CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD

TECHNICAL SUPPORT DOCUMENT

PROPOSED REGULATION FOR THE PROPOSED SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT FLEET RULES

July 2005

This report has been reviewed by the staff of the California Air Resources Board and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

State of California
California Environmental Protection Agency
AIR RESOURCES BOARD

Technical Support Document for the Proposed Regulations for the South Coast Air Quality Management District Fleet Rules

Table of Contents

I. Summary

The staff of the Air Resources Board (ARB) has conducted this technical review in support of its proposed regulations for diesel particulate matter (PM) and oxides of nitrogen (NO_x) from fleets of transit buses, school buses, and refuse collection vehicles in the South Coast Air Quality Management District (SCAQMD).

This report describes the availability of heavy duty engines (diesel and alternative fuel) and hybrid technology for transit buses, solid waste collection vehicles, school buses, and other heavy-duty vehicles during the time periods that would be impacted by the proposed regulations. In addition, this report discusses the retrofit strategies currently available and projected to be available to reduce PM, and NO_x, and global warming emissions from the three types of fleets. This discussion addresses the potential limitations of these strategies and identifies those technologies that have been verified by the ARB's Diesel Emission Control Strategy Verification Procedure. This report also provides information on the various public and private partnerships that have emerged to promote the use of alternative fuels by fleets and individual consumers to reduce petroleum consumption in the transportation sector. Finally, this report discusses the availability and accessibility of the necessary infrastructure to provide alternative fuels to the fleets covered by this measure.

II. Introduction

A variety of strategies can be used for controlling emissions from diesel engines, including aftertreatment hardware, such as filters, fuel strategies, engine modifications, and repowering with a newer engine with lower emissions. In addition, new vehicles can be purchased that use alternative fuels, such as compressed natural gas (CNG) and liquified natural gas (LNG), or that rely on the cleanest available diesel engine technology.

III. Engine Technology and Availability

This section discusses the availability of engines for transit buses, solid waste collection vehicles (collection vehicles), school buses, and other heavy-duty vehicles during the time periods that would be impacted by the proposed regulations: 2005-2006 (current), 2007-2009 (mid-term), and 2010 and beyond (long-term). The information has been obtained from engine manufacturers and other published sources. We have omitted information that engine manufacturers have indicated is confidential.

Conventional diesel engines use compression-ignition to generate power, whereas engines that operate on an alternative fuel, such as compressed natural gas (CNG), liquefied natural gas (LNG), and liquid petroleum gas (LPG), are typically spark-ignited. In the heavy-duty engine market, CNG and LNG are the most commonly used alternative fuels. For the purpose of this discussion, we use the definition of alternative-fuel adopted by the Air Resources Board (ARB or the Board) in Title 13, California Code of Regulations (CCR), section 2020: “natural gas, propane, ethanol, methanol, gasoline (when used in hybrid electric buses only), hydrogen, electricity, fuel cells, or advanced technologies that do not rely on diesel fuel.” Diesel hybrid-electric, dual fuel and bi-fuel trucks and buses are not considered to be alternative-fueled, although they can have significantly lower emissions than a straight diesel engine.

Alternative-fueled engines are typically certified to lower engine exhaust emissions than same model year diesel-fueled engines, although a diesel engine equipped with exhaust aftertreatment may have emissions comparable to an alternative-fuel engine. The ARB and the United States Environmental Protection Agency (U.S. EPA) adopted optional standards starting in 1995 to provide an opportunity for engine manufacturers to certify their engines to lower optional engine emission standards; the U.S. EPA terms these “Blue Sky Engines.” Currently, only natural gas engines have been certified to the optional standards in California. The higher purchase price of alternative-fuel, lower emission engines is often offset by various grants available in California.

1. Current Engine Availability

Manufacturers have been able to meet the current engine exhaust standards without the use of aftertreatment technologies, relying instead on modifications to engine and combustion related components. Engine modifications include such changes as improved electronic controls, improved turbocharger systems, and improved exhaust gas recirculation. Combustion modifications include improved engine timing, improved fuel injection systems, and improved cylinder design.

a. Diesel-fueled Engines

For the 2005 model year (MY), there is broad coverage of diesel engines for all vocations of vehicle, except urban buses, from Cummins, Caterpillar, Detroit Diesel Corp (DDC), Daimler Chrysler, and Volvo (Appendix A). There are 14 medium heavy-duty diesel (MHDD) engine families certified in California,[1] with displacements ranging from 4.25 to 8.9 liters (L) and 150 to 350 horsepower (HP). For heavy heavy-duty diesel (HHDD) engines, ranging from 8.8 to 15 L displacement and 280 to 600 HP, there are about 13 engine families certified.[1] The certified or family emission limit (FEL) NOx + NMHC levels for these engines range from 2.2 to 3.1 grams per brakehorsepower-hour (g/bhp-hr); the certified or FEL PM levels range from 0.04 to 0.1 g/bhp-hr, with two exceptions discussed below.

California has set different emission limits for urban bus engines. For the 2004 to 2006 MY, diesel engines must be certified at 0.5 g/bhp-hr NOx and 0.01 g/bhp-hr PM. There is no urban bus diesel engine certified to these limits. California regulations provide for an exception to this standard for the seven transit agencies that applied for and received an "alternative NOx strategy exemption." Engine manufacturers can certify urban bus diesel engines to the standards for 2003 in the 2004 to 2006 MY for sale to those transit agencies only. There is one diesel urban bus engine family, the Caterpillar C9, that is certified to 2.3 g/bhp-hr NOx + NMHC and 0.004 g/bhp-hr PM. In response to grant programs that require the purchase of a cleaner school bus when a diesel engine is purchased, Caterpillar has certified a C7 engine family to a lower PM level of 0.01 g/bhp-hr, with a NOx + NMHC certification of 2.4 g/bhp-hr.

Based on discussions with engine manufacturers, we expect much the same diesel engine product availability for the 2006 MY for school buses, and collection vehicles. For urban buses, in 2004, California adopted new engine standards for diesel hybrid-electric buses (HEB), applicable to the 2004 to 2006 MY only, of 1.8 g/bhp-hr NOx and 0.01 g/bhp-hr PM. Transit agencies on the

[1] As of February 15, 2005; certifications continue to be processed throughout the calendar year.

diesel path were allowed to apply for permission to purchase these buses, subject to certain requirements. Based on conversations with manufacturers, the staff expects that there will be one or more engine families certified and available for purchase in 2006, thus providing some transit agencies with an additional option for a diesel engine purchase.

b. Alternative Fuel Engines

As in other years, engine manufactures have certified fewer engine families to operate on alternative fuels, with less coverage over the range of engine size and horsepower, than is available for diesel fuels (Appendix A). For MHDD engines, Cummins and John Deere have certified a total of five[1] engine families to operate on natural gas and one certified to operate on LPG. The engines range from 185 to 320 HP and 5.9 to 8.9 L displacement. There are no HHDD natural gas engines certified, thus eliminating natural gas from use in the heavier classes of collection vehicles and transfer trucks. For urban buses, there are two natural gas engine families certified by Cummins, two certified by DDC, and one certified by John Deere.

Alternative-fuel engines are certified to the optional standards, beginning at the highest level of 1.8 g/bhp-hr NOx, and declining in 0.3 increments; the optional PM standards are 0.03, 0.02, and 0.01 g/bhp-hr. If an engine manufacturer certifies an engine family at one of these lower levels, and removes the engine family from use in averaging, banking, and trading, then the user may apply for grant funds to pay for the incremental cost based on the amount of NOx reduced. The 2005 MY engines are certified from 1.8 to 1.0 b/hp-hr NOx and 0.01 g/bhp-hr to a non-detectable level of PM.

The outlook for natural gas engine availability in 2006 is the same as for 2005. John Deere is currently involved in a demonstration project with United States Department of Energy's National Renewable Energy Laboratory (U.S. DOE NREL) and SCAQMD to certify this engine to the 1.2 g/bhp-hr NOx standard. This engine is equipped with an oxidation catalyst and will be available for transit buses, school buses, and refuse trucks. John Deere intends to have this product available by October 2005.

2. Mid-term Future Engine Availability (2007 – 2009)

A particulate emission standard of 0.01 g/bhp-hr for heavy-duty on-road diesel engines will take effect nationally and in California beginning with MY 2007, except for urban bus engines to be sold in California. The 0.01 standard for urban bus engines has been in effect in California for engines produced after October 1, 2002. These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies.

In 2007 the engine exhaust emission standards for heavy-duty engines drop to 0.2 g/bhp-hr for NOx. However, recognizing the challenge of decreasing the engine exhaust NOx emissions to 0.2 g/bhp-hr, engine manufacturers may phase-in the NOx standard as 50 percent of sales at the new standard in 2007 - 2009. In adopting the phase-in NOx standard, the U.S. EPA acknowledged the challenge that manufacturers face to be able to produce a diesel engine at the 0.2 g/bhp-hr NOx standard by 2007.

In general, manufacturers have indicated that they are taking a two-step approach to meeting the NOx standard, averaging their engines to meet the average of approximately 1.2 g/bhp-hr NOx from 2007 to 2009 and dropping to 0.2 g/bhp-hr NOx for 2010. According to the U.S. EPA's second highway diesel progress report (United States Environmental Protection Agency, 2004) and based on the ARB staff's recent meetings, manufacturers are on track to meet the requirements in 2007.

While most manufacturers have released details about their 2007 engines, some have not. Thus the information that follows includes general information where specifics are unavailable for publication. Staff's evaluation includes both publicly available and confidential information.

a. Diesel-fueled Engines

All major manufactures have announced that they will be using exhaust gas recirculation (EGR) to meet the 2007 NOx emission standard and diesel particulate filters to meet the particulate standard. EGR causes a portion of the exhaust gases to circulate through a heat exchanger to cool the exhaust before reintroducing the gases into the engine intake manifold. EGR has been used in some engines since 2003, but engine manufacturers have further refined the systems to allow lower NOx emissions.

Caterpillar, Cummins, and DDC plan to offer a full line of medium- and heavy-duty diesel engines; International focuses on the school bus and collection vehicle engine markets; and Mack/Volvo focuses on engines for collection vehicles.

Dual fuel systems for collection vehicles are no longer available in the U.S., as Clean Air Power, the sole manufacturer of these systems, has concentrated its efforts in Europe. Increased interest in its product may, however, prompt Clean Air Power to develop and certify in California a 2007 product for collection vehicles.

Diesel hybrid-electric systems are another technology that reduces both emissions and fuel use and that will be available in 2007. While not classified by ARB as an alternative-fuel technology, diesel hybrid-electric technology achieves lower emissions and better fuel economy than equivalently sized diesel buses or

trucks. Emissions testing studies at ARB and other facilities indicate a fuel consumption reduction of 25 percent and NOx emission reduction of about 50 percent for diesel-fueled hybrid-electric buses (HEBs) compared to conventional diesel transit buses.

There is a growing momentum toward advanced, fuel-saving hybrid technology in medium and heavy-duty work trucks. The national Hybrid Truck Users Forum is a joint program between WestStart-CALSTART and the U.S. Army's National Automotive Center to speed the commercialization of hybrid drivelines that could be used in both military and commercial vehicles (ISE, 2004). FedEx Express, a subsidiary of FedEx Corp., is currently operating 18 delivery trucks nationally (FedEx Express, 2005). Eaton Corporation and International Truck and Engine Corporation announced in October 2004 a plan to build more than 20 advanced pre-production hybrid-electric work trucks for national deployment and assessment for use in heavy-duty (19,000-33,000 GVWR) truck operation (WestStart, 2004). DHL Express is using a Solectria diesel hybrid class 7 delivery truck in regular operations (DHL, 2004). International is currently developing diesel hybrids for utility trucks, and refuse trucks that are designed to meet the 1.2 g/bhp-hr NOx level. International does not currently intend to market these systems for use in transit or school buses.

The past few years have seen a shift from research and development to production and use of HEBs. In 1998, New York City Transit began a demonstration program with four diesel-fueled HEBs. The success of the program has resulted in New York City Transit ordering an additional 325 diesel-fueled HEBs, which it will receive through 2005 (BAE Systems, 2004). In January 2002, fewer than 100 HEBs were in active service. To date, orders have been placed for approximately 650 additional HEBs throughout the United States. In addition to the New York City Transit order, large orders have been placed by King County Metro in Seattle, Washington (213 diesel HEBs) (General Motors, 2004), and Long Beach Transit in California (27 gasoline hybrid buses) (ISE, 2003). ISE has stated that it intends to have a diesel HEB available in California in 2007.

b. Alternative-fuel Engines

Manufacturers of natural gas engines are likely to be able to meet the upcoming 2007 standard without the use of aftertreatment. Cummins, through its joint partnership with Westport Innovations, Cummins Westport Inc., and John Deere will be offering alternative fuel products to meet the 2007 emission standards. Although we have only preliminary data, it appears that manufacturers of alternative-fuel engines or systems will certify to the 0.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM standards.

