SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Staff Report

Proposed Rule 1192 – Clean On-Road Transit Buses

June 2000

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INTRODUCTION

The South Coast Air Quality Management District (AQMD) is proposing Rule 1192 (PR1192) which would require fleets with 15 or more public transit vehicles or urban buses, to acquire alternative-fuel vehicles (AFVs) when procuring or leasing these vehicles for operation in the District. The applicability of this proposed rule is limited to vehicles weighing more than 14,000 lbs. gross vehicle weight (GVW, i.e., fully loaded design weight), operated by government agencies or operated by private entities under contract to government agencies, that provide passenger transportation services, including intracity and intercity shuttle services. Examples of transit fleets affected by this proposal include those operated by public transportation agencies, municipalities, and their private contractors, which provide passenger services. The proposed rule does not apply to school buses, long distance (interdistrict) services, or heavy-duty vehicles not used for the express purpose of public transportation. In addition, the rule does not apply to paratransit vehicles or evaluation/test vehicles (within certain limitations).

This proposal is based on Health and Safety Code Section 40447.5, which was promulgated in 1987. Specifically, Health and Safety Code Section 40447.5 allows the AQMD to require operators of public and commercial fleets, consisting of 15 or more vehicles, to purchase vehicles powered by methanol or other equivalently clean burning alternative fuel, when adding or replacing vehicle(s) to their fleet. Section 40447.5 specifically authorizes the AQMD to regulate fleets of 15 or more vehicles, operating substantially in the AQMD. This proposal is also based on Health and Safety Code Section 40919, which allows certain nonattainment air districts (those that are designated serious or above for ozone) to adopt measures requiring fleets to use a significant number of low-emission vehicles.

Despite the significant progress that has been made in reducing both mobile and stationary emissions over the past twenty years, the South Coast Air Basin (Basin), which includes Los Angeles, San Bernardino, Riverside, and Orange Counties, continues to experience extremely serious air quality problems, dominated by motor vehicle pollution. The Basin is still the only area in the country classified by U.S. Environmental Protection Agency (EPA) as an extreme ozone nonattainment area. Based on the latest information available, on-road motor vehicles contribute more than half of all hydrocarbons, oxides of nitrogen, and carbon monoxide to the entire emissions inventory. In addition, on-road motor vehicle pollution, specifically from diesel vehicles, has been identified as the principal source of public exposure to air toxics, based on recent work conducted by the AQMD and other agencies.

This proposed rule is being developed in an effort to reduce public exposure to transit bus emissions. It is intended that these benefits be surplus to existing state and federal regulations governing emission levels from on-road motor vehicles. Many of these fleets emit air emissions, including air toxics, into highly urbanized pedestrian breathing zones, where improvements in air quality are critical given the AQMD's status as an extreme ozone nonattainment area.

Transit buses are targeted in this proposed rule because they are a logical starting point to address public exposure to diesel toxic emissions. In particular, transit bus fleets are well suited towards the use of clean alternative fuel technology, which is an effective strategy to

reduce toxic emission impacts, since many of these fleets are primarily operated in well defined service areas and can be centrally fueled. Many government agencies operating transit vehicles have taken a leadership position in utilizing the cleanest vehicle technologies. These government fleets have implemented policies to purchase and operate clean alternative-fuel vehicles in an effort to improve air quality in their area of operation. For example, the Los Angeles County Metropolitan Transportation Authority adopted its Alternative Fuel Initiative (AFI) in 1993, which directed future transit bus purchases to be that of alternative-fuel buses. Orange County Transportation Authority, Omnitrans, Riverside Transit Agency, and Sunline Transit Agency have instituted similar policies. As a result of these policies, transit bus fleets operating in the District have gained significant experience demonstrating the feasibility of clean alternative-fuel transit vehicles in normal fleet operations. PR1192 builds upon and furthers the progress made by such agencies to lower emissions through the use of alternative fuels. Examples of alternative fuels/technologies that have been, are currently, or are being planned to be, utilized in these fleets, for revenue service and/or evaluation purposes, include compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), propane hybrid-electric, battery-electric, and fuel cells.

Proposed Rule 1192 is one of a series of rules being proposed that affect vehicle fleet operations in the District. The AQMD's objective is to promote the use of less-polluting vehicles to reduce criteria pollutant and toxic emissions.

BACKGROUND

Two important recent efforts to evaluate and identify air toxics include: (1) the AQMD Multiple Air Toxics Exposure Study II (MATES II); and (2) the California Air Resources Board's (ARB's) identification of particulate matter from diesel engine exhaust (as a surrogate for all diesel exhaust emissions including hydrocarbons) as a toxic air contaminant (TAC). The development of this proposed fleet rule is being driven by the results of these two very important research efforts and the need for further criteria pollutant reductions. The development of the fleet rule is also affected by recent state and federal rulemaking efforts and actions that are intended to, or have resulted in, lowering on-road mobile source emissions by reducing tailpipe emissions and/or requiring the sale or purchase of alternative fuel vehicles. Two of the more important rulemaking activities, as well as their significance to Proposed Rule 1192, will be described. They are: (1) the ARB's recently adopted Public Transit Bus Fleet Rule and Urban Bus Engine Standards; and (2) the U.S. Energy Policy Act (EPAct) requirements.

MATES II

In March 2000, the AQMD Governing Board received the final report of the MATES II study. The objectives of this study were to monitor and evaluate urban air toxics, update the toxics emission inventories for the Basin, and conduct air toxic dispersion modeling to simulate the monitored data. During the course of the study, the ARB listed diesel particulate emissions as a toxic air contaminant. As such, the study provided an analysis of the potential air toxic impacts of diesel emissions. The study represented one of the most comprehensive air toxics programs ever conducted in an urban environment. The scope of the study included the monitoring of more than 30 toxic air pollutants at 24 sites over a one-

year period ending in the spring of 1999. The AQMD collected more than 4,500 air samples, and together with the ARB, performed more than 45,000 separate laboratory analyses of these samples.

The findings of this study indicated that the cancer risk from some air toxics in the Basin has declined by as much as 75 percent over the last decade. However, it also showed that based upon more extensive monitoring of the variety of toxic compounds in the air, the current potential cancer risk from toxic air pollution averages about 1,400 in a million in the region. As shown in Figure 1, the study found that about 71 percent of this cancer risk may be attributable to diesel particulate. Other important toxic species contributing significantly to this cancer risk, originating from both gasoline- and diesel-powered mobile sources as well as stationary sources, are 1,3 butadiene (8 percent of risk), benzene (7 percent of risk), and carbonyls, which include formaldehyde and acetaldehyde (3 percent of risk). One objective of proposed Rule 1192, based on the findings of this study, is to reduce the contribution of overall toxic risk of diesel engine exhaust emitted by public transit bus fleets operating in the region, by accelerating the implementation of currently available less-polluting technology.

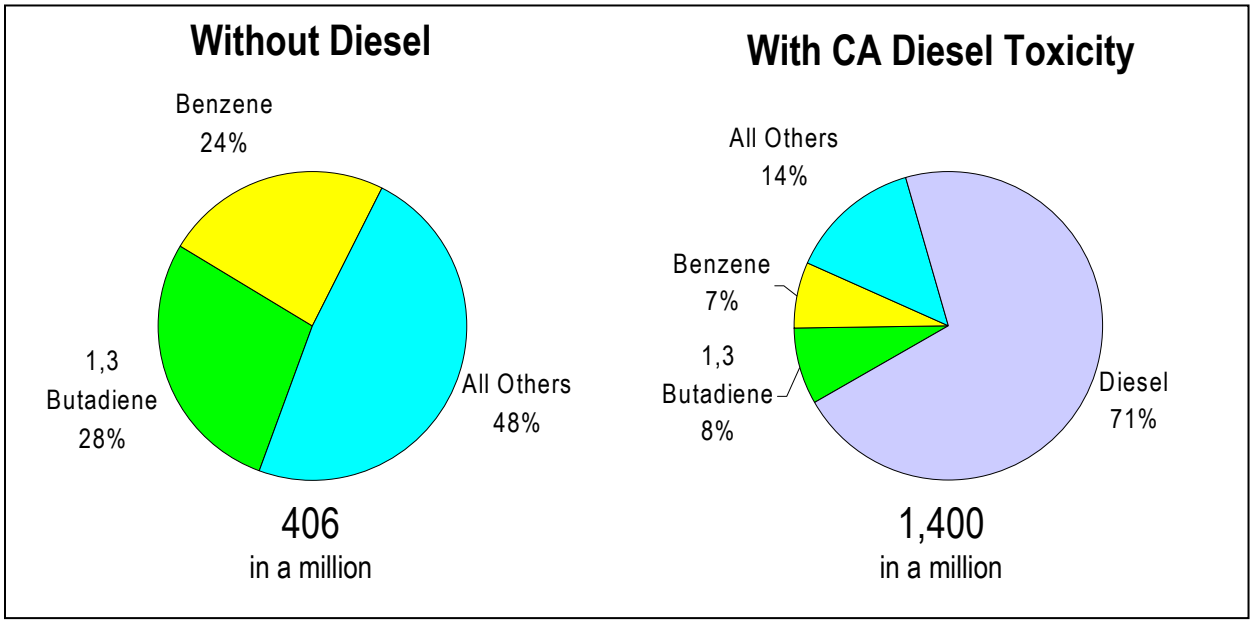


Figure 1
Estimated Average South Coast Air Basin Toxic Risk Contributions
based on Findings from the MATES-II Study

ARB Identification of Diesel Emissions as a Toxic Air Contaminant

In the early 1980s, the ARB established one of the nation's first comprehensive state air toxics programs — the California Air Toxics Program. Its goal is to protect public health by reducing toxic air emissions that pose the highest risk to Californians. This requires two separate steps. During the first step, risk assessment, the ARB identifies the highest risk substances called toxic air contaminants. In the second step, risk management, the ARB and local air pollution control districts investigate and adopt measures requiring air toxics sources to minimize risk to public health.

There are approximately 200 substances on the California TAC list. On August 27, 1998, the TAC list was expanded to include particulate emissions from diesel engine exhaust, culminating a near-decade long scientific investigation into the health effects of exposure to the fine particles and other pollutants in diesel exhaust. Over 30 other chemical species found in diesel exhaust have been identified as toxic air contaminants. Similar to the findings of the MATES II study, the ARB identification of diesel exhaust particulate matter (as a surrogate for all diesel exhaust emissions) as a TAC, provides another driving force for the AQMD to pursue the development of a transit bus fleet rule as a strategy to mitigate public exposure to this pollutant.

ARB's Public Transit Bus Fleet Rule – Summary

On February 24, 2000, the ARB approved a statewide regulation that will reduce the air pollution impacts of large diesel-powered urban transit buses (greater than 33,000 pounds GVW). The regulation specially requires: (1) reductions in PM and NOx fleet emissions by urban transit bus operators; and (2) more stringent exhaust emission standards applicable to engine manufacturers. To implement this regulation, urban transit bus fleet operators are required to choose between two different compliance paths – the diesel path or the alternative-fuel path. Fleet operators must make this decision and notify ARB by January 31, 2001. The ARB staff report supporting adoption of the regulation is contained in Attachment 6.

Summary of Diesel Path Requirements

Fleet operators choosing the diesel path may continue to purchase diesel powered buses; however, these buses must comply with emission standards. As shown in Table 1, these emission requirements specify that the engines meet a PM emission standard of 0.01 g/bhp-hr by October 2002. This emission standard represents an 80 percent reduction compared to the current mandatory standard of 0.05 g/bhp-hr. For the 2004 model year, ARB established an optional NOx emission standard of 0.5 g/bhp-hr for diesel urban bus engines (fleet operators not using 2004 model year urban buses equipped with 0.5 g/bhp-hr NOx certified engines must implement alternative strategies to obtain "greater" emission reductions), and for the 2007 model year, diesel transit bus engines must comply with a 0.2 g/bhp-hr NOx emission standard. These standards represent 87 and 95 percent emission decrease relative to the current 4.0 g/bhp-hr NOx standard, and about 75 and 90 percent NOx emission decrease, relative to the October 2002 NOx+NMHC emission standard of 2.5 g/bhp-hr (equivalent to a nominal 2.0 g/bhp-hr NOx standard, according to the ARB), which is to be met by engine manufacturers complying with the Heavy-Duty Diesel Settlement Agreements. (Reference is made here to the legal settlement between seven heavy-duty engine manufacturers, ARB, and U.S. EPA regarding the use of alternative emission control devices that increased NOx emissions beyond those expected on the Federal Test Procedure.) Engine manufacturers testified at ARB's rule adoption hearing that the 2004 NOx emission standards may not be feasible until 2007.

Transit agencies on the diesel path with more than 200 urban buses in their active fleet (on January 31, 2001) must place into service at least three zero-emission buses (ZEBs) by July 1, 2003, and operate them for a year as a required demonstration project. At least one manufacturer, Ballard Power Systems, expects to commercially produce ZEBs by 2002. These same agencies are also required to purchase (or lease) ZEBs. From model year 2008 through model year 2015, a minimum 15 percent of all new bus purchases (or leases) must be ZEBs for transit agencies on the diesel path. ZEBs must be certified by ARB and are

expected to be powered by fuel cells, electricity, or other fuels that result in zero-emission exhaust levels.

Table 1

Proposed Urban Transit Bus Fleet
Rule Requirements and Emission Standards

	"Diesel" Path		"Alternative-Fuel" Path	
Model Year	**NOx** (g/bhp-hr)	**PM** (g/bhp-hr)	**NOx** (g/bhp-hr)	**PM** (g/bhp-hr)
2000	4.0	0.05	2.5 optional(1)	0.05
10/2002	2.5 NOx+NMHC	0.01	1.8 NOx+NMHC optional(1)	0.03
7/2002	Low-sulfur diesel fuel		Low-sulfur diesel fuel(2)	
10/2002	4.8 NOx fleet average		4.8 NOx fleet average	
2003-07	PM Retrofit requirements		PM Retrofit Requirements	
7/2003	3 bus demo of ZEBs for large fleets (>200)		Not Applicable	
2004	0.5 (3)	0.01	Not Applicable	Not Applicable
2007	0.2	0.01	0.2	0.01
2008	15% of new purchases are ZEBs for large fleets (>200)		Not Applicable	
2010			15% of new purchases are ZEBs for large fleets (>200)	

Notes: Shaded area shows existing requirements and existing optional emission standards

(1) Although transit agencies on the alternative-fuel path are not required to purchase engines certified to these optional standards, the ARB staff expects that they will do so in order to qualify for incentive funding. At present, the only alternative-fuel engines available are certified to optional, lower-emission NOx standards.

(2) Applicable to up to 15% of purchases that may be diesel powered urban buses under the alternative-fuel path.

(3) Optional emission standard. Transit fleets must attain "greater" emission reductions through implementation of alternative strategies if 2004 model year buses are not equipped with 0.5 g/bhp-hr NOx certified engines. Engine manufacturers do not expect NOx control technology to be available in 2004.

Summary of Alternative-Fuel Path Requirements

This path requires at least 85 percent of new transit bus purchases to be alternative-fueled. Alternative fuels are defined as CNG, LNG, LPG, methanol, electricity, fuel cells, or other advanced technologies that do not rely on diesel fuel. As shown in Table 1, the emission standards applicable for alternative fuel path require that engines meet a PM emission standard of 0.03 g/bhp-hr by October 2002. Although this emission standard is numerically less stringent than the corresponding 0.01 g/bhp-hr PM emission standards for the diesel path, ARB still expects PM emission reductions from transit fleets choosing this path. This is because natural gas powered buses have demonstrated in-use PM emissions that are 20 to 100 times lower than their diesel counterparts. By 2007, alternative-fueled transit bus

engines must meet the same PM emission standards as corresponding diesel engines. With regard to NOx emission standards for the October 2002 through 2006 time period, alternative-fueled buses are expected by ARB to meet a 1.8 g/bhp-hr NOx+NMHC optional emission standard (nominal 1.4 g/bhp-hr NOx standard). By 2007, buses of either path must comply with a 0.2 g/bhp-hr NOx standard. The 15 percent ZEB purchase requirement for bus fleets over 200 buses choosing the alternative-fuel path begins in 2010 rather than 2008 for fleets choosing the diesel path.

Summary of Requirements Applicable to Either Path

For either path, ARB requires that transit bus fleet operators achieve emission reductions from their older in-use fleet. This is implemented through a minimum NOx fleet average standard and requirements for PM control. The NOx fleet average standard requires fleet emissions not to exceed 4.8 g/bhp-hr by October 2002, based on new or repowered engine certification standards. Compliance may be achieved through retrofitting or retiring older buses. The PM control requirement basically specifies that buses of a certain age be retrofitted with a system certified by ARB with a control efficiency of 85 percent or greater. Retrofitting must be accomplished between 2003 and 2007, depending on engine model year. ARB also requires that retrofitted buses be powered by a diesel fuel that meets a maximum sulfur content of 15 parts per million. This low-sulfur fuel is essential to ensure the durability of the particulate filters that are expected to be part of the retrofitting hardware.

U.S Energy Policy Act Requirements

The U.S. Energy Policy Act (EPAct – U.S. Code, Title 42, Sections 13211 to 13264) is administered by the U.S. Department of Energy (DOE) and is designed to reduce dependence on foreign oil supplies and increase the use of alternative fuel vehicles. By passing this legislation, Congress recognized that fleets are uniquely suited for introducing new fuel and vehicle technologies. According to U.S. DOE, fleet vehicles typically accumulate higher mileage than private vehicles and are replaced more frequently. As of 1997, federal, state, and alternative-fuel-provider fleet operators have been required to acquire new alternative fuel vehicles as a percentage of new vehicle acquisitions. This percentage starts out at 10 to 33 percent depending on fleet type, and gradually increases over time. EPAct alternative fuel vehicle purchase requirements are 75 percent for federal and state fleets and 90 percent for fuel provider fleets, by the years 2000 and 2002, respectively. Municipal and private fleet operator participation in EPAct is currently in question; U.S. DOE is due to rule on this issue by this year. If these fleets are ultimately included in EPAct, alternative fuel vehicle purchase requirements for these fleet operators will probably begin in 2002.

EPAct requirements are limited to fleets with 50 or more light- and medium-duty vehicles (up to 8,500 lb. GVWR), operating at least 20 of these vehicles in cities that had a population of at least 250,000 at the time of the 1980 U.S. census. In general, urbanized areas within the AQMD meet this criterion and would therefore be subject to EPAct requirements. EPAct defines an alternative fuel as any fuel that is substantially non-petroleum and yields energy security and environmental benefits. Examples of alternative fuels that can be used to power fleet vehicles under EPAct include methanol, ethanol, natural gas, liquefied petroleum gas, hydrogen, and electricity.

EPAct set a regulatory precedent by requiring large-scale purchases of alternative fuel vehicles by government and certain private fleets. The regulations have been in place since 1992, and thus EPAct-affected fleets, which constitute a significant proportion of vehicle

fleets operating in the AQMD, have been preparing for and have been gaining significant experience in the operation of light- and medium-duty alternative fuel vehicles. (It should be noted that fleets affected by EPAct have been utilizing and obtaining compliance credit through the use of alternative-fuel heavy-duty vehicles as well.) In essence, the AQMD's Proposed Rule 1192 builds upon federally mandated alternative-fuel fleet requirements that have been in place for nearly a decade.

Since EPAct requires certain public fleets and some private fleets to purchase alternative fuel light- and medium-duty vehicles and not heavy-duty vehicles, Proposed Rule 1192 has different requirements on transit operators that would require alternative fuel vehicles and would not be considered duplicative as required under Health and Safety Code Section 40727.2

GENERAL DESCRIPTION AND EXPLANATION OF RULE 1192 REQUIREMENTS

Applicability

The rule applies to public transit fleets operating in the AQMD with 15 or more public transit vehicles or urban buses, operated by government agencies or operated by private entities under contract to government agencies, that provide passenger transportation services including intra- and intercity shuttle services. For the purposes of this proposed rule, public transit vehicles include: (1) vehicles having a GVW of at least 14,000 pounds but no greater that 33,000 pounds, that are used for the express purpose of transporting passengers; and (2) buses having a GVW greater than 33,000 pounds GVW that are powered by a heavy heavy-duty diesel-cycle engine, have a load capacity of at least fifteen or more passengers, are intended primarily for intra-city operations, are equipped with quick-operating entrance and exit doors, and have installed equipment for the collection of fares. The second category of buses corresponds to the class of vehicles designated as "urban buses" by ARB and U.S. EPA.

Vehicle Purchase Requirements

The vehicle purchase provisions require affected fleets to purchase buses powered by alternative fuels. Primarily to address financial resource issues among affected fleets, the purchase requirement is divided into two tiers, in recognition that larger transit agencies and/or transit agencies with access to federal and state funding are expected to be better positioned to support a more rapid deployment of alternative-fueled transit buses, compared to smaller transit agencies with fewer financial resources. The first tier is applicable to transit fleet operators consisting of transit districts or included transit districts with 15 or more transit vehicles or urban buses, and municipal or included municipal operators with 100 or more transit vehicles or urban buses. These fleets will be required, upon adoption of the rule, to use alternative-fuel heavy-duty vehicles for all new transit vehicle or urban bus purchases or leases when adding or replacing buses to their vehicle fleet. The definition of an alternative-fuel heavy-duty vehicle is a heavy-duty vehicle or urban bus with an engine that uses compressed or liquefied natural gas, propane, electricity, fuels cells, or other advanced technologies that do not rely on diesel fuel, and meets the emission requirements of Title 13 Section 1956.1 of the California Code of Regulations, adopted as ARB's urban bus

fleet rule on February 24, 2000. (The diesel hybrid-electric technology is not considered an "alternative fuel." See discussion under " Diesel Hybrid-Electric Technology," below.)

The second tier requires that beginning July 1, 2001, for public transit fleet operators that are considered municipal operators or included municipal operators with 15 to 99 transit vehicles or urban buses, all new transit vehicle or urban bus purchases or leases must be alternative-fuel heavy-duty vehicles when adding or replacing buses to their vehicle fleets. Based on input received at transit agency workshops, staff believes that this extra lead-time is appropriate to the address additional time potentially necessary to identify funding sources as well as the construction of necessary infrastructure to support the operation of alternative fuel transit buses.

Exemptions

Because of concerns regarding the model availability of alternative-fuel paratransit vehicles, it is proposed that paratransit vehicles be exempt from the proposed rule. For these purposes, the AQMD considers paratransit vehicles as those that fit the definitions of "general public paratransit vehicle" or "paratransit vehicle" as contained in Sections 336 and 462, respectively, of the California Vehicle Code (CVC). Attachment 5 contains these two CVC definitions.

Additional exemptions for certain types of vehicles are also being proposed, based on input received regarding the impracticality of utilizing alternative fueled vehicles for certain niche vehicle applications, contractual commitments to purchase vehicles prior to rule adoption, as well as for general clarification purposes. These exemptions cover: (1) buses generally equipped with luggage compartments, restrooms and overhead storage that are used for the express purpose of providing long-distance service with destinations outside of the District, (2) evaluation/test vehicles (maximum seven per fleet) provided by or operated by the vehicle manufacturer for testing and evaluation purposes, (3) school buses as defined by the CVC, (4) buses that are not used for the express purposed of public transportation such as employee transportation or transportation of prisoners, and (5) signed contract agreements as of the date of adoption of this rule for the purchase or lease of new transit vehicles or urban buses. (Note that execution of multi-year options in a signed contract would still be subject to the proposed rule.)

ENGINE AND VEHICLE MODEL AVAILABILITY

Alternative-fuel engines used to power urban buses and public transit vehicles are commercially available, and these engines are currently in service in bus fleets operating in the District. Engine manufacturers include, for example, Detroit Diesel Corporation (DDC) and Cummins. A number of transit agencies are currently using alternative-fuel powered urban buses and public transit vehicles, such as Los Angeles County Metropolitan Transportation Authority, Riverside Transit Agency, Sunline Transit Agency, Omnitrans, and the Los Angeles Department of Transportation. Still others, such as Orange County Transportation Authority, Santa Monica Bus Lines, and Culver City Municipal Bus Lines, are planning to convert to or are continuing to implement alternative-fuel vehicles. Based on input from manufacturers, the availability of alternative-fuel bus engines for use in urban bus and other fixed-route transit applications appears assured in the future. Attachment 2 shows

a listing of alternative-fuel engines that are approved for use in California in urban bus applications and public transit vehicle applications (for the latter, medium-heavy-duty engines used to power vehicles weighing 14,000 pounds GVW to 33,000 pounds GVW).

Attachment 3 shows a listing of alternative fuel buses that are commercially available for the 2000 model year, for fixed-route transit buses and urban buses, based on information provided by the Natural Gas Vehicle Coalition. This information indicates that a variety of commercially available natural gas and propane powered buses are available. The Los Angeles Department of Transportation, for example, operates a significant number of propane and CNG vehicles in their operation.

DIESEL HYBRID-ELECTRIC TECHNOLOGY

The AQMD has been requested by various transit districts to include diesel hybrid-electric technology as an allowable "alternative fuel" based on its low emission characteristics and high efficiency. This technology uses a propulsion system consisting of electric traction drive motors, batteries, and a diesel engine/generator set, instead of the conventional engine/transmission combination. Much of this interest has resulted from current demonstration projects that are generating promising results.

