strategies consistent with the requirements of SB375. Transit fleets that participate in implementing the plan might receive additional flexibility in meeting zero emission bus purchase requirements. This approach would provide another opportunity for transit fleets and regional planning agencies to transform passenger transportation with creative methods and new technologies that are yet to be developed. We are interested in stakeholder input on ways that this concept could be implemented.

V. Building the Business Case for Zero Emission Technologies

Operating zero emission buses in public transit systems has many benefits that build the business case for these technologies. This business case, and the economic impacts of the concepts discussed in this paper on transit fleets is very important to consider. There are many benefits, and costs of zero emission bus technologies. As discussed above, upfront costs of zero emission technologies are higher than for conventional vehicles. However, zero emission technologies offer significant benefits including significantly reducing fuel consumption and emissions of GHGs and harmful criteria pollutants, lower engine and brake wear compared to diesel buses resulting in extended brake life and potentially reduced maintenance costs, and improved fuel efficiencies that may result in fuel savings. Zero emission buses also reduce exposure to NOx and PM that directly benefits the communities located near major roads, and offer a more pleasant, smoother and quieter ride to customers than diesel and CNG buses.

Staff's proposal for zero emission bus purchase requirements will be supported with State incentive funding to reduce the upfront capital cost to transit agencies, and help ensure program success.

A. Zero Emission Bus Capital Costs

Table V-1 below shows an example of the capital cost of diesel, natural gas, diesel hybrid electric, fuel cell electric, and battery electric buses including a typical Federal Transportation Administration (FTA) cost sharing, and the incremental cost for different technologies compared to a conventional diesel bus. This assumes the FTA funds for the region are available to cover about 82 percent of the costs of the bus. Some regions may have a more limited allocation and the incremental costs may vary.

Table V-1: Today's Capital Cost for Different Bus Technologies

Technology	Purchase Price	FTA Section 5307 Funding	Transit Agency Cost Share	Incremental Cost to Transit Agencies above Diesel
Diesel	$485,000	$398,000	$87,300	---
Natural Gas	$525,000	$431,000	$95,000	$7,000
Diesel Hybrid	$758,000	$622,000	$136,000	$49,000
Battery Electric	$800,000	$656,000	$144,000	$57,000
Fuel Cell Electric	$1,300,000	$1,066,000	$234,000	$147,000

B. Zero Emission Bus Total Cost of Ownership

Total costs of ownership comprise costs from the upfront capital cost of bus purchase and infrastructure construction, to bus operation and maintenance, to engine rebuild in midlife, and to bus disposal.

As shown above, zero emission buses have a higher upfront capital cost than their diesel or natural gas powered alternatives. However, the total cost of ownership of a zero emission bus may be lower than a conventional diesel or CNG bus. For example, battery electric buses have improved "fuel" efficiency (mile per diesel gallon equivalent (dge)), and the cost of electricity per mile to move the bus is generally substantially less than the cost for diesel or CNG resulting in fuel savings. In addition, zero emission buses may have lower maintenance costs over the lifespan of the bus because they have simpler mechanical systems and fewer moving parts compared to diesel and natural gas buses. Currently, while anecdotal discussions suggest lower maintenance costs, the data on maintenance costs of zero emission buses is limited. Data collection through ARB incentive programs will be used to further demonstrate lower maintenance and fuel costs over time.

The following battery electric bus example illustrates potential fuel and maintenance cost savings that could occur. Staff uses an annual average mileage of 36,400 miles for a transit bus.[29] Assuming cost of natural gas is $2.55/dge, and cost of electricity is $0.145/kWh,[30] it would cost about $27,000 annually in fuel for a CNG bus with a fuel efficiency of 3.4 miles/dge,[31] compared to $10,500 per year in electricity cost for a battery electric bus with a fuel consumption rate of ~2 kWh/mile (or a fuel efficiency of 0.5 mile/kWh).[32] This would result in an annual fuel saving of approximately $17,000. Staff used the capital costs presented in Table V-1 to estimate the payback period for a battery electric bus. After the federal funding for bus purchase is taken into account, the incremental cost for a battery electric bus over a CNG bus is about $49,000 for the transit agency. The maintenance costs for a CNG bus is estimated at $1 per mile and is $0.2 per mile for a battery electric bus,[33] and the annual fuel cost savings is about $12,000.