Compared to diesel offerings, however, customers will not have a wide a range of offerings to choose from when searching for engines. ISE Corporation

currently offers a California-certified gasoline hybrid electric bus and is developing hybrid electric systems with compressed natural gas, diesel, and hydrogen fuels, also for urban buses. While ISE focuses on the urban bus market, it is considering expanding into other vocations that use heavy heavy-duty engines, such as waste collection vehicles.

John Deere currently only certifies urban bus and medium heavy-duty natural gas engines (Appendix A), but is developing a heavy heavy-duty engine that would be suitable for use in waste collection vehicles. John Deere intends to produce a 250-325 horsepower, 9 L natural gas engine meeting the 0.2 g/bhp-hr NOx level by 2007. This engine could be used in transit buses, school buses, and refuse trucks.

Cummins will be marketing the natural gas engines developed by Cummins Westport Inc. and it intends to offer a full line of products. Although the engines are developed by Cummins Westport Inc., they will be following the “Cummins Value Package Introduction Process,” carry the Cummins warranty, and be serviced by Cummins dealers. Cummins is currently providing bids on both diesel and natural gas buses for 2007. Cummins Westport Inc. has partnered with U.S. DOE's NREL to develop a lower emission version of the L Gas Plus (8.9 L) engine for use in medium-duty trucks, refuse trucks, and urban buses. This engine is scheduled to be commercially available in early-2007. The SCAQMD is also currently sponsoring a project with Cummins to commercialize the C Gas Plus engine (8.2 L) to 0.2 g/bhp-hr NOx by 2007.

In 2004, Ford and General Motors stated that they would no longer be producing their smaller CNG engines used in cutaway vehicles. As a result, BAT Technologies, Clean Energy, and Teleflex/GFI Control Systems have jointly proposed a contract with the SCAQMD and the state of New York to "develop and certify in California a retrofit system that converts 2005 and subsequent model year gasoline-powered Ford Crown Victoria and E-450 cutaway vehicles to dedicated CNG operation" (South Coast Air Quality Management District, 2004). It is anticipated that once retrofitted, the engines will meet SULEV emission levels. This technology is scheduled to be certified by mid-year 2005.

A heavy-duty pilot ignition (HDPI) engine is a compression-ignition engine that operates on natural gas but uses diesel as a pilot ignition source. Diesel accounts for about six percent of the fuel consumed. The ARB has defined an HDPI engine in its fleet rule for transit agencies as an engine that uses diesel fuel at a ratio of no more than one part diesel fuel to ten parts total fuel on an energy equivalent basis. Furthermore, the engine cannot idle or operate solely on diesel fuel at any time. An engine that meets this definition and is certified to the lower optional PM standard (0.01 g/bhp-hr) would be classified as an alternative-fuel engine.

In October 2004, Westport Research announced that it has been awarded $1.5 million (USD) by the U.S. DOE's NREL in a cost-sharing subcontract to develop and deploy the next generation of its HDPI technology in heavy-duty natural gas trucks (Cummins ISXG, 14.9 L) in California. The NREL funding is provided through sponsorship from the U.S. DOE FreedomCAR and Clean Cities programs. Westport Research intends to certify this engine to 1.2 g/bhp-hr NOx by the end of 2005. Westport Research will also begin testing of the ISXG engine to reach a 0.2 g/bhp-hr NOx emission levels by 2008.

The trucks being deployed in California will be powered by Cummins ISX engines using liquefied natural gas (LNG) fuel systems and are targeted to meet the U.S. EPA 2007 emission standards (DieselNet, 2004).

3. Long-Term Engine Availability (2010 and beyond)

Engine technology for 2010 will most likely rely upon selective catalytic reduction (SCR), NOx adsorbers, and further improvements in engine technology to reduce NOx emissions.

A U.S. EPA research team, with industry partners, is developing a low NOx diesel engine system called Clean Diesel Combustion (CDC). The CDC technology utilizes management of the in-cylinder combustion process as the primary control for NOx reduction. In laboratory testing, the CDC system has demonstrated very low NOx emissions without the use of NOx after-treatment.

The CDC technology relies upon in-cylinder NOx control, where NOx emissions are reduced in the engine combustion chamber. In-cylinder NOx control is achieved through advances in technology in the engine's fuel system, boost control, EGR and PM aftertreatment systems. The CDC technology may be scaled to both light-duty and heavy-duty applications. The key features of CDC technology include the following:

- A hydraulically-intensified fuel system to lower PM emissions while improving engine efficiency,
- A boost system which increases engine power and the efficiency of the combustion process, thus reducing emissions and increasing fuel economy,
- Cooled low pressure exhaust gas re-circulation which lowers peak combustion temperatures, reducing the formation of NOx, and
- Aftertreatment to reduce remaining PM, unburned hydrocarbons, and carbon monoxide in the exhaust.

Several engine and vehicle manufacturers are working to advance this technology with the U.S. EPA research team. These industry partners include both automotive manufacturers and heavy-duty diesel engine manufacturers. Detailed test results have been publicly disclosed for small-bore "automotive" sized engines.

Two aftertreatment technologies that will most likely play a large role in meeting the 2010 NOx standard are selective catalytic reduction (SCR) and the NOx adsorber.

The SCR catalysts that use ammonia as a NOx reductant have been used for control of NOx emissions from stationary sources for a number of years. Urea may also used as the source of ammonia for SCR catalysts, and such systems are commonly referred to as urea SCR systems. In recent years, considerable effort has been invested in developing urea SCR systems that could be applied to heavy-duty diesel vehicles with low sulfur diesel fuel. Urea SCR systems were introduced in 2003 and 2004 in European passenger cars and will be used to comply with the EURO IV heavy-duty diesel emission standards. The actual introduction dates in some countries will be earlier than the EURO IV implementation requirements because of tax incentives in those countries to promote early technology introduction (United States Environmental Protection Agency, 2004).

Transit agencies that received an alternative NOx strategy exemption under title 13, CCR, section 1956.2(c)(8) or (d)(9) were required to conduct a demonstration of an advanced NOx aftertreatment system that could reduce NOx emissions by 70 percent or more on buses operating in urban bus revenue service. Staff is monitoring the demonstration of an ammonia SCR system on urban buses being conducted by the seven transit agencies that received the exemption.

Three SCR NOx aftertreatment devices were selected, produced and installed by Extengine for demonstration on three urban buses. Initiated in October 2002, VTA conducted baseline and emissions testing prior to placing the buses into revenue service. Preliminary data submitted in January 2004 are favorable and buses continue operating in revenue service (VTA, undated).

Unlike catalysts, which continuously convert NOx to N_2, NOx adsorbers are materials that store NOx under lean conditions and release and catalytically reduce the stored NOx under rich conditions. NO and NO_2 are acidic oxides and can be trapped on basic oxides. Fuel sulfur can be converted to stable sulfates providing competition with NOx for storage sites, thus poisoning the catalysts. NOx adsorber catalysts have a wide operating temperature window and thermal stability consistent with diesel applications and are capable of providing NOx conversions in excess of 90 percent over much of the operating range. However, fuel intended for adsorber regeneration is wasted if it reacts with O_2 instead of with NOx. The additional heat generated by excessive combustion may induce thermal desorption of NOx.

IV. Diesel Emission Control Strategies

The ARB has developed the Diesel Emission Control Strategy (DECS) Verification Procedure.[2] The purpose of the procedure is to verify strategies that provide reductions in diesel PM emissions. A complete and up-to-date list of verified DECSs and the engine families for which they have been verified can be found on our web site: http://www.arb.ca.gov/diesel/verdev/currentlyverifiedtech.htm.

There are a number of retrofit technologies that may be applied to reduce emissions from late-model (1994 and subsequent) diesel engines. Some of the more common ones are discussed briefly below.

A. Diesel Oxidation Catalyst

A diesel oxidation catalyst (DOC) is a flow through device that consists of a canister containing a honeycomb-like structure or substrate. The substrate has a large surface area that is coated with an active catalyst layer containing platinum or palladium. DOCs are temperature dependent, but are generally considered to be widely applicable to diesel engines, including two-stroke engines.

A DOC reduces the soluble organic fraction (SOF) of diesel particulates, typically reducing particulate matter by 25 percent. However, DOCs may not achieve a 25 percent reduction consistently, due to differing SOF emissions among engines or modes of operation. One verified DOC-based system includes crankcase filtration to ensure a minimum 25 percent reduction on a variety of engines and operations. DOCs in general can reduce hydrocarbons (HC) and carbon monoxide (CO) by 37 to 71 percent. DOCs do not reduce NO_X emissions

B. Passive Diesel Particulate Filters

Diesel particulate filters (DPFs) essentially trap particulates which are then oxidized at a later time to "regenerate" the filter. Passive filters use the heat in the engine exhaust along with a catalyst to burn off the collected soot. Most passive filters use platinum group metals to convert NO to NO2, which then reacts with the soot. Special attention must be paid when applying passive filters to engines with exhaust gas recirculation (EGR) or other technologies that reduce NOx emissions before they reach the catalyst to ensure that sufficient NO is available for the regeneration process.

Because passive DPFs rely on exhaust heat to trigger regeneration, their applicability is determined by the engine and duty cycle of the vehicle. In

[2] Approved by the Board in May 2002. Sections 2700 through 2710, Title 13, California Code of Regulations.

general, low-sulfur fuel is needed to prevent sulfate formation. In addition to reducing PM by 85 percent or more, the passive filters catalytically reduce HC and CO emissions by 60-90 percent as well. Passive DPFs do not reduce NO_X emissions.

The passive DPFs verified for on-road use include the Donaldson DPM, the Johnson Matthey continuously regenerating technology (CRT) and catalyzed continuously regenerating technology (CCRT) filters, and the Lubrizol Purifilter. The Cleaire Longview, which includes a lean NOx catalyst system, as well as a passive DPF, is also verified for on-road engines. At this time, only the Johnson Matthey CRT and CCRT are verified for use with EGR-equipped engines, although other manufacturers have indicated they plan to extend their verifications to include this category of engines.

C. Active Diesel Particulate Filters

Active diesel particulate filters rely on another source of heat besides the engine exhaust. The additional source of heat is typically a fuel burner, fuel injection, or electrical. Some use off-board regeneration by plugging into the electrical grid, or removing the filter element and placing it into some sort of regeneration station. Active regeneration may be combined with passive regeneration to maximize regeneration opportunity.

As with passive filters, the active systems reduce PM by 85 percent or greater. However, if no catalytic material is used, there is no significant reduction in HC or CO. Because active systems are not dependent on exhaust heat, they are relatively insensitive to duty cycle. If there is no catalytic element, there is no need to be restricted to low-sulfur fuel, and no increase in NO2 emissions. Active systems are potentially more costly than passive systems, due to the need for sophisticated controls.

Currently, one active system has been verified, the ECS Lubrizol Combifilter, for off-road use.

D. Lean NOx Catalyst

A Lean NOx catalyst system uses the injection of hydrocarbons, often diesel fuel, into the exhaust system upstream of a catalyst to reduce NOx emissions. The catalyst can reduce NOx by 25 percent. There is a slight fuel economy penalty involved. A lean NOx catalyst does not reduce PM emissions by itself, but can be combined with other controls such as diesel particulate filters. A lean NO_X catalyst does not reduce CO or HC emissions.

There is one lean NOx catalyst system verified for on-road engines at present, the Cleaire Longview, which includes a passive DPF.

E. Selective Catalytic Reduction (SCR)

An SCR system injects ammonia or urea into the exhaust gas stream to react with NOx in the presence of a catalyst. There is the possibility of ammonia slip into the exhaust, but this can be addressed through careful calibration, and/or the use of a clean up oxidation catalyst following the SCR catalyst. Verification requires that ammonia slip not exceed 25 parts per million on average over a test cycle.

SCR systems have been used commercially for many years with stationary diesel engine and marine applications. SCR can reduce NOx by 55 to 90 percent, and can be used in conjunction with PM control strategies such as DOCs and DPFs.

There is one SCR system verified at present, the Extengine ADEC for select off-road engines. The ADEC achieves a 25 percent PM reduction.

F. NOx Adsorbers

During lean driving conditions, NOX is adsorbed and stored in catalyst washcoat. During rich operation, NOx is desorbed and catalytically reduced. This results in NOx reductions of up to 90 percent. NOx adsorbers require a closed loop control in tight integration with the engine management and other vehicle systems such as, on-board diagnostics. Operation of NOx adsorbers can carry a fuel economy penalty (typically 3 to 5 percent). The thermal durability and resistance to sulfur are potential issues for implementation of this strategy. NOx adsorbers do not reduce PM by themselves, but may potentially be combined with a DPF.

At this time, there are no verified NOx adsorbers for retrofit use.

G. Crankcase Filters

Crankcase filters reduce blow-by contaminants, including PM, that can foul a turbocharger and aftercooler components. They have been used with DOCs to ensure that PM is reduced by 25 percent. Among their other benefits are a cleaner engine compartment, reduced engine oil consumption, and reduced underhood odor/fumes.

Donaldson has a verified DOC/crankcase filter combination.

H. Exhaust Gas Recirculation

Exhaust Gas Recirculation (EGR) reduces NOx through lowering the oxygen concentration in the combustion chamber, as well as, through heat absorption. It

displaces some of the oxygen inducted into the engine as part of its fresh charge air with inert gases. EGR can reduce NOx by 40-50 percent. However, it does bring with it a potential PM emission increase and engine wear issues. These issues can be minimized by combination with a DPF.