Of particular interest is the report issued on February 15, 2000 by the Northeast Advanced Vehicle Consortium that documented emissions testing of diesel hybrid-electric heavy-duty vehicles and corresponding late model diesel and CNG powered buses. The report indicated that the data generated from this testing will serve as a "baseline starting point" to initiate discussions on comparing these three vehicle technologies in terms of efficiency and emission performance. Two different types of hybrid-electric bus models were tested including the Orion VI bus from Orion Bus Industries equipped with a Lockheed Martin Control System powerplant and an RTS bus from Nova Bus Incorporated equipped with an Allison Transmission hybrid powerplant. With respect to the technological and commercial development, the Orion VI bus is considered a "pre-commercial hybrid design" and the RTS bus is considered "proof of concept prototype demonstration vehicle." The CNG buses included in the study were powered by a 1998 model-year Cummins L10 280G engine, and 1998 and 1999 model year DDC Series 50G engines. The diesel bus was powered by a 1998 model year DDC Series 50 engine. Emission testing was conducted using a chassis dynamometer test procedure, and the bus cycles utilized were primarily based on driving patterns experienced in the New York area.

Based on this emission testing, the report generally concluded that diesel hybrid-electric vehicles with particulate traps produced emissions, including particulate matter, that were lower than conventional diesel buses, and comparable to CNG powered buses. The one exception was nitrogen oxides emissions, where the diesel hybrid electric bus emission levels were 20 to 30 percent below corresponding conventional diesel bus levels, and the CNG bus emission levels were 50 to 60 percent below corresponding diesel bus levels.

Although AQMD staff is very encouraged by the above test results in terms of the low-emissions potential of diesel-hybrid electric buses, AQMD believe that it is not appropriate at this time to allow this technology to be included as an "alternative fuel" as part of PR1192, since a specific test procedure has yet to be developed to accurately characterize the emission

levels of this technology. Toward this end, as part of ARB transit bus rulemaking, their Board directed staff to report on the development of a test procedure for the evaluation of hybrid electric emissions by mid-2001. AQMD staff intends to closely monitor and work with ARB staff in this development effort. In addition, as part of the continuing evaluation of this technology, AQMD's Technology Advancement Office plans to issue a Request for Proposals, to be considered for approval by the Governing Board in August or September 2000, to help fund the development and on-road emission testing of various hybrid electric technologies. In the future, should this or any other technology be certified by ARB as an "alternative fuel" or the equivalent, it will be proposed for inclusion in PR1192 through future rule amendments.

SUMMARY OF DATA COLLECTION/ANALYSIS OF FLEET CHARACTERISTICS

Attachment 4 summarizes vehicle population data of transit fleets potentially affected by the proposed rule. These data include information solicited to date from transit agencies and municipalities that operate transit buses for the counties of Los Angeles, Orange, Riverside, and San Bernardino. Staff is attempting to obtain additional transit bus related information from municipalities in Los Angeles County, where there is a large data gap. Based on information obtained, the Los Angeles Metropolitan Transportation Authority is the principal provider of transit services in Los Angeles County. In addition, about 45 local public agencies provide transit services in Los Angeles County as well as Foothill Transit Authority (covering San Gabriel and Pomona Valleys). For the other three counties under AQMD's jurisdiction, regional transit agencies provide nearly all transit bus related services. These include Orange County Transportation Authority, Omnitrans (San Bernardino County), Riverside Transit Agency, and Sunline Transit Agency (Coachella Valley portion of Riverside County).

Based on information solicited from public transportation agencies, there are basically two categories of transit bus operations -- fixed-route and demand-response. Fixed route refers to buses that have pre-designated pick-up and drop-off destinations, and includes the entire category of urban buses and typically the larger buses making up vehicle category defined in the proposed rule as the public transit vehicles. By design, these buses are usually intended to operate in highly populated, congested areas to maximize their usage, consistent with the large passenger capacities of these transit vehicles. Demand response refers to transit vehicles that are sent to specific drop-off and pick-up locations upon rider request, and are usually shared-ride operations. Demand response is also commonly referred to as "dial-a ride." The types of vehicles used in the demand-response mode of operation are usually smaller than their fixed-route counterparts, since they may operate for a significant portion of time in less-traveled residential areas. Examples of these vehicles include minivans that have been adapted for this use as well as specialized vehicles in the 12,000 to slightly over 14,000 pound GVW range that have been specially fitted with a bus body to accommodate 15 to 20 passengers. Vehicles used in the demand-response mode may either be dedicated for transporting elderly and disabled persons for compliance with the Americans with Disabilities ACT (ADA), or may be used for both general public transportation and ADA compliance purposes. (ADA basically requires that all new fixed-route public-transit buses be accessible to, and that supplementary paratransit services be provided for, those individuals with disabilities who cannot use fixed-route bus service.) Some public transit

agencies use the same vehicles for both the fixed-route and demand-response transit operations.

EMISSION BENEFITS

Criteria Pollutants

The goal of the proposed fleet rule is to help ensure that emission reductions are achieved from transit bus operations. These emission benefits are expected to consist of reduced toxic exposure to diesel particulate matter and reduced NOx from primarily urban transit buses weighing more than 33,000 lbs., and to a lesser extent other public transit vehicles weighing between 14,000 and 33,000 lbs. GVWR.

With regard to quantifying surplus emission reductions, the specific rule that affects this quantification procedure to the greatest degree is ARB's Public Transit Bus Fleet Rule and Emission Standards for New Urban Buses (Urban Bus Fleet Rule), adopted February 24, 2000. At the time the emission benefits were first estimated for transit buses as part of the AQMD's Rule 1190 series of proposed fleet rules, there were some uncertainties regarding the specific requirements that would ultimately be adopted by ARB as part of their Urban Bus Fleet Rule, as evidenced by significant changes made to the rule at their public hearing. PR1192's baseline emission benefit calculation methodology has been revised to reflect the requirements in the adopted version of ARB's Urban Bus Fleet Rule. In addition, AQMD staff has requested and received specific emission factors and other relevant input that was used by ARB staff to quantify the benefits from the ARB Urban Bus Fleet Rule. Based on comments received by potentially affected parties regarding the overall consistency in the emissions quantification methodology, AQMD staff utilized these emission factors and other relevant input as part of PR1192's emission benefit quantification methodology. These assumptions and corresponding explanations are listed below along with other relevant assumptions that AQMD staff has developed based on AQMD staff's current state of knowledge and feedback received from organizations reviewing AQMD calculation methodologies.

1. Emission benefits accrue beginning 2002, which is based on a June 2000 implementation date plus an 18-months lead time for the ordering and delivery of buses.

2. Based on input from ARB staff, the ARB Urban Bus Fleet Rule emission benefit methodology is based on a 100 percent of the fleet choosing the diesel path. The effect of PR1192, therefore, will be to basically require affected fleet operators to choose the alternative fuel path. Based on the most up-to-date data that AQMD staff has received from fleet operators, it is estimated that there are approximately 3,400 diesel powered urban buses and another 800 powered by natural gas. For consistency with ARB's calculation, as well as to recognize the alternative-fuel buses that are currently in place, PR1192's emission benefit methodology will be based on the eventual replacement of 3,400 diesel buses with alternative-fuel buses (specifically, natural gas).

3. Only <u>adopted</u> ARB and U.S. EPA emission regulations are considered in PR1192's emission benefit calculation methodology.

4. Standard assumptions for urban buses are used for annual average vehicle miles traveled per bus and bus life, which are 40,000 miles per year and 12 years, respectively.

5. The following NOx emission rates are used for diesel powered urban buses:

Timeframe	Rate	Explanation
2002 - 9/2002	4.0 g/bhp-hr	Mandatory ARB/U.S. EPA Emission Std.
10/2002 - 2003	2.0 g/bhp-hr	Nominal NOx emission level assumed by ARB as the NOx portion of the mandatory 2.5 g/bhp-hr NMHC+NOx emission standard, specified in Urban Bus Fleet Rule.
2004 - 2006	2.0 g/bhp-hr	Based on mandatory ARB combined NMHC+NOx standard of 2.5 g/bhp-hr for diesel urban bus engines.
2007 - 2010	0.2 g/bhp-hr	Mandatory ARB emission standard in specified in Urban Bus Fleet Rule

6. The following NOx emission rates are used for alternative-fuel powered urban buses:

Timeframe	Rate	Explanation
2002 - 9/2002	2.5 g/bhp-hr	Optional NOx emission standard, consistent with ARB's Urban Bus Fleet Rule documentation.
10/2002 - 2006	1.4 g/bhp-hr	Based on discussions and concurrence with ARB technical staff regarding the appropriate nominal NOx emission level that corresponds with the expected certification level of 1.8 g/bhp-hr NMHC+NOx for alternative-fuel urban buses, as indicated in their Urban Bus Fleet Rule documentation.
2007 - 2010	0.2 g/bhp-hr	Mandatory ARB emission standard in specified in Urban Bus Fleet Rule.

7. For the NOx emission benefit calculation, the standard conversion factor ARB has specified for urban bus applications, 4.3 bhp-hr/mi, was utilized.

8. The following PM emission rates are used for diesel powered urban buses:

Timeframe	Rate	Explanation
2002 - 9/2002	0.44 g/mi	Utilized in ARB Urban Bus Fleet Rule, based on National Renewal Energy Laboratory (NREL) data for chassis-based emission testing of diesel urban transit buses, based on input from ARB technical staff.

10/2002 - 2010	0.09 g/mi	Based on input from ARB technical staff, assuming 80 percent reduction in the applicable engine-based PM emission standard will result in corresponding gram per mile emission reductions.

9. Zero to 100 percent of emission reductions associated with ARB's optional 0.5 g/bhp-hr NOx standard for 2004 through 2006 will occur. Based on input from ARB staff, urban bus engine manufacturers are not required to and are not anticipated to certify engines meeting this emission standard. This situation would force affected urban bus fleets to implement alternative strategies to generate these emission reductions, which are uncertain since affected fleets are already constrained relative to actions they could implement to achieve these emission reductions, such as early bus retirement. Based on input from ARB technical staff, these constraints include, for example, the mandatory 4.8 g/bhp-hr NOx fleet average standard that transit fleets already must meet, as well as certain federal rules that transit fleets must comply with in terms of the time period fleet operators must keep their buses in operation. It should be noted that because of these uncertainties, ARB Governing Board, rather than its staff, will consider for approval the first alternative strategy to be proposed by a transit fleet for compliance with this provision of ARBs Urban Bus Rule.

10. The PM emission rate for alternative fuel transit buses, as utilized in ARB's Urban Bus Fleet rule is 0.02g/mi, which is based on NREL chassis dynamometer emission testing of natural gas powered urban buses, based on input from ARB staff.

11. The number of buses weighing 14,000 to 33,000 lbs. GVW operated by fleets potentially affected by PR1192 has not been included, since many of these fleets have not provided requested data to AQMD staff. However, it appears the number of these vehicles is small, possibly adding only a small percentage to the transit bus fleet population.

The year 2010 PM and NOx emission reductions for the urban bus portion of the transit bus fleet, using the above assumptions, are 11 tons PM per year and zero to 197 tons NOx per year. The lower limit of zero tons per year for the NOx emission reduction is based on a determination by ARB staff that the diesel and alternative-fuel paths provide equivalent NOx emission reductions. The upper limit of 197 tons per year of NOx emission reduction is based on ARB staff input regarding the anticipated unavailability of urban buses equipped with 0.5 g/bhp-hr NOx certified engines in the 2004 through 2006 time frame, as well as the uncertain nature of alternative emission control strategies as discussed in assumption 9 above, to be implemented by transit bus fleets. Overall staff believes that the 197 tons per year provides the best estimate for NOx emission reductions for PR1192, surplus to ARB's Urban Bus Fleet Rule. PR1192 will also ensure that there are no unnecessary delays in achieving the emissions reductions attributed to parts of ARB's efforts.

Table 2

Cumulative Emission Benefits (t/yr) 2010	
Particulate Matter	Oxides of Nitrogen
11	197 (maximum)

Table 3 details the specific annual emission reductions used to develop the 2010 emission benefits given in Table 2, with the understanding that emission reductions can continue beyond 2010. AQMD staff believes that the PM emission reduction, though small, is important relative to the fact that diesel particulate emissions are also considered toxic air contaminants.

Table 3

Estimated Annual Emission Reductions

PR1192	Annual Emissions Reductions (tons)			
	Oxides of Nitrogen		Particulate Matter	
Year	current	cumulative	current	cumulative
2002-2003	68	68	4.2	4
2003-2004	32	101	0.9	5
2004-2005	32	133	0.9	6
2005-2006	32	165	0.9	7
2006-2007	32	197	0.9	8
2007-2008	0	197	0.9	9
2008-2009	0	197	0.9	9
2009-2010	0	197	0.9	10
2010-2011	0	197	0.9	11

Air Toxics

Estimated Relative Toxicity of Diesel and Natural Gas Powered Urban Buses.
The relative air toxic risks of diesel and corresponding natural gas urban buses were estimated using an approach based on determining weighted toxic risk factors for the two fuels under consideration. The weighted toxic risk factor is determined by multiplying the individual toxic constituents of the exhaust by their respective cancer potency factor, and then proportionately adjusting these values by an estimated annual mass emission rate of particulate matter (PM) and non-methane hydrocarbon emissions (NMHC). The purpose of this analysis is to use these weighted toxicity factors to estimate the number of natural gas urban buses that would be roughly equivalent to one diesel urban bus based on toxic risk.

For the purposes of this analysis, the toxic component analyzed for diesel urban buses is limited to total PM emissions. This is because ARB staff has indicated that the toxic risk factor for diesel PM already incorporates toxic risks from all other constituents in diesel exhaust. For natural gas urban buses, the relative toxic risk was estimated based on the PM

contribution of nickel and hexavalent chromium emissions, and the NMHC emissions of formaldehyde, acetaldehyde, benzene, and 1,3 butadiene. ARB speciation profiles were used to develop nickel and hexavalent fraction of the natural gas PM exhaust. With regard to NMHC components, a paper from West Virginia University (SAE paper 972971) was used to develop the benzene and 1,3 butadiene NMHC fractions, and an ARB speciation profile from an industrial natural gas-powered internal combustion engine was used to develop the formaldehyde and acetaldehyde NMHC fractions. (The West Virginia University paper provided speciation data generated from a CNG-powered engine used in on-road vehicle applications, but did not specifically include formaldehyde and acetaldehyde data.)

For the purposes of this specific analysis, the annual PM emission rates for diesel and natural gas urban buses were developed using the same assumptions contained in the criteria pollutant benefit methodology. These assumptions include diesel bus emissions of 0.44 g/mi from 2000 to 9/2002 and 0.09 g/mi for 10/2002 and beyond, and natural gas bus emissions of 0.02 g/mi for 2000 and beyond. The annual mass emission rate of NMHC emissions for natural gas engines are highly variable based on input received by engine manufacturers, as evidenced by ARB certification data for natural gas engine families approved for sale in California. For the purposes of this analysis, a range of NMHC emissions was estimated using this certification data. Using this range, which corresponds to 0.3 g/bhp-hr to 0.8 g/bhp-hr, for the 2000-to-9/2002 time period and 0.3 to 0.5 g/bhp-hr for the 10/2002-and-beyond time period, assumed conversion factors of 4.3 bhp-hr/mi for urban buses, and an annual mileage assumption for urban buses (40,000 mi/yr), annual NMHC emissions were determined.

Table 4 shows the annual PM and NMHC mass emission rates, relative toxicity factors for PM and NMHC exhaust components, and the overall weighted toxicity factor. Based on these overall weighted toxicity factors, Table 5 shows the number of CNG urban buses that is roughly equivalent to one corresponding diesel-powered urban bus. The number is equal to the overall weighted toxicity factor for the diesel urban bus divided by the corresponding value for the natural gas urban bus. Different time frames are utilized in this analysis to account for more stringent emission standards for PM, NOx, and NMHC that are implemented in the overall time frame being analyzed.

Based on this analysis, it can be concluded that significant toxic emission benefits will occur on a per vehicle basis from the use on a natural gas urban bus versus a diesel urban bus. Depending on the time frame, one diesel urban bus is estimated to have the same toxicity as up to 95 corresponding natural gas urban buses. It should also be noted that these toxic reductions will mostly occur in the urban areas where MATES II results indicated significant toxic exposure.

Table 4

ESTIMATED RELATIVE TOXIC RISK

POLLUTANT	COMPOUND	2000 THRU 9/2002		10/2002 & LATER	
		DIESEL	CNG	DIESEL	CNG
PM (lb/yr)		38.8	1.8	7.8	1.8
NMHC (lb/yr)		----	114-303	----	114-189
Resultant Emission-weighted Toxicity Risk Factors					
	DIESEL PM[1]	116.3	----	23.3	-----
	METALS[2]	----	0.06	----	0.06
	NMHC[3]	----	1.16-3.09	----	1.16-1.93
OVERALL WEIGHTED TOXIC RISK		116.3	1.22-3.15	23.3	1.22-1.99

1. Based on ARB input, the unit risk factor associated with diesel PM includes toxic risk contributions for all other compounds in exhaust.
2. Toxic risk for PM exhaust in CNG vehicles based on nickel and hexavalent chromium(Cr^{+6}).
3. Toxic compounds in NMHC exhaust emissions for CNG vehicles included in this analysis are formaldehyde, acetaldehyde, benzene, and 1,3 butadiene.

Table 5

ESTIMATED VEHICLE TOXIC RISK RATIO[1]

TIME PERIOD	RISK RATIO	
	MINIMUM	MAXIMUM
2000 thru 9/2002	37	95
10/2002 and later	12	19

1. Number of CNG vehicles equal to one equivalent diesel vehicle based on toxic risk.

COST ANALYSIS

Fleet Cost Impacts and Cost-Effectiveness

The cost impacts of the proposed rule are expected to range from savings to substantial increased costs depending on the individual public agency's experience and circumstances associated with the implementation of alternative-fuel technology. Cost impacts may be incurred through increased purchase, maintenance, building upgrade, and refueling infrastructure costs. These impacts may be largely offset by lower fuel cost, available local, state, and federal funding to cover the purchase cost of alternative fueled buses (for eligible

public agencies), and increased transit bus ridership (experienced by some transit agencies that have advertised the clean air benefits of alternative-fuel buses).

To illustrate the range of cost impacts, Sunline Transit Agency has estimated that their overall costs have decreased by 27 percent through the use compressed natural gas (CNG) urban buses compared to diesel-powered buses. Although not in the District, Sacramento Regional Transit experienced similar cost savings through the operation of their CNG urban buses compared to their diesel powered buses. On the other hand, Los Angeles County Metropolitan Transportation Authority has experienced 40 percent higher operating costs for their 1995 model year CNG buses compared to their diesel counterparts. However, it could be argued that these costs would be reduced in the future since CNG bus/engine technology has improved compared to the current CNG-powered buses that yielded these relatively high operating costs. In addition, staff believes these costs will decrease due to improvement in preventative maintenance and repair practices, and improved repair technician training. On the other hand, diesel technology is about to become more complex, and needed low-sulfur fuel will be more costly.

The socioeconomic report prepared by the AQMD staff provides additional information relative to the costs and potential economic impacts of PR1192. Using the cost impacts ascribed to PR1192 and the emission benefits as detailed above based on best-available information, the cost-effectiveness ranges between $15,000 per ton of emission reduction for the "most likely funding scenario" and $110,000 per ton of emission reduction for the "full-cost scenario." These cost-effectiveness values utilize staff's assessment that PR1192 will achieve emission reductions of 11 tons per year PM and 197 tons per year or NOx for the year 2010.

Funding Programs

Various federal, state and local funding programs are available to assist public transit agencies in the acquisition and operation alternative-fuel buses. These are generally described below; however, a more detailed analysis is included in a socioeconomic report.

Federal Transit Administration (FTA). FTA administers a federal program, Transportation Equity Act for the 21st Century (TEA 21), that will fund up to 83 percent of the purchase of a new urban bus. Congress annually appropriates funds, so the overall amount of federal moneys that can be used for TEA 21 transportation projects is not constant and potentially could be increased to accommodate air quality needs in the District. TEA 21 funding provisions can be characterized by the following sections: (1) Section 5307, formula grant funds are assigned by urban area, and the funds can be used for any transit-related project. In addition, government agencies do not have to apply for these funds; (2) Section 5309, earmarked funds, are allocated by congressional grant for a specific, defined project, through an application process; (3) Section 5308 provides funding for clean buses (no money has yet been allocated through this section); and (4) Congestion Mitigation and Air Quality (CMAQ) are formula grants funds, which can be used for congestion mitigation projects such as new alternative-fuel transit bus purchases. (It should be noted that the CMAQ formula accounts for air quality, so that areas with poorer air quality will receive more funding). Federal funding is not available to all transit agencies in the AQMD. It is distributed to "included operators" in Los Angeles County (see Attachment 4), as well as Orange County Transportation Authority, Riverside Transit Agency, Sunline Transit Agency, and

Omnitrans. Also, local municipal operators in Riverside County have access to federal funding.

State of California Transportation Development Act (TDA). This funding source is available to the same group of transit agency operators that receive federal funding (except Laguna Beach, which is eligible for TDA funding and ineligible for federal funding). It is similar to TEA 21 Section 5307 funding, in that formula allocation is utilized. In addition, the state legislature appropriates TDA funding annually; therefore, it could be increased to accommodate additional funding needs as required by public transit agencies to implement the proposed fleet rule.

Los Angeles County Propositions A and C. All public agencies operating transit vehicles in Los Angeles County receive Proposition A and C funding to support transit bus operations. Proposition A funds can be used for demand-response and fixed-route transit services, while Proposition C funds can be used for street/road improvements and/or transit services. The magnitude of the funding depends on sales tax revenue. This funding source does not contain a mechanism that would provide additional moneys needed for transit agencies to offset costs associated with Proposed Rule 1192 implementation. This is an important issue for the municipal operators that do not have access to federal TEA 21 funding and state TDA funding.

State Energy Program. States will promote the conservation of energy, reduce the rate of growth of energy demand, and reduce dependence on imported oil through the development and implementation of a comprehensive State Energy Program. The State Energy Program is the result of the consolidation of two formula grant programs -- the State Energy Conservation Program and the Institutional Conservation Program. The State Energy Program includes provisions for competitively awarded financial assistance for a number of state-oriented special project activities, including alternative fuels. In addition to funding for special project activities, states may choose to allocate base formula funds to program activities to increase transportation efficiency, including programs to accelerate the use of alternative transportation fuels for government vehicles.

For more information, contact your State Energy Office or the DOE Regional Office for your region, listed under the Points of Contact section for your state, or contact Ron Santoro at DOE Headquarters at (202) 586-8296.

Mobile Source Air Pollution Reduction Review Committee's ***(MSRC)*** *Discretionary Funds*. Thirty percent of the funds collected each year from a $4 surcharge on vehicle registration created by **AB 2766** (Sher) goes to the Mobile Source Air Pollution Reduction Review Committee **(MSRC)** to be used to implement programs to reduce mobile source emissions. Managers of the program have apportioned the available funding into several technology-specific categories, including: heavy-duty vehicles; zero-emission/ultra-low emission vehicles; research, development and demonstration of advanced low-emission transportation technologies; transportation control measures; and intelligent transportation systems.

MSRC has funded a number of projects resulting in the deployment of hundreds of alternative-fuel transit buses operating in the District over the last three to four years. Specifically, the following public agencies have used MSRC funds to subsidize the capital cost of compressed and liquefied natural gas-powered transit buses, and electric/liquefied petroleum gas hybrid transit buses: (1) LACMTA, (2) OCTA, (3) Santa Monica Bus Lines,

(4) Culver City Municipal Bus Lines, (5) City of Glendale, (6) RTA, (7) Omnitrans, and (8) Los Angeles Department of Transportation. To support alternative fuel vehicle operation, MSRC can also fund alternative fuel infrastructure projects and training programs.

The AQMD contact is Ray Gorski (MSRC Technical Advisor) at 909-396-2479.

Carl Moyer Program. The Carl Moyer Program is administered ARB and the California Energy Commission (CEC). ARB and CEC funds are distributed through local air districts. ARB funds are to be used as incentives, in the form of grants for private companies or public agencies operating heavy-duty engines in California, to cover an incremental portion of the cost of cleaner on-road, off-road, marine and locomotive engines. CEC funds are intended to provide limited funding for heavy-duty low emission vehicle fueling infrastructure. For the 1998/1999 and 1999/2000 fiscal years, ARB allocated $11,300,000 and $9,500,000, respectively, to the District, and the CEC allocated $900,000 in the 1999/2000 fiscal year to the District. To date, public transit agencies that have utilized the Carl Moyer program to partly fund alternative fuel transit bus acquisitions include LACMTA, Sunline Transit Agency, and Omnitrans.

The AQMD staff contact is Cindy Sullivan (AQMD) at 909-396-3249.

Local Government Subvention Funds. Forty percent of the **AB 2766** funds collected go to local governments based on a pro-rated share of population and must be used to reduce mobile source emissions. Cities can use their funds to purchase alternative-fuel vehicles or engines. While these funds are used primarily by municipalities for their own projects, these monies can be allocated by the city for public-private partnerships to pursue AFV and EV projects. Funds not expended carry over from year to year.

The AQMD staff contacts are Larry Rhinehart (AQMD) at 909-396-2898 and Oscar Abarca (AQMD) at 909-396-3242.

COMPLIANCE AUDITING AND ENFORCEMENT

PR1192 will require that affected public agencies keep sufficient vehicle data records to document rule compliance, and that these records be maintained for a minimum of two years. The AQMD intends to audit these records, either at the vehicle fleet location or by requesting appropriate documents to be submitted to the AQMD for review. The specific data to be kept for each new vehicle will include the DMV Certificate of Title and registration, vehicle manufacturer, model-year, model, engine family number, and fuel type. If a public agency is found to be in non-compliance with rule requirements, then the public agency will be subject to penalties specified in Health and Safety Code Division 26, Part 4, Chapter 4, Article 3. The AQMD also plans to develop an enforcement guideline document that will stress the implementation of corrective actions by public fleets rather than punitive monetary penalties during the initial years of rule implementation, for first time violators.