The cost of hardware for a direct current (DC) fast charging station ranges from $12,000 to $35,000.[34] However, the installation cost is site specific. The batteries for medium- and heavy-duty trucks and buses are currently in the $500 to $700 per kWh range. If we assume the battery is replaced in the mid-life of a bus, the replacement cost for a 324kWh battery at $700/kWh would be $226,800.[35] Assuming the installed cost of a DC fast charging station is $40,000, the payback period, including vehicle incremental cost, mid-life battery replacement and charging infrastructure investment, would be around 7 years. This is less than the expected 12-year lifespan of a bus.

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[29] See Average Annual Vehicle Miles Traveled of Major Vehicle Categories at http://www.afdc.energy.gov/data/10309.

[30] Fuel and electricity price data are available at U.S. Energy Information Administration (EIA)'s website at http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_jan_2015.pdf and http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a.

[31] See Average Fuel Efficiency of Major Vehicle Categories at http://www.afdc.energy.gov/data/10310. Transit bus has an average fuel efficiency of 3.3 miles/gge (about 3.8 miles/dge). A CNG bus has slightly lower fuel efficiency than a diesel bus. Here staff assumes the fuel efficiency of a CNG bus is 10 percent less than that of a diesel bus.

[32] See Altoona Test Report for a BYD 40 feet electric bus at http://www.altoonabustest.com/buses/reports/441.pdf?1340301410. (p. 141).

[33] The $1 per mile maintenance cost estimate for a diesel bus is used by the Federal Land Management Agencies. See http://ntl.bts.gov/lib/44000/44200/44244/Bus_Lifecycle_Cost_Model_User_s_Guide.pdf. It is assumed that the maintenance costs for a diesel bus and a CNG bus are the same. The maintenance cost for electric buses at Stanford University ranges from $0.16 to $0.41 per mile. See "Electric buses at Stanford" at http://cahigheredusustainability.org/documents/ThomasWard_Jun173113Adams4.15pm_000.pdf.

[34] Clean Technica (2014) EV Charging Station Infrastructure Costs. http://cleantechnica.com/2014/05/03/ev-charging-station-infrastructure-costs/

[35] It is expected that the battery cost will reduce over time. If the battery cost decreases, the payback period will be shorter. Gigafactories would be needed to bring down the battery cost. However, the scale-up and mass production of batteries from research lab to market is slow. See ARB research seminar on the future for energy storage by V. Srinivasan at http://www.arb.ca.gov/research/seminars/srinivasan/srinivasan.htm.

There are multiple factors and uncertainties when estimating the total cost of ownership of a zero emission bus. We expect the capital cost of zero emission buses to decrease over time, and the benefits of fuel efficiency, fuel costs, and maintenance savings to become clearer over time as additional data are collected and analyzed.

C. Normal Bus Replacement Funding

Transit agencies receive federal, State and local funding for capital projects like bus purchases with a majority of the bus capital funding being formula funds from FTA and the remainder from local funds. Buses purchased with FTA formula funding are subject to certain requirements. We estimate about 80 percent of a typical transit fleet's operating revenue comes from local funds including ticket fares and parking charges, sales taxes, gas taxes, property taxes, developer fees, and roadway and bridge tolls.

MPOs are federally-mandated transportation planning organizations designated for large urbanized areas, are responsible for allocating federal funds to transit agencies, and in some cases provide a portion of the local match to transit agencies (e.g., bridge toll funds in the Bay Area). Regional policies also establish the acceptable funding limits for bus replacement. For non-urbanized or rural areas, Caltrans provides planning and technical assistance to transportation planning agencies and transit operators at the local level.

Three FTA grant programs under the Moving Ahead for Progress in the 21st Century (MAP-21) Act provide the primary support for transit bus purchases: 1) Urbanized Area Formula Grants (Section 5307); 2) Bus and Bus Facilities Formula Program (Section 5339); and 3) State of Good Repair Program (Section 5337).

1. Urbanized Area Formula Grants (Section 5307)

This program makes federal resources available to urbanized areas for transit capital, planning, and operating assistance in certain circumstances. This program traditionally funds scheduled replacements of conventionally fueled transit buses. There is an 80/20 cost share between FTA and a transit agency or regional transit authority for capital projects. Funding cost share up to 90/10 is possible, if an agency is required to comply with Americans with Disabilities Act or Clean Air Act requirements. The federal share is 50 percent for operating assistance. Approximately $4 billion was available nationally in FY 2014.

2. Bus and Bus Facilities Program (Section 5339)

The Bus and Bus Facilities Program is a capital-only program. It provides capital funding to replace, rehabilitate, and purchase buses and bus-related equipment, and to construct bus-related facilities. Funds must be spent in accordance with Section 5307. Transit agencies can use funds to augment bus and bus facilities purchases being made with Section 5307 grant program. Approximately $400 million was available nationally in FY 2014. The federal share is 80 percent with a required local match of 20 percent.