At this time, the Johnson Matthey EGRT, which includes a passive DPF, is the only verified retrofit EGR system.

I. Alternative Diesel Fuels

An alternative diesel fuel is a fuel that does not require engine or fuel system modifications for a standard diesel engine to operate. ADFs include water/diesel emulsions, biodiesel, and gas to liquid (GTL) fuels.

Water/diesel emulsions involve a mixture of diesel fuel with water and emulsifying and stabilizing additives. Depending on the product, the water content may vary from 8 to 35 percent. Water/diesel emulsions can reduce PM emissions by 50 percent or greater and NOx emissions by 15 percent. The addition of water decreases combustion temperatures and lowers NOx emissions, while PM is reduced through improved atomization and mixing of air and fuel. Due to replacement of fuel volume by water, the engine may not reach its rated power, and there will be a fuel economy penalty. At this time, Lubrizol's PuriNOx fuel (also marketed as ProFormix) is the only emulsion that has been verified.

Biodiesel is produced from vegetable and tree oils, animal fats, or used cooking oils and fats. It is commonly used in blends with standard diesel fuel. While use of biodiesel can reduce PM by up to 25 percent, it does increase NOx emissions, which must be addressed before it could be verified as an emissions control strategy. However, several cities and other groups use biodiesel blends voluntarily, and other retrofit manufacturers are looking into verifying their systems for compatibility with those blends.

GTL fuels are produced from natural gas, coal feedstocks and biomass. They are most commonly used in blends with standard diesel fuel. GTL Fuels can reduce PM by 20 to 25 percent. Issues include a decrease in lubricity and poor cold flow properties. No GTL fuels have been verified as Diesel Emissions Control Strategies.

J. Fuel Additives

Fuel additives are designed to be added to fuel or fuel systems or other engine-related systems such that it is present in-cylinder during combustion. There are different mechanisms by which fuel additives can work. In particular, fuel-borne catalysts facilitate regeneration in diesel filters.

An assessment of multimedia effects is required before any fuel additive can be verified as a diesel emission control additive. Additionally, registration with the U.S. EPA is required. These conditions have been set in place to ensure that the fuel additive will not cause other problems as it is emitted into the environment.

No fuel additives have been verified at this time.

K. Future plans

Conversations with manufacturers of retrofit controls have revealed that there are plans to expand NOx control technologies available. In particular, Extengine has taken action to extend its existing SCR verification, and Johnson Matthey has indicated that it would pursue verification of its SCRT, a combination of their CRT filter and selective catalytic reduction.

Most manufacturers have expressed a preference to devote resources to items for which a rule or funding program is already in place, as that assures them of a market for their products. Thus, staff has a reasonable expectation that as new fleet rules are adopted, verification activity would increase for the market segments covered by those rules.

V. Goals and Implementation of Alternative Fuels Programs

In 2003, pursuant to AB 2076, the California Energy Commission (CEC) and ARB jointly adopted the following goals for the reduction in petroleum dependence:

- Reduced demand for on-road gasoline and diesel fuel of 15 percent below the 2003 levels by the year 2020, and to maintain this level of demand for the foreseeable future and
- Increased use of non-petroleum fuels to 20 percent of on-road fuel consumption by 2020 and to 30 percent by 2030.

These goals were developed in response to concerns about the increasing dependence on imports of refined petroleum products, rising greenhouse gas emissions, and the adverse health effects associated with exposure to air pollution. A significant reduction in petroleum demand can be achieved by substituting non- petroleum fuels, such as natural gas for gasoline and diesel. (California Air Resources Board and California Energy Commission, 2003).

The United States Department of Energy Clean Cities program has promoted the use of natural gas-fueled public fleets. The mission of the Clean Cities program is to advance the economic, environmental, and energy security of the United States by supporting local decisions to adopt practices that contribute to reduced petroleum consumption in the transportation sector. The objectives of the Clean Cities program are:

- to facilitate the deployment of alternative fuel vehicles,
- to support the installation of an alternative fuel refueling infrastructure throughout the nation,
- to increase the use of fuel blends (diesel/biodiesel, ethanol/gasoline, and compressed natural gas/hydrogen),
- to accelerate sales of hybrid electric vehicles,
- to promote informed consumer choice on fuel economy, and
- to encourage the use of idle reduction technologies for heavy-duty trucks and other vehicles.

The Clean Cities program has carried out this mission through a network of more than 80 volunteer, community-based coalitions, which have developed public/private partnerships. Since 1993, Clean Cities coalitions have steadily increased the number of alternative fuel vehicles on the United States highways, with gains averaging around 15 percent in recent years (United States Department of Energy, 2005).

California is the nation's leading user of natural gas vehicles. The Clean Cities Program has been responsible for encouraging the successful development and implementation of a number of alternative fuel fleets in California. These have included waste management vehicles in San Diego County powered on LNG and CNG ; CNG-fueled school buses in San Diego County; CNG-fueled transit buses in Lodi, Los Angeles, and Davis; and CNG-fueled shuttle buses at Hearst Castle. Table 1 contains detailed information about a selection of CNG and LNG-fueled fleets in California (United States Department of Energy, 2005).

Table 1

Information Regarding CNG and LNG-Fueled Fleets in California

Organization	Applications	Fuel Type	Number of Vehicles
Waste Management, Inc. (various parts of California)	Heavy-Duty Delivery Vehicles, Refuse Haulers	CNG, LNG	360
City of Lodi, CA	Transit Buses	CNG	19
Los Angeles Metropolitan Transit Authority	Transit Buses	CNG	1570
Unitrans (City of Davis)	Transit Buses, Support Operations, Vans	CNG, Hydrogen	19
San Marcos Unified School District (San Diego)	School Buses	CNG	55
State of California Department of Parks and Recreation (Hearst Castle)	Trams and Internal Transit	CNG	16

VI. Infrastructure for Alternative Fuels

The SCAQMD reports an increase in alternative fuel fueling sites in the District over the past five years. The SCAQMD draft document entitled Status Report of Natural Gas Infrastructure Expansion in the South Coast District, 2005 (Appendix B) says "From a pre-year 2000 station inventory of approximately 25 stations that mostly dispensed CNG and had very limited public access; there are now over 100 CNG or LNG stations that have or will (soon) have full public access." The web site Clean Car Maps, which tracks alternative fuel fueling sites, reports 66 CNG and 10 LNG fueling stations that are open to the public in Southern California (Clean Car Maps, 2005).

As shown in Figures 1 through 5 of Appendix C, there are sufficient fueling stations distributed at appropriate distances to meet the current demand for

alternate fueled vehicles in the SCAQMD. However, the increase in alternative fuel vehicles in the SCAQMD that would be expected to occur as a result of implementation of these proposed fleet rules means that additional fueling facilities would need to be constructed. While doing calculations on the potential costs of the waste collection vehicle rule, the ARB staff estimated that each increase of approximately 100 alternative fuel vehicles would create the need for one fueling station.

A. Compressed Natural Gas

The cost of fueling facilities varies depending on the number of vehicles to be filled each day and the speed with which they must be filled. Sempra Utilities estimates the cost of a CNG filling station with the ability to fill 100 solid waste collection vehicles overnight at $700,000. A similar facility for 50 trucks would be $445,000 (Sempra Utilities, 2005).

In a cost analysis done for transit bus fleets, Clean Energy, a supplier of alternative fuels and fueling facilities, estimated the cost of a CNG filling station for 25-50 buses at $700,000 to $800,000. For fleets of 50 to 100 buses, the cost was estimated to be $1.3 million to $1.5 million. Large fleets of more than 100 buses would require fueling facilities costing $2.5 to $3 million (Clean Energy, 2005).

B. Liquefied Natural Gas

In costs for LNG fueling facilities, Clean Energy estimated $600,000 for a facility capable of fueling 12 buses per hour in a fleet of 100 buses. For fleets of 200 buses, Clean Energy estimated $1.5 million to $2 million for a LNG fueling facility (Clean Energy, 2005). Waste Management, California's largest waste hauling company, estimates an average cost of approximately $600,000 each for construction of LNG fueling stations at eight of its terminals in the state (Stoddard, 2005). The City of Los Angeles Department of General Services estimates the cost of construction and equipment for an LNG fueling station to service 120 waste collection vehicles at $3.5 million (Tran, et al., 2005).

In many cases, these costs are defrayed by government incentives. Of $40.6 million in expenditures for alternative fueling sites to serve waste hauler fleets in the SCAQMD, the District reports supplying $10.9 million in incentive funds (Appendix B).

Clean Energy will build fueling facilities or build and operate the facilities under an arrangement where the end user pays for the facility through an amortized fee built into the cost of the fuel purchased (Clean Energy, 2005).

Another issue with LNG is delivery cost. The fuel is trucked in from Arizona to the SCAQMD at a cost of approximately $1000; from Texas at $2,500 per load

and from Wyoming at $3,000 per load. Several Waste Management staff mentioned that recent problems at LNG processing facilities had delayed the trucking of fuel into California and caused supply disruptions (Curtis, et al., 2005).

The SCAQMD requires public access when it provides incentive funding to defray the cost of a fueling station. However, the term "public access" generally refers to access for other fleets and not necessarily members of the general public. To allow general public access could open the municipality or private company to liability issues and also hinder the use of fueling facilities at times when they are most needed. Fleet operators generally make pre-arrangements concerning times of use and fees to be paid for use of another operator's fueling station (Saito, 2005).

VII. References

BAE Systems. June 2004. Orion VII Hybrid Transit Bus, Product Overview.

California Air Resources Board and California Energy Commission. August, 2003. Reducing California's Petroleum Dependence. http://www.energy.ca.gov/reports/2003-08-14_600-03-005.PDF.

Clean Car Maps. April 14, 2005. An Internet Web Page Listing Alternative Fuel Fueling Sites. http://www.cleancarmaps.com/home/

Clean Energy. April 12, 2005. Information conveyed by telephone and email to the staff of ARB from Dave Aasheim and James N. Harger, staff of Clean Energy.

Curtis, Thomas, Frank Dopp, and Darrell Kato. March 2005. ARB survey interviews with three management-level staff of Waste Management.

DHL. June 21, 2004. Press Release. "DHL Places Two Alternative Fueled Vehicles Into the Field".

DieselNet. October, 2004. "Westport Secures NREL Funding for HPDI Truck Program." http://www.dieselnet.com.

FedEx Express. April 22, 2005. Press Release. "FedEx Announces Plans to Add Up to 75 'Clean Air' Hybrid Trucks to Fleet."

General Motors. May 27, 2004. Press Release. "GM Delivers Nation's Largest Hybrid Bus Fleet to King County."

ISE Corporation. 2003 Annual Report.

ISE Corporation. July 19, 2004. Press Release. "ISE Corporation Announces New Army Contract for Hybrid Truck."

Saito, Dean. April 13, 2005. Telephone conversation with Dean Saito of South Coast Air Quality Management District and the staff of the Air Resources Board.

Sempra Utilities. April 8, 2005. E-mail response from Stan Sinclair of Sempra Utilities responding to ARB questions concerning costs of setting up CNG filling stations for fleets of 50 and 100 waste collection vehicles.

Stoddard, Kent. March 22, 2005. E-mail from Waste Management responding to the questions concerning costs of LNG filling stations for waste collection vehicles.

South Coast Air Quality Management District Board. December 3, 2004. Board Meeting, Agenda Number 4.

Tran, Kim et al., City of Los Angeles Department of General Services. Undated. Case Study: City of Los Angeles Dual-Fuel Refuse Collection Vehicles and LNG Refueling Infrastructure.

United States Department of Energy. 2005. www.eere.energy.gov/cleancities An Internet web page listing Clean Cities alternative-fueled fleets.

United States Environmental Protection Agency. March 2004. Highway Diesel Progress Review Report 2.

VTA, Undated. California Transit Agencies Advanced NOx Reduction Demonstration Program.

WestStart. 2004. Announcements During the Hybrid Truck Users Forum Held in Kalamazoo, Michigan, October 14-15, 2004.

APPENDICES

Appendix A

Diesel Engine Availability

The following table (Table A-1) list the 2005 model year California certified heavy-duty diesel engines (as of March 2005).