PUBLIC COMMENTS

Comments and Responses

The following summarizes significant/common public comments and staff responses regarding the development of Proposed Rule 1192 – Clean On-Road Transit Buses. These comments were received in writing and in discussions at various meetings, including public workshops and focused working group meetings. The AQMD received comments from representatives of local transit agencies and municipal transit operators, as well as other interested parties.

Comment 1. The proposed rule takes away a government agency choice in vehicle purchasing.

Response 1. Proposed Rule 1192 requires affected public agency fleets and private fleets under contract to government agencies to purchase transit vehicles powered by alternative fuels. The intent of the proposal is to ensure the AQMD goal of reducing public exposure to particulate matter emissions from diesel vehicles, as well as reducing nitrogen oxide emissions, while providing adequate model availability to satisfy transit bus fleet requirements. With regard to nitrogen oxide emissions, AQMD staff is particularly concerned about the NOx emission reductions ascribed to the 0.5 g/bhp-hr standard specified in ARB's Transit Bus Fleet Rule under the diesel path. Although diesel transit bus purchases would be prohibited, vehicles powered by natural gas, for example, have been commercially available and used in fleets located in the AQMD since the early 1990s. Nevertheless, it is recognized that there may be insufficient alternative-fuel model availability for certain transit vehicles used in paratransit vehicle applications. In an effort to address this issue, a provision in the proposed rule was included to exempt these vehicles from purchase requirements. Staff is continuing to evaluate this situation and intends to refine the rule language to ensure that alternative-fuel transit bus purchases are required where there is sufficient alternative-fuel model availability.

Comment 2. The proposed rule does not provide adequate funding for the purchase of compliant vehicles. For example, cities in Los Angeles County that rely on Propositions A and C funding do not have access to federal and state funding sources, and will suffer financially if Proposed Rule 1192 is adopted as currently proposed.

Response 2. Staff believes that adequate funding to support the purchase and operation of alternative-fuel transit buses is important for the successful implementation of the rule. The AQMD staff believes that the federal government and the State of California should provide sufficient funding, in combination with local incentive program funds, to support rule implementation. Toward this end, staff is evaluating funding availability, and is working on increasing Carl Moyer Program funds and identifying other funding sources to help support rule implementation.

Comment 3. Model availability for paratransit vehicles powered by alternative fuels may be problematic since none of these vehicles are commercially available at the present time.

Response 3. Proposed Rule 1192 contains provisions that would exempt these vehicles from the purchase requirements. (See response to Comment 1.) Staff may reconsider this exemption if alternative-fuel paratransit vehicles become more widely commercially available in the future.

Comment 4. PR1192 should recognize the proactive efforts that public fleets have implemented to purchase clean alternative-fueled vehicles in recent years, and PR1192 should reflect this in providing compliance credit to these fleets.

Response 4. The AQMD board and staff appreciate the proactive efforts and clean air accomplishments of the transit operators. Their practice of implementing alternative fuel purchasing policies for the last seven years already demonstrates the feasibility of the proposed rule's intent. AQMD has supported these efforts by facilitating the availability and use of incentive funding and by the awarding of Mobile Source Emission Reduction Credits (MSERCs) to offset the costs associated with the use of these vehicles. Given the critical need to move forward to reduce diesel-based particulate matter and nitrogen oxide emissions, staff does not believe that additional compliance credit for past alternative-fuel transit bus purchases is appropriate, since it would detract from the near-term effectiveness of rule implementation.

Comment 5. The penalties associated with noncompliance with PR1192 are not clear.

Response 5. The AQMD intends to enforce PR1192 using its enforcement authority as specified in Health and Safety Code Division 26, Part 4, Chapter 4, Article 3. The AQMD also plans to follow an enforcement guideline document that will stress the implementation of corrective actions by public fleets rather than punitive monetary penalties for first time violators during the initial years of rule implementation.

Comment 6. AQMD's legal authority to regulate fleets may be preempted by the Clean Air Act.

Response 6. PR1192 is not a rule setting motor vehicle emission standards as contemplated by the Clean Air Act's preemption provision, but is a requirement that fleets purchase cleaner vehicles than they may have otherwise purchased in the absence of the proposed rule. Staff believes that such fleet requirements are consistent with the Clean Air Act. It should be noted that the authority being utilized for PR1192 is based on Health & Safety Code sections 40447.5 and 40919. If the Clean Air Act preempts AQMD's authority, then these statutes would be invalid.

Moreover, if this rule were preempted, U.S. EPA is required to waive such preemption pursuant to federal Clean Air Act Section 209 except in

specified circumstances. U.S. EPA waiver of preemption, upon submittal of the rule to U.S. EPA, would fully address this issue.

Comment 7. PR1192 should allow diesel-electric hybrid transit buses to qualify as an alternative-fuel vehicle for rule compliance purposes.

Response 7. Staff is following ARB's recently adopted transit bus fleet rule as it relates to the definition of alternative fuels, which does not include any diesel fuel. Staff is evaluating this issue very closely, and intends to work with ARB to evaluate the inclusion of diesel-electric hybrids as a compliant vehicle.

Comment 8. PR1192 should allow for the use of diesel-powered transit buses where CNG buses or other alternative-fuel buses do not provide sufficient range.

Response 8. Based on transit agency input, the range of current technology compressed natural gas buses is estimated to be at least 320 to 350 miles, which is relatively close to the approximate 400 mile range for corresponding diesel powered buses. Staff is evaluating the range impact issue, but AQMD staff believes that since PR1192 results in the gradual utilization of alternative-fuel vehicles, fleets should be able to accommodate the generally shorter range of CNG transit buses in the near term. In addition, based on input from one-heavy-duty engine manufacturer, further improvements in natural gas heavy-duty engine efficiencies are possible, which should result in continued improvements in CNG bus range. It should be noted that any engine that operates on CNG could also operate on LNG to provide a range approximately equivalent to any diesel bus. The OCTA, for example, when it begins operating LNG buses within the next several months, will be among the many transit agencies around the country, which operate transit buses on LNG.

Comment 9. PR1192 should include language that would allow for the procurement of diesel-powered transit buses in cases of contracts executed prior to the rule effective date.

Response 9. Staff has added such language into PR1192. However, options executed after the rule goes into effect would not be exempt.

Comment 10. PR1192 should consider the use of particulate filter retrofit technology as an alternative method of compliance.

Response 10. Staff is currently evaluating this technology in concert with ARB. For this purpose, staff has recently visited various companies that are commercializing this technology in an effort to obtain the latest information on diesel particulate filters. At this point AQMD staff is waiting for ARB to certify and approve for use in California this technology for various diesel engines used in transit bus applications.

Comment 11. PR1192 is not fuel neutral. Vehicle emission standards should be specified rather than allowable fuels.

Response 11. The AQMD cannot specify vehicle emission standards because of legal restrictions. The AQMD's authority over fleets is primarily based on California Health & Safety Code Section 40447.5, which basically allows the AQMD to require fleet operators of 15 or more vehicles to purchase only vehicles powered by methanol or equivalently clean-burning vehicles. Because of methanol's inherently low particulate matter (PM) emissions when used as a heavy-duty engine application, equivalently clean-burning fuels (including equivalent technologies) have been determined to include CNG, LNG, LPG, battery-electric, and fuel cells. These fuels are also consistent with permitted alternative fuels as contained in ARB's recently adopted Urban Bus Fleet Rule.

Comment 12. PR1192 should allow transit agencies to implement alternative-fuel vehicle purchase requirements one year after rule adoption, rather than immediately upon rule adoption as is currently being proposed.

Response 12. In order to address this issue, staff has modified the proposed rule language to include approximately one year of additional lead-time for municipal operators with 15 to 99 transit vehicles. This modification reflects the additional time these fleets may need to implement the proposed rule.

Comment 13. The definition of "paratransit vehicle" should be clarified, since it does not describe all types of paratransit vehicles being used by transit agencies.

Response 13. In response to this comment, staff has modified the definition of paratransit vehicle to incorporate California Code Sections 336 and 462, which define "General Public Paratransit Vehicle" and "Paratransit Vehicle."

Comment 14. PR 1192 should allow the use of clean-burning diesel vehicles for compliance with the purchase requirement.

Response 14. Staff is evaluating the use of low-sulfur diesel fuel in combination with particulate filter technology as an alternative method of compliance. One of the principal advantages of vehicles powered by alternative fuels, such as natural gas, is their inherently low certification and in-use PM emissions without the use of any aftertreatment devices. This advantage of alternative fuels has to be carefully evaluated relative to PM aftertreatment technology, which has not yet been certified by ARB. In addition, alternative fuels vehicles have lower NOx emissions as well.

Comment 15. The AQMD should not allow small transit bus fleet operators to delay implementation of the proposed rule until July 1, 2001.

Response 15. AQMD staff has received significant comment from a number of small transit bus agencies in the District relative to issues associated with technical and funding resource limitations, as well as the limited or lack of

experience with alternative fuel transit bus operation. In addition, many of these agencies have indicated that they may have to cut back on bus service if forced to prematurely purchase alternative fuel buses. To address these issues, and based on our understanding of which specific transit bus agencies have significant experience with alternative fuel bus operation, AQMD staff has revised PR 1192 to allow these agencies until July 1, 2001 for rule implementation.

Comment 16. The proposed rule is likely to have the effect of slowing fleet conversion and undermining the policy objective of reducing fleet emissions.

Response 16. Staff acknowledges this issue, but it is speculative to assume that this will generally occur throughout affected vehicle fleets. For example, at least two transit agencies have converted or will soon convert a significant portion of their transit bus operation without any resultant decreases in transit bus service. These include Sunline Transit Agency and Orange County Transportation Authority. AQMD staff believe that available funding will play a key role in determining the rate of alternative fuel bus purchases by affected transit agencies. As discussed in the funding section of the staff report, available state and federal funds can be used to help pay for the additional costs of alternative fuel buses relative to their diesel counterparts, and funding is available for infrastructure development as well. Also, CEQA analysis has accounted for this possible effect.

Comment 17. AQMD should conduct site-specific analyses on the environmental and socioeconomic implications of the proposed rule.

Response 17. It is not possible to conduct site-specific analyses for each of the potentially hundreds of fleets affected by Proposed Rule 1192 and other proposed fleet rules. Rather, AQMD staff have developed compendium documents to the staff report -- the Program Environmental Assessment and the Economic Assessment, Assumptions, Funding Sources, and Socioeconomic Report -- which evaluate environmental and socioeconomic impacts of the entire series of proposed rules on an overall District-wide basis. In developing these analyses, AQMD staff solicited a large amount of site specific information regarding fleet vehicle population from potentially affected fleets which was used to develop these two reports but additional information needed for the environmental or socioeconomic assessment would be considered speculative.

Comment 18. The proposed rule will increase CO emissions and hydrocarbon emissions.

Response 18. Diesel engines, because they operate with excess air, produce inherently low CO and hydrocarbon emissions. Natural gas powered engines are also inherently low emitters of CO and hydrocarbons (nonreactive) as well, since this fuel combusts easily during cold start conditions and

nonreactive methane is the primary component of natural gas (i.e., the fuel itself is primarily nonreactive). Overall, based on existing certification emission data, it can be concluded that diesel engines have lower CO and hydrocarbon emission levels based on current technology. However, staff believes that this is not a significant issue since the natural gas CO emissions are substantially below the applicable emission standard. In addition, with the implementation of the 2.5 g/bhp-hr non-methane hydrocarbon + NOx emission standard in October 2002, natural gas engine manufacturers will have to further reduce hydrocarbon emissions to levels that would not be significantly different than corresponding diesel engine levels.

Comment 19. The proposed fleet rule will eliminate MSRC and Carl Moyer monies as potential funding sources to help pay for the increased costs associated with implementation of the proposed rule.

Response 19. With regards to MSRC, this committee has chosen to commit substantial resources to supporting the fleet rules in the upcoming work program. With regards to Carl Moyer, AQMD staff has been evaluating this issue with ARB. Based on CARB's comments, the proposed rule, as crafted, will not eliminate these funding sources from being utilized by affected fleets to help pay for rule implementation costs. This is because the proposed rule does not specify the alternative fuel engine emission compliance level; this level can be designated by MSRC and Carl Moyer for funding justification purposes.

Comment 20. The proposed rule violates interstate commerce laws.

Response 20. AQMD staff disagrees with this comment. The proposed rule affects government agency vehicle fleets whose areas of jurisdiction are within the District boundaries.

Comment 21. The AQMD is inappropriately becoming involved with local fleet government contracts. Specifically, fleets that receive incentive money to help subsidize their operations would have a competitive advantage for receiving a government contract.

Response 21. AQMD staff believes that this is speculative, and it is an issue that can be satisfactorily addressed as part of the funding selection process utilized by the funding source in determining which projects are able to secure monies to help pay for the additional incremental costs associated with alternative fuel vehicle operation.

Comment 22. The proposed rule does not allow sufficient flexibility in achieving air quality goals and limited public transit resources would be used to support the development of alternative fuel technologies.

Response 22. AQMD staff have been sensitive to the needs of public transit agencies in the development of the proposed rule, in an effort to be as flexible as possible while maintaining the air quality goals of the proposed rule. The proposed rule implementation date have been delayed for transit agencies that have more limited access to public funding. AQMD does not expect public transit agencies to support the development of alternative fuel technologies. These technologies are already commercially available and are successfully being used by a number to transit agencies within the AQMD's area of jurisdiction.

Comment 23. The AQMD should adopt a voluntary program in lieu of the current mandatory rule and acquire all funds necessary for the program.

Response 23. AQMD staff believes that this concept is already being implemented with regard to the various government based funding programs (e.g., Carl Moyer, MSRC) being used to solicit voluntary private and public fleet participation in air pollution reduction programs. During the past several years, AQMD staff has been actively involved in attempting to secure the maximum amount of available public funding for use in these voluntary programs. With regard to the proposed rule, AQMD's goal is to achieve further air quality benefits beyond current voluntary efforts by requiring certain fleets to use commercially available clean vehicle technology, that is already being successfully demonstrated within the District. With regard to acquiring all funds necessary for program implementation, as mentioned previously, the AQMD will always strive towards achieving maximum available public funding to help pay for air quality programs, but the AQMD does not have to authority to increase our existing revenue base to the extent necessary to pay for all program costs. In this regard, these rules are not different from the AQMD's stationary source rules, which impose some costs on affected sources.

Comment 24. Government should assert leadership in the campaign to clean air and support alternative fuels and other clean technologies.

Response 24. Staff agrees with the commentator, and this is the primary reason why the proposed rule focuses on public agency transit fleets. Since public funds are primarily being used to support the operation of these fleets, and these fleets are used in highly urbanized areas where these is significant public exposure to their emissions, government agencies should take a leadership position in using clean vehicle technologies.

Comment 25. Diesel vehicle pollution should be reduced through the use of clean fuel vehicles. They are available and cost-effective, and there are significant public monies to help make the transition to cleaner fuels. The use of green diesel technologies is problematic since in use testing demonstrates that add-on technologies for which clean and green diesel technologies depend deteriorate more rapidly that are therefore considered less durable

than clean engines that burn cleanser without the use of add-on technologies. Also, green diesel technology is not certified by ARB and diesel PM is a toxic air contaminant.

Response 25. AQMD staff agrees with the commentator, in that clean fuel technologies are inherently clean, commercially available, currently being successfully demonstrated in the District, and should be used to the maximum extent feasible by public transit fleets operating in the District. Green diesel technology is a promising technology, but the concern, as identified in the comments, is that ARB has not certified its use in California. In addition, green diesel technology, unlike clean fuel technology, will not result in NOx reductions.

Comment 26. The term alternative fuel includes reformulated gasoline and diesel.

Response 26. Under the federal Clean Air Act, Section 241(2) does have a definition of clean alternative fuel that includes reformulated gasoline and diesel. Howver, the Code of Federal Regulations, Section 86.000-02 explicitly excludes gasoline and diesel. Under state law, Title 13, Section 2290 of the California Code of Regulations list alternative fuels explicitly and does not include gasoline or diesel. The AQMD's authority in Section 40447.5 is to require "equivalently clean burning alternative fuel". Diesel is not equivalently clean burning and thus do not meet this test.

Comment 27. The emissions analysis is flawed: it assumes that 100 percent of fleet is diesel, emission rates are prejudicial to diesel fuel and favorable to alternative fuel, assumes that the 0.5 g/bhp-hr NOx standard or equivalent emission reductions will not be enforced by ARB, and the toxicity analysis is flawed.

Response 27. AQMD staff disagrees with the commentator. The emissions analysis does not assume that 100 percent of the fleet is diesel powered. ARB survey data was used to help determine the alternative fuel vehicle penetration, and these vehicles were not used to development the emission reduction potential of the proposed rule. With regard to the 0.5 g/bhp-hr NOx standard or equivalent emission reductions, AQMD staff believes that ARB will enforce this provision of their urban bus fleet rule to the maximum extent feasible, but it should be noted that engine manufacturers do not have to comply with 0.5 g/bhp-hr NOx standard, and the ability of affected fleets to achieve equivalent emission reductions is not assured, based on ARB staff input, due to other competing urban bus fleet rule requirements and federal requirements. In addition, engine manufacturers testified at the ARB Hearing on the Transit Bus Rule that the 0.5 g/bhp-hr NOx requirement will not be met by 2004. With regard to the toxicity analysis, AQMD staff has attempted to use the best available information to develop the comparison between diesel and natural gas buses based on toxic risks, and has clearly outlined the assumptions used in this analysis.

AQMD staff believes that this information is sufficient to support the overall conclusion that the toxic risk associated with diesel buses is significantly higher than corresponding natural gas buses. As new information becomes available, AQMD staff intends to revise this analysis as necessary in an effort to provide the public and affected organizations with the best available information on this issue.

Comment 28. The proposed rule should only apply to centrally fueled fleets.

Response 28. AQMD staff agrees that the applicability of the proposed rule should consider centrally fueled fleets as a criterion for developing the scope of the rule, as well as assuring that the rule's applicability is as wide as possible in order to maximize the emission reduction potential of the proposed rule. Central fueling capability was one of the main considerations for limiting the scope of the proposed rule to public transit fleets, which are primarily centrally fueled. However, fleets that are capable of using clean alternative fuels, even if not currently centrally fueled, should still be required to comply.

SUMMARY AND DRAFT FINDINGS

Summary

Proposed Rule 1192 is part of the AQMD's strategy to attain federal and state ambient air quality standards. Long-term air quality benefits are expected from attaining and maintaining the ambient air quality standards for particulate matter, nitrogen dioxide, and ozone. Improved air quality will ultimately reduce negative public health impacts from these criteria pollutant. Moreover, Proposed Rule 1192 will reduce toxic emissions from transit buses in the District's most heavily populated areas.

Proposed Rule 1192 is technologically feasible and cost-effective, while reducing particulate matter and nitrogen oxide emissions from diesel-powered vehicles; and the proposed rule addresses concerns raised by the public, wherever possible. Therefore, staff recommends the adoption of Proposed Rule 1192.

These findings are being made in compliance with state law requirements.

Draft Findings Required by the California Health and Safety Code

Health and Safety Code Section 40727 requires the AQMD to adopt written findings of necessity, authority, clarity, consistency, non-duplication and reference.

Necessity - The emission reductions associated with Proposed Rule 1192 are needed for the following reasons:

a) State and federal health-based ambient air quality standards for particulate matter and ozone are regularly and significantly violated in the South Coast Air Basin. The reduction of particulate matter and nitrogen oxide emissions from diesel powered vehicles from Proposed Rule 1192 is needed to meet federal and state air quality standards.

b) By exceeding state and federal air quality standards, the health of people within the South Coast Air Basin is impaired.

c) By exceeding state and federal air quality standards, the quality of life is reduced in the South Coast Air Basin in numerous respects.

d) The California Clean Air Act (CH&SC Section 40910 et seq.) requires that the air districts make every effort to attain federal and state ambient air quality standards as soon as practicable. Proposed Rule 1192 makes progress toward that goal. Section 40919 requires air districts to include measures in their plans to achieve the use of a significant number of low-emission vehicles in fleets.

e) About 71 percent of cancer risk from air toxics is attributed to diesel particulate emissions, which would be reduced by the proposed rule.

Authority - The AQMD Board obtains its authority to adopt, amend, or repeal rules and regulations from Health & Safety Code Sections 40000, 40001, 40440, 40441, 40447.5, 40463, 40702, 40725 through 40728, and 40910 through 40920.5, inclusive.

Clarity - The AQMD Board determines that Proposed Rule 1192 is written or displayed so that its meaning can be easily understood by persons directly affected by it.

Consistency - The AQMD Board determines that Proposed Rule 1192 is in harmony with, and not in conflict with or contradictory to, existing federal or state statutes, court decisions, or regulations.

Non-Duplication - Proposed Rule 1192 does not impose the same requirements as any existing state of federal regulation and is necessary and proper to execute the powers and duties granted to, and imposed upon, the AQMD.

Reference - In adopting this proposed rule, the Board references the following statutes which the AQMD hereby implements, interprets or makes specific: H&S Code Sections 40001 (rules to achieve ambient air quality standards), 40440(a) (rules to carry out AQMP), and 40447.5(a) (rules to require fleets of 15 or more vehicles operating substantially in the AQMD to purchase vehicles powered by methanol or other equivalently clean burning alternative fuel when adding or replacing vehicles), 40919(a)(4).

ATTACHMENT 1

PROPOSED RULE LANGUAGE

PROPOSED RULE 1192 IS PROVIDED IN AN EARLIER PART OF THE BOARD PACKAGE AND WILL BE INSERTED HERE UPON ADOPTION BY THE AQMD GOVERNING BOARD.

ATTACHMENT 2

2000 ON-ROAD HEAVY-DUTY ENGINES FOR TRANSIT BUSES

Attachment 2

2000 On-Road Heavy-Duty Engines for Transit Buses

Mfr	Engine Family	MAX BHP	FUEL TYPE	Service Class	THC	NMHC	CO	NOx	Opt NOx	PART
IMPCO	YTJXH07.4502	224	LPG	MHD	0.7	0.6	5.3	1.5		
IMPCO	YTJXH07.4505	229	LPG	MHD	0.7		20.6	0.8	1.5	
GM	YGMXH05.7582	255	GAS	MHD	0.3		4.9	2.4		
GM	YGMXH07.4502	270	GAS	MHD	0.6		8.9	1.5		
GM	YGMXH07.4503	290	GAS	MHD	0.6		11.1	3.9		
GFI	YG9XH06.88CP Dual-Fuel	310	GAS	MHD	0.1	0.1	2.4	0.5		
			LPG	MHD	0.3	0.3	4.1	1.3		
FORD	YFMXH05.4CF5	255	GAS	MHD	0.12		2.24	1.01		
FORD	YFMXH06.8BHF	310	GAS	MHD	0.157		2.6	0.407		
FORD	YFMXH06.8CF5	305	GAS	MHD	0.153		2.49	0.439		
Baytech	YBYTH05.7050 Dual-Fuel	211	NG	MHD	1.4	0	5.9	1.3		
		245	GAS	MHD	0.3	0.2	1.5	1.3		
Baytech	YBYTH05.7ILV	211	NG	MHD	1.4	0	5.9	1.3	1.5	
Baytech	YBYTH05.7LEV Dual-Fuel	245	GAS	MHD	0.3	0.2	1.5	1.3	1.5	
		211	NG	MHD	1.4	0	5.9	1.3	1.5	
Baytech	YBYTH05.7ULV Dual-Fuel	211	NG	MHD	1.4	0	5.9	1.3	1.5	
		245	GAS	MHD	0.3	0.2	1.5	1.3	1.5	
Deere	YJDXH08.1003	254	NG	MHD		0.4	1.8	2.2	2.5	0.02
Deere	YJDXH06.8004	239	NG	MHD		0.3	1.9	2.4	2.5	0.04
Deere	YJDXH08.1001	247	NG	MHD		0.4	2.2	2.6		0.05
Deere	YJDXH06.8002	229	NG	MHD		0.48	2.8	3.2		0.07
DDC	YDDXH08.5FJF	275	NG	UB		0.8	2.2	1.5		0.01
DDC	YDDXH08.5FJG	275	NG	UB		0.8	2.2	1.5	2.5	0.01
DDC	YDDXH12.7FGF	330	NG	UB		0.6	1.87	1.99		0.019
DDC	YDDXH12.7FGF	330	NG	UB		0.8	2	2		0.02
DDC	YDDXH12.7FGG	330	NG	UB		0.8	2	2	2.5	0.02
Cummins	YCEXH0359BBL	195	NG	UB	0.8		1	2.3	2.5	0.01
Cummins	YCEXH0505CBJ	275	NG	UB		0.2	0.6	1.7	2.5	0.01
Cummins	YCEXH0359BBK	230	NG	UB		0.06	2.7	1.83	2.5	0.02
Cummins	YCEXH0505CBI	275	NG	UB		0.6	0.9	1.837	2.5	0.02
Cummins	YCEXH0505CBG	275	NG	UB		1.1	7.1	2.19		0.07
Cummins	YCEXH0359BBJ	230	NG	UB	0.1		7.2	2.72		0.08

Dual-Fuel identifies engine families certified to operate on either of the two fuels designated.

