BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Establish Policies and Rules to Ensure Reliable, Long-Term Supplies of Natural Gas to California.	))))))	R.04-01-025 (Filed January 22, 2004)

COMMENTS OF SAN DIEGO GAS & ELECTRIC COMPANY (U 902 G) AND SOUTHERN CALIFORNIA GAS COMPANY (U 904 G) ON NATURAL GAS QUALITY ISSUES

DAVID B. FOLLETT
DAVID J. GILMORE

Attorneys for
SAN DIEGO GAS & ELECTRIC COMPANY and
SOUTHERN CALIFORNIA GAS COMPANY
555 West Fifth Street, Suite 1400
Los Angeles, California 90013-1011
[Telephone: (213) 244-2945]
[Facsimile: (213) 629-9620]
[E-mail: dgilmore@sempra.com]

February 11, 2005

TABLE OF CONTENTS

BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Establish Policies and Rules to Ensure Reliable, Long-Term Supplies of Natural Gas to California.	)	R.04-01-025 (Filed January 22, 2004)

COMMENTS OF
SAN DIEGO GAS & ELECTRIC COMPANY (U 902 G)
AND SOUTHERN CALIFORNIA GAS COMPANY (U 904 G)
ON NATURAL GAS QUALITY ISSUES

In accordance with the procedures set forth in the "Notice of Joint Workshop Between the Energy Resources Conservation and Development Commission and California Public Utilities Commission" ("Notice") dated December 23, 2004, San Diego Gas & Electric Company ("SDG&E") and Southern California Gas Company ("SoCalGas") hereby submit their Comments with respect to natural gas quality issues. SDG&E and SoCalGas appreciate the commitment of the Public Utilities Commission of the State of California ("CPUC") and the California Energy Resources Conservation and Development Commission ("CEC") to examine natural gas quality issues and further appreciate the opportunity to submit these Comments and to participate in the upcoming workshops.[1/] SDG&E and SoCalGas herein provide their general policy

[1/] This document is being filed concurrently today with the CEC in its Docket No. 04-IEP-01.

recommendations with respect to natural gas quality and recent studies related to gas quality issues.

SDG&E and SoCalGas recommend that the following policy principles be adopted by both the CPUC and the CEC:

- Natural gas quality standards should be designed first and foremost to protect the health and safety of utility customers and employees and the operational integrity of the pipeline system.

- Natural gas quality standards should allow the introduction of natural gas supplies located both within California and transported to California from other states or countries.

- Natural gas quality standards should not be changed in a manner that would inhibit the attainment of air quality objectives.

- Natural gas quality standards should not be changed in a manner that would result in the inefficient operation of natural gas-fired equipment.

- California natural gas quality standards should not be more stringent than standards adopted by the Federal Energy Regulatory Commission ("FERC") applicable to natural gas transported in interstate commerce.

As described below in more detail, SDG&E and SoCalGas believe that these policies can be effectuated by modifications to existing natural gas quality standards. Based on the research to date, existing gas quality standards should be modified in a way that permits the introduction of new natural gas supplies while protecting utility customers and employees, maintaining pipeline integrity, and avoiding a material adverse effect on air quality. SDG&E and SoCalGas specifically recommend that a Wobbe Number of 1400 be included in the existing tariff gas quality standards to help achieve these goals. Additional research will likely support further changes to gas quality standards.

I.

BACKGROUND

A. INTERCHANGEABILITY HAS BECOME A NATIONAL ISSUE.

Natural gas "interchangeability"[2/] has been an issue since natural gas began to replace manufactured gas (gas derived from coal and oil) in streetlighting and other applications. Interchangeability has been primarily a regional issue as new domestic supplies came on line. In areas where the gas supply has changed significantly with time or by region, gas utilities have managed the interchangeability issues in various ways, including BTU stabilization (nitrogen or air blending) and appliance readjustment. In addition, several local distribution companies ("LDCs") have studied regional impacts of interchangeability extensively as new liquefied natural gas ("LNG") imports containing varying levels of hydrocarbons were planned and/or introduced into the pipeline system. Interchangeability is now a national issue as more non-traditional domestic supplies, coupled with increases in global LNG imports, are expected to play a more significant role in meeting natural gas demand.