2005 MY Diesel Fuel Heavy Duty Engines

MFR[1]	SERVICE CLASS	DISP (L)	NMHC+NOx STD	MODELS(HP)
CAT	MHD	7.2	2.5	C7 (275-300hp)
CAT	MHD	7.2	2.5	C7 (207-350hp)
CAT	UB	8.8	2.5	C9 (285-330hp)
CAT	MHD	8.8	2.5	C9 (335-440hp)
CAT	MHD	11.1	2.5	C11 (315-385hp)
CAT	MHD	12.5	2.5	C13 (395-525)
CAT	MHD	15	2.5	C15 (435-625hp)
CUMM	HHD	10.8	2.5	ISM (400-500hp)
CUMM	MHD	5.9	2.5	ISB (260hp)
CUMM	MHD	5.9	2.5	ISB (185-230hp)
CUMM	MHD	5.9	2.4[2]	ISE (300hp)
CUMM	MDV[3]	5.9	2.5	ISB (325hp)
CUMM	MHD	5.9	2.5	ISB (245-275hp)
CUMM	MHD	8.3	3.1[2]	ISC (326hp)
CUMM	HHD	10.8	2.4[2]	ISM (340-500hp)
CUMM	HHD	10.8	2.4[2]	ISM (291-380hp)
CUMM	HHD	14.9	2.5	ISX (425-600hp)
CUMM	HHD	14.9	2.4[2]	ISX (400-450hp)
CUMM	MHD	8.8	3.3[2]	ISL (310-380hp)
CUMM	MHD	8.3	2.8[2]	ISC (255-326hp)
CUMM	MHD	8.3	2.9[2]	ISC (240-260hp)
DCAG	HHD	12.8	2.5	OM460LA (350-450hp)
DCAG	MHD	7.2	2.5	OM926LA (250-300hp)
DCAG	MHD	4.25	2.5	OM904LA (150-170hp)
DCAG	MHD	6.37	2.5	OM906LA (190-260hp)
DDC	HHD	12.7	2.5	Series 60 (380-455hp)
DDC	HHD	14.0	2.5	Series 60 (455-515hp)
GEP	MDV	6.5	2.5	L65 (205hp)

GM	MDV	6.6	2.5	LLY (300-310hp)
GM	MDV	6.6	2.5	LLY (310hp)
GM	MDV	6.6	2.5	LLY (210-300hp)
HINO	HHD	7.7	2.5	J08E-TB (260hp)
HINO	LHD	4.7	2.5	J05D-TA (175hp)
HINO	MHD	7.7	2.5	J08E-TA (220-230hp)
INT	LHD	6.0	2.5	A (235-325hp)
INT	LHD	4.5	2.5	A (200hp)
INT	LHD	6.0	2.5	A (175-230hp)
INT	MHD	6.0	2.5	A (235-325hp)
INT	MHD	7.6	2.5	D (210-300hp)
INT	MHD	9.3	2.5	D (285-340hp)
ISUZU	LHD	5.2	2.5	4HK1TC (190hp)
ISUZU	MHD	7.8	2.5	6HK1X (200-230hp)
MACK	HHD	11.9	2.4[2]	AC (310-480hp)
MACK	HHD	11.9	2.8[2]	AI (375-360hp), AMI (370hp)
MACK	HHD	11.9	2.7[2]	AMI (370hp)
MACK	HHD	11.9	2.5	AI (300-400hp), AMI (300-335hp)
MACK	HHD	11.9	2.4	E7G (325-425hp)
MACK	HHD	11.9	2.3[2]	AC (427hp)
MFTB	LHD	4.9	2.5	4M50 (147-175hp)
MFTB	MHD	7.5	2.5	6M60 (243-274hp)
Volvo	HHD	12.1	2.5	VE D120 (385-485hp)

[1]Abbreviations used - CAT: Caterpillar; CUMM: Cummins, INC.; DCAG: Daimler Chrysler AG; DDC: Detroit Diesel Corporation; GEP: General Engine Products; GM: General Motors; HINO: Hino Motors Limited; INT: International Truck and Engine Corp.; ISUZU: Isuzu Motors Limited; MACK: Mack Truck; MFTB: Mitsubishi Fuso and Bus Corp.
[2]NOx+NMHC FEL (Family Emission Limits)
[3]Medium-duty Vehicle

The following table (Table A-2) lists the 2005 model year California certified heavy duty alternative fueled engines (as of March 2005). Alternative-fuel engines are currently available for most of the same applications as heavy-duty diesel applications

2004 MY Alternative Fuel Heavy Duty Engines

MFR[1]	SERVICE CLASS	FUEL	DISP (L)	NMHC +NOx STD	MODELS(HP)
BIPT	HDO	LPG	8.1	1.5	GM 8.1 (325 hp)
CUMM	MHD	CNG	5.9	1.8	BG (195-230hp),
CUMM	BUS	CNG	8.3	1.8[2]	CG (250-280hp)
CUMM	MHD	LPG	5.9	2.2[2]	BLPG (185-195hp)
CUMM	MHD	CNG	8.3	1.8	CG (250-280hp)
CUMM	MHD	CNG	8.9	1.5[3]	LG (320hp)
CUMM	MHD	CNG	8.8	1.4[2]	LG (320hp)
DDC	BUS	CNG	8.5	1.2[2]	CNG (275hp), LPG (275hp)
DDC	BUS	CNG	8.5	1.2[3]	CNG (275hp), LPG (275hp)
DEER	MHD	CNG	8.1	1.5[3]	6081H (250hp)
DEER	BUS	CNG	8.1	1.8[3]	6081H (250-280hp)

[1]Abbreviations used - BIPT: Bi-Phase Technologies, LLC; CUMM: Cummins, INC.; DDC: Detroit Diesel Corporation; DEER: John Deere and Company
[2]NOx+NMHC FEL (Family Emission Limits)
[3]NOx+NMHC Optional Standard
are operating in revenue service (VTA 2004).

Appendix B

Status Report of Natural Gas Infrastructure Expansion in the South Coast District (Draft)

DRAFT

STATUS REPORT OF NATURAL GAS INFRASTRUCTURE
EXPANSION IN THE SOUTH COAST DISTRICT
April 22, 2005

Background

The AQMP relies on the expedited implementation of advanced technologies and clean–burning fuels in Southern California to achieve air quality standards. In addition, the AQMP has identified the use of alternative clean fuels in mobile sources as a primary attainment strategy. To that end, the 1190 rules, which require implementation of alternative fuel heavy-duty vehicles in public and selected private fleets in the Basin promote government fleets (with more than fifteen vehicles) to purchase low-emission or alternative fuel vehicles when adding or replacing vehicles to their fleet. These important Rules have set the stage for widespread penetration of clean fuel, low emission technologies.

Fleets that were impacted by Rules 1192, 1193, 1194, 1195 and 1196 required additional fueling infrastructure, with public access, in place as soon as possible to effect a smooth transition to an alternative fuel fleet. New infrastructure would also diminish the obstacle of the lack of fueling locations throughout the greater Los Angeles basin. In order to meet public and private fleet fueling needs, existing infrastructure needed to be upgraded and new natural gas fueling infrastructure needed to be developed in areas where these fleets operate. These new natural gas fueling stations needed to be built in areas that would accommodate taxis, shared ride operators, hotel/parking shuttles and municipal fleets.

By constructing more natural gas fueling facilities, benefits from these projects accrue to all cities and area residents. Such new construction provides a coordinated effort and plan for growth of the overall fueling infrastructure and helps reduce costs associated with duplication of effort. There are economies of scale captured as a result of the many infrastructures planned and installed, possibly reducing the cost of infrastructure and making alternative refueling stations more affordable. While having no direct impact on air emission reductions, new natural gas fueling stations help facilitate the introduction of low emission, natural gas fueled vehicles (NGVs) initially in private and public fleets in the area. Such increased penetration of NGVs will provide direct emissions reductions of NOx, VOC, CO, PM, and toxic air contaminants throughout the Basin.

Incentive Program Funding

Key to the implementation of alternative fuel heavy-duty vehicles and equipment is the establishment of fueling infrastructure. Public funding has been made available under various programs for the establishment of alternative fuel fueling infrastructure. These funding programs include the Clean Fuels Fund, the AES

Settlement Fund, funding through the Mobile Source Air Pollution Reduction Review Committee (MSRC) and AB 2766, and the Carl Moyer Program. To date, over $30 million has been spent by the AQMD alone for such infrastructure programs. These different funding programs tend to solicit cost-share proposals from private and public fleet owners and fuel vendors intending to install alternative fuel dispensing facilities with an emphasis on providing publicly accessible fueling for heavy-duty vehicles. The goal of these programs is to provide cost-share funds to assist both public and private fleet owners and fuel vendors to establish publicly accessible natural gas fuel dispensing facility projects within the South Coast Air Basin (SCAB).

The AQMD has actively been involved in promoting the use of alternative fuels by providing cost-sharing assistance for the establishment of alternative fuel infrastructure. These funds are normally designed to offset the capital investment required to establish these facilities. Funding of this nature also helps reduce the risk assumed by the fuel provider relative to the future recovery of their capital investment, thereby allowing the fuel provider to make a business case for a strategically significant location and allow the alternative fuel to be priced more competitively compared to conventional fuels due to the smaller amount of amortized capital costs. In addition, they help implement and increase widespread penetration of low emission, alternative fuel, and heavy-duty vehicles in public, commercial and private fleets. Furthermore, these projects provided applicants and other alternative fuel vehicle participants experience and knowledge of alternative fuel storage and dispensing systems.

In recognition of the contribution of heavy-duty vehicles to the emissions inventory, and the difficulty in implementing low emission technologies, approximately $30 million has been spent by the AQMD on projects totaling over $94 million over the past five years to provide incentives for alternative fuel infrastructure. The incentive program has provided cost-share funds to assist public agencies and fleet owners to establish alternative fuel dispensing facility projects in the SCAB. This incentive program and the subsequent additional infrastructure have directly supported the implementation of the Fleet Rules.

Participants in these funding programs were required to install either CNG or LNG fuel infrastructure and documentation which clearly showed a commitment that the proposed fuel infrastructure would dispense a significant amount of fuel on an annual basis, averaged over a 5 year period to heavy duty vehicles. In addition, the participants were required to provide documentation signed by other vehicle owners that would be using the fuel to demonstrate that throughput requirements would be met.

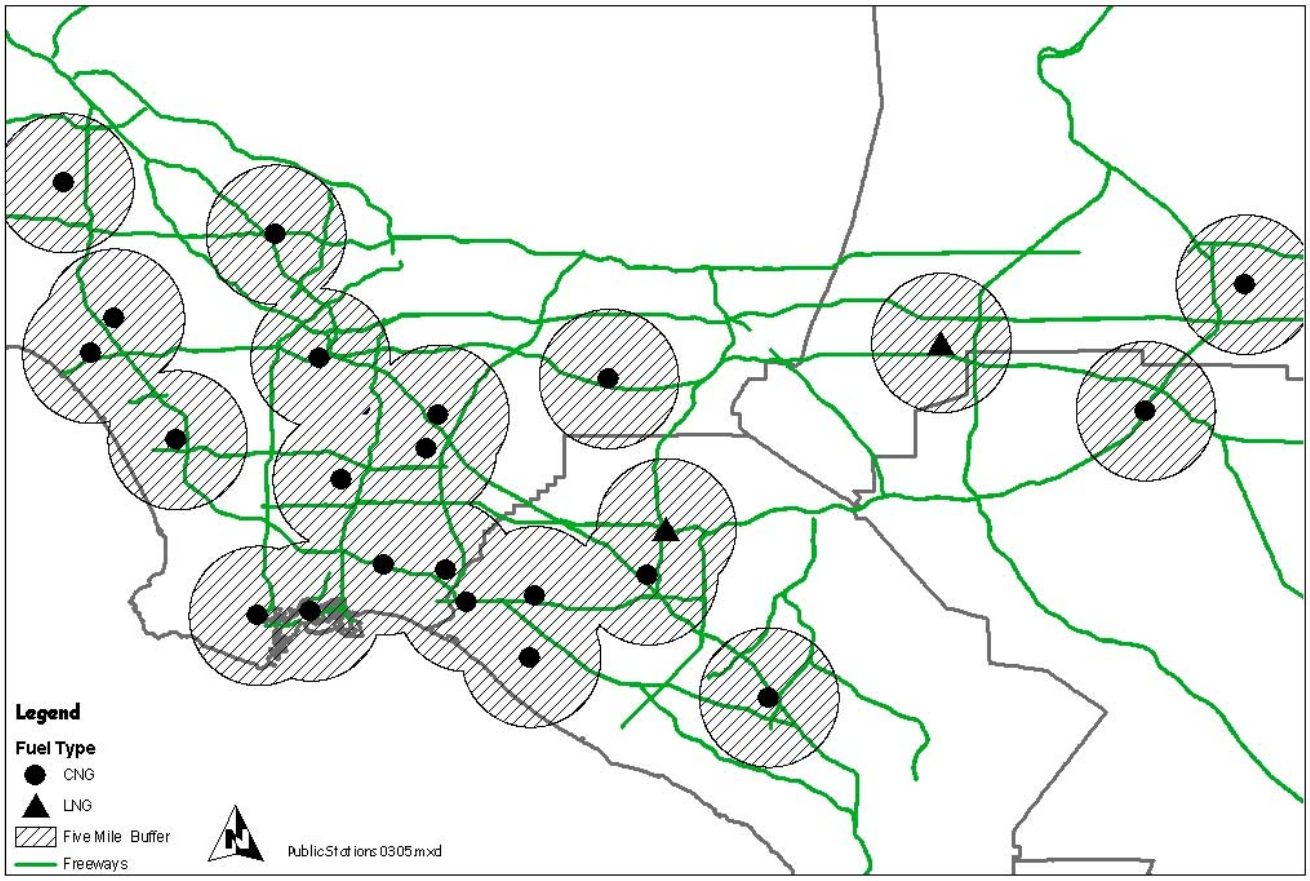
Participants in these funding programs are normally project owner/developer's that own and operate the intended natural gas fueling stations and may include public agencies or private entities. Participants also included fleet owners, state and local governments, as well as automobile manufacturers, alternative fuel

suppliers, storage and equipment component manufacturers whose intention is to own and operate the intended natural gas fueling station. Projects that were strategically located or assisted fleet owners or public agencies subject to the Fleet Rules to establish alternative fuel dispensing facilities in California were eligible. Projects that partnered with school districts or fleet owners subject to the Fleet Rules were given a priority and granted additional consideration. Grant funds could only be requested for costs associated with the physical fueling facility including, but not limited to, storage, dispensing, and/or electronic point-of-sale (EPOS) equipment at designated fueling facilities. Funding for EPOS equipment had to have universal capability (i.e., it must accept Voyager, Visa, MasterCard and other proprietary cards where applicable) where cross fueling was not an issue and where the general public may fuel where it is practical.