ATTACHMENT 3

NATURAL GAS BUSES

– AVAILABLE –

Attachment 3

Natural Gas Buses

– Available –

Manufacturer	Model	Engine	GVWR (lbs)	Bus Length	ADA
Blue Bird Corp	QBRE Q Bus	Cummins 5.9BG or J Deere 6.8L or 8.1L	30,000 - 36,000	29 - 37	
Blue Bird Corp	CSRE Commercial Series	Cummins 5.9BG or J Deere 6.8L or 8.1L	30,000 - 36,000	32 - 39	
Blue Bird Corp	C1FE Transhuttle	Cummins 5.9BG in CNG or LNG	24,000 - 25,000	25	
Blue Bird Corp	CSFE Commercial Series	Cummins 5.9BG in CNG or LNG	30,000 - 36,000	25 - 37	
Boyertown Trolley Co	Bus/Trolley/Step Van Bodies	Cummins or DDC	35,000		
Champion Bus Inc	Crusader Bus (Ford E-350)	5.4L V8 Ford CNG or LPG	11,500	21	
Champion Bus Inc	Challenger GT Bus	5.7L V8 Chevrolet CNG or LPG	12,300	21 - 28	
Champion Bus Inc	Contender Mid-Size Coach	Cummins B5.9G LNG, CNG, or LPG	31,000	28 - 30	
Champion Bus Inc	Commodore Bus	5.7L V8 Chevrolet CNG or LPG	14,100	25 - 27	
Champion Bus Inc	CTS Bus	Cummins 5.9L CNG or LPG	19,000 - 25,000	26 - 29	
Champion Bus Inc	SoLo Low-Floor Bus	Cummins 5.9L CNG or LPG	31,000	31	
Chance Coach Inc	American Heritage streetcar	CNG	29,500	28	Yes
ElDorado National	Transmark 29/32 Bus Conventional Floor	Cummins 5.9 or 8.3 CNG or Propane		29 - 32	Yes
ElDorado National	E-Z Rider 30 Bus, Low Floor	Cummins 5.9 or 8.3 CNG, LNG or LPG		30	Yes
ElDorado National	MST 28/30 Bus Conventional Floor	Cummins 5.9 CNG or Propane	19,000	24 - 28	Yes
Ford Motor Co	Econoline Dedicated Van E-250, E-250 extended, E-350 super-duty	5.4L Triton V8 Meets CA SULEV	9,300		
Ford Motor Co	Econoline Dedicated Van E-450	5.4L V8	14,050		
Freightliner Custom Chassis Corp	MB-19 Shuttle Bus Chassis GVWR 19,000 lb	Cummins B5.9G	19,000		
Freightliner Custom Chassis Corp	MB-55 Shuttle Bus Chassis GVWR 20,500 - 25,500 lb	Cummins C5.9G Range 300+ miles	20,500 - 25,500		
Neoplan USA Corp	AN 440 Transliner Low-Floor Bus	CNG			
Neoplan USA Corp	AN 440 Transliner Standard-Floor Bus	CNG			
Neoplan USA Corp	AN 340/345 Metroliner High-Floor Coach	CNG			
Neoplan USA Corp	AN 460 Articulated Bus	CNG			

Attachment 3 (continued)

Natural Gas Buses

– Available –

Manufacturer	Model	Engine	GVWR (lbs.)	Bus Length	ADA
New Flyer of America	C30LF Transit Coach, low flr	CNG		30	
New Flyer of America	C35LF Transit Coach, low flr	CNG or LNG		35	
New Flyer of America	C40LF Transit Coach, low flr	CNG or LNG		40	
New Flyer of America	C40HF Transit Coach, high flr	CNG or LNG		40	
North American Bus Industries (NABI)	40 LFW Transit Bus	DDC S50G or Cummins C8.3G	40,600	40	
North American Bus Industries (NABI)	35 LFW Transit Bus	DDC S50G or Cummins C8.3G	40,600	35	
North American Bus Industries (NABI)	45 LFW Transit Bus	DDC S50G or Cummins C8.3G	40,600	45	
North American Bus Industries (NABI)	60 LFW Transit Bus	DDC S50G or Cummins C8.3G	66,600	60	
Nova Bus	RT 82 NFD V-Drive Bus LNG, roof or under-floor CNG	DDC Series 50G or Cummins 8.3			
Nova Bus	RT 82 WFD V-Drive Bus LNG, roof or under-floor CNG	DDC or Cummins			
Nova Bus	RT 82 WFD T-Drive Bus roof-mounted CNG or LNG	DDC or Cummins			
Nova Bus	RT 72 NFD Bus LNG, roof or under-floor CNG	DDC or Cummins			
Nova Bus	RT 72 WFD V-Drive Bus LNG, roof or under-floor CNG	DDC or Cummins			
OmniTrans Distributing Inc	Cutaway Shuttle Bus CA ULEV, low NOx	5.7L Chevrolet/GMC CNG	12,000 - 16,000		
OmniTrans Distributing Inc	GM Passenger Van CA ULEV, low NOx	5.7L Chevrolet/GMC CNG	12,000 - 16,000		
OmniTrans Distributing Inc	Chevrolet Suburban 2500 CA ULEV, low NOx	5.7L Chevrolet/GMC CNG	12,000 - 16,000		
OmniTrans Distributing Inc	Workhorse Bus Body P-Chassis	5.7L CA ULEV, low NOx	14,500		
Orion Bus Industries	Transit Bus	Cummins B Series	41,000	21 - 26	
Orion Bus Industries	Transit Bus	Cummins L10G or DDC Series 50G	41,000	30 - 40	
Orion Bus Industries	Low-Floor Transit Bus	Cummins L10G	41,000	40	
Spartan Motors Chassis Inc	TB Rear-Engine Bus Chassis Transit-shuttle	Cummins 195-250 hp	26,000 - 36,200		
Spartan Motors Chassis Inc	SLF Super Low Floor Bus Chassis, Transit-shuttle	Cummins 195-230 hp	31,000 - 34,000		
Spartan Motors Chassis Inc	SP Front-Engine Bus Transit shuttle, Trolley	Cummins 195-230 hp	24,000 - 36,200		
Supreme Corp / Specialty Vehicles Inc	Classic American Trolley Tour Shuttle bus	Cummins B5.9 195G	20,500 - 25,500		
United Bus Corp	Braun/Ford Transit Van 15 person capacity	5.4L, 200-mi range	9,400	23	Yes

ATTACHMENT 4

TRANSIT BUS/VEHICLE POPULATION PROFILE

Transit Bus/Vehicle Population Profile –
For Government Agencies Potentially Affected by PR1192
Fleet Characteristics as of: 5/16/2000

GOVERNMENT AGENCY	TOTAL	TRANSIT BUS (14,000 - 33,000 lb. GVW)														URBAN BUS						
	NUMBER	Fixed-Route Fleet							Demand Response/Dial-a-Ride Fleet[1]							Fixed-Route Fleet						
	VEHICLES	Gasoline	Diesel	Meth	LPG	CNG	LNG	EV	Gasoline	Diesel	Meth	LPG	CNG	LNG	EV	Gasoline	Diesel	Meth	LPG	CNG	LNG	EV
Los Angeles County - Included Operators																						
Arcadia Dial-a-Ride	18								18													
Claremont Dial-a-Ride	3								3													
Commerce Municipal Bus Lines	20																20					
Culver City Municipal Bus Lines	42																22			20		
Foothill Transit	259																259					
Gardena Municipal Bus Lines	59																59					
La Mirada Dial-a-Ride	0																					
Long Beach Transit	216																211			5		
Los Angeles DOT[2]	313	31	91		40	41		8									102					
Los Angeles County MTA	2,355																1,680			675		
Montebello Bus Lines	54																54					
Norwalk Transit System	27																27					
Redondo Beach Wave	2								2													
Santa Clarita Transit	54																54					
Santa Monica Bus Lines	170																167			3		
Torrance Transit System	70																69					1
Los Angeles County - Not-Included Operators																						
City of Alhambra	13					5			8													
City of Azusa	2		2																			
City of Baldwin Park	0																					
City of Bellflower[3]	-																					

GOVERNMENT AGENCY	TOTAL NUMBER VEHICLES	TRANSIT BUS (14,000 - 33,000 lb. GVW)															URBAN BUS						
		Fixed-Route Fleet							Demand Response/Dial-a-Ride Fleet[1]							Fixed-Route Fleet						
		Gasoline	Diesel	Meth	LPG	CNG	LNG	EV	Gasoline	Diesel	Meth	LPG	CNG	LNG	EV	Gasoline	Diesel	Meth	LPG	CNG	LNG	EV
City of Bell Gardens[3]	-																					
City of Beverly Hills[3]	-																					
City of Burbank	4							4														
City of Carson	2									2												
City of Cerritos[3]	-																					
City of Compton	12		6						6													
City of Cudahy[3]	-																					
City of Downey	0																					
City of Duarte[3]	-																					
City of El Monte[3]	-																					
City of Glendale	27				11	16																
City of Inglewood[3]	-																					
City of La Canada Flintridge	1					1																
City of Lawndale	1								1													
County of LA (unincorp.)[3]	-																					
City of Lynwood[3]	-																					
City of Monterey Park	11		7						4													
City of Paramount	2	1				1																
City of Pasadena	15		13		2																	
Pomona Valley Transportation Authority	3								3													
City of Rosemead	0																					
City of Santa Fe Springs	2		1							1												
City of Sierra Madre	2	2																				
City of Temple City	0																					
City of West Covina	0																					
City of West Hollywood	0																					
City of Westlake Village	3		3																			

City of Whittier	5		5																			

GOVERNMENT AGENCIES	TOTAL	TRANSIT BUS (14,000 - 33,000 lb. GVW)															URBAN BUS						
	NUMBER	Fixed-Route Fleet							Demand Response/Dial-a-Ride Fleet[1]							Fixed-Route Fleet						
	VEHICLES	Gasoline	Diesel	Meth	LPG	CNG	LNG	EV	Gasoline	Diesel	Meth	LPG	CNG	LNG	EV	Gasoline	Diesel	Meth	LPG	CNG	LNG	EV
Orange County																						
OCTA	705									225							480					
City of Laguna Beach	10	6			2			2														
San Bernardino County																						
MARTA	5	5																				
Omni-Trans	245								40				48			4	122			31		
Riverside County																						
Sunline Transit Agency	67												20							47		
Riverside Transit Authority	90																65			25		
City of Banning[4]	8								3	1			4									
City of Beaumont[5]	7			2						5												
City of Corona	5												5									
City of Riverside	2								2													
TOTAL	**4,941**	**45**	**128**	**2**	**55**	**64**	**0**	**14**	**90**	**234**	**0**	**0**	**77**	**0**	**0**	**4**	**3,391**	**0**	**0**	**806**	**0**	**1**

[1] A majority of vehicles would be considered paratransit vehicles and exempt from the proposed rule language.
[2] Los Angeles DOT operates 8 hybrid (electric/propane) buses in its Fixed-Route fleet.
[3] Agency has been contacted but no information has been received yet.
[4] Operates both Dial-a-Ride and Fixed Route services.
[5] Operates 5 of the buses for both Dial-a-Ride and Fixed Route services.

Updated 5/16/2000

ATTACHMENT 5

CALIFORNIA VEHICLE CODE DEFINITIONS – FOR "GENERAL PUBLIC PARATRANSIT VEHICLE" AND "PARATRANSIT VEHICLE"

336. “General public **paratransit vehicle**” means any motor **vehicle** designed for carrying no more than 24 persons and the driver, that provides local transportation to the general public, including transportation of pupils at or below the 12th-grade level to or from a public or private school or school activity, under the exclusive jurisdiction of a publicly owned and operated transit system through one of the following modes: dial-a-ride, subscription service, or route-deviated bus service. Vehicles used in the exclusive transportation of disabled persons as defined in Section 99206.5 of the Public Utilities **Code**, or of persons 55 years of age or older, including any persons necessary to provide assistance to these passengers, are not general public **paratransit** vehicles. However, transportation of attendants, companions, or both traveling together with those individuals with disabilities who are determined to be eligible for complementary **paratransit** services in accordance with Title II of the Americans with Disabilities Act of1990 (Public Law 101-336) and federal regulations adopted pursuant thereto, shall not be sufficient to qualify a **vehicle** as a general public **paratransit vehicle**. A **vehicle** that provides local transportation for the general public through one of the following modes: dial-a-ride, subscription service, or route-deviated bus service, but does not provide transportation of pupils at or below the 12th-grade level to or from a public or private school or school activity, is a transit bus, as defined by Section 642, and is not a general public **paratransit vehicle**.

462. A “**paratransit vehicle**” is a passenger **vehicle**, other than a bus, school bus, school pupil activity bus, youth bus, general public **paratransit vehicle**, or taxicab that is both of the following: (a) (1) Operated for hire by a business, nonprofit organization, or the state, or a political subdivision of the state utilizing drivers who receive compensation for their services and who spend a majority of their workweek operating a passenger **vehicle**. (2) For the purposes of this subdivision, compensation does not include reimbursement to volunteer drivers of the cost of providing transportation services at a rate not greater than that approved by the United States Internal Revenue Service for volunteers. (3) For the purposes of this subdivision, “for hire” means that the entity providing transportation services is compensated for the transportation under contract or agreement. (b) Regularly used to provide transportation services to any of the following: (1) Handicapped persons, as defined in Section 99206.5 of the Public Utilities **Code**. (2) Persons with a developmental disability, as defined in subdivision (a) of Section 4512 of the Welfare and Institutions **Code**. (3) Individuals with disabilities who are determined to be eligible for complementary **paratransit** services under Title II of the Americans with Disabilities Act of 1990 (P.L. 101-336). (4) Persons who are 55 years of age or older.

ATTACHMENT 6

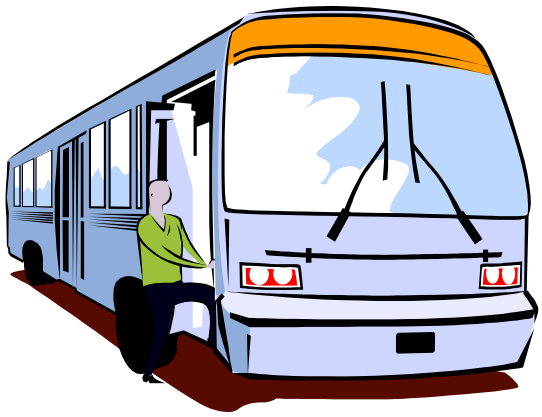
ARB STAFF REPORT
FOR A PUBLIC TRANSIT BUS FLEET RULE
AND EMISSION STANDARDS FOR NEW URBAN BUSES

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS

PROPOSED REGULATION FOR A PUBLIC TRANSIT BUS FLEET RULE AND EMISSION STANDARDS FOR NEW URBAN BUSES



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Date of Release: December 10, 1999
Scheduled for Consideration: January 27, 2000

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EXECUTIVE SUMMARY

The Air Resources Board's (ARB) major goal is to provide clean, healthful air to all the citizens of California. The staff's proposal for clean public transportation is an important step in achieving this goal. Public transportation provides important societal benefits. It provides access to work and education, reduces congestion, and meets the mobility needs of the public, including the elderly and disabled. It also has the potential to positively impact air quality. To do so, however, transit agencies must use the lowest-emission technology available to reduce ozone-forming emissions and reduce the public's exposure to cancer-causing pollutants, such as diesel particulate matter (PM). The ARB identified PM from diesel-fueled engines as a toxic air contaminant in August 1998. Current diesel urban buses usually emit more emissions of oxides of nitrogen (NOx) and PM than if all bus riders were driving separately. However, significant improvements in heavy-duty vehicle technology can result in clean public transportation and help reduce the public's exposure to harmful PM emissions. By taking advantage of engine improvements and new aftertreatment technologies, transit agencies and the ARB can be partners in achieving new air quality benefits from public transportation.

In September 1998, the ARB adopted Resolution 98-49 to encourage public agencies to purchase cleaner, alternative-fuel buses to reduce emissions and decrease the public's exposure to toxic air contaminants. Compared to conventional diesel technology, natural gas technology has already shown in-use emission reductions in the range of 50 percent for NOx and 90 percent for PM. Further advances in alternative-fuel technology, including hybrid-electric, battery-electric, and fuel cell technology, will provide even more opportunities for emission reductions from urban transit buses. Many transit agencies have been active in implementing the goals set forth in the resolution; others have not. As a result, additional strategies, in the form of this regulatory proposal, are necessary to achieve emission reductions from urban buses.

Summary of Proposal

This regulatory proposal contains two elements to reduce emissions from urban buses: 1) a multi-component transit bus fleet rule applicable to transit agencies; and 2) more stringent emission standards for engines used in urban buses, applicable to engine manufacturers. The fleet rule is designed to achieve nearer-term emission benefits while the engine standards are designed to achieve long-term emission benefits resulting from new bus engines with ultra-low, near-zero, and zero-emissions.

The staff's proposal is structured to encourage transit agencies to voluntarily purchase cleaner alternative-fuel buses in order to reduce emissions of NOx and PM. To provide transit agencies with flexibility in determining their optimal fleet mix, the proposed rule allows transit agencies to choose between two compliance paths, either the diesel path or the alternative-fuel path.

The two-path system provides flexibility to transit agencies in making independent decisions for their region, while ensuring that maximum emission benefits are achieved.

The alternative-fuel path provides immediate NOx and PM emissions benefits, although the two paths have been structured to provide approximately equivalent NOx emissions over the lifetime of the requirements. The alternative-fuel path will provide greater PM emission benefits due to inherently low in-use PM emissions from alternative-fuel buses. Transit agencies on the diesel path would be responsible for being the first to implement low-emission and zero-emission buses.

Within the two paths, the staff is proposing a comprehensive transit bus program that encompasses a combination of different requirements. In total, these requirements will ensure low-emission public transportation within California. These requirements include: 1) an in-use NOx fleet average requirement that will encourage the retirement of the oldest, dirtiest diesel buses (1987 and earlier model year urban buses); 2) a PM retrofit requirement, with an emphasis on the dirtiest buses, to reduce public exposure to toxic diesel PM emissions; 3) a low-sulfur diesel fuel requirement; 4) low-emission bus purchase requirements, based on new urban bus emission standards; 5) a zero-emission bus demonstration project; and 6) zero-emission bus purchase requirements. A brief summary of each of these proposed requirements is presented below.

In-use NOx fleet average

In order to reduce NOx emissions from the in-use urban bus fleet, the ARB staff proposes that transit agencies on both the diesel and alternative-fuel paths must meet and maintain a minimum fleet average NOx standard of 4.8 grams per brake horsepower-hour (g/bhp-hr) by October 2002.

PM Retrofit Requirements

The PM retrofit requirements, applicable to transit agencies on both the diesel and alternative-fuel path, are intended to reduce PM emissions from existing diesel buses and those model year buses up to the year 2004. The ARB staff's proposal provides for a phase-in of the requirements from 2003 through 2009, with an emphasis on requiring retrofits for the oldest, dirtiest diesel buses first.

Low-sulfur Diesel Fuel Requirement

Low-sulfur diesel fuel is necessary for most aftertreatment technologies to function more efficiently and reliably. Therefore, the ARB staff's proposal includes requirements for transit agencies to purchase low-sulfur diesel fuel with a cap of 15 parts per million (ppm) sulfur beginning July 1, 2002. This requirement is timed to coincide with the PM retrofit requirements.

Low-emission Bus Purchase Requirements

The ARB staff's proposal includes new emission standards for NOx, PM, non-methane hydrocarbons, carbon monoxide, and formaldehyde for 2004 and subsequent model year diesel and dual-fuel urban bus engines, and for 2007 and subsequent model year

urban bus engines, regardless of fuel type. Under the proposed transit fleet rule, the 2004 model year requirements for transit agencies purchasing diesel and dual-fuel engines include a 0.5 g/bhp-hr NOx standard and 0.01 g/bhp-hr PM standard. These levels represent approximately a 75 percent NOx reduction and an 80 percent PM reduction from existing standards. The 2007 model year standards for all new bus purchases include a 0.2 g/bhp-hr NOx standard and a 0.01 g/bhp-hr PM standard, representing an additional 60 percent NOx reduction.

Zero-emission Bus Demonstration Project

The ARB staff's proposal requires large transit agencies (an active fleet of more than 200 urban buses) on the diesel path to participate in zero-emission bus demonstration projects beginning in July 2003. At that time, each participating agency would be required to place at least three urban buses producing zero exhaust emissions in revenue service. Bus technologies qualifying as zero-emission include battery-electric buses, electric trolley buses, and fuel cell buses.

Zero-emission Bus Purchase Requirements

The ARB staff's proposal also includes zero-emission bus purchase requirements for large transit agencies on both the diesel and alternative-fuel paths. For large transit agencies on the diesel path, a minimum 15 percent of all new urban bus purchases must be zero-emission buses beginning in 2008. For large transit agencies on the alternative-fuel path, the same purchase requirement applies beginning in 2010.

Environmental Impacts

The ARB staff estimates that the proposed fleet average NOx requirement will reduce NOx emissions statewide by about 2 tons per day (tpd) in 2002. Although the staff's proposal ensures this reduction, it will mostly occur as a result of normal fleet turnover. Therefore, the staff does not assume any NOx benefit (or cost) due to the fleet average requirement. For the PM retrofit requirements, the ARB staff estimates that PM emissions will be reduced statewide by about 300 pounds per day (lbs/day) in 2005 and by about 100 lbs/day in 2010. The ARB staff estimates that the proposed low-emission bus purchase requirements, based on the new urban bus engine standards, together with the zero-emission bus purchase requirements, will reduce NOx emissions statewide in 2010 by about 5 tpd and PM emissions by about 50 lbs/day. In 2020, these emission reductions will increase to about 7 tpd of NOx and about 67 lbs/day of PM. All of these emission reduction estimates are based on the emission inventory model EMFAC 2000, which has not yet been adopted by the Board.

The estimated cost-effectiveness of the proposed low-emission bus purchase requirements, based on the new urban bus engine standards, together with the zero-emission bus purchase requirements, is $1.80 per pound of NOx reduced in 2010. In 2020, the cost-effectiveness is $1.50 per pound of NOx reduced. This cost-

effectiveness compares favorably with that of other mobile source and motor vehicle fuel regulations adopted over the past decade.

The estimated cost-effectiveness of the proposed PM retrofit requirements is $17.90 per pound of PM reduced annually from 2003 to 2009. This includes the costs associated with the requirement to purchase low-sulfur diesel fuel. The PM retrofit requirement cost-effectiveness does not include the value of health benefits associated with a reduction in exposure to a toxic air contaminant.

Recommendations

The ARB staff recommends that the Board adopt this regulatory proposal. It will provide for significant reductions of NOx and toxic PM emissions, especially in highly-populated urban environments. This proposal will ensure that the emissions of both new and in-use urban transit buses are significantly reduced while protecting the viability of transit operations.

I. INTRODUCTION

Despite significant improvements in California's air quality over the last thirty years, there is still more work to do to achieve our air quality goals and provide healthful air for all Californians. California currently has eight major areas that are not in attainment with the one-hour federal ambient ozone standard. These areas are: the South Coast Air Basin, the Sacramento Metropolitan area, San Diego Air Basin, San Joaquin Valley Air Basin, Southeast Desert Air Basin, the San Francisco Bay Area, Santa Barbara County, and Ventura County. In addition, four of the six serious national nonattainment areas for particulate matter (PM) are located in California.

Mobile source controls are vital to the attainment of air quality standards. Mobile sources account for about 60 percent of ozone precursors and about 40 percent of combustion particulate emissions, statewide. Of the combustion particulate emissions, mobile source diesel engines account for about 30 percent. The Air Resources Board (ARB) identified particulate emissions from diesel exhaust as a toxic air contaminant in August 1998. Thus the control of particulate matter from diesel-fueled engines is critical.

The ARB's major goal is to provide clean, healthful air to all the citizens of California. The staff's proposal for clean public transportation is an important step in achieving this goal. Public transportation in California provides significant societal benefits. It provides mobility for those without cars, and reduces congestion when those with cars ride the bus. It also has the potential to positively impact air quality. Although current diesel urban buses usually emit more emissions of oxides of nitrogen (NOx) and PM than if all bus riders were driving separately, significant improvements in bus engine technology can result in clean public transportation and help reduce public exposure to harmful emissions. By taking advantage of these engine improvements, transit agencies and ARB can be partners in achieving new air quality benefits from congestion relief.

This proposal contains two components to reduce emissions from urban buses: 1) a fleet rule applicable to transit agencies; and 2) more stringent emission standards for engines used in urban buses, applicable to engine manufacturers. The fleet rule is designed to achieve nearer-term emission reductions, either through low-emission new bus purchases or through retrofitting or repowering older, higher-emitting urban bus engines to lower-emitting configurations. The engine standards are designed to achieve long-term emission benefits resulting from new bus engines with ultra-low, near-zero, and zero-emissions.

In September 1998, the ARB adopted Resolution 98-49 encouraging public agencies to purchase low-emission, alternative-fuel urban buses and school buses to achieve emission reductions and reduce the public's exposure risk to toxic air contaminants. While diesel engine technology may meet the staff's proposed engine standards in the future, this regulatory proposal is designed to increase low-emission, alternative-fuel engine use, including advanced battery and fuel cell technology use. Low-emission, alternative-fuel technology is already available today to achieve significant emission reductions. The ARB staff has identified at least 18 transit agencies throughout California that are already using or have committed to purchasing significant numbers of low-emission, alternative-fuel urban buses. Other transit agencies are also purchasing smaller numbers of low-emission, alternative-fuel urban buses. Further improvements in low-emission, alternative-fuel technology, including advances in battery and fuel cell technology, will ensure its place as a key component in California's long-term clean air strategy.

II. BACKGROUND

This chapter provides a brief overview of California's current air quality status; urban buses and applicable emission standards; and defines key terms used throughout the report. California is the only state that has the authority to establish motor vehicle emission standards different from federal standards. California's standards must be equivalent to or more stringent than the federal standards.

A. California's Air Quality Status

Over the past three decades, there has been dramatic progress toward cleaner air in California, largely as a result of California's leadership in developing unique pollution control programs to reduce emissions from both vehicular and non-vehicular sources. For example, the peak one-hour ozone concentrations in southern California, the area in California with the most serious air quality problems, were as high as 0.65 parts per million during the 1960s. Peak ozone concentrations in southern California today are about one-third of the values in the 1960s, despite significant increases in population and the number of motor vehicles. In addition, the number of days exceeding both the federal and state one-hour ambient ozone standards has steadily declined. Since 1980, the number of days exceeding the federal and state standards has decreased by about 60 percent and 50 percent, respectively.