3. State of Good Repair Program (Section 5337)

The State of Good Repair program offers funding to repair and upgrade rail transit systems along with high intensity motor bus systems that use high occupancy vehicle lanes, including bus rapid transit (BRT). Approximately $2 billion was available nationally in FY 2014, about $60 million of which was for High Intensity Motorbus State of Good Repair. The federal share is 80 percent with a required match of 20 percent.

Buses that are purchased with the FTA funds must meet strict guidelines that require a minimum of 60 percent domestic content, and final assembly in the U.S. Also, buses must be used for at least 12 years, and must be tested at the Altoona facilities to provide information on the reliability and performance of the buses.[36]

D. Financing and Lease Options

To reduce the incremental capital cost of zero emission buses, some battery electric bus manufacturers are already using a financing option of leasing the high value battery component, which allows transit agencies to purchase an electric bus at a cost similar to a conventional bus. FTA has agreed that FTA funds could be used for the leasing of the battery component as shown in Appendix 1. Having the battery under lease and warranty for the 12-year lifetime of a bus reduces the upfront costs and reduces the risk to the transit agency. The operational savings can also be used to partially offset the battery lease cost.

ARB is interested in exploring other innovative financing strategies that can increase the effectiveness of existing public funds or leverage private funds to foster the market of zero emission buses. Several financing options may be worth exploring:

- Low-interest loans;
- Bond financing, similar to those offered by the California Alternative Energy and Advanced Transportation Financing Authority; and/or
- Other opportunities to take advantage from benefits of zero emission technologies.

E. Incentive Funding Programs for Zero Emission Technologies

The upfront capital cost of zero emission buses currently remains a barrier to widespread adoption thus incentive investments over the next few years are critical. Currently, there are several public funding programs established to reduce incremental costs associated with zero emission technologies. Staff will be evaluating incentive funding opportunities in combination with potential rule requirements and would like to

[36] See FTA's Bus Testing Program background at http://www.fta.dot.gov/about_FTA_8866.html.

discuss how existing funding programs could be improved to provide more certainty about available funds and achieve more zero emission bus deployments in public transit.

1. ARB Hybrid Vehicle Improvement Program (HVIP)

This program is part of the AB118 Air Quality Improvement Program (AQIP) and provides vouchers up to $110,000 per vehicle for hybrid and zero emission trucks and buses.

2. ARB Zero-Emission Truck and Bus Pilot Projects in Disadvantaged Communities

This program provides up to $25 million in FY 2014-15 for pilot projects, which may include zero emission transit buses, zero emission school buses, zero emission freight/delivery trucks, and infrastructure that operate within a concentrated, well-defined geographic area and benefitting disadvantaged communities. Staff is also proposing in the FY 2015-16 AQIP/Low Carbon Transportation Funding Plan to allocate additional significant funding for Zero Emission Truck and Bus Pilot Commercial Deployments, and may add this proposed funding to the FY 2014-15 $25 million solicitation.

3. FTA Low or No Emission Vehicle Deployment Program (LoNo)

This program is funded with FTA discretionary funds and provides funding for transit agencies for capital acquisitions and leases of zero emission and low emission transit buses, including acquisition, construction, and leasing of required supporting facilities such as recharging, refueling, and maintenance facilities. The program provided $24.9 million in funding for FY 2013.

4. Caltrans Low Carbon Transit Operations Program

This program is funded with greenhouse gas reduction funds and provided funding for transit agencies for capital and operations projects that reduce GHG emissions, increase mode share, and benefit disadvantaged communities. The program received $25 million in funding for FY 2014-15. For FY 2015-16, the budget proposes $50 million in funding.

5. California State Transportation Agency Transit and Intercity Rail Capital Program

This program is funded with greenhouse gas reduction funds and provided funding for transit and intercity rail capital projects that reduce GHG emissions and benefit disadvantaged communities. The program will receive $25 million in FY 2014-15 and ten percent of annual state Cap-and-Trade auction proceeds beginning in FY 2015-16.

VI. Challenges

The Advanced Clean Transit strategy is an important part of the State's strategy to transition to near-zero and zero emission technologies and meet its air quality, climate and public health goals. However, this transition to a zero emission transit system faces many challenges in order to become a success. While there are many challenges, the two main issues involve understanding and addressing the costs of zero emission technologies and ensuring a full zero emission bus fleet given current zero emission technology operational limitations.