Comparison in Infrastructure Between Years 2000 and 2005

At the time the last Economic Assessment was published in June of 2000 by the AQMD in preparation for the Fleet Rules, there were few compressed natural gas (CNG) fueling stations located in southern California and only two liquefied natural gas (LNG) station that was accessible to public or private fleet vehicles. Figure 1 shows the pre- year 2000 station inventory in the greater metropolitan areas of southern California consisting of approximately 25 stations that mostly dispensed CNG and had very limited public access. It is apparent from the concentric circles drawn around each of the stations, representing 5 mile radii, that there wasn't much in the way of penetration of alternative fuel fueling infrastructure. It also shows that, in order for the Fleet Rules to succeed, additional fueling infrastructure was required.

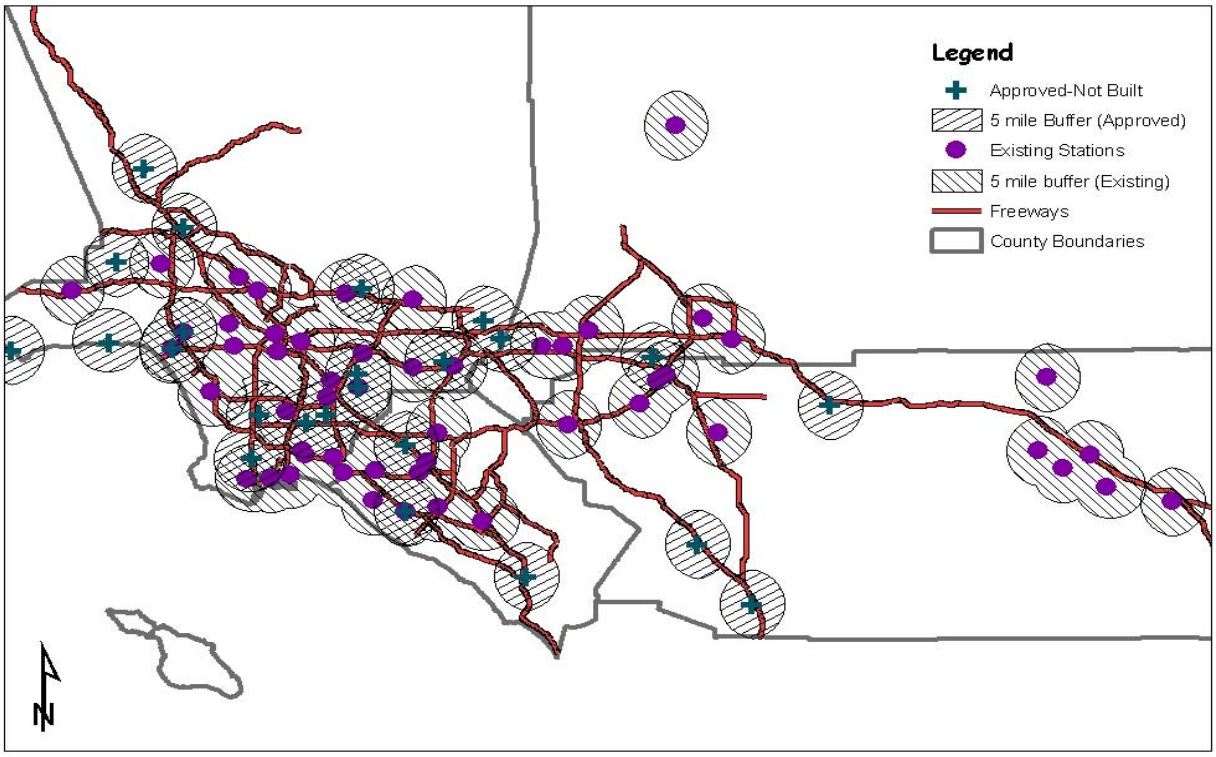
Figure 1 – Pre Year 2000 Alternative Fuel Infrastructure



The incentive funding programs offered by the AQMD have had a significant impact in the number of conveniently located publicly accessible fueling stations that are now in operation within the SCAB. From a pre- year 2000 station inventory of approximately 25 stations that mostly dispensed CNG and had very limited public access, there are now over 100 CNG or LNG stations that have or will have full public access. This type of access includes the ability to use popular credit cards, including Visa and MasterCard, as well as cards issued by different natural gas providers, allowing for convenient fueling throughout the SCAB.

Figure 2 is a map of the southern California metropolitan area and includes the four different counties as well as the major freeways that run through them. The map clearly shows the significant increase in the number of stations that are either fully operational or in the planning and permitting stage.

Figure 2 – Current Year 2005 Alternative Fuel Infrastructure



The map also includes a striped 5 mile "buffer" zone around each station, existing or planned, that was created as a planning tool to determine where possible "gaps" in the location of convenient fueling stations might exist. The gap analysis, or demographic optimization study, depicts all existing clean fuel facilities in the South Coast Air Basin and determines their proximity to new and proposed clean fuel fleets. The analysis program provided tremendous insight as to those areas that did not have adequate penetration of alternative fuel fueling infrastructure. The analysis program helped fleet operators to analyze their needs in relation to the existing or planned infrastructure and helped facilitate the decision to build or share a clean fuel fueling station by determining if using a nearby fueling station was more cost effective than building their own station. In other cases, operators found it more cost effective to build their own station and recruit other fleets in the vicinity to use their station. The filling of these different gaps in and around the major metropolitan areas and along the main corridors throughout the SCAB became a priority and applicants to the various funding programs that located stations in these gaps were given additional consideration during the scoring of competitive solicitations.

Project Funding

Appendix A contains a listing of all partially or fully funded projects through the AQMD incentive programs. All told, over $30 million in funding has been provided for projects totaling over $130 million in total costs. These projects include alternative fuel infrastructure for CNG, LNG and L/CNG fueling stations at public and private organizations and businesses as well as production of LNG from pipeline quality or landfill gas, development of advanced CNG equipment, and equipment upgrades for existing infrastructure. Funding from the MSRC for the different projects has not been included in the Appendix or any of the following tables even though the majority of projects did apply to both programs.

The funded stations vary greatly from one another with respect to their location, the type of fuel being dispensed, the type of (fleet) vehicles that are being fueled, the fuel throughput and in the cost associated with the construction. Depending on the overall intent of the station owners, i.e. if the station is to fuel a captive fleet or if it is more generally situated to capture privately owned vehicles, the overall business opportunity and financial return that the station owner requires may also be very different. There are several categories that the funded stations fall into. They are:

1. CNG Stations
2. LNG Stations
3. Refuse Haulers
4. Transit Fleets
5. Schools and Private School Bus Service Providers

Tables appearing in the following sections list the infrastructure-related projects that have been awarded funding by the AQMD's Governing Board. The categories appearing in each of the tables include the company or agency that was awarded funding, the name of the project, the total overall cost of the project and the amount of the award from the AQMD. In the last column there appears the annual fueling throughput, expressed in 1,000's of gasoline equivalent gallons, for the station as originally proposed or agreed to by contract by the company or agency requesting funds.

CNG Stations

Generally speaking, stations falling into the CNG category may have a dedicated fleet but are required to provide some form of public access and have either card readers or have in place fuel provider agreements with fleets that desire to use the facilities. Projects listed all have access to the general public unless otherwise noted. Of the CNG stations, fully 76 different stations have utilized funding from the AQMD. These funds were used from simply upgrading stations with new dispensers and credit card readers to the construction of new fueling

infrastructure. Funding was provided to agencies, cities, fuel vendors, equipment vendors and schools. Table 1 - CNG STATIONS lists the projects where over $8 million in funding was provided under the AQMD incentive programs for projects totaling over $22 million. Some of the projects listed in this and other tables were recently approved for funding by the Governing Board and are still in the planning or permitting stage. All projects have been completed unless otherwise noted.

Table 1 - CNG STATIONS

Company	Project Title	Project Total	AQMD Award	Annual Fuel Throughput (000's GGE)
City Of Banning	Construct Natural Gas Fueling Station	$725,000	$140,000	85
City Of Burbank	Construct CNG Refueling System	$942,436	$230,000	300
City Of La Verne[1]	Construct New CNG Fueling Station	$425,000	$120,000	15.3
City Of Monterey Park	Construct CNG Refueling System	$84,300	$59,000	1
City Of Placentia[1]	Construct CNG Refueling System	$635,000	$200,000	59
City Of Sierra Madre[1]	Construct CNG Fueling Station	$368,000	$73,776	3
City Of Whittier	Upgrade CNG Fueling Station	$325,000	$150,000	75
Clean Energy	Construct one CNG Fueling Station	$546,535	$144,400	200
Clean Energy [2]	Construct 5 CNG Stations in Pomona, Mission Viejo, Santa Monica, Riverside & Canoga Park	$3,098,550	$924,000	1,450
Clean Energy	Construct Four Natural Gas Refueling Stations	$2,440,400	$800,000	800
Clean Energy	Construct Natural Gas Refueling Station	$904,585	$88,800	200
Clean Energy	Upgrade 17 Existing CNG Fueling Stations	$1,445,112	$892,615	N/A
Foothill Transit[2]	Construct CNG Station with Public Access	$760,000	$188,710	
Fuelmaker Corporation	Develop/Demonstrate Advanced CNG Home Refueling Appliance	$1,225,000	$750,000	N/A
Fuelmaker Corporation	Phase II Support to Develop/Demonstrate Advanced CNG Home Refueling Appliance	$1,341,000	$550,000	N/A
Gas Equipment Systems[2]	Construct Four CNG Fueling Stations	$1,860,000	$570,000	197
Orange County Sanitation District[2]	Upgrade CNG Fueling Station	$80,000	$24,000	302
Pinnacle CNG Company	Maintenance and Management of CNG Fueling Station	$239,000	$239,000	N/A
Pinnacle CNG Systems, LLC	Construct CNG Fueling Station	$615,200	$615,200	95
R. F. Dickson Co.	Construct CNG Fueling Facility	$730,000	$180,000	400
R.F. Dickson Co. [2]	Upgrade Existing CNG Fueling Station in Bellflower	$703,828	$211,148	N/A

Southern California Gas Company	Upgrade 10 Existing CNG Fueling Stations	$641,280	$448,900	N/A
Thermo Power Corp	Low-Cost Natural Gas Compressor & Natural Gas Vehicle Refueling Station	$1,016,000	$250,000	N/A
UCLA Fleet & Transit Services	Upgrade Existing Public Access Station	$32,000	$15,921	46
Valley Power Products	CNG-Fueled Airport Service Equipment @ LAX	$863,960	$348,803	N/A
Yellow Cab Company	Construct New CNG Fueling Station	$450,000	$150,000	150
		$22,497,186	**$8,364,273**	**4,378**

1 Limited public access
2 Not yet completed or in planning stage

LNG Stations

Stations that were funded under the LNG category have captive fleets but also have made a concerted effort to provide fuel to outside agencies and businesses. Even though they have LNG fueling systems, they have made significant extra investment and installed equipment necessary to provide CNG from the LNG system. This category would not include hauling or transit fleets. Table 2 - LNG STATIONS lists the projects where approximately $1.5 million in funding was provided under the AQMD incentive programs for projects totaling almost $6 million.

Table 2 – LNG STATIONS

Company	Project Title	Project Total	AQMD Award	Annual Fuel Throughput (000's GGE)
City Of Long Beach[2]	Construct L/CNG Production Facility	$3,500,000	$500,000	300
City Of San Bernardino[1]	Construct L/CNG Refueling Station	$1,250,000	$143,208	48
Downs Commercial Fueling, Inc.[2]	Construct CNG Refueling System	$850,000	$453,137	300
Sysco Food Services Of Los Angeles	Construct LNG Fueling System	$1,002,476	$450,000	900
		$6,602,476	**$1,546,345**	**1,548**

1 Limited public access
2 Not yet completed or in planning stage

Refuse Haulers

The refuse haulers that have been funded include both contract and government operated refuse services. The refuse company had the option of determining what type of fueling technology as well as the type of vendor product that satisfied their needs. Types of fueling infrastructure funded include LNG, CNG and L/CNG stations. In some cases, the station operator installed L/CNG fueling technology after the LNG station was constructed. Table 3 -REFUSE HAULERS

lists the projects where approximately $11 million in funding was provided under the AQMD incentive programs for projects totaling approximately $40 million.