Despite this progress, including significant improvements resulting from the implementation of every feasible measure in the 1994 State Implementation Plan for Ozone, many areas of the state still fail to meet federal and state health-based air quality standards. This proposal is but one of several necessary measures to further California's progress in meeting its clean air challenges. Other measures to be considered in the near future include enhanced vapor recovery, more stringent emission standards for medium and heavy-duty gasoline vehicles, additional reductions from consumer products, and a suggested control measure for architectural coatings.

B. Urban Buses and Emission Standards

In general, urban buses operate in heavily populated areas with a typical route consisting of stops and starts as passengers are routinely picked up and delivered to their destinations. Urban buses are typically 40 feet long, although they do vary in length; are normally powered by a heavy-duty diesel engine; and fall within the heavy heavy-duty vehicle classification of greater than 33,000 pounds gross vehicle weight (GVW). These buses are owned (or leased) by public transit agencies that receive federal, state, and local funds to subsidize new bus purchases and to operate and maintain their bus fleets and facilities. The ARB staff estimates that there about 8,500 full-size transit buses operating in California. Of these, approximately 80 percent are operated by 16 large-sized transit fleets with more than 100 buses in their fleet. The remaining buses are spread among more than 60 other transit agencies operating throughout California.

Urban buses have relatively high emissions (on a per vehicle basis) of NOx and PM. Based on the emission inventory model EMFAC 2000, which has not yet been adopted by the Board, urban buses will emit approximately 24 tons per day of NOx, and 1,000 pounds per day of PM in the year 2000. NOx is critical because it is one of the two major components in ozone formation. Particulates are critical because of their adverse effect on respiratory health and because they are a significant toxic air contaminant. Diesel engines have relatively low emissions of carbon monoxide (CO), carbon dioxide (CO_2), and hydrocarbons (HC). CO emissions create "hot spots" that affect public health, although nearly all areas of California are in attainment for CO. CO_2 is a greenhouse gas that contributes to global warming. Emissions of HC are important because in combination with NOx emissions, they create ozone.

In contrast, a natural gas bus engine will have significantly lower NOx and PM emissions than a comparable diesel bus engine, but it will likely have higher CO and CO_2 emissions and slightly higher HC emissions. However, the increase in these emissions is small compared to the decrease in NOx and PM emissions.

Tables 1 and 2 below present a recent history of both California and federal NOx and PM emission standards for urban bus engines. The heavy-duty emissions certification cycle is an engine-based test. This engine certification test determines emissions in units of grams per brake horsepower-hour (g/bhp-hr) or, in other words, emissions per unit of work performed.

TABLE 1

California and Federal Urban Bus Engine NOx Emission Standards (g/bhp-hr)		
	California	**Federal**
1988	6.0	10.7
1990	6.0	6.0
1991	5.0	5.0
1996	4.0	5.0
1998	4.0	4.0
October 2002	2.0(1)(2)	2.0(1)(2)

1. Nominal NOx level based on U.S. EPA and ARB emission standards of 2.4 g/bhp-hr NOx plus non-methane hydrocarbons (NMHC) or 2.5 g/bhp-hr NOx plus NMHC with 0.5 g/bhp-hr NMHC cap to take effect in October 2002.

2. For those engines subject to the Settlement Agreements between the heavy-duty engine manufacturers, the U.S. Environmental Protection Agency, and ARB. As part of the Settlement Agreements, the federal and state heavy-duty engine emission standards adopted for 2004 are to take effect in October 2002.

TABLE 2

California and Federal Urban Bus Engine PM Emission Standards (g/bhp-hr)		
	California	**Federal**
1988	0.6	0.6
1991	0.1	0.25
1993	0.1	0.1
1994	0.07	0.07
1996	0.05(1)	0.05(1)
October 2002	0.05	0.05

(1) In-use standard of 0.07 g/bhp-hr.

In addition to the mandatory emission standards shown above, the ARB also has optional, reduced-emission standards, which are integrated into the fleet rule component of the proposed regulation. A table presenting the optional, reduced-emission standards is presented in Chapter IV of this report.

C. Federal Urban Bus Retrofit/Rebuild Program

The United States Environmental Protection Agency (U.S. EPA) has adopted requirements for an urban bus retrofit/rebuild program as required by the Clean Air Act Amendments of 1990. The program applies to 1993 and earlier model year urban buses whose engines are rebuilt or replaced after January 1, 1995. The program is limited to urban buses operating in metropolitan areas with 1980 populations of 750,000 more.

The U.S. EPA's rule, which became effective on January 2, 1995, includes two options for reducing PM emissions from in-use urban buses, implicitly based on particulate trap or oxidation catalyst technology. It also includes cost ceilings that limit the cost a transit operator must pay in order to comply with the regulation.

Option 1 requires the transit operator to retrofit each applicable engine to achieve compliance with a PM emission standard of 0.1 g/bhp-hr or less, assuming it can be done for an incremental life-cycle cost maximum of $7,490 per engine. If no equipment is available that meets these requirements, then each engine must be rebuilt to achieve a 25 percent reduction in PM emissions for an incremental life-cycle cost of $2,000 or less. If there is no equipment available that meets either of these options, then each engine must be rebuilt to its original new engine configuration or, at the transit operator's choice, to a configuration with PM emissions lower than the original engine configuration. Formulae for calculating the life-cycle costs are included in the U.S. EPA's regulation. New facility costs and incremental fuel costs are included in the incremental cost calculations.

Option 2 is an averaging program set up to yield overall emission reductions equivalent to those expected under Option 1. This option provides a transit operator with enhanced flexibility to reduce PM emissions while minimizing costs. The averaging calculations included in the regulation provide guidance for determining the target level for an applicable fleet (TLF, the average PM emission value the fleet is expected to meet) and the fleet level attained (FLA, the actual average PM emission value after retrofits have been conducted). The TLF calculation indirectly takes into account the cost limits developed for Option 1.

The ARB staff's proposed regulation also includes retrofit requirements for PM control from the older, in-use diesel urban bus fleet. However, because California required new urban bus engines to meet a 0.10 g/bhp-hr standard in 1991, two years prior to the federal 0.10 b/bhp-hr PM standard went into effect, the federal retrofit requirements only apply to 1990 and earlier urban bus engines in California. While the ARB staff's proposal does include a retrofit requirement for urban bus engines certified to 0.60 g/bhp-hr PM, which are 1990 and earlier model year engines in California, it is expected that the proposed requirement would be met by retiring most of the 0.60 g/bhp-hr PM engines, rather than retrofitting them.

D. Regulatory Focus on Urban Buses

Diesel urban buses are ideally suited for improved controls due to relatively high NOx and PM emissions (on a per bus basis) and other factors described below,. The ARB and the local air pollution control districts and air quality management districts have already adopted control measures for nearly all sources----mobile, stationary, consumer products, and pesticides----to ensure California's continued progress in attaining federal and state air quality standards. However, more work needs to be done to achieve our air quality goals. Therefore, those sectors that still have opportunities for emission reductions, such as the heavy-duty vehicle sector, must be proactive in reducing emissions. This proposal focuses strictly on urban buses. The ARB will consider a

separate proposal to reduce emissions from school buses at a later date. In addition, other heavy-duty vehicles will be required to comply with new emission standards in late 2002, and both the ARB and the U.S. EPA will be considering even more stringent emission standards for heavy-duty vehicles for beyond the 2004 time frame.

In September 1998, the ARB adopted Resolution 98-49 to encourage public agencies to purchase cleaner, alternative-fuel buses to reduce emissions and decrease the public's exposure to toxic air contaminants. While the staff recognizes that the primary responsibility of transit agencies is to provide efficient, convenient transportation, we also believe transit agencies, as publicly funded entities, should bear some of the responsibility for providing the people they serve with clean, less polluting transportation. Many transit agencies have been active in implementing the goals set forth in the resolution; others have not. As a result, additional strategies, in the form of this proposal, are necessary to achieve emission reductions from urban buses. In addition to requiring clean, low-emitting and zero-emitting new bus purchases, this proposal relies on retrofit strategies, a NOx fleet average system, and requirements to purchase low-sulfur diesel fuel to achieve emission reductions from the diesel urban bus fleet.

As stated above, diesel urban buses contribute relatively high NOx and PM emissions on a per bus basis. However, there are other contributing factors that make the diesel urban bus sector an ideal candidate for achieving emission reductions. First, many of these buses operate in the most heavily congested urban areas where air quality is critical and direct exposure to toxic diesel particulates occurs for large numbers of people, thus making toxic particulate emissions an even greater public health concern. Second, they are centrally-fueled with known, fixed-routes, which allows for a cleaner, alternative fuel to be utilized more efficiently. Third, the entire cost of a new bus is not borne by the local transit agency. Transit agencies do not rely entirely on local funding for new bus purchases; the federal government subsidizes 83 percent of the purchase price of a new, low-emission alternative-fuel bus and 80 percent of the purchase price of a new diesel bus (funding issues are discussed in Chapter VI of this report). Finally, cost-effective emission reductions can be immediately achieved as cleaner, alternative-fuel engine technology is already available. Current natural gas bus engines emit about 50 percent less NOx and PM than comparable diesel bus engines based on engine certification levels. For PM, in-use test data also show that PM emissions from diesel buses are significantly higher than PM emissions from natural gas buses.

E. Definitions

Urban Bus - Current California regulations, by reference to the Code of Federal Regulations (CFR), Section 86.091-2, define an urban bus as a heavy heavy-duty diesel-powered passenger-carrying vehicle (+33,000 pounds GVW) with a load capacity of fifteen or more passengers intended primarily for intra-city operation, i.e., within the confines of a city or greater metropolitan area. Urban bus operation is characterized by short rides and frequent stops. To facilitate this type of operation, more than one set of quick-operating entrance and exit doors are normally present. Since fares are usually paid in cash or tokens, rather than purchased in advance in the form of tickets, urban

buses normally have equipment installed for collection of fares. Urban buses are also typically characterized by the absence of equipment and facilities for long distance travel, e.g., rest rooms, large luggage compartments, and facilities for stowing carry-on luggage.
(Note: A diesel-powered urban bus refers to a bus powered by a diesel-cycle engine, which includes alternative-fuel engines such as natural gas, propane, and methanol.)

Zero-emission Bus (ZEB) - "Zero-emission bus" means an urban bus, certified by the ARB Executive Officer, that produces zero exhaust emissions of any criteria pollutant (or ozone precursor pollutant) under any and all possible operational modes and conditions. The following provisions are applicable in defining a zero-emission bus:

(a) A hydrogen fuel cell bus shall qualify as a zero-emission bus.

(b) An electric trolley bus with overhead twin-wire power supply shall qualify as a zero-emission bus.

(c) A battery-electric bus shall qualify as a zero-emission bus.

(d) The incorporation of a fuel-fired heater shall not preclude an urban bus from being certified as a zero-emission bus provided that the fuel-fired heater cannot be operated at ambient temperatures above 40°F, and that the heater has zero evaporative emissions under any and all possible operational modes and conditions.

Alternative-fuel - "Alternative-fuel " means compressed and liquefied natural gas, propane, methanol, electricity, fuel cells, or other advanced technologies that do not rely on diesel fuel. For the purpose of this regulatory proposal, hybrid-electric and dual-fuel technologies that use diesel fuel are not considered alternative-fuel technologies.

Fleet Size - "Fleet size" means the total active fleet of urban buses, including spare buses, but not contingency vehicles (e.g., for emergencies) or non-revenue producing vehicles. This definition is consistent with that used by the Federal Transit Administration.

Transit Agency – "Transit agency" means a public entity responsible for administering and managing transit activities and services. Public transit agencies can directly operate transit service or contract out for all or part of the total transit service provided. This definition is consistent with that used by the Federal Transit Administration.

III. NEED FOR CONTROL

The proposed emission standards for urban bus engines and the proposed fleet rule represent an important step in further reducing the human health and environmental

impacts of ground-level ozone and the toxic impacts of PM emissions from diesel-fueled engines. This chapter summarizes the air quality rationale for the staff's proposal.

A. Ozone

California has a serious, statewide ozone air pollution problem, which until very recently, included the worst air quality in the nation in the South Coast Air Basin (Houston, Texas recently acquired the distinction of having the worst air quality in the nation). Ozone, created by the photochemical reaction of NOx and HC, causes harmful health effects ranging from eye irritation, sore throats and coughing, to lung damage, cancer, and premature death. People with compromised respiratory systems and children are the most severely affected; however, even healthy children and adults who play or exercise outdoors are also at risk. Beyond their human health effects, other negative environmental effects are also associated with ozone and NOx. Ozone has been shown to injure plants and materials; NOx contributes to the secondary formation of PM (nitrates), and acid deposition.

California has made significant progress in controlling ozone. Statewide exposure to unhealthful ozone concentrations has been cut in half since 1980. The frequency and severity of pollution episodes is declining, and emissions are on a downward trend. However, as stated earlier, more needs to be done. California still has eight major areas that are designated as nonattainment with the one-hour federal ambient ozone standard. These are: the South Coast Air Basin (Los Angeles, San Bernardino, Riverside, and Orange counties), the Sacramento Metropolitan Area, San Diego Air Basin, San Joaquin Valley Air Basin, Southeast Desert Air Basin, the San Francisco Bay Area, Santa Barbara County, and Ventura County. In addition, many more areas of the state violate our more stringent state ambient air quality standard for ozone.

The staff estimates that this proposal, once adopted, will reduce NOx emissions statewide by about seven tons per day (tpd) in 2020.

B. Particulate Matter

In addition to California's serious ozone challenges, many areas of California violate the federal and state PM emission standards. This proposal, when adopted, will provide dual PM emission benefits: 1) it will help in the effort to attain the federal and state PM standards throughout California; and 2) it will reduce the public's direct exposure to toxic particulate emissions.

Particulate matter, like ozone, has been linked to a range of serious health problems. Particles are deposited deep in the lungs and can result in increased hospital admissions and emergency room visits; increased respiratory symptoms and disease; decreased lung function, particularly in children and individuals with asthma; alterations in lung tissue and respiratory tract defense mechanisms; and premature death.

In August 1998, the ARB identified particulate emissions from diesel-fueled engines as a toxic air contaminant, one that causes cancer. Preliminary estimates indicate that the particulate emissions from diesel-fueled engines are by far the most significant toxic risk faced by the citizens of California. Diesel buses operating in heavily congested urban areas cause direct exposure for the public to toxic diesel particulates. It is the ARB's goal to protect public health by reducing exposure to diesel particulate emissions.

This proposal, once adopted, will reduce PM emissions from urban buses by requiring new buses to meet more stringent PM standards and by requiring retrofits to reduce PM from certain portions of the older, diesel urban bus fleet. The staff estimates the PM reduction in 2005 as a result of the PM retrofit requirements is 300 pounds per day statewide. As a result of the proposed new emission standards, staff estimates the PM reduction will be 67 pounds per day in 2020 statewide.

IV. SUMMARY OF THE PROPOSED REGULATIONS

The staff recommends that the Board adopt sections 1956.1, 1956.2, 1956.3 and 1956.4, and amend section 1956.8, Title 13, California Code of Regulations, and the incorporated "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Year Heavy-duty Engines and Vehicles," as set forth in Appendix A. All the provisions in the proposed regulation apply to engines and vehicles produced for sale in California. There are two components to this proposal: 1) a transit bus fleet rule applicable to transit agencies; and 2) more stringent emission standards for new urban bus engines applicable to urban bus engine manufacturers. The transit bus rule would require fleet operators to chose between operating a diesel bus fleet (the diesel path) or an alternative-fuel bus fleet (the alternative-fuel path). The fleet rule contains different requirements for each path. For both paths, there is a requirement to achieve reductions from the older in-use fleet through a minimum NOx fleet average system and through requirements for retrofits for PM control. The alternative-fuel path achieves equivalent NOx reductions and greater PM reductions than the diesel path due to inherently low in-use PM emissions from alternative-fuel buses. PM emissions from alternative-fuel buses are on the order of 20 to 100 times lower than diesel buses. The fleet rule also contains requirements for larger fleets on the diesel path to undertake a zero-emission bus demonstration project, and for larger fleets on both paths to purchase a required percentage of zero-emission buses. The fleet rule would be in effect from the date of adoption of this regulation in 2000 through 2015. The proposed emission standards are applicable to urban bus engine manufacturers and begin in model year 2004 for diesel and dual-fuel urban bus engines and in the model year 2007 for all urban bus engines. The following sections discuss the major provisions of the proposed regulation in detail.

A. Applicability

The current urban bus definition, as specified in Section 86.094-2 of Subpart N, Part 86, Title 40, CFR, is a passenger-carrying vehicle (+33,000 pound GVW) powered by a

heavy heavy-duty diesel-powered engine with a load capacity of fifteen or more passengers and intended primarily for intra-city operation. Equipment on urban buses usually includes quick-opening exit and entrance doors and fare collection equipment. Urban buses are of various lengths, and include articulated buses, but are usually at least 25 feet long.

The proposed regulation does not apply to buses used in shuttle services, airport shuttle services, paratransit services, school transportation services and commuter services unless urban buses are used to provide those services. Buses used to provide long-distance service, that are generally equipped with luggage compartments, rest rooms, and overhead storage, are not included.

Smaller transit buses (14,001 to 33,000 pounds GVW) have historically been regulated as heavy-duty trucks. Both the U.S. EPA and the ARB will be evaluating the need for more stringent standards for heavy-duty trucks, including school buses and smaller transit buses.

The proposed fleet rule applies to those public transit fleets operated by government agencies or operated by private entities under contract to government agencies.

B. Emission Standards

1. Advancement of the 2004 Heavy-duty Engine Standards to 2002

The ARB and the U.S. EPA have already adopted heavy-duty engine emission standards to take effect in 2004. In addition, as a result of the Heavy-duty Diesel Settlement Agreements between the U.S. EPA, the ARB, and seven engine manufacturers, the engine manufacturers will introduce engines produced for sale in California meeting the 2004 heavy-duty engine emission standards beginning in October 2002. The Settlement Agreements are the result of engine manufacturers using alternative emission control strategies that increased emissions of NOx beyond what would be expected on the Federal Test Procedure. Similar agreements, referred to collectively as the federal Consent Decree, are applicable to engines produced for sale outside of California. In October 2002, engine manufacturers subject to the Settlement Agreements must certify new urban bus and other heavy-duty engines to either a 2.4 g/bhp-hr NOx + NMHC standard, or a 2.5 g/bhp-hr NOx + NMHC standard with a cap of 0.5 g/bhp-hr of NMHC. The NOx emission level is assumed to be 2.0 g/bhp-hr in California's State Implementation Plan for Ozone and in calculating the ARB's emission inventory. Therefore, in discussing the standards to take effect in October 2002, the term "nominal 2.0 g/bhp-hr NOx" is sometimes used. The Settlement Agreements do not affect PM emission standards.

2. Proposed Emission Standards

Under this proposal, engine manufacturers can continue to certify urban bus engines to one of two sets of existing NOx emission standards until 2007: 1) the ARB's mandatory standards (either the current 4.0 g/bhp-hr NOx standard or the NOx + NMHC standard

taking effect in October 2002); or 2) the ARB's optional, reduced-emission NOx standards. Currently, there are no heavy-duty diesel engines certified to the ARB's reduced-emission optional NOx standards. However, as discussed in Chapter V, some natural gas engines are certified to the optional standards. All new urban bus engines must currently certify to the 0.05 g/bhp-hr PM standard.

The staff is proposing that the Board adopt new mandatory emission standards for 2007 and subsequent model year urban bus engines for NOx, PM, NMHC, and formaldehyde. Urban bus engines would be required to certify to the standards for each pollutant as shown in Table 3 below. The staff is in the process of developing a certification procedure for zero-emission buses required under the fleet rule.

TABLE 3

Proposed Emission Standards for 2007 and Subsequent Model Year Urban Bus Engines

(g/bhp-hr)

NOx	PM	NMHC	Formaldehyde	CO
0.2	0.01	0.05	0.01	5.0

Prior to implementation of the mandatory emission standards proposed for 2007 and subsequent model year urban bus engines, the NOx and PM standards discussed below would apply, based on fleet rule requirements (specific fleet rule requirements are discussed later in this chapter).

a. Urban Buses on the Diesel Path

For the 2000 to October 2002 model years, diesel engines must be certified to current emission standards. From October 2002 through 2003, diesel engines made by all but one manufacturer subject to the Settlement Agreement must be certified to the existing 2.4/2.5 g/bhp-hr NOx + NMHC standard and the existing PM standard of 0.05 g/bhp-hr.

For 2004 through 2006 model year diesel and dual-fuel engines, the staff proposes that the Board adopt the emission standards shown in Table 4 below.

TABLE 4

Proposed Emission Standards for 2004 - 2006 Model Year Diesel or Dual-Fuel Urban Bus Engines

(g/bhp-hr)

NOx	PM	NMHC	Formaldehyde	CO
0.5	0.01	0.05	0.01	5.0

Engine manufacturers can choose to meet these standards with an engine certified at the 2.5 g/bhp-hr standard and an applied aftertreatment system that together demonstrate NOx at 0.5 g/bhp-hr and PM at 0.01 g/bhp-hr. Manufacturers are responsible for full certification of the base engine; durability, testing, in-use compliance, and emissions warranty requirements. For the aftertreatment, the ARB is proposing that manufacturers have reduced certification requirements but full functional warranty requirements.

For 2007 and subsequent model year urban bus engines, the staff proposes that the Board adopt the emission standards shown in Table 6 below. The proposed standards for 2007 and subsequent model year urban bus engines are applicable to diesel and alternative-fuel engines.

b. Urban Buses on the Alternative-Fuel Path

From the adoption of the regulation through the 2015 model year, for transit agencies on the alternative fuel path, at least 85 percent of all new bus purchases must be alternative-fuel bus buses. Although transit agencies are not required to purchase alternative fuel buses that are certified to one of the ARB's existing reduced-emission optional NOx standards (at 2.5 g/bhp-hr NOx or lower), those are the only alternative fuel bus engines currently available. In addition, bus engines certified to an optional NOx standard could qualify for incentive funding. Existing California standards for NOx and NOx plus NMHC, (both required and optional standards) are shown in Table 5. The applicable PM standard from now until October 2002 would be the existing 0.05 g/bhp-hr standard.

TABLE 5

Existing California Required and Optional, Reduced-Emission Standards for Urban Buses (g/bhp-hr)

Model Year	Primary Standard	Optional Standards	Increment
2000 to 10/2002	4.0 (NOx)	2.5 – 0.5	0.5
10/2002 through 2006	2.4 NOx+NMHC or 2.5 NOx+NMHC with 0.5 NMHC cap	1.8-0.3	0.3

For October 2002 through 2006 model years, urban bus engines, in buses purchased by transit agencies on the alternative fuel path, must be certified to either the 2.4/2.5 NOx + NMHC standard that takes effect in October 2002, or to one of the ARB's existing reduced-emission optional NOx + NMHC standards beginning at 1.8 g/bhp-hr. Only those engines certified to one of the ARB's optional, reduced NOx + NMHC standards would generally be eligible to receive incentive money to assist with the incremental purchase price. In either case, the engines must be certified to a new, proposed optional PM standard of 0.03 g/bhp-hr. This proposed new standard, plus the proposed 2004 NOx and PM standards for the diesel path, and the proposed new NOx and PM standards for 2007, applicable to both paths, are summarized in Table 6.

TABLE 6

Proposed Emission Standards for Urban Buses (g/bhp-hr)				
Model Year	"Diesel" Path		"Alternative Fuel" Path	
	NOx (g/bhp-hr)	PM (g/bhp-hr)	NOx (g/bhp-hr)	PM (g/bhp-hr)
2004	0.5	0.01	(1)	0.03
2007	0.2	0.01	0.2	0.01

Dates shown indicate bus model years.

(1) No new standard is proposed for NOx on the alternative fuel path. The existing standard for 2004 is 2.4 g/bhp-hr NOx plus NMHC. Although transit agencies on the alternative-fuel path are not required to purchase engines certified to optional lower-NOx plus NMHC standard (1.8 g/bhp-hr NOx + NMHC or below), the staff expects that they will in order to qualify for incentive funding. At present, the only alternative-fuel engines available are certified to optional, lower-emission NOx standards.

Engines certified to the optional standards may not participate in any averaging, banking or trading program. However, the purchase of the buses with optional lower-NOx engines may be eligible for certain California mobile source emission reduction credit programs, or for low-emission vehicle incentive funding programs

C. Transit Bus Fleet Rule

The ARB staff is proposing specific fleet requirements for transit agencies. First, transit agencies and other bus purchasers (e.g., bus leasing companies) would be required to buy buses that comply with the emission standards shown in Tables 3 and 4 above when making new bus purchases. Second, transit agencies would be required to choose between operating diesel bus fleets or low-emission, alternative-fuel bus fleets. Such a choice would put a transit agency on either the "diesel path" or the "alternative fuel path" of the proposed transit bus fleet rule. The proposed regulation contains different requirements for each path. The alternative fuel path achieves equivalent NOx and greater PM reductions than the diesel path. It would provide transit agencies incentives to continue implementing low-emission, alternative-fuel bus technology, or to start doing so immediately. Provisions of the fleet rule extend from the effective date of the proposed regulation in 2000 through 2015.

For the purpose of the fleet rule, low-emission, alternative-fuel buses are buses powered by natural gas, propane, ethanol, or a combination of those fuels and other non-diesel fuels, and electricity and fuel cells. Buses powered by diesel fuel or a combination of fuels that includes diesel fuel (such as a diesel hybrid-electric) are not considered low-emission, alternative-fuel buses for the purpose of the proposed regulation.