- *Understanding and addressing costs*

In developing this regulatory approach, costs are a critical consideration. ARB has a common interest with transit fleet operators to have an open and transparent analysis of costs associated with actions required by any regulatory implementation strategy. Costs associated with owning and operating zero emissions buses which includes infrastructure costs can impact transit fleet's ability to provide other services. Funding programs can offset early capital costs and lower risks associated with uncertainty from purchasing new technologies. Understanding the total cost of ownership and how existing funding programs can be modified or structured to leverage existing federal funds will be important to determine in developing a proposed schedule.

- *Ensuring a full zero emission bus fleet*

Current deployments show that zero emission buses can meet the needs of many routes without any significant changes to existing bus schedules or routes. However, they cannot yet displace all buses, because of existing limits on daily range, access to fueling/charging infrastructure, or route length. How many zero emission buses can be operated by fleets depends on a number of factors such as length of bus runs and space limitations for necessary infrastructure. In addition, zero emission technology is expected to continue improving and more and more routes will become practical to serve with zero emission buses. We need to determine how to ramp up zero emission bus purchases over the next 20 years in a manner that provides enough certainty for transit fleets to plan bus purchases, but is structured in a way that is feasible for a transit fleet to continue to meet its customer service needs.

VII. Next Steps

Staff will continue to work to align public incentive funding programs with ACT goals to overcome the cost barriers and ensure program success of widespread adoption of zero emission buses. Staff will also develop a total cost of ownership model and work with transit fleets, vehicle manufacturers and equipment suppliers to determine near term and projected future costs and zero emission bus performance characteristics. After obtaining the necessary information staff can then develop more in depth regulatory concepts and determine how available public funding could be leveraged.

Continuing to work with transit agencies, staff plans to meet with individual transit fleet operators in the next few months to discuss the proposed rule concepts and the needed route information for feasibility of zero emission buses in current transit service.

Staff will then workshop in depth regulatory concepts in the summer of 2015. The current proposed rulemaking schedule involves an update to the Board in September 2015 on the progress and status of the proposed regulation. Staff plans workshop draft regulatory language in the winter of 2015 and to present the proposed regulation to the Board in spring of 2016.

The proposed schedule for this rulemaking is as follows:

Date	**DRAFT Milestones**
Summer 2015	Public Workshops
September 2015	Present update on proposal to Board
Winter 2015	Public Workshops with draft regulatory language
Spring 2016	Present regulatory proposal to Board

Appendix 1

U.S. Department of Transportation

Federal Transit Administration

Administrator

1200 New Jersey Avenue, SE
Washington, DC 20590

SEP 1 2 2014

Ms. Julie M. Austin
Executive Director
Antelope Valley Transit Authority
42210 6th Street West
Lancaster, CA 93534

Dear Ms. Austin:

I am writing in response to your June 19, 2014 letter requesting feedback from the Federal Transit Administration (FTA) on an innovative approach that Antelope Valley Transit Authority (AVTA) is considering for purchasing an electric bus. Specifically, AVTA would like to purchase an electric bus based on a similarly priced clean diesel model and separately lease the battery from the manufacturer for a period of 12 years. As you mentioned in your letter, this approach has the potential to free up cash required for other major capital investments during the period of bus replacements. We appreciate your interest in FTA's capital program requirements and offer the following guidance in response to your particular inquiry.

In general, FTA's grant recipients may enter into a capital lease agreement for acquiring FTA-funded equipment. In accordance with FTA's Third Party Contracting Guidance Circular 4220.1F, grantees must comply with FTA's capital lease regulations, which require a grantee to make a written comparison of the cost of leasing the asset to the cost of purchasing or constructing the asset. See 49 C.F.R. Part 639. Based on the information you have provided, there are no obvious regulatory, statutory, or policy impediments that would preclude AVTA from proceeding with the leasing of the battery component of the bus. Please note, however, that FTA's participation in this procurement action presumes that the solicitation is structured in a manner that fully meets FTA's requirements for full and open competition as well as compliance with Buy America.

I understand that in June you discussed several procurement options for acquiring an electric bus with FTA's Region I Counsel, Wendy Lee. The procurement approach you have presented that includes leasing of the battery is just one of several options available to AVTA to manage its cash flow requirements. If you require further technical assistance, please do not hesitate to contact Ms. Lee at 617-494-2409 or Regional Administrator Leslie Rogers at 415-744-3133.

Sincerely,

Therese W. McMillan
Acting Administrator

cc: Leslie Rogers, Administrator, Region 9
Renee Marler, Regional Counsel, Region 9
Joonsik Maing, Assistant Regional Counsel, Region 9