Table 3 – REFUSE HAULERS

Company	Project Title	Project Total	AQMD Award	Annual Fuel Throughput (000's GGE)
Burrtec, Inc. [1, 2]	Construct LNG Fueling System	$627,141	$188,000	198
City Of Los Angeles, Dept. Of Public Works[1]	Construct LNG Fueling Station	$3,200,000	$200,000	480
Consolidated Disposal Service[2]	Construct LNG Fueling System	$740,127	$222,038	820
CR&R Inc. [2]	Construct 2 L/CNG Fueling Stations	$1,164,948	$582,474	380
Dept. Of Water & Power / City of Los Angeles[1]	Construct 2 LNG Fueling Stations	$24,000,000	$6,000,000	N/A
Riverside County Waste Management	Construct LNG Fueling Station	$1,140,000	$200,000	68
Riverside County Waste Management	Construct LNG Fueling Station	$1,282,400	$148,350	N/A
Riverside County Waste Management	Supplemental Funding for LNG Fueling Station	$1,188,350	$165,000	N/A
Sanitation Districts Of Los Angeles County	Construct LNG Refueling Systems	$1,120,000	$818,750	350
Sanitation Districts Of Los Angeles County[2]	Construct CNG Fueling Station at JWPCP in Carson	$850,000	$250,000	150
Taormina Industries	Construct L/CNG Fueling Station	$1,059,850	$413,000	300
USA Waste Of California, Inc. [1]	Construct L/CNG Fueling Station	$850,000	$400,000	1,400
Valley Power Products Inc[1]	CNG-Fueled Airport Service Equipment @ LAX	$863,960	$348,803	N/A
Valley Vista Services	Construct CNG Fueling Station	$840,844	$200,000	300
Waste Management Of San Gabriel[1]	Construct L/CNG Fueling Station	$850,000	$400,000	1,360
Waste Management Recycling And Disposal Services[1]	Construct L/CNG Fueling Station	$850,000	$400,000	680
		$40,627,620	**$10,936,415**	**6,486**

1 Limited public access
2 Not yet completed or in planning stage

Transit Fleets

Of the four transit fleets that requested incentive funding from the AQMD, three use CNG in their buses, but two of them opted to install L/CNG fueling systems instead of a straight CNG system. The cost of installing an L/CNG fueling system is often believed to be less than the cost of a CNG system. Table 4 - TRANSIT FLEETS lists the projects where approximately $4 million in funding was provided under the AQMD incentive programs for projects totaling almost $18 million.

Table 4 – TRANSIT FLEETS

Company	Project Title	Project Total	AQMD Award	Annual Fuel Throughput (000's GGE)
Santa Monica Big Blue Bus[1]	Purchase/Install L/CNG Refueling Systems	$6,501,930	$500,000	8,500
Foothill Transit[1]	Purchase/Install CNG Refueling System	$3,800,000	$700,000	600
OmniTrans[1]	Purchase/Install two New L/CNG Fueling Systems	$5,810,360	$1,650,000	4,000
Orange County Transportation Authority[1, 2]	LNG Equipment Upgrade and New Alternative Fueling Infrastructure	$2,000,000	$1,000,000	N/A
		$18,112,290	**$3,850,000**	**13,100**

1 Limited public access
2 Not yet completed or in planning stage

Schools

Overall, 86 different alternative fueling infrastructure projects were funded under the school category. Funding was provided under the Lower-Emission School Bus Replacement Program as well as the Clean Fuels Fund and the AES Settlement Fund. Table 5 - SCHOOLS lists the projects where approximately $5 million in funding was provided under the AQMD incentive programs for projects totaling almost $7 million. A significant difference exists in the amount of funding provided between some of the school districts. For those districts that have fewer than 20 buses a time fill system was normally specified while those having greater than 20 buses opt for a fast fill system. Time fill systems generally cost much less than a fast fill system.

Table 5 – SCHOOLS AND PRIVATE SCHOOL BUS SERVICE PROVIDERS

Company	Project Title	Project Total	AQMD Award
Capistrano USD[1]	Install CNG Fueling Facility	$ 111,200	$ 111,200
Coachella Valley USD[1]	CARB Emissions Reduction Credit Bank Program	$ 257,950	$ 257,950
Colton Joint USD[1]	CARB Emissions Reduction Credit Bank Program	$ 302,600	$ 302,600
First Student, Inc. [2]	New Public Access CNG Fueling Station at Gardena Bus Yard	$ 842,000	$ 250,000
Fuelmaker Corporation[1]	Upgrade CNG Fueling Stations at Various School Districts and Municipalities	$ 180,000	$ 90,000
Fullerton Joint USD[1]	New CNG Refueling System in Fullerton	$ 274,632	$ 137,300
Jurupa USD[1]	New CNG Refueling System for 34 Buses	$ 1,075,244	$ 390,244
Lake Elsinore USD[1]	New CNG Fueling Station at Maintenance Yard	$ 190,000	$ 75,000
Whittier Union High School[1]	Upgrade Existing Public Access Station	$ 32,000	$ 15,921
		$3,265,626	**$1,630,215**

1 Limited public access
2 Not yet completed or in planning stage

Lower-Emission School Bus Replacement Program

School	Program	Project Total	AQMD Award
Alhambra USD	PA 2005-01	$13,380	$13,380
Alta Loma USD	FY 2000-	$10,730	$10,730
Alta Loma USD	FY 2003-04	$13,316	$13,316
Alta Loma USD	PA 2005-01	$11,815	$11,815
Arcadia USD	FY 2001-	$38,096	$38,096
Arcadia USD	FY 2002-03	$11,500	$11,500
Arcadia USD	FY 2003-04	$11,880	$11,880
Arcadia USD	PA 2005-01	$47,522	$47,522
Azusa USD	FY 2003-04	$13,380	$13,380
Azusa USD	PA 2005-01	$26,761	$26,761
Banning USD	FY 2000-01	$12,589	$12,589
Banning USD	FY 2001-02	$60,954	$60,954
Banning USD	FY 2003-04	$11,815	$11,815
Beaumont USD	FY 2002-03	$11,500	$11,500
Bellflower USD	FY 2002-03	$92,000	$92,000
Bellflower USD	FY 2003-04	$47,520	$47,520
Bellflower USD	PA 2005-01	$11,880	$11,880
Bonita USD	FY 2002-03	$11,500	$11,500
Bonita USD	FY 2003-04	$13,380	$13,380
Bonita USD	PA 2005-01	$40,141	$40,141
Buena Park USD	FY 2002-03	$46,000	$46,000
Buena Park USD	PA 2005-01	$59,079	$59,079
Chaffey Joint USD	FY 2000-01	$22,143	$22,143
Chino Valley USD	FY 2000-01	$15,569	$15,569
Chino Valley USD	FY 2001-02	$35,958	$35,958
Chino Valley USD	FY 2002-03	$34,500	$34,500
Chino Valley USD	FY 2003-04	$11,815	$11,815
Colton Joint USD	FY 2000-01	$86,926	$86,926
Colton Joint USD	FY 2001-02	$25,866	$25,866
Colton Joint USD	PA 2005-01	$39,947	$39,947
Covina-Valley USD	FY 2002-03	$11,500	$11,500
Covina-Valley USD	FY 2003-04	$13,380	$13,380
Desert Sands USD	FY 2000-01	$64,384	$64,384
Fullerton Joint USD	FY 2000-01	$75,532	$75,532
Fullerton Joint USD	FY 2002-03	$11,500	$11,500
Fullerton Joint USD	FY 2003-04	$11,815	$11,815
Fullerton Joint USD	PA 2005-01	$35,447	$35,447
Garden Grove USD	FY 2000-01	$85,846	$85,846
Garden Grove USD	FY 2001-02	$116,292	$116,292
Garden Grove USD	FY 2002-03	$11,500	$11,500

Garden Grove USD	FY 2003-04	$13,316	$13,316
Garden Grove USD	PA 2005-01	$23,631	$23,631
Hacienda-La Puente USD	PA 2005-01	$71,283	$71,283
Hemet USD	FY 2002-03	$11,500	$11,500
Hemet USD	FY 2003-04	$11,815	$11,815
Hemet USD	PA 2005-01	$11,815	$11,815
Huntington Beach City School District	FY 2002-03	$11,500	$11,500
Huntington Beach City School District	FY 2003-04	$13,316	$13,316
Huntington Beach City School District	PA 2005-01	$13,315	$13,315
Lake Elsinore USD	PA 2005-01	$35,447	$35,447
Los Alamitos USD	PA 2005-01	$39,947	$39,947
Los Angeles USD	FY 2000-01	$396,729	$396,729
Los Angeles USD	FY 2001-02	$186,408	$186,408
Los Angeles USD	FY 2002-03	$126,500	$126,500
Menifee USD	FY 2002-03	$11,500	$11,500
Menifee USD	FY 2003-04	$13,316	$13,316
Menifee USD	PA 2005-01	$11,815	$11,815
Monrovia USD	FY 2000-01	$53,924	$53,924
Montebello USD	FY 2000-01	$95,526	$95,526
Moreno Valley USD	FY 2000-01	$37,766	$37,766
Moreno Valley USD	FY 2002-03	$11,500	$11,500
Moreno Valley USD	FY 2003-04	$11,815	$11,815
Moreno Valley USD	PA 2005-01	$23,631	$23,631
Mountain View USD	FY 2000-01	$75,545	$75,545
Newport-Mesa USD	PA 2005-01	$39,947	$39,947
Ontario-Montclair School District	FY 2000-01	$16,498	$16,498
Orange USD	PA 2005-01	$13,315	$13,315
Placentia-Yorba Linda USD	FY 2000-01	$43,052	$43,052
Pupil Transportation Cooperative	FY 2000-01	$75,617	$75,617
Pupil Transportation Cooperative	PA 2005-01	$66,902	$66,902
Redlands USD	FY 2002-03	$11,500	$11,500
Redlands USD	FY 2003-04	$11,815	$11,815
Redlands USD	PA 2005-01	$23,631	$23,631
Santa Monica-Malibu USD	FY 2000-01	$11,353	$11,353
Torrance USD	FY 2000-01	$13,196	$13,196
Upland USD	PA 2005-01	$11,815	$11,815
Walnut Valley USD	FY 2000-01	$11,379	$11,379
Walnut Valley USD	FY 2002-03	$11,500	$11,500
Walnut Valley USD	PA 2005-01	$13,380	$13,380
		$3,014,419	**$3,014,419**
	GRAND TOTAL	**6,915,044.64**	**$4,844,634**

CNG vs. Diesel Fuel Retail Pricing

The prices contained within this report are meant to represent retail, at-the-pump sales prices for natural gas and diesel. Prices for natural gas were collected from the Southern California Gas Company and a local commercial vendor of natural gas, where taxes are not included.

Diesel fuel averaged $2.132 per gallon nationwide during the week of November 15, 2004. This represented an increase of 42.1¢ per gallon from June 2004. During the week of November 15, diesel prices ranged from a low of $2.056 in the Gulf Coast region to a high of $2.274 on the West Coast. Between June and November, 2004, prices for diesel increased in every region of the country. The diesel prices here are retail prices and include federal, state, and local taxes. These prices were obtained from the Energy Information Administration.

Average natural gas (CNG) retail pump prices for the West Coast during the week of November 15, 2004 were $1.80 per GGE.