The diesel and alternative-fuel paths differ primarily with respect to requirements for:

- New bus purchases and leases, emission standards, and fuel type.
- Zero-emission bus demonstration programs.
- Timing of zero-emission bus purchases.

1. Requirements for Transit Agencies on the Diesel Path

a. New Bus Purchases and/or Leases

New diesel urban buses would be required to use diesel engines certified to the applicable existing and proposed NOx, PM, NMHC, and formaldehyde emission standards or to the ARB's optional, reduced emission standards discussed in the previous section.

Some transit agencies on the diesel path may also want to purchase low-emission alternative-fuel buses, but not in quantities sufficient to qualify for the alternative-fuel path. Any model year 2004 through 2006 low-emission, alternative-fuel buses purchased by a diesel path transit agency must meet the 2004 proposed emission standards of 0.5 g/bhp-hr NOx and 0.01 g/bhp-hr PM. This is to prevent transit agencies on the diesel path from purchasing an alternative-fuel bus with higher NOx and PM emissions than a comparable diesel bus meeting the proposed emission standards of 0.5 g/bhp-hr NOx and a 0.01 g/bhp-hr PM. Fuel cell buses, electric trolley buses, and battery-electric buses would meet or exceed the proposed 2004 standards. Hybrid-electric buses may also meet these proposed emission standards. The proposed 2007 NOx and PM emission standards are applicable to all bus engines, whether diesel or low-emission, alternative-fuel.

b. Fleet Averaging for NOx Emissions

The staff proposes that transit agencies meet a minimum active fleet average standard of 4.8 g/bhp-hr NOx by October 2002. The fleet average for each transit agency's fleet would be based on the NOx engine certification standard (new or repowered engine) for each urban bus, and all heavy-duty zero-emission buses, in the active fleet, whether owned or leased, of all fuel types. To achieve the proposed fleet average 4.8 g/bhp-hr NOx standard, transit agencies or their bus leasing companies may have to repower or retire older, high-emitting buses. It is possible to repower existing diesel urban buses with engines certified to 5.0 and 6.0 g/bhp-hr NOx standards with new 4.0 g/bhp-hr NOx engines. However, staff assumes that all but a few transit agencies on the diesel path would be able to meet and maintain the minimum required fleet average standard through normal bus retirement rates.

The staff also proposes that transit agencies have the option of retiring all 1987 and earlier model year diesel urban buses as a way to comply with the NOx fleet average requirement. This retirement option is intended to provide transit agencies flexibility in achieving fleet turnover, while maintaining the benefits of the NOx fleet average requirement.

c. PM Retrofit Requirements

The ARB staff proposes that transit agencies could only operate buses in their active fleets that are in compliance with the PM retrofit requirements discussed here. The PM retrofit requirements would start in 2003 and extend to 2009. Diesel buses with the highest PM emissions would be given priority and would be the first buses to be

retrofitted. A retrofit device that demonstrates 85 percent conversion efficiency would have to be installed. All low-sulfur fuel would have to be purchased beginning in July 1, 2002, to assure the durability of the retrofit devices. These requirements apply to transit agencies on both paths, but only diesel buses would have to be retrofitted. As discussed earlier, in-use emissions data show significant particulate benefits from CNG buses compared to diesel buses. Even with the bus retrofits, PM emissions would be lower for those agencies on the alternative-fuel path utilizing natural gas buses.

The staff has proposed that transit agencies with active fleets consisting of less than 20 buses operating in federal ozone attainment areas be allowed a delay in the Tier 1 and Tier 2 PM retrofit requirements, as described below, until 2007. This is primarily due to the projected cost and difficulty of securing delivery of low-sulfur diesel in outlying rural areas before 2007. By 2007, many of the buses subject to the Tier 1 and Tier 2 requirements would be retired and would not have to be retrofitted; this would be a cost savings for the smaller districts. These smaller transit agencies would be required to comply with the Tier 3 requirements as shown below.

Several types of buses would be exempt from the proposed PM retrofit requirements:

- Model year 2004 and newer buses certified at 0.01 g/bhp-hr PM.
- Buses scheduled for retirement within two years would be exempt from the 100 percent retrofit requirement, except as discussed below for 0.6 g/bhp-hr PM engines. Documentation of planned retirement schedules would be required.
- All alternative-fuel buses owned or leased by a transit agency.

The proposed PM retrofit requirements for fleets on the diesel path are shown below.

TIER 1
All 0.6 g/bhp-hr PM buses would require retrofits by January 1, 2003. The ARB staff assumes that most 1990 and older buses with 0.6 g/bhp-hr PM engines would be retired by 2003, so most transit agencies would be retiring, not retrofitting, their oldest buses. Only buses that have already been retrofitted to 0.10 g/bhp-hr PM with an ARB-certified retrofit device meeting the requirements of the U.S.EPA urban bus rebuild and retrofit program would be eligible for the two-year retirement exemption; buses retrofitted to 0.45 g/bhp-hr PM would not be eligible.

TIER 2
- 1/1/03 -- 20 percent of 0.10 and 0.07 g/bhp-hr PM engines would have to be retrofitted
- 1/1/04 -- 75 percent of 0.10 and 0.07 g/bhp-hr PM engines would have to be retrofitted
- 1/1/05 -- 100 percent of 0.10 and 0.07 g/bhp-hr PM engines would have to be retrofitted

TIER 3
- 1/1/07 -- 20 percent of 0.05 g/bhp-hr PM engines would have to be retrofitted
- 1/1/08 -- 75 percent of 0.05 g/bhp-hr PM engines would have to be retrofitted

- 1/1/09 -- 100 percent of 0.05 g/bhp-hr PM engines would have to be retrofitted

d. Zero-emission Bus Demonstration Project

The ARB staff proposes that transit agencies with over 200 urban buses in their active fleets, either owned or leased, on January 31, 2001, would be required to buy or lease three zero-emission buses (ZEBs) and operate them in service for a minimum of a year, starting no later than July 1, 2003. The transit agencies would be required to secure refueling infrastructure and take any other actions necessary for implementation of the project. To qualify as a ZEB, a bus would have to be certified by the ARB Executive Officer. ZEB engines could be powered by fuel cells or electricity.

Transit agencies could petition the Executive Officer for approval to undertake a joint zero-emission bus demonstration project. At a minimum, transit agencies that want to participate in a joint project would have to designate the host agency and jointly fund the project. Electric trolley buses would not qualify as ZEBs for purposes of a joint demonstration project. To assure market penetration, staff proposes that no more than three transit agencies can participate in any one joint project.

e. Zero-emission Bus Purchases and/or Leases

The ARB staff proposes that transit agencies with over 200 urban buses in their active fleets, either owned or leased on January 1, 2007, would be required to purchase and/or lease ZEBs in 2008. A minimum of 15 percent per year, from model year 2008 through model year 2015, of a transit agency's urban bus purchases and/or leases would have to be ZEBs. If flexibility is needed in scheduling bus purchases, a transit agency could apply to the Executive Officer for approval to deviate from the required purchase schedule. To qualify as a ZEB, an urban bus would have to be certified by the ARB Executive Officer. ZEB engines could be powered by fuel cells, electricity, or fuels that result in zero-emission exhaust levels.

This requirement does not apply if a transit agency's active urban bus fleet is composed of 15 percent or more zero-emission buses on January 1, 2008, or at any time thereafter.

2. Requirements for Transit Agencies on the Alternative-Fuel Path

a. New Bus Purchases and/or Leases:

In order for a transit agency to qualify for the alternative-fuel path, the ARB staff is proposing that at least 85 percent of all new urban bus purchases or leases must be low-emission, alternative-fuel buses, beginning with the adoption of the proposed regulation through model year 2015. If flexibility is needed in scheduling bus purchases,

a transit agency could apply to the Executive Officer for approval to deviate from the proposed purchase schedule.

The staff is not proposing a 100 percent purchase or lease requirement as some types of urban buses used by transit agencies, such as articulated buses, may not be immediately available with low-emission, alternative-fuel engines. Additionally, there may not be an adequate number of alternative-fuel buses immediately available for lease.

One advantage to being on the alternative-fuel path is that transit agencies could buy or lease low-emission, alternative-fuel buses meeting the 2.5 g/bhp-hr NOx + NMHC standard through the model year 2006. However, in order for transit agencies to be eligible for state and local air quality incentive monies after October 2002, buses would have to be certified to one of the ARB's reduced-emission optional NOx + NMHC standards beginning at 1.8 g/bhp-hr NOx + NMHC.

b. Fleet Averaging for NOx Emissions

The staff proposes that transit agencies meet a minimum fleet average emission standard of 4.8 g/bhp-hr NOx by October 2002. The fleet average for each transit agency's fleet would be based on the NOx engine certification standard (new or repowered engine) for each urban bus in the active fleet, whether owned or leased, of all fuel types. This is the same as the NOx fleet average requirement proposed for transit agencies on the diesel path. However, the ARB staff expects those transit agencies on the alternative-fuel path will be able to achieve and maintain the fleet average requirement fairly easily due to the low emissions of their alternative-fuel buses.

c. PM Retrofit Requirements

The ARB staff is proposing identical PM retrofit requirements for transit agencies on the diesel and alternative-fuel paths as well as purchase of low sulfur diesel fuel, if any diesel fuel is required. However, since alternative-fuel buses already have significantly lower in-use PM emissions and are exempt from the PM bus retrofit requirements, transit districts on the alternative-fuel path would have a smaller percentage of their buses to retrofit. Transit agencies that have phased out their diesel buses, or do so by 2003, will not be required to do any PM retrofits.

d. Zero-emission Bus Demonstration Project

No demonstration program is required for transit agencies on the alternative-fuel path.

e. Zero-emission Bus Purchases and/or Leases

The ARB staff proposes that transit agencies with over 200 urban buses in their active fleets, either owned or leased on January 1, 2009, would be required to purchase or lease ZEBs beginning in 2010 (two years later than transit agencies on the diesel path). Transit agencies on the alternative-fuel path are allowed more time to comply with the

ZEB purchase requirements because they have lower NOx fleet average emission levels and have already made investments in alternative-fuel infrastructure. From model year 2010 through model year 2015, a minimum of 15 percent per year of a transit agency's urban bus purchases and/or leases would have to be ZEBs. If flexibility is needed in scheduling bus purchases, a transit agency could apply to the Executive Officer for approval to deviate from the required purchase schedule. To qualify as a ZEB, an urban bus would have to be certified by the ARB Executive Officer. ZEB engines could be powered by fuel cells, electricity, or fuels that result in zero-emission exhaust levels.

This requirement does not apply if a transit agency's active urban bus fleet is composed of 15 percent or more zero-emission buses on January 1, 2010, or at any time thereafter.

3. Comparison of Fleet Rule Requirements

Table 7 below provides a comparison of the fleet rule components discussed above for transit agencies on the diesel path and on the alternative fuel path.

TABLE 7

Comparison of Fleet Rule Requirements		
Year	**Diesel Path**	**Alternative-Fuel Path**
10/2002	NOx fleet average requirement	NOx fleet average requirement
2003-09	PM retrofit requirement	PM retrofit requirement
7/2003	3 bus demo of ZEBs for large fleets (>200)	
1/2008	15% of new buses are ZEBs for large fleets (>200)	
1/2010		15% of new buses are ZEBs for large fleets (>200)

Although the NOx emission average and the diesel bus retrofit requirements are identical for the two paths, they are likely to have a significantly greater impact on those transit agencies on the diesel path. This is because the low NOx emissions of the alternative-fuel buses would allow for easier attainment of the fleet average standard. Also, natural gas buses, with their inherently low in-use PM emission are exempt from the retrofit requirements.

4. Requirements for Low-sulfur Diesel Fuel

Low-sulfur diesel fuel is necessary for most aftertreatment technologies to function more efficiently and reliably. Low-sulfur fuel enables catalysts and particulate filters to operate more efficiently and with increased durability. With higher sulfur fuel, trap plugging and catalyst fouling can occur. Therefore, the proposed transit fleet rule requires most transit agencies (on both the diesel and alternative-fuel paths) using diesel fuel to purchase and use diesel fuel with a sulfur limit of 15 parts per million (ppm) or less. This requirement is effective beginning July 1, 2002, in order to be consistent with the proposed PM retrofit requirements. However, transit agencies with

less than 20 buses in their active fleets that operate in federal ozone attainment areas would not be subject to this requirement until July 1, 2006, since the staff has proposed that these fleets be allowed a delay in the Tier 1 and Tier 2 PM retrofit requirements until January 1, 2007, due to the projected cost and difficulty of securing delivery of low-sulfur diesel fuel in outlying rural areas before 2007.

5. Reporting Requirements

To assure compliance with the fleet rule, the ARB staff proposes that transit agencies submit reports shown below. Table 8 presents an overview of the proposed applicable reporting requirements and the dates on which they must be met.

- New bus purchases and/or leases by transit agencies on the alternative-fuel path.
- Fleet averaging for NOx emissions.
- Compliance with PM retrofit requirements for Tiers 1, 2, and 3.
- Zero-emission bus demonstrations.
- Zero-emission bus purchases and/or leases.

TABLE 8

Proposed Fleet Rule Reporting Requirements

Requirement	Applicable Dates	Path	Initial Reports	Date	Final Report
Bus purchase	2000-15	AF	Intent; Records	1/2001	No
Fleet average	10/02	Both	Schedule	1/2001	1/2003
PM retrofits Tier 1	1/00-03	Both	Schedule; Records	1/2002	No
PM retrofits Tier 2	1/03-05	Both	Schedule; Records	1/2002	No
PM retrofits Tier 3	1/07-09	Both	Schedule; Records	1/2005	No
ZEB demo	7/03	D	Purchase/demo plan	1/2003	1/2005
ZEB purchase	2008-15	D	Plan; Records	1/2007	No
ZEB purchase	2010-15	AF	Plan; Records	1/2009	No

Notes: AF indicates alternative-fuel; D indicates diesel
Some requirements and a delayed compliance date are based on fleet size.

a. New Bus Purchases and/or Leases by Transit Agencies on the Alternative Fuel Path

Transit agencies that intend to qualify for the alternative-fuel path would be required to report such intent by letter to the ARB by January 31, 2001. The responsible transit district would maintain and produce on request records of the number, model year, and fuel used for engines in transit buses they currently own or operate, bus purchases and/or leases beginning in January 1, 2000, fuel types, and annual average percentage of total bus purchases and/or leases that were alternative-fuel buses. Any requests for

deviation from the requirement that 85 percent of buses purchased per year must be alternative-fuel buses would be submitted to the Executive Officer.

b. Fleet Averaging for NOx Emissions:

The ARB staff is proposing that all transit agencies calculate their current urban bus NOx fleet average and submit that information to the ARB by January 31, 2001. If the fleet average exceeds 4.8 g/bhp-hr NOx, a schedule adopted by their governing board for meeting the 4.8 g/bhp-hr NOx fleet average standard by October 1, 2002, would be included in the submittal. Agencies planning on complying with the requirement by retiring all model year 1987 and earlier buses would submit that information instead. By January 1, 2003, a final report demonstrating compliance with the NOx fleet average requirement would be submitted to the ARB.

c. PM Retrofit Requirements

The ARB staff is proposing that affected transit agencies submit to the ARB a report showing their schedule for Tier 1 and Tier 2 retrofits (or retirements, as applicable), and the number and type of exempt buses, by January 31, 2002. For Tier 3 retrofits, a similar report would be due January 31, 2005. The transit agencies would maintain and produce on request, records of the number and model year of buses retrofitted, types of retrofit devices used and number of buses exempt.

d. Zero-emission Bus Demonstration

The applicable transportation agency and/or the transit district governing board would submit by January 1, 2003 plans for the purchase and/or lease and demonstration of at least three ZEBs. The plan would indicate planned expenditures for buses, the projected bus order and delivery schedule, fuel type and facilities, plus information about how the buses will be demonstrated. A final report on the demonstration project would be due on January 31, 2005.

e. Zero-emission Bus Purchases

The responsible transportation agency and/or the transit district governing board would submit a report giving a description of the zero-emission technology to be utilized and overall plans for implementation of the purchase requirement, and any request for exemption from the purchase requirement based on existing zero-emission bus fleet composition, by January 1, 2007, for transit agencies on the diesel path and by January 1, 2009, for transit agencies on the alternative-fuel path.

The responsible transit agency would maintain and produce on request, records on the the number, model year and fuel used for engines they currently own or operate, bus purchases and/or leases beginning in 2008 or 2010, fuel types, and annual average percentage of total bus purchases and/or leases that were ZEBs. Any requests for deviation from the requirement that 15 percent of buses purchased per year must be zero-emission buses would be submitted to the Executive Officer.

6. Future Feasibility Review

The ARB staff proposes that the Board provide for review of zero-emission bus technology, and the feasibility of implementing the proposed requirements. The ARB would conduct its review no later than January 2006. This review would reassess the need for the requirements and their technical and economical feasibility, based on information available in 2005 from the ZEB demonstration projects. If the technical feasibility of the zero-emission bus requirements are confirmed, the staff would recommend to the Board the implementation of the 2008 and 2010 zero-emission bus purchase requirements.

V. TECHNOLOGICAL FEASIBILITY

Diesel engines have long been the engines of choice for use in urban buses. This is due to the efficiency and durability of diesel engines, as well as the operators' familiarity with diesel engine technology. Historically, this preference is also due to the lack of viable alternative-fuel engine technology for use in heavy-duty vehicle applications. This is no longer the case. Recent advances have enabled alternative-fuel engines to close the performance and reliability gaps with diesel engines and, at the same time, clearly outperform diesel engines in terms of emissions. This chapter focuses on the technologies that make the proposed standards technologically feasible. Included here are discussions of currently-available technologies, retrofit technologies for reducing NOx and toxic PM emissions from the older diesel urban bus fleet, and emerging diesel and advanced, alternative-fuel technologies.

A. Currently-Available Technology

1. Diesel Technology

Diesel engines operate by compression ignition that causes the fuel to ignite upon injection into highly compressed air at elevated temperatures. NOx formation is directly dependent on the flame temperature. As combustion temperatures increase, NOx emissions also increase. Therefore, NOx control technologies generally focus on reducing the combustion temperatures and the duration of these high temperatures within the cylinder. In general, however, emission control strategies that reduce NOx tend to increase PM. Current emission control technologies such as combustion chamber modifications, advanced induction systems, and fuel injection strategies have resulted in diesel engines that emit about 30 percent less NOx than diesel engines manufactured a decade earlier, while still allowing for decreases in PM emissions.

a. Combustion Chamber Modifications

Manufacturers have made significant progress in the area of combustion chamber modifications. If the fuel/air mixing rates and the shape of the flame in the combustion chamber are sufficiently controlled, they can be optimized over the range of engine

operating conditions to control and minimize the formation of pollutants. This involves careful attention to combustion chamber geometry to optimize air flow parameters.

Proper air flow in the combustion chamber is also important to allow proper fuel injection penetration. If injected too far, the fuel spray will wet the cylinder wall leading to increased unburned HC emissions and increased wear. If the fuel spray is not injected far enough, inadequate mixing will lead to increased HC and PM emissions.

b. Advanced Induction Systems

Manufacturers have incorporated advanced turbochargers/aftercoolers in current diesel engines to provide better air/fuel management and lower intake air temperatures to meet lower emission standards. Turbocharging has a positive influence on the pumping losses of an engine and on the combustion efficiency through control of the air/fuel ratio. Aftercoolers cool the intake charge to reduce peak combustion temperatures, thus reducing NOx emissions.

c. Injection Timing/High Pressure Fuel Injection

Retarding injection timing (starting combustion later) reduces NOx through a reduction in the peak combustion temperature. However, this tends to increase PM emissions and fuel consumption. Manufacturers have developed higher pressure injection systems as one approach to reduce fuel economy impacts and PM emission increases. Higher injection pressures result in better atomization, better air utilization, more complete combustion, and consequently reduce PM emission, while improving fuel efficiency.

2. Alternative-Fuel Technology

a. CNG and LNG

Alternative fuels such as methanol, ethanol, propane, compressed natural gas (CNG), and liquefied natural gas (LNG) have provided manufacturers with new options in meeting increasingly stringent emission standards. Currently, only natural gas technology has developed sufficiently for commercial heavy-duty vehicle applications. Compared to conventional diesel technology, natural gas technology has already shown emission reductions in the range of 50 percent for NOx and PM. As discussed earlier, PM in-use emissions are inherently lower, from 20 to 100 times lower.

Unlike diesel engines, which ignite by compression, natural gas engines are spark-ignited. In this respect, they are similar to gasoline engines, which also use the electrical energy provided by spark plugs to initiate the combustion process. Spark-ignition engines are slightly less efficient than compression-ignition engines (i.e., diesel engines). However, current heavy-duty natural gas engine technology, such as lean-burn, closed-loop, electronic fuel management, has enabled natural gas engines to approach diesel-like fuel economy and performance, while emitting 50 percent less NOx and PM than comparable diesel engines.

Both CNG and LNG engines are currently available for heavy-duty vehicle applications. CNG engines have traditionally been used in urban buses, although LNG engines have also been ordered. Some transit agencies, in fact, prefer LNG since its higher energy density provides for longer vehicle range, reduced weight and lower capital costs than CNG. However, LNG is not readily available in California today, therefore the incremental fuel cost is higher. Ongoing demonstration programs could allow for LNG availability in the future at significantly lower costs.

Most heavy-duty engine manufacturers sell both natural gas and diesel fuel engines. Some engine manufacturers have certified their natural gas engines to the ARB's optional, reduced-emission NOx standards, which start at approximately 40 percent less than the current 4.0 g/bhp-hr NOx standard. Table 9 below shows the 1999 model year urban bus engines certified to the ARB's optional, reduced-emission NOx standards.

TABLE 9

1999 Model Year Urban Bus Engines Certified to ARB's Optional, Reduced-Emission NOx Standards
(Emission Levels for NOx, PM, and NMHC are in g/bhp-hr)

MY	Manuf.[a]	Service Type	Fuel Type	Displ. (ltr)	NOx	PM	NMHC	Cert. Std. NOx/PM	HP
1999	DDC	UB/HHD	CNG	12.7	2.0	0.02	0.8	2.5/0.05	330
1999	DDC	UB/HHD	CNG	8.5	2.2	0.01	0.6	2.5/0.05	275
1999	Cummins	UB/HHD	L/CNG	10.0	1.4	0.02	0.03	2.0/0.05	280/ 300
1999	Cummins	UB/HHD	L/CNG	8.3	1.7	0.01	0.2	2.5/0.05	250/ 275

[a]Service Type: UB(Urban Bus); HHD(Heavy Heavy-Duty)

b. Electric Trolley Buses

Trackless electric trolley systems have been operated in North America and Europe for decades. Electric trolley buses are commercially available and in regular use in several transit districts nationwide. In California, the San Francisco Municipal Railway's transit fleet includes over 340 electric trolley buses.[1] Electric trolley buses are rubber-tired urban buses with electric motors powered by electricity distributed through an overhead twin-wire power supply. The electric power from the utility is converted to 750 volts DC at substations located at approximately one mile intervals and is fed from the substation through underground cable to the overhead twin-wire. Onboard batteries provide electric trolley buses with limited emergency propulsion capabilities.

While electric trolley buses do not produce exhaust emissions, there are emissions associated with the generation of electricity used to power the buses. These emissions depend on the mix of power plants supplying the electricity. While this technology provides opportunities for significant emission reductions from conventional urban buses, it provides transit agencies with less flexibility due to the extensive and expensive public infrastructure and fixed routes.

A. Retrofit Technology

Retrofit technologies are available to reduce emissions from the older urban bus fleet. A retrofit involves a hardware modification to an existing engine to reduce its emissions from the standards to which it was originally certified. This section discusses only NOx and PM retrofit technologies, although other pollutants may also be reduced through retrofits.

1. PM Retrofit Technology

a. Diesel Particulate Trap Oxidizer

A trap oxidizer system consists of a filter positioned in the exhaust stream designed to collect a significant fraction of the particulate emissions while allowing the exhaust gases to pass through the system. Since the volume of particulate matter generated by a diesel engine is sufficient to fill up and plug a reasonably sized filter over time, a means of disposing of the trapped particulate must be provided. The most promising means of disposal is to oxidize the particulate in the trap, thus regenerating the filter. Different techniques are available to facilitate trap regeneration since the exhaust temperature of diesels is not always sufficient to initiate regeneration. Trap systems do not appear to cause any additional engine wear or affect vehicle maintenance.[2]

Several promising particulate trap technologies are Johnson Matthey's Continuously Regenerating Technology (CRT™) diesel particulate filter and Engelhard's DPX™ catalytic soot filter. The CRT™ combines a platinum-based catalyst with a filter element. The catalyst oxidizes NO to NO_2 and uses the produced NO_2 as an oxidant to remove the PM trapped in the filter material following the catalyst. The CRT™ does require the use of low-sulfur diesel fuel (< 50 parts per million sulfur). Englehard manufacturers different DPX™ PM systems that can work at different fuel sulfur levels, including current California fuel. Programs are underway to evaluate appropriate levels of sulfur for future diesel fuel. In one such program in southern California, Detroit Diesel Corporation, Johnson Matthey, and Engelhard will demonstrate ARCO's new diesel fuel containing virtually no sulfur, thus enabling catalysts and particulate filters to operate more efficiently and with increased durability.[3] The CRT™ has demonstrated reductions in PM emissions by greater than 90 percent.

b. Diesel Oxidation Catalyst

An oxidation catalyst transforms pollutants into harmless gases by mean of oxidation. The catalyst oxidizes CO, gaseous HC, and the liquid HCs adsorbed on the carbon particles present in diesel exhaust gases. The liquid HCs are referred to as the soluble organic fraction (SOF) and make up part of the total PM. Oxidation catalysts can reduce the SOF of particulate by 90 percent under certain operating conditions[4], and according to staff estimates, could reduce total particulate emissions by greater than 30 percent.