B. GAS EQUIPMENT SENSITIVITY TO CHANGES IN FUEL COMPOSITION.

Natural gas and natural gas liquids ("NGLs") found a ready market in the burgeoning petrochemical industry that began its rapid growth as part of the WWII war effort and accelerated after the war. The regional growth of the interstate pipeline systems in the 1950s and the 1960s coupled with relatively low cost natural gas

---

2/ "Interchangeability" is defined by the American Gas Association ("AGA") as: A measure of the degree to which combustion characteristics of one gas are compatible with those of another gas. Two gases are said to be interchangeable when one gas may be substituted for the other gas without interfering with the operation of gas burning appliances or equipment.

encouraged the installation of gas burning equipment (furnaces, hot water heaters, stoves, etc.) in residential and commercial settings. In general, gas-burning equipment from this period through the 1980s was designed to optimize combustion by creating stoichiometric conditions, *i.e.*, chemically equivalent amounts of oxygen and natural gas. As a result, properly installed and maintained equipment from this period is tolerant of normal fluctuations in the underlying gas quality caused by seasonal demand patterns. Generally, inter- or intrastate pipeline supply meets the majority of non-peak natural gas demand and is supplemented with storage during the peak usage periods.

Combustion burner designs vary widely among end users and, in some equipment such as gas turbines, have been undergoing a substantial shift since the early 1990s. This shift was initiated by ever-increasing requirements to increase fuel efficiency and reduce emissions. This shift has affected combustion equipment including residential appliances, commercial/industrial appliances, reciprocating engines, and even the newest combustion turbine technology used to generate electric power. The net effect of such designs has been a greater sensitivity to gas composition characteristics and less tolerance of fluctuations in gas composition after the equipment has been set for a specific quality of natural gas.

Varying natural gas composition beyond acceptable limits can have the following effects on combustion equipment:

///

///

///

(1) In appliances, it can result in soot formation, elevated levels of carbon monoxide and pollutant emissions, incomplete combustion, flashback,[3/] lifting[4/] and yellow tipping.[5/] It can also shorten heat exchanger life, and cause nuisance shutdowns from extinguished pilots or tripping of safety switches.

(2) In industrial boilers, furnaces and heaters, it can result in degraded performance, damage to heat transfer equipment and noncompliance with emission requirements.

(3) In reciprocating engines, it can result in engine knock, negatively affect engine performance and decreased parts life.

(4) In combustion turbines, it can result in an increase in emissions, reduced reliability/availability, and decreased parts life.

Varying gas compositions beyond acceptable limits can also be problematic in non-combustion applications such as where natural gas is used as a manufacturing feedstock or in peak shaving liquefaction plants because historical gas compositions were used as the basis for process design and optimization of operating units.

C. INTERCHANGEABILITY INDICES.

A variety of methods have been developed to define the interchangeability of fuel gases. Multiple methods date back to the late 1940s and include the AGA Bulletin 36 Indices and the Weaver Indices among others. These methods are generally based upon empirical parameters developed from the results of interchangeability experiments using specific gas compositions and specific appliances. A range of heating values is specified

3/ "Flashback" is defined by the AGA as: The burning of gas in the mixing chamber of a burner or in a piping system, usually due to an excess of primary air or too low a velocity of the combustible mixture through the burner part.

4/ "Lifting" is defined by the AGA as: If the speed of the air-gas mixture issuing from the burner is considerably greater than the ignition velocity of the gas, the flames will lift from the burner ports.

5/ "Yellow tipping" is defined by the AGA as: Tendency of gases to burn with yellow tips at any given primary aeration that depends on their chemical composition.

in many pipeline tariffs, but this alone is not considered a good indicator of the interchangeability of gases. The most common single index parameter is the Wobbe Number, which is sometimes referred to as the "interchangeability factor." The definition of the Wobbe Number is based on the heating value and specific gravity of a gas, and is related to the thermal input to a burner.[6/] While the Wobbe Number is an effective, easy-to-use screening tool for interchangeability, the gas industry historically has not recognized the Wobbe Number alone as sufficient to fully predict gas interchangeability as it does not adequately predict all combustion phenomena.

A great deal of research has been performed to develop and assess interchangeability indices. This work is continuing as appliances and other end-use combustion devices become more sophisticated to meet present day efficiency and emissions requirements.