Price Trends

	June 14, 2004	November 15, 2004
	Change in Price	
Diesel Price Trends	$1.998	$2.274
$0.276		
CNG Price Trends	$1.54	$1.82
$0.28		
SoCalGas Price	$1.57	$1.40
($0.27)		

APPENDIX A – ALL FUNDED PROJECTS

Company	City	Project Title	Project Total	AQMD Award
Burrtec, Inc.	Santa Clarita	New LNG Fueling System	$627,141	$188,000
Capistrano USD	San Juan Capistrano	New CNG Fueling Facility	$111,200	$111,200
City Of Banning	Banning	New CNG Fueling Station	$725,000	$140,000
City Of Burbank	Burbank	New CNG Refueling System	$942,436	$230,000
City Of La Verne	La Verne City Hall	New CNG Fueling Station	$425,000	$120,000
City Of Long Beach	Long Beach	New LNG Production Facility	$3,500,000	$500,000
City Of Los Angeles, Dept. Of Public Works	Los Angeles	Construct & Operate New LNG Fueling Station	$3,200,000	$200,000
City Of Monterey Park	Monterey Park	New CNG Refueling System City Yard	$84,300	$59,000
City Of Placentia	Placentia	New CNG Refueling System in the City Yard	$635,000	$200,000
City Of San Bernardino	San Bernardino	Development of LNG-L/CNG Refueling Station	$1,250,000	$143,208
City Of Santa Monica (Big Blue Bus)	Santa Monica	Install Two L/CNG Refueling Systems	$6,501,930	$500,000
City Of Sierra Madre	Sierra Madre	Install New Public Access CNG Fueling Station	$368,000	$73,776
City Of Whittier	Whittier	New CNG Fueling Station at City Yard	$325,000	$150,000
Clean Energy	Downey, Long Beach, Thousand Palms, Baldwin Park	Construct & Operate 1 LNG & 4 CNG Fueling Stations	$546,400	$144,400
Clean Energy	Pomona, Mission Viejo, Santa Monica, Riverside & Canoga Park	New CNG Stations in Pomona, Mission Viejo, Santa Monica, Riverside & Canoga Park	$3,098,550	$924,000
Clean Energy	Pasadena, Burbank, Garden Grove, Los Angeles	Construction/Upgrade of Four Natural Gas Refueling Stations	$2,440,400	$800,000
Clean Energy	Palm Desert	Purchase/Installation of NG Refueling Station	$904,585	$88,800
Clean Energy	17 different cities	Upgrade Existing CNG Fueling Stations	$1,445,112	$892,615
Coachella Valley USD	Coachella Valley	CARB Emissions Reduction Credit Bank Program		$257,950
Colton Joint USD	Colton	CARB Emissions Reduction Credit Bank Program	$302,600	$302,600
Consolidated Disposal Service	Long Beach	New LNG Fueling System	$740,127	$222,038
CR&R Inc.	San Juan Capistrano	New LNG-L/CNG Refueling	$1,164,948	$582,474

	& Stanton	Stations		
Dept. Of Water & Power	Los Angeles	Construction of LNG Fueling Facilities for Refuse Haulers	$24,000,000	$6,000,000
Downs Commercial Fueling, Inc.	Temecula	New CNG Refueling System	$850,000	$250,000
Downs Commercial Fueling, Inc.	Temecula	New L/CNG Fueling System		$203,137
First Student, Inc.	Gardena at Bus Yard	New CNG Fueling Station	$842,000	$250,000
Foothill Transit	Pomona	New CNG Refueling System	$3,800,000	$500,000
Foothill Transit	Pomona	New CNG Fueling Facility		$200,000
Foothill Transit	Pomona	New CNG Station with Public Access	$760,000	$188,710
Fuelmaker Corporation	N/A	Develop/Demonstrate Advanced CNG Home Refueling Appliance	$1,225,000	$750,000
Fuelmaker Corporation	N/A	Phase II Support to Develop/Demonstrate Advanced CNG Home Refueling Appliance	$1,341,000	$550,000
Fuelmaker Corporation	N/A	Upgrade CNG Fueling Stations at Various School Districts and Municipalities	$180,000	$90,000
Fullerton Joint USD	Fullerton	New CNG Refueling System	$274,632	$137,300
Gas Equipment Systems	Malibu, Zuma Beach, City of San Fernando & City of Beaumont	New CNG Fueling Stations	$1,860,000	$570,000
Jurupa USD	Jurupa	New CNG Refueling System	$310,000	$125,000
Jurupa USD	Jurupa	Supplemental Funding for CNG Fueling Station	$609,826	$109,826
Jurupa USD	Jurupa	CNG School Bus Replacements and CNG Infrastructure	$155,418	$155,418
Lake Elsinore USD	Lake Elsinore	New CNG Fueling Station	$190,000	$75,000
OmniTrans	San Bernardino & Montclair	New L/CNG Fueling System	$5,810,360	$750,000
OmniTrans	San Bernardino & Montclair	New 2 L/CNG Fueling Facilities		$400,000
OmniTrans	San Bernardino & Montclair	New L/CNG Refueling Station in City of Montclair		$250,000
OmniTrans	San Bernardino & Montclair	New L/CNG Refueling Station in San Bernardino		$250,000
Orange County Sanitation District	Fountain Valley Facility	New Dispenser/Payment System	$80,000	$24,000
Orange County Transportation Authority	Santa Ana	Cost-Sharing Equipment to Upgrade Transit LNG Tanks & Expand New Alternative Fueling Infrastructure	$2,000,000	$1,000,000

PG&E	Sacramento	Cost-Share Small-Scale Natural Gas Liquefaction Plant	$7,400,000	$200,000
Pinnacle CNG Company	Diamond Bar	Maintenance and Management of CNG Fueling Station at AQMD Headquarters	$239,000	$239,000
Pinnacle CNG Company	Diamond Bar	Construction of Fast-Fill CNG Fueling Station at AQMD Headquarters	$615,200	$615,200
R. F. Dickson Company	Bellflower	Cost-share Installation of CNG Fueling Facility	$730,000	$180,000
R.F. Dickson Co.	Bellflower	Upgrade Existing CNG Fueling Station in Bellflower	$703,828	$211,148
Riverside County Waste Management	Aqua Mansa	New LNG Fueling Station	$1,140,000	$200,000
Riverside County Waste Management	Aqua Mansa	New LNG Fueling Station at Agua Mansa Road	$1,282,400	$148,350
Riverside County Waste Management	Aqua Mansa	Supplemental Funding for LNG Fueling Station	$1,188,350	$165,000
Sanitation Districts Of Los Angeles County	La Puente	New LNG Refueling Systems at Puente Hills Landfill	$1,120,000	$258,750
Sanitation Districts Of Los Angeles County	La Puente	New LNG-L/CNG Fueling Station at Puente Hills Landfill		$560,000
Sanitation Districts Of Los Angeles County	Carson	New Fast-Fill Public Access CNG Fueling Station at JWPCP	$850,000	$250,000
Southern California Gas Company	10 different cities	Upgrade Existing CNG Fueling Stations	$641,280	$448,900
SunLine Services Group	Thousand Palms	New LNG Production Facility	9,800,000	$549,054
Sysco Food Services, Inc.	Walnut	Construct & Operate L/CNG Fueling Station	$1,002,476	$200,000
Sysco Food Services, Inc.	Walnut	New LNG Fueling System	$1,002,476	$250,000
Taormina Industries	Anaheim	New CNG refueling System	$1,021,850	$200,000
Taormina Industries	Anaheim	New LNG-L/CNG Refueling Station	$1,059,850	$203,682
Taormina Industries	Anaheim	New LNG-L/CNG Refueling Station at Taormina		$9,318
Thermo Power Corp	N/A	Low-Cost Natural Gas Compressor & Natural Gas Vehicle Refueling Station	$1,016,000	$250,000
UCLA Fleet & Transit Services	Westwood	Upgrade Existing Public Access Station	$32,000	$15,921
USA Waste Of California		New LNG-L/CNG Fueling System	$850,000	$400,000

Valley Power Products Inc	Los Angeles	CNG-Fueled Airport Service Equipment @ LAX	$863,960	$348,803
Valley Vista Services	City of Industry	New CNG Fueling System at Waste Transfer Facility	$840,844	$200,000
Waste Management Of San Gabriel	Baldwin Park	Purchase/Install LNG-L/CNG Fueling System	$850,000	$400,000
Waste Management Recycling And Disposal Svcs	Los Angeles	Development of LNG-L/CNG Fueling Station at Bradley Landfill	$850,000	$400,000
Whittier USD	Whittier	Upgrade Existing Public Access Station	$32,000	$15,921
Yellow Cab Company	Anaheim	New CNG Fueling Station	$450,000	$150,000
			$130,984,060	$30,785,673

*Some or all of these projects funding were de-obligated

Appendix C

Distribution of Alternative Fuel Stations within the South Air Quality Management District