Oxidation catalysts have proven effective in achieving modest PM emission reductions on older buses. Under the U.S. EPA's urban bus rebuild/retrofit program, five manufacturers have certified diesel oxidation catalysts as providing at least a 25 percent reduction in PM emissions.

1. NOx Retrofit Technology

a. Selective Catalytic Reduction

Selective catalytic reduction (SCR) systems use a reductant, usually ammonia or urea, to convert NOx to nitrogen and oxygen. These systems are common in stationary sources and are also used on some mobile sources in Europe. In this system, the reductant is injected into the exhaust upstream of the catalyst . As the exhaust gases, along with the reductant, pass over a catalyst applied to either a ceramic or metallic substrate, NOx emissions can be reduced by more than 70 percent[5]. The staff estimates PM emissions could be reduced by 25 percent and HC emissions by 50 to 90 percent. SCR retrofit systems are expected to be available for urban bus applications within two to three years.

C. New Technology

To comply with future, more stringent NOx emission standards, diesel engine manufacturers are researching several promising technologies for diesel engines, such as cooled exhaust gas recirculation (EGR) and aftertreatment technologies. Incorporation of these technologies into natural gas engines will also lower their emissions significantly from current levels, continuing to make them lower-emitting than even the best available diesel technology.

Other technologies capable of reducing emissions to near-zero or zero levels, such as hybrid-electric, battery-electric, and fuel cell technologies, are rapidly emerging. However, few of these technologies are at a commercial stage for urban buses today. The proposed regulation's aggressive time frame for longer-term engine standards is necessary to move near-zero and zero-emission urban buses from the developmental stage to commercial production. The proposed regulation requires the ARB staff to perform a technology assessment of zero-emission technology for urban transit buses no later than January 2006.

1. Future Diesel Technology

a. Exhaust Gas Recirculation

Exhaust gas recirculation is one of the most effective engine control methods for reducing NOx emissions. Spent combustion gases recirculated back into the intake system serve as a diluent to lower the oxygen concentration and to also increase the heat capacity of the air/fuel charge. Cooled EGR (cooled through the aftercooler) is used to minimize combustion temperatures. This reduces peak combustion temperature and the rate of combustion, thus reducing NOx emissions. However, PM emissions may increase and fuel economy may decrease. The proper balance of EGR and temperature may provide the proper characteristics necessary for decreasing NOx emissions without increasing PM emissions. It is anticipated cooled EGR would be an integral part of the engine manufacturers' effort to meet the lower NOx emission requirements in October 2002.

b. Aftertreatment Technologies

Heavy-duty engine exhaust aftertreatment for NOx is currently limited by the lean environment (excess oxygen) of diesel engines. Automotive catalysts rely on a nearly perfect balance of oxygen in the exhaust stream to maximize catalytic converter efficiency. One solution for heavy-duty vehicles, including urban buses, is the use of SCR systems described above in the Retrofit Technology section. The estimated cost of an SCR system appears reasonable and NOx emissions are reduced by more than 70 percent. Most of the challenges to SCR use appear to be pragmatic (e.g., packaging, communication of the SCR system with the engine's computer controls, etc.). SCR systems are expected to be commercially available on new buses within two to three years.

For the 2004 time frame, NOx adsorbers are expected to be available. NOx adsorbers do not require an additional reductant to be added. Again, the cost is expected to be reasonable and NOx emissions are expected to be reduced by more than 70 percent. However, a critical element of this technology and other aftertreatment technologies is the necessity to have low-sulfur fuels. Although an SCR system may not need low-sulfur fuel, most other heavy-duty aftertreatment technologies will not function efficiently and reliably in an exhaust environment with a significant quantity of sulfates present, which cause trap plugging and catalyst fouling. As mentioned previously, programs are underway to evaluate appropriate levels of sulfur for future diesel fuel.

As discussed in the retrofit section, several particulate trap systems are available to reduce PM emission levels by more than 90 percent. It is expected that to meet the proposed 2004 requirements particulate trap systems will be used in conjunction with a NOx aftertreatment (SCR or absorbers). Low-sulfur fuel (less than 30 ppm sulfur) will be necessary with this technology.

a. Diesel Hybrid-Electric

Bus manufacturers and transit agencies have expressed interest in diesel hybrid-electric technology because of their familiarity with diesel technology and its compatibility with current fueling infrastructure. Diesel hybrid-electric technology utilizes electric traction drive motors, batteries, and a diesel engine/generator set combination, rather than the conventional engine/transmission combination. The batteries can be charged by the engine/generator set and through regenerative braking. On site "plug-in" charging may also be used to recharge batteries

Several demonstration projects with diesel hybrid-electric buses are underway with promising results. Preliminary reports indicate that the higher efficiencies associated with diesel hybrid-electric technology, compared to conventional diesel technology, can reduce fuel consumption by 25 percent, and reduce emissions of NOx and PM by

30 percent and 80 percent, respectively. In addition, an engine operating in a hybrid vehicle generally operates in a limited operating range. Therefore, without the severe transient parameters that typically accompany urban bus operation, exhaust aftertreatment can be designed far more efficiently. Significant emphasis is being placed on cost reductions for future hybrid-electric buses.

b. Additional Controls

In order to reach the 0.2 g/bhp-hr NOx levels in 2007, additional engine controls and refined aftertreatment are expected to be necessary. It is anticipated that significantly lower NOx levels can be achieved through increased and optimized exhaust gas recirculation rates under all operating conditions. Relatively high PM emissions resulting from increased exhaust gas recirculation usage can be significantly reduced with a particulate filter, as discussed earlier. The ARB staff has attempted to harmonize the proposed 2007 model year urban bus engine standards (0.2g/bhp-hr NOx and 0.01 g/bhp-hr PM) with the heavy-duty engine standards under consideration by the U.S. EPA for the 2007 time frame.

2. Alternative-Fuel Technology

a. Natural Gas

The engine and aftertreatment technologies discussed above in the Diesel Technology section are generally applicable to lean-burn natural gas engines. Because natural gas engines operate at higher temperatures, which can improve the efficiency of aftertreatment technologies, higher aftertreatment efficiencies could be achieved than from comparable diesel engines. In addition, natural gas contains little or no sulfur so aftertreatment systems would not have the efficiency and durability issues associated with sulfur poisoning from diesel fuel.

b. Hybrid-electric (non diesel)

In the developmental and early demonstration stage, hybrid-electric buses have been designed with power systems integrating battery-electric motors with internal combustion engines (or fuel cells). Hybrid-electric bus designs can incorporate internal combustion engines fueled by alternative-fuels, such as LPG and CNG, in addition to diesel fuel, as discussed above in the Diesel Technology section. These buses can operate in pure electric mode or in hybrid mode. A bus operating in pure electric mode does not have emissions. A bus operating in hybrid mode will have emissions, which will vary depending on fuel type, but will have the potential for significantly lower emissions than a conventional diesel urban bus.

c. Battery-electric

Battery electric motor propulsion systems offer quiet, exhaust free, and odorless bus operation without the fixed route constraints of electric trolley buses. Batteries are devices that store electrochemical energy, without the polluting byproducts of combustion. When the stored energy is depleted, the batteries must be recharged (refueled) by the process of passing electricity into the battery. The current practice is

to connect the buses to an electricity generation grid overnight. As noted in the previous discussion on electric trolley buses, emissions from power plants supplying electricity are a consideration.

An electric powertrain can process stored energy more than five times as efficiently as a diesel engine and can be further enhanced with the presence of regenerative braking. However, compared to diesel buses, the range of battery-electric buses is severely limited by the energy storage capacity of the various chemical battery technologies. For example, diesel #2 fuel has nearly 300 times by weight and 90 times by volume the stored energy of a lead-acid battery. Utilization of advanced lead-acid or nickel cadmium batteries will provide buses with more range -- up to 120 miles. While the passenger capacity of battery-electric buses is also reduced by the weight and volume of current batteries, these buses are suitable for the many short-range duty cycles typical of urban bus operations. Furthermore, range can be extended with opportunity charging (with fast or rapid charging), battery-exchange, or on-board auxiliary power units.

Commercial battery-electric bus technology is currently limited to smaller buses, known as electric shuttles, that do not meet the gross vehicle weight rating classification for conventional urban buses (>33,000 pounds). These electric shuttles are in regular service in many transit districts nationwide. In California, about 30 percent of the Santa Barbara Municipal Transit District fleet is battery-electric shuttles, which are used primarily on waterfront and downtown routes. Electric shuttle utilization is constrained by range requirements, terrain, and climate. Current development efforts are focusing on battery and recharging technology. Larger electric buses that would meet the definition of an urban bus are still in the developmental stage.

d. Fuel Cells

Fuel cell vehicles operate quietly, efficiently, and have the potential for zero or near-zero exhaust emissions. Fuel cells generate electric power through an electrochemical reaction in the same manner as batteries. While batteries must be recharged when the stored reactants (fuels) are depleted, fuel cells can produce power as long as hydrogen and oxygen fuels are continuously supplied.

Each cell of a fuel cell stack contains two electrodes (usually containing platinum to catalyze the anodic and cathodic reactions) separated by an electrolyte (either aqueous or nonaqueous). Hydrogen (H_2) is supplied to the anode, and oxygen (O_2) to the cathode. The anodic oxidation of hydrogen results in protons (H^+) and electrons (e^-). Protons migrate through the electrolyte membrane to the cathode. The electrons flow through an external circuit to the cathode. The external circuit can power a load while the protons, electrons, and oxygen recombine at the cathode to produce water.

The choice of fuel will impact emissions, overall fuel efficiency, and cost of the fuel cell bus. The type of fuel supplied to a fuel cell bus will determine the exhaust emissions. If onboard hydrogen (either delivered or produced at a transit agency's central fueling station) is the fuel source, the exhaust emissions will be zero. On-site production of hydrogen would be primarily by electrolysis of water or reforming of hydrogen-

containing fuels. If fuels such as natural gas, methanol, diesel, or gasoline are reformed onboard the bus (to produce hydrogen for the fuel cell), then some level of controlled emissions will occur, although at lower amounts than those emitted by internal combustion engines. Onboard fuel reforming reduces fuel efficiency because a percentage of the energy content of the original fuel is lost in the conversion. Onboard reforming also increases the purchase cost of the bus.

Proton exchange membrane (PEM) fuel cell and phosphoric acid fuel cell (PAFC) technologies have proven to be reliable. PAFCs are currently used worldwide to produce heat and electricity. They are particularly suited for hospitals and high technology facilities where a highly reliable source of energy is needed. The two most prominent types of fuel cells currently under development for transit applications are PEM fuel cells and PAFCs. In particular, the PEM fuel cell technology has emerged as the prime candidate in the transportation market. Ballard Power Systems has employed the PEM technology in demonstration fuel cell bus programs in Chicago, Illinois, and Vancouver, Canada. Additionally, dbb fuel cell engines, inc. expects to commercially produce fuel cell bus engines by 2002.[6] Fuel cell buses using the PAFC technology with onboard methanol reforming have been built under a Department of Energy/Federal Transit Administration contract and demonstrated by Georgetown University.

VI. ISSUES

The following sections discuss issues and topics pertaining to the proposed regulation.

A. Compressed Natural Gas Urban Bus Fleets

Several transit agencies have indicated that CNG bus operating costs are higher than diesel bus operating costs. However, some transit agencies have reported lower operating costs for CNG buses than for diesel buses. As natural gas fleets are relatively new, a comprehensive long-term comparison of operating costs of CNG buses to diesel buses is difficult to do at this time. Operating costs include both maintenance and fuel costs. While maintaining diesel fleets can currently cost less than for CNG fleets, the requirements for diesel engines to meet more stringent emission standards, along with the availability of more reliable natural gas engines, should close that gap and equalize the costs. Fuel costs per mile for natural gas buses, including natural gas compression or liquefaction, is less than for diesel buses. The increased price of low-sulfur diesel fuel needed in the future should increase this difference. Future operating costs for natural gas fleets and diesel fleets are expected to be comparable. Transit agencies can project local costs for operating different types of fleets and consider that information when choosing the diesel path or the alternative-fuel path.

B. Funding Sources

Funding constraints have been raised by many transit agencies as a concern associated with this proposal, and the ARB staff has looked into the urban bus funding process. The Federal Transit Administration (FTA) pays 80-83 percent of the purchase

cost of a new urban bus. The remaining cost is made up from local and state transportation funds. Local and regional transportation planning agencies control the allocation of federal, state and local transportation funding in urban areas; the State Department of Transportation allocates some funds in rural areas.

The transportation planning agencies prioritize project categories and assign funding to each category. Transportation projects can include planning projects, streets and highways, bridges, public transit, rail projects, ferry operation, pedestrian and bicycle facilities, and other services and projects. Without additional transit funding in some regions, any additional cost of buying and operating transit buses meeting lower emission standards could result in service cut-backs or fare increases. In order to adequately fund transit operations, some transportation planning agencies would have to re-prioritize their project categories. The ARB staff and some local air districts are encouraging transportation planning agencies to provide more funding for transit agencies.

Various incentive programs to assist with new bus purchases are also available in most areas of the state. These incentive programs include the federal TEA-21 Congestion Mitigation and Air Quality Improvement Program (CMAQ), the state Carl Moyer Memorial Program, grants from the California Energy Commission (CEC), and air districts' motor vehicle registration fee (MV) programs. Additional funding should become available from other TEA-21 programs, as well as from state transportation accounts.

Projected statewide funding for new alternative-fuel buses is shown below in Table 10. In addition to new alternative-fuel bus purchases, some programs can also fund infrastructure costs.

TABLE 10

Funding Scenario for Alternative-Fuel Buses and Infrastructure		
Funding Program	**$M for New Bus Purchases**	**Infrastructure Costs Covered**
FHWA CMAQ [2]	60	Yes
FTA Formula 5307[1]	102	Yes
FTA Clean Fuels Formula Grants[2]	10	Yes
FTA Transit Capital 5309[2]	11	Yes
Moyer Incentive[3]	4.0	No
State, local [1]	34	Yes
MV Projects[1]	12	Yes
CEC grants	0	Yes ($2M)

1. Based on historical funding.
2. Best case scenario in California
3. Estimated amount as statewide data not yet available

The incentive programs generally co-fund the cost of an alternative-fuel bus and, in some cases, the cost of the infrastructure. In general, the staff found that adequate funding -- from transportation, air quality and energy-related sources -- is available to subsidize the incremental cost of alternative-fuel buses in urban areas, assuming a normal bus turnover rate. However, enough transportation or incentive funding has not been identified to cover the entire cost of the required infrastructure. The ARB staff is working with other agencies to assist in securing additional funding from federal, state, and local sources.

Only the purchase of buses with engines meeting the ARB's optional, reduced-emission standards or other low-emission standards (as defined by the air districts) meet the eligibility criteria for air quality incentive funds. Only the incremental cost of buses meeting the lower standards is generally funded. The ARB expects alternative-fuel buses that certify to the ARB's optional 2.5 g/bhp-hr NOx standard from 2000 to October 2002 to be eligible for grant funding. After October 2002 when a more stringent NOx + NMHC engine standard is in effect, only buses with engines meeting the 1.8 g/bhp-hr optional NOx + NMHC standard (or a lower reduced-emission optional standard) are expected to be eligible for incentive funding. Air quality incentive funds may also be used for technology advancement. Therefore, emerging zero-emitting technologies, such as fuel cell buses, would be eligible for co-funding with air quality incentive funds.

C. School Buses

The ARB staff has received numerous comments that school buses should be included in this proposal, and, in fact, ARB sets a high priority on reducing student exposure to toxic particulate emissions from diesel-powered school buses. Originally, a school bus fleet rule was included in this proposal. However, the ARB staff has found barriers to including school districts in the fleet rule. The most significant barrier is the lack of available funding for new bus purchases and infrastructure for the approximately 900 school districts in the state that provide school bus service. The ARB will consider a separate proposal to reduce emissions from school buses at a later date. In the interim, the ARB staff will assist and encourage transportation agencies, air districts, state agencies, environmental groups, school districts and others to identify funding opportunities and regulatory methods that would reduce student exposure to toxic PM emissions from diesel-fueled engines.

D. Long-term Viability of Natural Gas Fleets

One of the concerns expressed to the ARB staff during the development of this proposal was the possibility of stranding transit agencies' investments in natural gas infrastructure as fleet operators acquire zero-emission buses. The ARB encourages and supports the purchase of clean natural gas buses and believes this technology has long-term viability. The staff proposal for transit agencies on the alternative fuel path requires that 85 percent of new bus purchases be alternative-fuel through model year 2015. Therefore, 85 percent of new bus purchases for transit agencies on the alternative-fuel path would likely be natural gas or, eventually, for large fleets, zero-

emission buses. An option for producing hydrogen is to reform CNG on site. In this case, the existing natural gas infrastructure will be transferable to the operation of fuel cell buses and could substantially reduce the infrastructure cost for fuel cell bus fleets.

E. Natural Gas Availability

Pipeline natural gas is not available in some areas, including the Lake Tahoe area and some rural counties. In those areas, transit districts have little opportunity to operate natural gas buses. The ARB staff expects that in areas of the state where natural gas is unavailable, transit fleets will continue to purchase and/or lease diesel buses, thus participating in the diesel path of the transit bus fleet rule. Diesel bus purchases or leases will be required to meet the emission standards for the years 2002, 2004, and 2007, as proposed in this regulation.

F. Safety Issues

The safety of all motor vehicle technologies is a concern. Compressed natural gas tanks, which are under high pressure, have the potential to rupture. A rupture of a CNG tank can cause severe damage. One such rupture occurred several years ago at the Los Angeles County Metropolitan Transit Authority. To help ensure safety, operators with natural gas buses have instituted rigorous inspection procedures and provided safety training, in addition to other safeguards. Since CNG is more volatile than diesel fuel, modifications to existing maintenance facilities are generally necessary. The modifications usually consist of a methane detection system, an improved ventilation system, new lighting, employee training, and containment procedures.

Safety issues for battery-electric buses (and passenger vehicles) have been addressed by codes, standards or recommended guidelines for battery recharging stations, by onboard systems, and by training programs for emergency response personnel. One California transit district reports no battery-related incidents after 25,000 duty cycles. The ARB staff is aware of only two emergency incidents, both of which occurred on the East Coast.

For fuel cell buses, safety concerns vary according to the fuel feedstock, but frequently focus on hydrogen handling and use. Hydrogen and natural gas, as flammable substances, have similar safety issues. Gaseous fuels have been used in transit applications for several years. This existing base of information can be fairly easily extrapolated to hydrogen. Some work has gone into the preparation and publication of guidelines for hydrogen systems and equipment.

G. Ridership Issues

Transit agencies that operate low-emission, alternative-fuel buses advertise the clean air benefits of their buses. Some studies show a definite increase in ridership

attributable to reduced air pollution and smoke-free exhaust. However, a lack of transportation funding due to increased capital and operating costs of alternative-fuel buses could cause delays in replacing older, less reliable diesel buses or increases in fares, thus decreasing ridership. This could adversely impact emission reduction opportunities and those who depend on public transit. Adequate availability of incentive funding can help avoid such impacts.

H. Statement of Principles

The Statement of Principles (SOP), an agreement signed by the ARB, U.S. EPA, and heavy-duty engine manufacturers in 1995, provides a fixed schedule for the introduction of new heavy-duty engine standards. It is intended to result in consistency nationwide, where possible, in heavy-duty engine standards, including urban bus engine standards. The adoption of a transit bus fleet rule is not in conflict with the SOP agreement. In lieu of adopting new mandatory urban bus engine standards effective in the short term, the ARB staff is proposing a transit bus fleet rule to achieve near term emission reductions. For the long term, the ARB staff has attempted to harmonize the new urban bus engine standards in this proposal (0.2g/bhp-hr NOx and 0.01 g/bhp-hr PM) with the heavy-duty engine standards under consideration by the U.S. EPA for the 2007 time frame. If the proposed levels are not the emission levels ultimately adopted by the U.S. EPA, staff would consider modifications to the proposed long-term emission standards.

I. Settlement Agreements

The ARB and the U.S. EPA have already adopted heavy-duty engine emission standards to take effect in 2004. As a result of the Heavy-duty Diesel Settlement Agreements between the U.S. EPA, the ARB, and seven engine manufacturers, signed in 1998, the engine manufacturers will “pull-ahead” the introduction of new engines, i.e., they will introduce engines meeting the 2004 heavy-duty engine emission standards into California buses beginning in October 2002. However, there is an issue related to one engine manufacturer not subject to the pull-ahead requirement that is producing urban bus engines being marketed and sold by a second engine manufacturer that is subject to this requirement. The ARB staff believes that if these engines were indeed marketed by the second manufacturer beginning in October 2002, this would jeopardize the emission benefits of this proposal and would be a circumvention of the Settlement Agreements and a violation of its applicable requirements.

J. Buses Designated as Alternative-fuel Buses

For the purposes of the fleet rule, ARB staff proposes that buses designated as alternative-fuel buses are: natural gas, propane, ethanol buses, battery-powered buses, electric trolley buses, hybrid-electric CNG buses, fuel cell buses and other advanced technologies that do not rely on diesel fuel. Diesel, diesel hybrid-electric, dual-fuel buses, and other buses that use diesel fuel would not be considered alternative-fuel buses.

The purchase of diesel hybrid-electric buses is allowed on the alternative-fuel path, as 15 percent of new purchases can be something other than alternative-fuel buses. However, engine manufacturers have expressed concern that purchase of diesel-hybrid-electric buses would not count towards the 85 percent alternative-fuel purchase requirement. Engine manufacturers maintain that emissions from diesel hybrid-electric buses, and from newer technology diesel buses from 2004 to 2007, could be lower than those of natural gas buses.

The ARB staff agrees that, at a particular point in time, NOx emissions from a new diesel hybrid-electric or newer technology diesel bus could be lower than NOx emissions from a new CNG bus (though not as low as emissions from electric-powered buses, hybrid-electric CNG buses, or hydrogen fuel cell buses). However, ARB staff does not believe lower NOx emissions for some model years is sufficient justification to allow diesel buses or diesel hybrid-electric buses to qualify toward the 85 percent alternative-fuel purchase requirement.

One of the main purposes of the alternative-fuel path is to encourage transit agencies to make a firm commitment to operating an alternative-fuel fleet. In the long-term, this helps engine manufacturers justify continued reliability and emission reduction improvements to their alternative-fuel engines. Second, staff estimates, based on existing in-use test data, that PM in-use emissions would be 30 to 50 percent lower for a natural gas bus engine certified to the proposed 0.03 g/bhp-hr PM standard than for a diesel bus engine certified to the proposed 0.01 g/bhp-hr PM standard.

K. Zero-emission Bus Demonstration Projects

The ARB staff is proposing that transit agencies that are required to undertake a zero-emission bus demonstration project could conduct a joint project with a limit of no more than three agencies per project. A joint demonstration project would mean significant cost-savings for those transit agencies involved because the cost of management, training, infrastructure, any new facilities or modifications, and other costs would be shared. In the proposal, a demonstration project would include three zero-emission buses. A request has been made to allow fewer than the required three buses per agency in a joint project. In light of the cost-savings already achieved, and the need to provide a broad-based demonstration that includes mechanic and driver training, public visibility, revenue service over a large area, passenger reaction, and overall experience with this new technology, the staff believes its proposal requiring three buses per agency is also appropriate for joint zero-emission bus demonstration projects.

L. Composite Buses

The possible exemption of lightweight composite buses from urban bus standards is an issue. Urban buses are defined by several characteristics including a gross vehicle weight of more than 33,000 pounds. Innovative bus manufacturers are proposing development of diesel, hybrid-electric and alternative-fuel buses made of lightweight composite materials with a nominal curb weight as low as 22,000 pounds. Even when fully loaded, such buses may weigh less than 33,000 pounds GVW. Staff proposes that

lightweight buses that are powered with heavy-duty diesel engines, diesel-derived engines, or zero-emission engines, carry comparable passenger loads in urban bus service, and meet other definitions of urban buses, would be considered urban buses for the purposes of this proposal.

VII. REGULATORY ALTERNATIVES

A. Do Not Adopt Transit Agency Fleet Rule and Amend California Urban Bus Standards

One alternative to this proposal would be to continue using the current heavy-duty diesel engine standards. In addition to being less stringent than the proposed emission standards for urban bus engines, the current standards do not include a transit bus fleet rule component to increase low-emission, alternative-fuel use in the new fleet and to reduce NOx and PM emissions from the in-use fleet. Low-emission, alternative-fuel technology can provide significant emission reductions over conventional diesel technology, and can reduce the public's exposure to toxic PM emissions. Retrofit technologies can provide additional emission reductions and also reduce the public's exposure to toxic PM emissions. While some transit agencies have voluntarily taken steps to reduce emissions immediately, others have not. Many areas of California are still in violation of health-based state and federal air quality standards and therefore emission reductions are necessary from those sources with the ability to provide them. The staff recommends the Board adopt the regulation, as proposed, presented in this report.

B. Adopt Low-Emission Standards Requiring Alternative-Fuel Use

Another alternative to the current proposal would be to adopt emission standards that would immediately require all new bus purchases to be low-emission, alternative-fuel buses. Alternative-fuel technology has the ability to meet low-emission NOx and PM levels now. Furthermore, this technology is well established and many transit agencies already have practical experience with converting their fleets to low-emission, alternative-fuels.

However, during the development of this regulatory proposal, many transit districts and transportation agencies expressed the need for greater flexibility. As such, the staff's proposal incorporates provisions to allow diesel technology as an alternative for reducing emissions, yet includes mechanisms to remove the most polluting diesel engines from service and to introduce advanced, alternative-fuel technologies (e.g., battery-electric buses and fuel cell buses). The staff believes the current proposal will provide more flexibility to transit districts than emission standards requiring the use of low-emission, alternative fuel only.