D. FEDERAL GAS QUALITY ACTIVITIES.

A national initiative has begun to examine and update interchangeability/gas quality standards resulting from the confluence of several events and issues. LNG imports have begun to rise and forecasts are for future imports to be a significant

---

6/ The Wobbe number, or Wobbe index, of a fuel gas is found by dividing the high heating value of the gas in Btu per standard cubic foot by the square root of its specific gravity with respect to air. The higher the Wobbe number, the greater the heating value of the quantity of gas that will flow though a hole of a given size in a given amount of time. It is customary to give a Wobbe number without units–even though it has the dimensions Btu per scf–because to do so would lead to confusion with the volumetric heating value of the gas.

In almost all gas appliances, the flow of gas is regulated by making it pass through a hole or orifice. The usefulness of the Wobbe number is that for any given orifice, all gas mixtures that have the same Wobbe number will deliver the same amount of heat. Pure methane has a Wobbe number of 1363; natural gas as piped to homes in the United States typically has a Wobbe number between 1310 and 1390.

Occasionally Wobbe numbers are calculated on the basis of megajoules per cubic meter instead of Btu per scf; that this is being done is usually obvious from the great difference in the values. For example, using SI units the Wobbe number for methane is 50.7.

percentage of total North American gas supply. LNG regasification terminals have regained active status and are expanding. The National Petroleum Council's 2003 report "Balancing Natural Gas Policy – Fueling the Demands of a Growing Economy" presented projections for LNG imports to increase from 1 percent of U.S. natural gas supply in 2003 to as much as 14 percent by 2025. The characteristics of natural gas supply in North America have evolved over time as conventional sources are depleted and new sources in the Rockies, Appalachians, and the Gulf of Mexico have been developed. Direct receipt of unprocessed gas by transmission pipelines has grown and also has contributed to the change in the natural gas composition. In addition, the U.S. has experienced prolonged periods of pricing economics that make it more profitable to leave NGLs in the natural gas stream rather than process the gas and extract the NGLs for petrochemical feedstock and other traditional markets. The need to address gas quality/interchangeability issues has been exacerbated by North American natural gas supply being unable to meet projected demand.

The transition from historical gas composition to the evolving gas supply profile presents specific technical challenges throughout the stakeholder value chain. Consequently, the FERC has undertaken the effort to begin addressing these issues in its annual Natural Gas Markets Conference (Docket No. PL03-6-000) on October 14, 2003 and a technical conference on gas quality issues (Docket No. PL04-3-000) on February 18, 2004. There are also several proceedings before the FERC that highlight these issues on an individual project basis.[7/] The FERC has encouraged the gas industry to develop a

---

ASTM D 1945 (AGA Bulletin No. 36).

7/ *See*, *e.g.*, *AES Ocean Express L.L.C. v. Florida Gas Transmission Company*, Docket No. RP04-242-004, "Certification of Uncontested Partial Settlement," 110 FERC process to identify the issues associated with gas interchangeability in a comprehensive fashion and, wherever possible, to recommend courses of action developed by consensus. A group of stakeholders, under the leadership of the Natural Gas Council ("NGC+"), formed a technical work group[8/] to address the hydrocarbon liquid dropout issues specific to domestic supply and another technical work group to address the interchangeability/gas quality issues associated with LNG imports. SDG&E and SoCalGas actively participated on the interchangeability task group and monitored the progress of the liquid dropout task group. The "White Paper on Natural Gas Interchangeability and Non-Combustion End Use" currently being developed by the NGC+ Task Group on interchangeability is not yet available for publication.[9/] SDG&E and SoCalGas understand that a representative from the NGC+ Task Group will discuss its work at the upcoming workshop.

E. SOUTHERN CALIFORNIA GAS QUALITY STANDARDS.

In southern California, the natural gas quality standards of SDG&E and SoCalGas are reflected in their tariff rules. For example, SoCalGas' Rule No. 30 contains the following provisions:

///

///

¶ 63,007 (January 19, 2005) addressing Florida Gas Transmission Company's temperature specification.

8/ The NGC+ Task Group on interchangeability issues includes representatives from the following stakeholders: LNG suppliers, interstate pipelines, natural gas utilities, power generators, feedstock customers, appliance manufacturers, and a representative from the Gas Technology Institute, the State of Utah, and the Gas Processors Association.

9/ SDG&E and SoCalGas will file a supplement to these Comments attaching the NGC+ Task Group White Paper as soon as it becomes final.