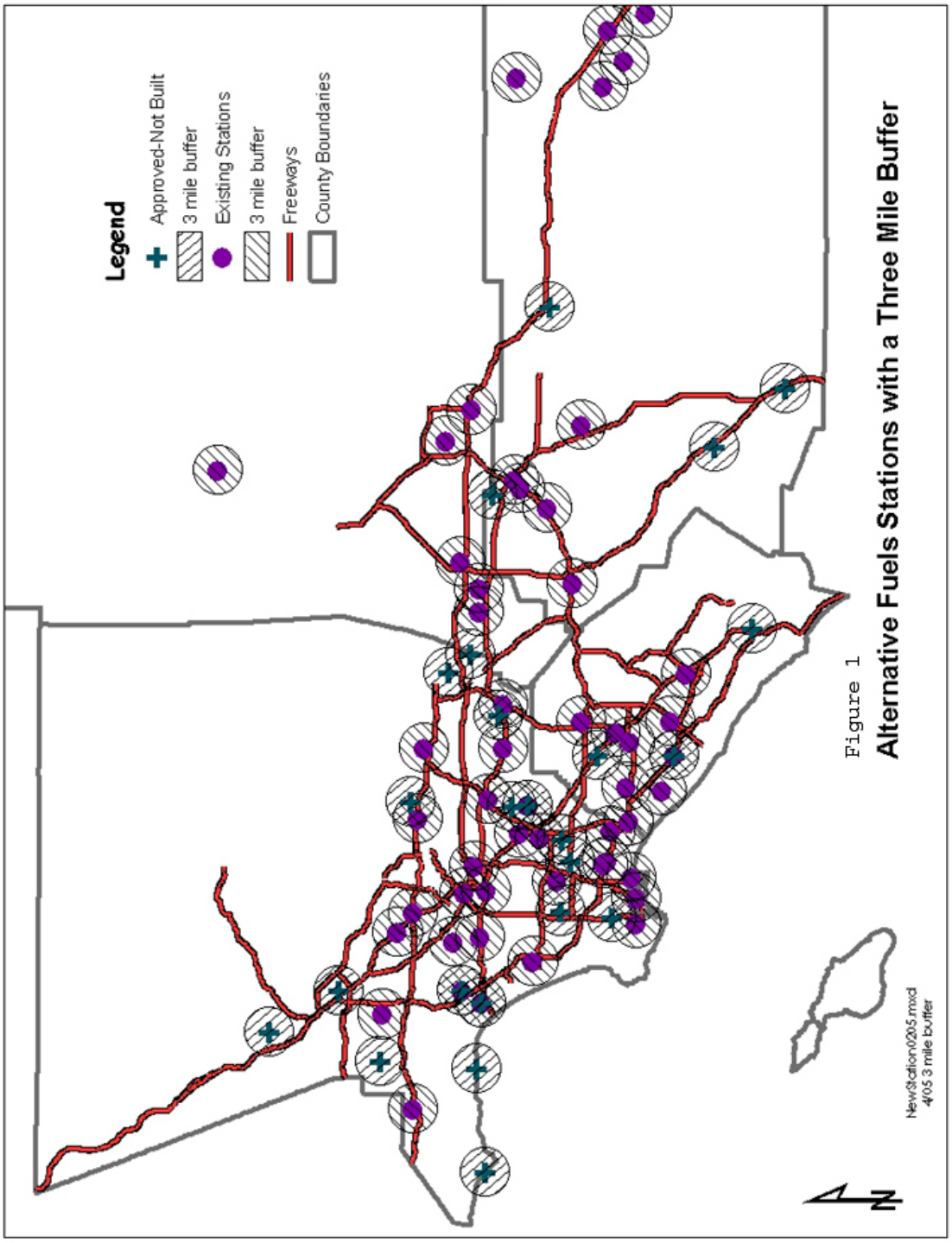


Figure 1
Alternative Fuels Stations with a Three Mile Buffer

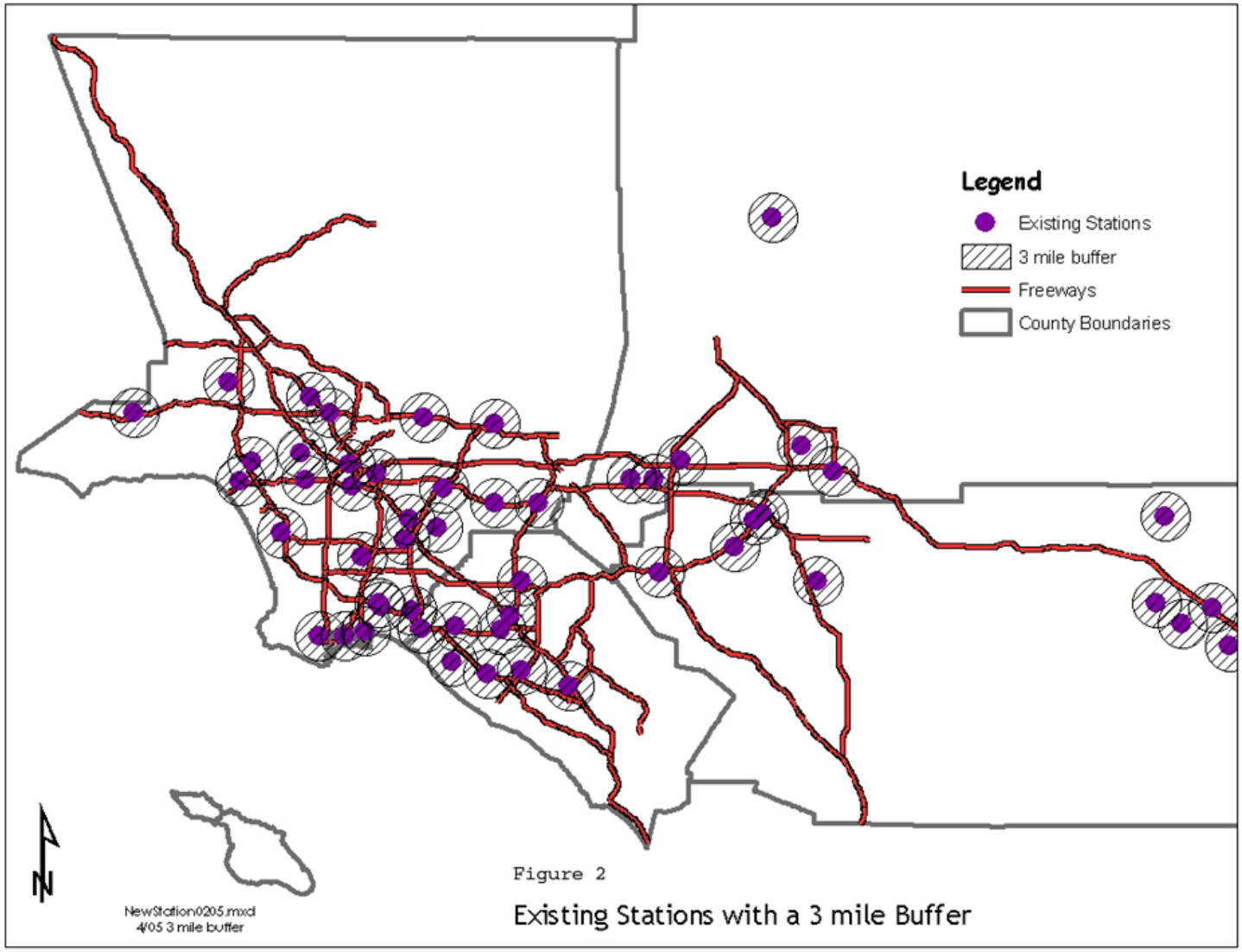


Figure 2

Existing Stations with a 3 mile Buffer

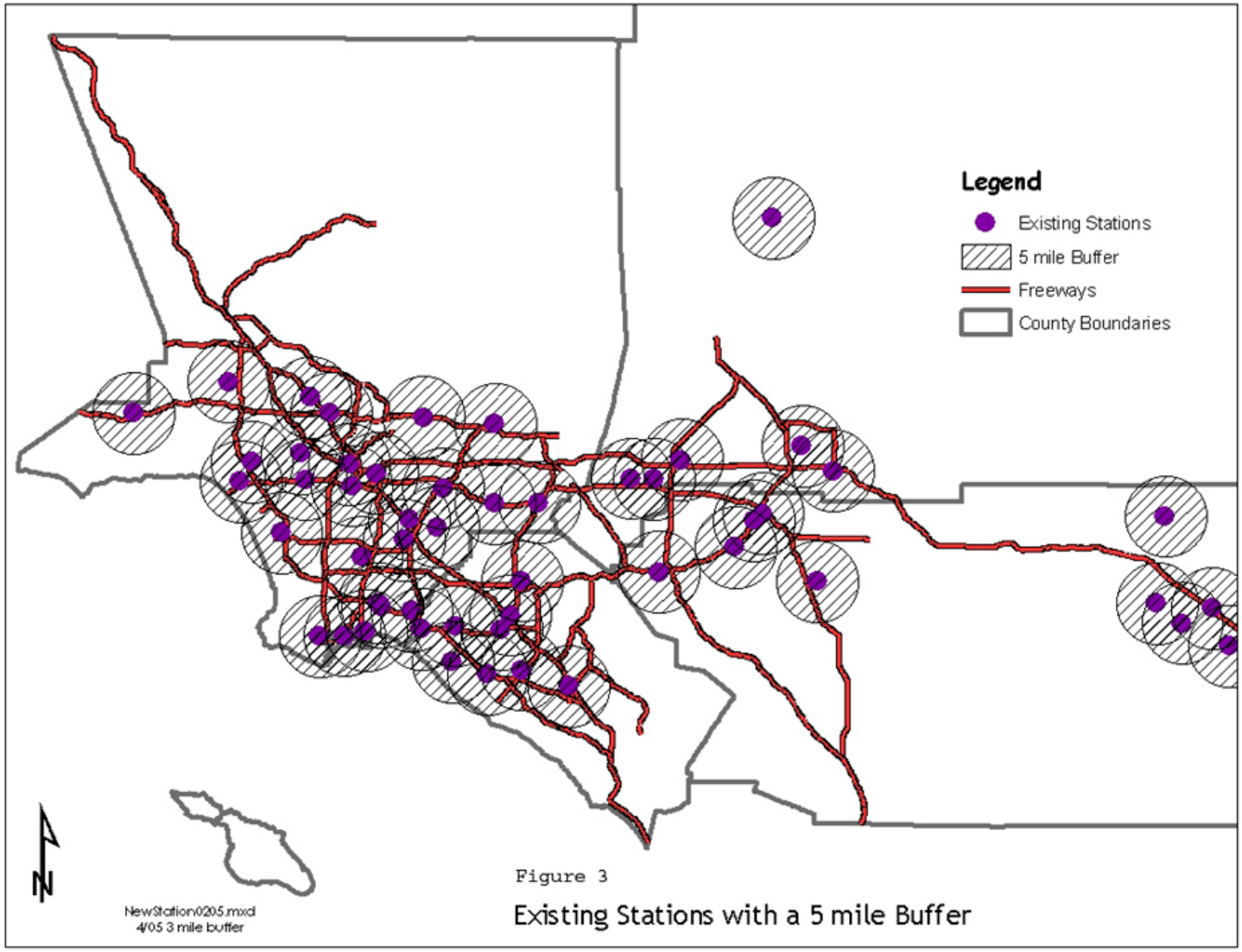


Figure 3

Existing Stations with a 5 mile Buffer

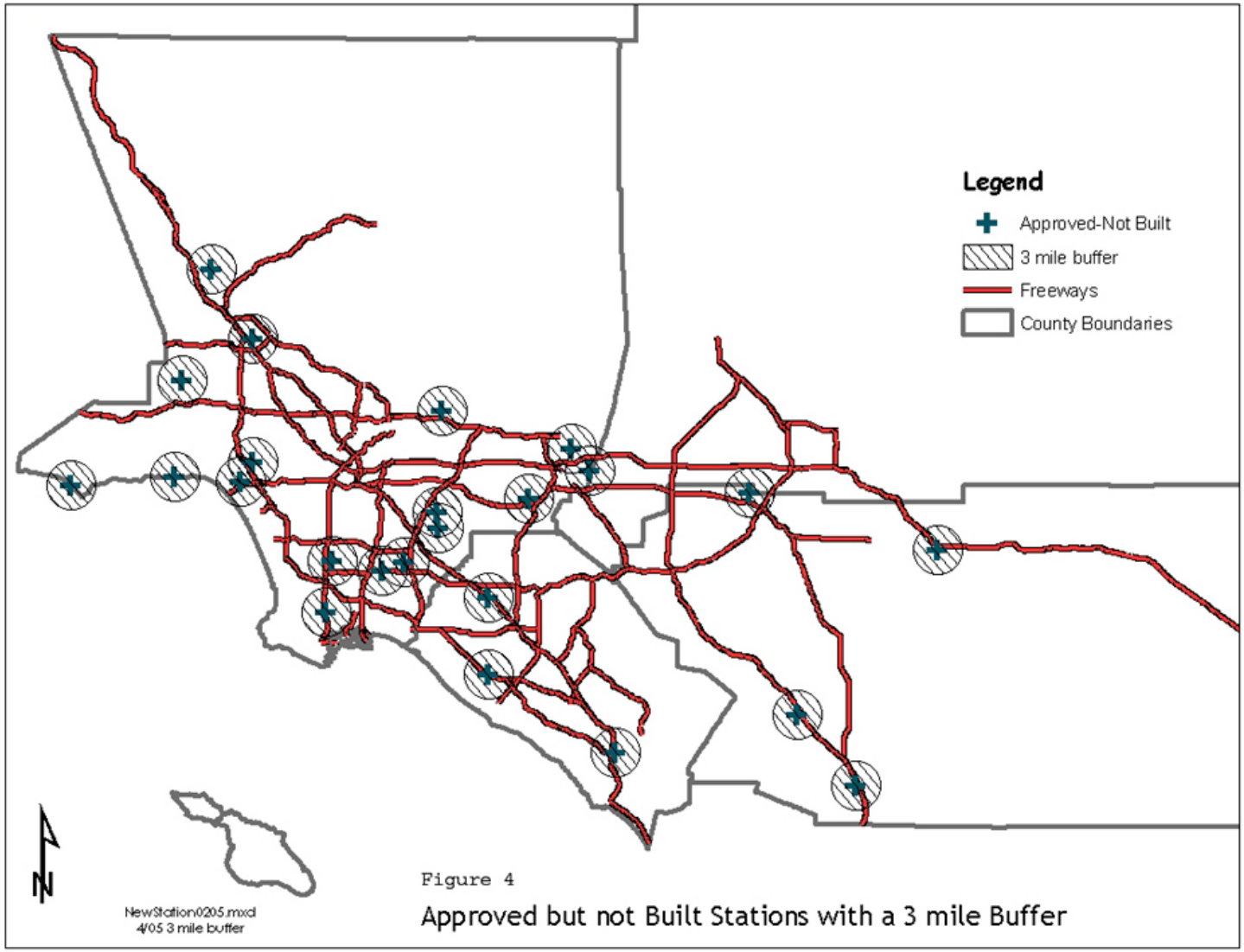


Figure 4

Approved but not Built Stations with a 3 mile Buffer

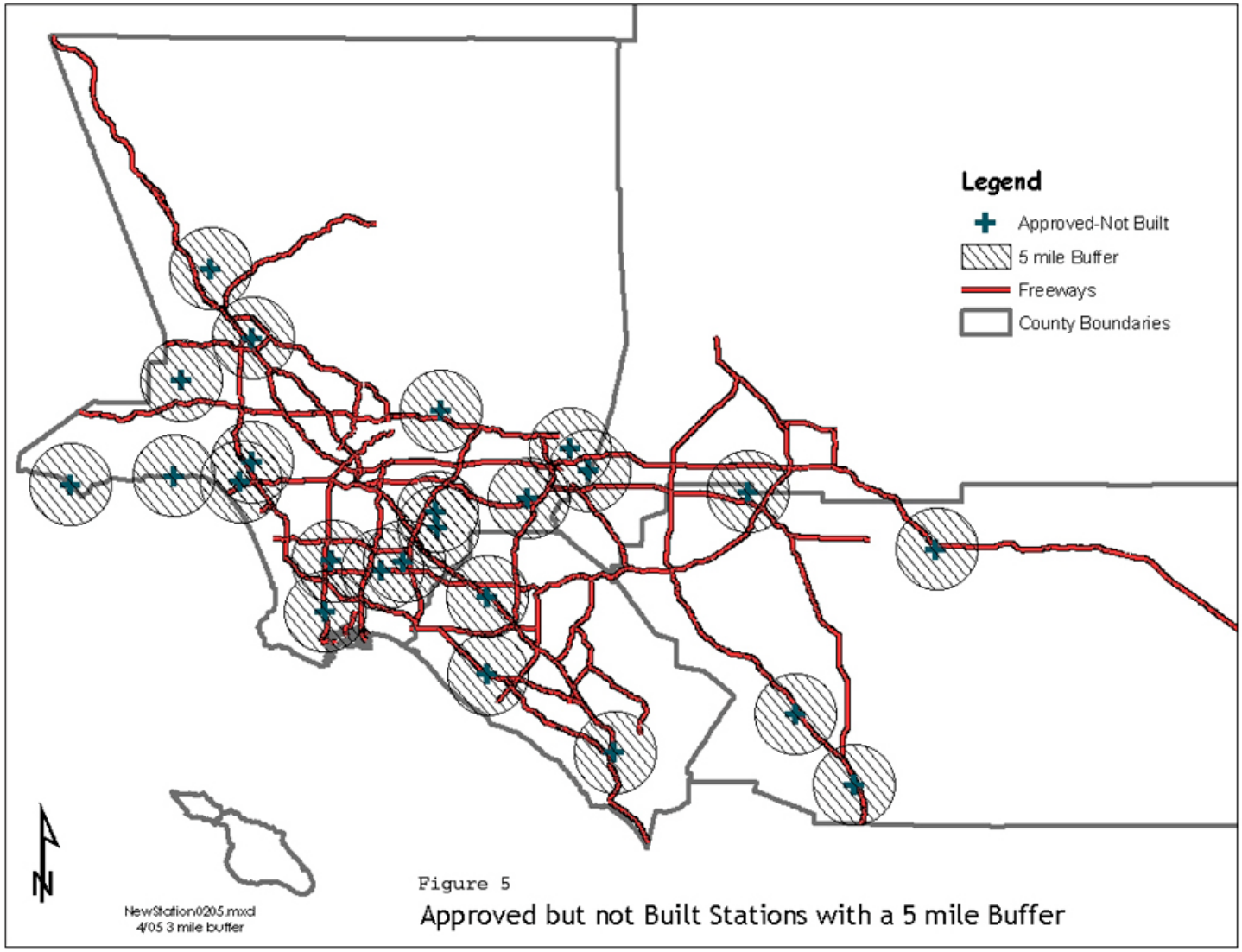


Figure 5

Approved but not Built Stations with a 5 mile Buffer