C. Adopt A Fleet Average Rule

An additional alternative to the current proposal would be to adopt a fleet average rule, in lieu of new emission standards, that takes into account new bus purchases and buses already in-use. However, in analyzing the fleet average concept, the staff discovered that fleet characteristics differed so significantly between transit agencies that an effective fleet average system could not be established unless the baseline emission rate started so low as to challenge even the most proactive transit agencies. Alternatively, the baseline emission rate could be set higher to accommodate the transit fleets with large numbers of older buses, but this would drastically reduce achievable emission benefits.

Instead, the ARB staff is proposing a modified fleet average rule that is just one component of the overall transit bus fleet rule. The modified fleet average component reduces the challenges associated with the "fleet average rule only" alternative.

D. Adopt Public Workshop Proposal Dated September 23, 1999

On October 18 and 20, 1999, the staff held two public workshops to discuss a publicly released proposal dated September 23, 1999. Like the current proposal, the September 23, 1999, proposal contained two paths for transit agencies to choose from in reducing emissions from their urban bus fleets. It was clear from the workshops, however, that the proposed paths, both of which allowed the use of diesel technology, did not adequately induce an increased penetration in low-emission, alternative-fuel technology, or an investment in advanced, alternative-fuel technologies that are zero-emitting. Additionally, the September 23, 1999, proposal did not contain any retrofit or repower provisions to reduce NOx and toxic PM emissions from the in-use urban bus fleet.

In the current proposal, one of the two paths that transit agencies must choose requires the use of low-emission, alternative-fuel technology, while the other path allows the use of diesel technology. Structured this way, the staff's current proposal provides for increased penetration of low-emission, alternative-fuel technology, including investment in advanced, alternative-fuel technologies, yet it still provides flexibility to transit agencies. It is intended that the emission standards in the proposal harmonize with the standards that U.S. EPA is expected to adopt in 2000. Furthermore, the current proposal contains a modified fleet average component for NOx control, as well as retrofit requirements to achieve both NOx and PM emission reductions.

VIII. ECONOMIC IMPACTS

A. Legal Requirement

Sections 11346.3 and 11346.54 of the Government Code require state agencies to assess the potential for adverse economic impacts on California business enterprises and individuals when proposing to adopt or amend any administrative regulation. The assessment shall include consideration of the impact of the proposed regulation on

California jobs, business, expansion, elimination, or creation, and the ability of California businesses to compete.

State agencies are also required to estimate the cost or savings to any state or local agency and school districts in accordance with instruction adopted by the Department of Finance. This estimate is to include any nondiscretionary costs or savings to local agencies and the costs or savings in federal funding to the state.

B. Affected Businesses

Businesses that may be affected as a result of the proposed regulation include heavy heavy-duty diesel or alternative-fuel urban bus engine manufacturers, urban bus manufacturers, engine retrofit kit manufacturers, exhaust aftertreatment emission control manufacturers, and manufacturers of advanced, alternative-fuel technologies, such as batteries and fuel cells. Since there are no urban bus engine manufacturers located in California and only one urban bus manufacturer in California, most impacts to business, both positive and negative, will occur in other states.

C. Potential Impacts on Business

The proposed regulation is projected to have some cost impact on companies involved in the manufacture and production of engines and transit buses by creating the need for new engines and buses. Currently, there are no urban bus engine manufacturers located in California and only one urban bus manufacturer. The staff estimates that the cost of the proposed regulation to engine and bus manufacturers would be less than $10,000 per bus. The total impact on businesses in California will be determined by the extent to which these companies choose to expand production in California, as well as the extent to which any increases in costs could be passed on to the final purchasers of engines and buses. As an example, ddb fuel cell engines, inc. has recently opened a research and development site near San Diego, California, to promote the use of fuel cell technology in passenger cars and urban transit buses. Specific to the retrofit requirements, California businesses capable of performing engine retrofits will be positively affected with increased workload.

The proposed regulation will also have a financial impact on transportation agencies and commissions statewide by requiring these entities to fund retrofits of existing engines to low-emission configurations and purchase new clean buses. For new bus purchases, federal funds are available to cover 80 percent of the total cost of a diesel urban bus, and 83 percent of a low-emission alternative-fuel bus. The remaining percent of new bus purchase costs not covered by federal funds, as well as costs for retrofits, will have to be covered by other funding sources, which include transportation, air quality, and energy funds.

D. Potential Impact on Business Competitiveness

The proposed regulation is not expected to impact the ability of California businesses to compete with businesses in other states. As indicated above, most businesses that produce the products needed to meet the proposal are located in other states. By requiring new, clean technology, this proposal may actually provide new opportunities for California businesses engaged in advanced technology.

E. Potential Impact on Employment

The proposed regulation will likely create a market for manufacturers of heavy-duty diesel or natural gas urban bus engines, urban buses, and exhaust aftertreatment devices. For those businesses located in California, the creation of new jobs is expected to meet this demand. Services to retrofit existing buses are expected to take place in California creating new opportunities for existing businesses.

F. Potential Impact on Business Creation, Elimination, or Expansion

The proposed regulation could impact any California companies involved in the manufacture and production of engines and transit buses. Currently, there are no engine manufacturers and only one bus manufacturer located in California. Requiring new, cleaner engines and buses, could create new business opportunities for manufacturers of heavy-duty diesel or natural gas bus engines, urban buses, and exhaust aftertreatment control devices. While most businesses that could benefit from the increased business are located outside of California, the total impact on California business will be determined by the extent to which these companies choose to expand in California. As an example, ddb fuel cell engines, inc. has recently opened a research and development site near San Diego, California, to promote the use of fuel cell technology in passenger cars and transit buses. This expansion is a result of the expected new business opportunities created by the need for cleaner transportation technologies.

G. Potential Costs to Local and State Agencies

The proposed regulation is expected to have an impact on transportation planning agencies and commissions (the entities that fund transit agencies), and transit agencies statewide. This is due to the proposed requirements for a NOx fleet average standard, low-sulfur diesel fuel, new bus purchases, and PM retrofits. The following provides a summary of the costs to agencies for complying with the proposed regulation.

1. Fleet NOx Average Emission Requirements

The ARB staff projects that most transit agencies will comply with the fleet average NOx emission standard by retiring 1987 and earlier buses and then replacing them with new buses meeting more stringent emission standards. The ARB staff anticipates that in most cases, transit agencies will be able to obtain sufficient funding from available state and federal sources to purchase the new buses. As a result, no significant additional costs to transit agencies are expected for compliance with the fleet average NOx

emission standard in 2002. There may be, however, instances where a transit agency is not able to obtain sufficient funds to purchase the new buses necessary for compliance with the fleet average NOx emission standard. Reasons for insufficient funding could include gaps in a particular funding cycle or the requirement for an inordinately large number of pre-1988 buses that need to be replaced. In these cases, there will be some cost to the transit agency to comply with the fleet average NOx emission standard.

This cost cannot be determined accurately since it would be based on specific fleet composition and internal bus replacement policy of each transit agency and their local transportation commission. An alternative available to transit agencies is to repower or retrofit a certain number of existing buses to lower emission configurations. The cost of an engine repower or retrofit kit is several times less expensive than the cost of a new bus, although the remaining useful life of a repowered or retrofitted bus will likely be less than that of a new bus. The ARB staff estimates that an engine repower or a retrofit kit will have an incremental cost of less than $10,000, including installation. This may be done instead of, or in addition to, buying new buses. A transit agency will need to evaluate the most cost-effective method for its specific fleet to comply with this requirement.

2. PM Retrofit Requirements

Under the proposed PM retrofit requirements, transit agencies are responsible for installing PM retrofit devices that are certified with a conversion efficiency of at least 85 percent. To provide the time necessary to accomplish this program and to focus on the most serious problems first, the PM retrofit requirements are divided in three Tiers. Table 11 provides estimated costs for a “typical” 200-bus fleet, as well as statewide costs.

Tier 1: Tier 1 requires that buses certified to a PM standard of 0.6 g/bhp-hr be retrofitted by January 1, 2003. These are 1990 and earlier model-year buses and have extremely high emission levels of toxic particulates. On-road emissions of these buses are estimated as greater than 1.7 g/mile, compared to 0.02 g/mile for a natural gas bus. The ARB estimated that there are currently over 4,300 of these buses statewide. Many of these older buses are expected to be retired by 2003 a part of normal fleet turnover and because of the proposed NOx fleet average requirement. A conservative estimate would be that 12 and 13 year old buses are still within the fleet, but that all buses 14 year old and older have been retired. Therefore, given the current in-use fleet distribution, staff estimates that approximately 800 buses would be affected by this requirement. For a “typical” evenly distributed 200-bus fleet, this would represent approximately 16 buses. At a cost of $3,000 per bus, the total cost for a typical 200-bus fleet would be $50,000. Larger fleets would obviously have greater costs and smaller fleets would have lower costs. Total statewide costs are estimated at $2,400,000.

Tier 2: Tier 2 requires that buses certified to 0.10 g/bhp-hr PM and 0.07 g/bhp-hr PM be retrofitted in the 2003 to 2005 time frame. These are 1991 to 1995 model-year buses. On-road emissions of these buses are estimated as greater than 1.0 g/mile of PM. The

ARB staff currently estimates that there are about 2,000 of these buses. The staff estimates that most of the 1991 model year buses are likely to be normally retired prior to requiring retrofits. Therefore, based on the current in-use fleet, the Tier 2 requirements are likely to affect approximately 1,500 buses total. For a typical 200-bus fleet, approximately 70 buses would require retrofits, for a cost of $200,000. Total costs statewide are estimated at $4,500,000.

Tier 3: Tier 3 requires that buses certified to 0.05 g/bhp-hr PM be retrofitted in the 2007 to 2009 time frame. These are 1996-2003 model-year buses, although it is likely that new buses delivered to transit districts in 2002 and 2003 could already be equipped with the "retrofit" installed. If the particulate aftertreatment were marketed by the engine or bus manufacturer as part of a new bus, it is likely that the cost could be reduced substantially. In addition, staff is assuming that by the time Tier 3 requirements are needed, at least modest cost reductions of 25 percent would have occurred. Therefore, staff is assuming a retrofit cost of $2,250. ARB staff estimates that there are a total of about 3,800 of these 1996-2003 model year buses, but only about 2,200 of these buses will be required to retrofit. This is because the retrofit requirements do not apply to alternative-fuel buses. For a "typical" 200-bus fleet on the diesel path, 130 vehicles would require retrofit systems at a total cost of $300,000. A transit agency on the alternative-fuel path would have retired most of their diesel buses and is expected to have a cost of no more than $70,000. Total statewide costs, assuming half of the transit districts are on the alternative-fuel path, are $5,000,000.

TABLE 11

Average Annual Cost of PM Retrofit Requirements (2003-2009)		
	"Typical" 200-bus fleet	Statewide Transit Costs
Tier 1 (by 1/1/03)	$50,000	$2,400,000
Tier 2 (by 1/1/05)	$200,000	$4,500,000
Tier 3 (by 1/1/09)	$300,000	$5,000,000
Total (average annual cost 2002-2008)	$80,000	$1,700,000

3. Low-Sulfur Diesel Fuel

ARB staff is proposing that by July 1, 2002, all diesel fuel used by transit districts must have a sulfur content no greater than 15 parts per million (ppm). The incremental cost of the lower sulfur diesel fuel is estimated to be five cents per gallon. However, some fuel providers have quoted lower incremental costs for lower sulfur diesel fuel, while other fuel providers have quoted incremental costs as high as 15 cents per gallon. For a 200-bus diesel fleet, the estimated cost would be $120,000 per year. Transit districts are assumed to have modest savings with the fuel due to increased engine durability. This should be especially significant with engines produced after October 1, 2002, which are likely to incorporate EGR in order to meet lower emission standards. The savings, however, are not quantifiable at this time. For transit districts on the alternative-fuel path, the incremental fuel cost will be directly proportional to the percentage of diesel buses remaining. Total statewide annual costs are expected to be approximately $3,000,000 in 2003, dropping to $2,000,000 by 2010.

4. New Bus Purchase Requirements

The ARB staff projects that a total of about 420 diesel buses will be purchased annually that would meet the proposed 2004 emission standards of 0.5 g/bhp-hr NOx and 0.01 g/bhp-hr PM. In 2007, staff projects that about 440 diesel buses will be purchased annually that would meet the proposed emission standards of 0.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM. For large transit fleets, the ARB staff estimates that 18 demonstration ZEBs will be purchased in 2003, 30 commercial ZEBs will be purchased in 2008, and 80 ZEBs in 2010.

The incremental costs for the low-emission buses required are estimated at $8,000 to meet the proposed 2004 standards, and an additional $1,000 to meet the lower standards in 2007. For ZEB technology, staff estimates incremental costs at $275,000 in 2002, $50,000 in 2007, and nominal incremental cost in 2010.

Combining the total number of buses needed with the incremental cost allows the ARB staff to calculate the total annual cost of the requirement. In 2004-2006, the total cost of the program is $5,900,000 per year, including the cost of zero-emission bus demonstration program. In 2007-2009, this total becomes $5,300,000 per year. This total is reduced by 80 percent due to Federal Transit Administration (FTA) grants and results in a cost to transit agencies of $1,200,000 per year in years 2004-2006 and $1,300,000 per year in 2007-2009. The estimated statewide incremental cost to transit agencies in 2010 of $800,000 is attributable to the expected reductions in costs of zero-emission buses in that time frame. Table 12 provides a summary of the costs associated with the new bus purchase requirements.

TABLE 12

Estimated Incremental Costs To Transit Agencies of New Buses

Year	"Typical" 200-bus fleet		Statewide[2]
	Conventional	ZEB purchase[1]	
2004	$27,000	$35,000	$1,200,000
2005	$27,000	$35,000	$1,200,000
2006	$27,000	$35,000	$1,200,000
2007	$30,000	$35,000	$1,300,000
2008	$30,000	$25,000	$1,300,000
2009	$30,000	$25,000	$1,300,000
2010	$30,000	$25,000	$800,000

1 State and local incentives for advanced technologies may be available to offset a significant portion of the remaining incremental costs after FTA funding

2 Federal funding covers 80 percent of new bus purchases and is not included in the costs shown in this table.

5. Alternative-Fuel Buses

Under the proposed regulation, no transit agencies are required to buy natural gas buses if they want to continue buying conventional diesel buses. This section provides

estimates of the costs that could be incurred if a transit agency elects to go on the alternative-fuel path as a means of compliance with the proposed regulation. Based on current fleet composition of transit agencies that have a significant presence of alternative-fuel buses, ARB staff estimates that about 300 alternative-fuel buses would be purchased annually, which could increase to 320 buses in 2007. Thus, the total incremental bus purchase cost to transit agencies, based on an incremental cost of $40,000 per bus and an 83 percent fund match from FTA grants, is about $2,200,000 per year. This cost is based on current purchasing trends from transit agencies that already have a significant number of alternative-fuel buses in their fleets. These transit agencies would be expected to continue to purchase alternative-fuel buses in the absence of this proposed regulation. Incentive funding by state and local air quality agencies has been available in the past to offset the incremental bus purchase cost not covered by FTA grants. It is not clear whether sufficient funding will continue to be available to offset the entire incremental purchase and infrastructure costs. Based on information obtained from transit agencies that already have significant numbers of alternative-fuel buses, operating costs vary significantly from one transit agency to another. Some transit agencies have shown cost savings.

IX. ENVIRONMENTAL IMPACTS

This chapter presents the air quality benefits resulting from the implementation of the proposed public transit bus fleet rule and new urban bus engine emission standards. Adoption of the proposed regulation would benefit California's environment and would reduce the public's exposure to toxic diesel particulate emissions. The air quality benefits presented here are based on the mobile source inventory, EMFAC 2000, which has not yet been adopted by the Board.

In developing this regulation, the ARB staff has attempted to strike a balance between the need to reduce emissions as much as technologically feasible, and the desire to minimize the economic impact on affected businesses and transit organizations. A cost-effective approach is to reduce the emissions from the oldest buses in operation in fleets throughout the state. Under the proposed regulation, this could be accomplished by retrofitting an existing engine in a bus to a lower-emitting configuration, replacing an existing engine with a new lower-emitting engine, or retiring an old bus and replacing it with a new bus.

The useful life of an urban bus is twelve years. This is the minimum life required for buses purchased with FTA funds. However, many transit agencies are typically keeping at least a portion of their buses several years beyond the twelve-year useful life. These older buses are sometimes kept as reserve buses, but in actual practice, many of them are being placed in revenue service on a regular basis. Currently, a number of transit agencies in California have a significant number of pre-1988 buses in their fleets. Some agencies are operating 1984 and older buses. Based on information obtained by the ARB staff, pre-1988 buses comprise about 25 percent of the total number of buses in California. These older buses emit more than one-and a half times the NOx emissions and twelve times the PM emissions of diesel buses meeting current emission standards. Significant emission benefits would be achieved if these older buses are retired and new buses are purchased to replace them. However, some transit agencies may be unable

to obtain sufficient funding to replace all those older buses in their fleets in the time frame specified by the proposed fleet average NOx emission requirement. Significant emission benefits could also be achieved, particularly for PM emissions, by retrofitting these older engines to lower- emission configurations.

The proposed fleet average NOx emission level of 4.8 g/bhp-hr in 2002 could be easily achieved by most transit agencies simply by retiring their pre-1988 buses and replacing them with new buses. Depending on the actual fleet composition for each transit agency, staff believes that this is the most cost-effective way for many transit agencies to achieve the proposed fleet average emission level. In addition to retiring older buses, transit agencies could also repower or retrofit their existing buses to lower NOx emission levels. Engine repowering options are now available that can reduce emissions of engines from 6.0 g/bhp-hr to 4.0 g/bhp-hr and from 5.0 g/bhp-hr to 4.0 g/bhp-hr. In addition, engine manufacturers may make available a retrofit kit for urban bus engines that would reduce NOx emissions from 4.0 g/bhp-hr to 2.5 g/bhp-hr in the time frame of this regulation. Based on the fleet average emission level of existing buses, staff estimates that NOx emissions from urban buses would be reduced by about two tpd statewide in 2002. Although the staff's proposal ensures these two tpd are reduced, most of the reductions will be occurring through normal fleet turnover. Therefore, staff will not be assuming any NOx benefit (or cost) due to the fleet average requirement.

The proposed PM retrofit requirements are intended to reduce toxic diesel particulate emissions from existing diesel buses and those model year buses up to the year 2004. As discussed above, the PM emission standard for pre-1988 buses is about twelve times higher than the PM emission standard for current buses. The PM emission standards for pre-1996 buses are up to two times higher than the PM emission standard for current buses and model year buses up to the year 2004. As significant as these numbers are, in-use emissions data from chassis dynamometer tests show greater differences of PM emissions from diesel buses and CNG buses than would be predicted from the engine emission certification standards. Available chassis dynamometer data for urban buses operated on a Central Business District (CBD) test cycle show that for 1988 to 1990 buses, the average in-use PM emission level is about 1.7 grams per mile (g/mi). For 1991 to 1997 model year buses, the CBD data show the average in-use PM emission level to be about 1.0 g/mi. Even the current diesel buses have in-use particulate emissions of about 0.23 g/mi. By comparison, CNG bus emissions average 0.02 g/mi, regardless of their age. For these reasons, the ARB staff is proposing PM retrofit requirements for diesel buses. The ARB staff estimates that the retrofit requirements will reduce toxic PM emissions by about 300 pounds per day (lbs/day) statewide in 2005, and by about 100 lbs/day in statewide 2010, based on in-use CBD data.

While retrofit technology can yield immediate emission reductions from the existing bus fleet, future emission reductions from the urban bus sector can only be sustained through more stringent emission requirements for new urban buses. Therefore, the proposed regulation contains new emission standards for buses, as well as requirements for larger transit agencies (fleets >200) to purchase zero-emission buses. As discussed previously, the ARB staff is proposing a 0.5 g/bhp-hr NOx standard and a

0.01 g/bhp-hr PM standard for diesel and dual-fuel urban bus engines effective in 2004. In 2007, all heavy-duty urban bus engines, diesel and alternative-fuel, will have to meet NOx and PM emission standards of 0.02 g/bhp-hr and 0.01 g/bhp-hr, respectively. To encourage the early introduction of zero-emission technologies for urban bus applications, the ARB staff is proposing a zero-emission bus purchase requirement for larger transit fleets. Transit fleets with more than 200 buses in their active fleets that are on the diesel path of the fleet rule will be subject to a zero-emission purchase requirement applicable to 15 percent of their new bus purchases starting in 2008. This same zero-emission purchase requirement will apply in 2010 for transit fleets with more than 200 buses in their active fleets that are on the alternative-fuel path of the fleet rule.

The ARB staff estimates the proposed new engine emission standards and the zero-emission bus purchase requirements will cumulatively reduce emissions statewide in 2010 by about 5.4 tpd of NOx and about 0.04 tpd (50 lbs/day) of PM. The emission benefits for the proposed regulation are summarized in Table 13 below.

TABLE 13

Emission Benefits of Proposed Regulation

	2005	**2007**	**2010**		**2020**	
Proposed Regulation Component	PM (lbs/day)	PM (lbs/day)	NOx (tpd)	PM (lbs/day)	NOx (tpd)	PM (lbs/day)
PM Retrofit	300 [1]	100 [1]				
New Low-Emission and Zero-Emission Requirements			5.4 [2]	50 [2]	7.2 [2]	67 [2]

(1) Based on in-use CBD emission data from chassis tests.
(2) Based on combined benefits of 2004 and 2007 emission standards.

X. COST-EFFECTIVENESS

The estimated cost-effectiveness of the proposed regulation is given in Table 14. The cost-effectiveness of engine emission standards and zero-emission bus purchase requirements is estimated to be about $1.80/lb of NOx in 2010. The cost-effectiveness for these requirements is estimated to be reduced to $1.50/lb by 2020. The cost-effectiveness of the proposed requirements compares favorably with the cost-effectiveness of mobile source and motor vehicle fuels regulations adopted over the past decade. Those adopted measures had cost-effectiveness values from $0.17 to $2.55 per pound of ozone precursors reduced.

As shown in Table 14, the cost-effectiveness for the PM retrofit requirements averages about $17.90 per pound ($/lb) annually from 2003 to 2009. This cost-effectiveness includes the cost associated with the requirement to purchase low-sulfur diesel fuel. In

comparison, the cost-effectiveness of previously adopted PM control measures ranges from $1.44/lb to $3.20/lb. The cost-effectiveness of the PM retrofit requirement under this proposal does not include the value of health benefits associated with a reduction in exposure to a toxic air contaminant. The risk management process for the control of toxic PM emissions from diesel-fueled engines is ongoing. Any PM control measures resulting from the risk management process will produce additional PM reductions and health benefits that are not included in this regulatory proposal and that are not part of this cost-effectiveness determination.

TABLE 14

Estimated Cost-Effectiveness of Proposed Regulation			
Proposed Requirement	**Cost-Effectiveness**		
	2003-2009 ($/lb PM)	**2010 ($/lb NOx)**	**2020 ($/lb NOx)**
PM Retrofit	17.90		
Engine Standards		1.80 [1]	1.50 [1]

(1) Estimated cost-effectiveness of engine standards includes federal contribution to bus purchase costs.

XI. SUMMARY AND STAFF RECOMMENDATION

A. Summary of Staff's Proposal

As presented in the previous chapters, the ARB staff's proposal is designed to reduce ozone precursor emissions, particularly NOx, and toxic air contaminants (diesel PM) by encouraging transit agencies to purchase or lease low-emission, alternative-fuel urban buses. The staff's proposal includes the following:

- A public transit fleet rule with two paths for compliance – a diesel path and an alternative-fuel path.
- A 4.8 g/bhp-hr NOx fleet average requirement for transit agencies.
- PM retrofit requirements for 2003 and earlier model year diesel urban buses.
- Zero-emission bus demonstration project requirements in 2003 for large transit agencies on the diesel path.
- Zero-emission bus purchase requirements beginning in 2008 for large transit agencies on the diesel path and in 2010 for large transit agencies on the alternative-fuel path.
- Requirements for transit agencies using diesel fuel to use low-sulfur fuel (15 ppm or less) beginning July 1, 2002.

- Reporting requirements as a means to determine a transit agency's compliance with the public transit fleet rule.

- More stringent emission standards, including a 0.5 g/bhp-hr NOx standard and 0.01 PM g/bhp-hr PM standard, for 2004 and subsequent model year diesel and dual-fuel urban bus engines.

- More stringent emission standards, including a 0.2 g/bhp-hr NOx standards and a 0.01 g/bhp-hr PM standard, for all 2007 and subsequent model year engines.

A. Staff Recommendation

The ARB staff recommends that the Board adopt new sections 1956.1, 1956.2, 1956.3, and 1956.4, Title 13, California Code of Regulations, and amend section 1956.8, Title 13, California Code of Regulations, and the incorporated "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Year Heavy-duty Engines and Vehicles." The regulation is set forth in the proposed Regulation Order in Appendix A.

XII. References

1. Magary, Kerstin Fraser, San Francisco Municipal Railway, Information Provided on November 15, 1999.

2. Manufacturers of Emissions Controls Association (MECA), Emission Control Retrofit of Diesel-Fueled Vehicles, March 1998.

3. Detroit Diesel Corporation, Press Release, October 7, 1999.

1. MECA, Emission Control Retrofit of Diesel-Fueled Vehicles, March 1998.

5. MECA, Emission Control Retrofit of Diesel-Fueled Vehicles, March 1998.

6. Rothwell, Bruce, Marketing Manager, dbb fuel cell engines, inc., Information Provided on December 2, 1999