I. Gas Quality

1. The gas stream delivered by the customer into the Utility's system shall conform to the gas quality specifications as provided in any applicable agreements, contracts, service contracts and tariff schedules in effect between the delivering interstate or intrastate pipeline and the Utility at the time of the delivery.

2. All gas delivered into the Utility's system for the account of the customer for which there is no existing contract between the delivering pipeline and the Utility shall be at a pressure such that the gas can be integrated into the Utility's system at the point(s) of receipt and shall conform to the following minimum specifications:

   a. Heating Value: The minimum heating value is nine hundred and seventy (970) Btu (gross) per standard cubic foot on a dry basis. The maximum heating value is one thousand one hundred fifty (1150) Btu (gross) per standard cubic foot on a dry basis.

   b. Moisture Content or Water Content: For gas delivered at or below a pressure of eight hundred (800) psig, the gas shall have a water content not in excess of seven (7) pounds per million standard cubic feet. For gas delivered at a pressure exceeding of eight hundred (800) psig, the gas shall have a water dew point not exceeding 20F at delivery pressure.

   c. Hydrogen Sulfide: The gas shall not contain more than twenty-five hundredths (0.25) of one (1) grain of hydrogen sulfide per one hundred (100) standard cubic feet. The gas shall not contain any entrained hydrogen sulfide treatment chemical (solvent) or its by-products in the gas stream.

   d. Mercaptan Sulfur: The mercaptan sulfur is not to exceed three tenths (0.3) grains per hundred standard cubic feet.

   e. Total Sulfur: The gas shall not contain more than seventy-five hundredths (0.75) of a grain of total sulfur compounds per one hundred (100) standard cubic feet. This includes COS and CS2, hydrogen sulfide, mercaptans and mono, di and poly sulfides.

   f. Carbon Dioxide: The gas shall not have a total carbon dioxide content in excess of three percent (3%) by volume.

   g. Oxygen: The gas shall not at any time have an oxygen content in excess of two-tenths of one percent (0.2%) by volume, and customer will make every reasonable effort to keep the gas free of oxygen.

   h. Inerts: The gas shall not at any time contain in excess of four percent (4%) total inerts (the total combined carbon dioxide, nitrogen, oxygen and any other inert compound) by volume.

i. Hydrocarbons: For gas delivered at a pressure of 800 psig or less, the gas hydrocarbon dew point is not to exceed 45F at 400 psig or at the delivery pressure if the delivery pressure is below 400 psig. For gas delivered at a pressure higher than 800 psig, the gas hydrocarbon dew point is not to exceed 20F at a pressure of 400 psig.

j. Dust, Gums and Other Objectionable Matter: The gas shall be commercially free from dust, gums and other foreign substances.

k. Hazardous Substances: The gas must not contain hazardous substances (including but not limited to toxic and/or carcinogenic substances and/or reproductive toxins) concentrations which would prevent or restrict the normal marketing of gas, be injurious to pipeline facilities, or which would present a health and/or safety hazard to Utility employees and/or the general public.

l. Delivery Temperature: The gas delivery temperature is not to be below 50F or above 105F.

m. Interchangeability: The gas shall meet American Gas Association's Wobbe Number, Lifting Index, Flashback Index and Yellow Tip Index interchangeability indices for high methane gas relative to a typical composition of gas in the Utility system near the points of receipt. Acceptable specification ranges are:

   * Wobbe Number (W for receiving facility)
     (WP for producer)
     0.9 W <= WP< = 1.1 W

   * Lifting Index (IL)
     IL <= 1.06

   * Flashback Index (IF)
     IF <= 1.2

   * Yellow Tip Index (IY)
     IY >= 0.8

* Specifications are in relation to a typical composition of gas serving the area to be supplied by the new source.

3. The Utility, at its option, may refuse to accept any gas tendered for transportation by the customer or on his behalf if such gas does not meet the specifications as set out in I. 1 and I. 2 above, as applicable.

In addition to the gas quality specifications set forth above, the compressed natural gas ("CNG") specifications of the California Air Resources Board ("CARB") must be met for CNG used to fuel natural gas vehicles ("NGVs"). The current CARB specifications are set forth below.[10]

Specification	Value*	Test Method
Methane	88.0 % (min.)	ASTM D 1945-81
Ethane	6.0 % (max.)	ASTM D 1945-81
C3 and higher HC	3.0 % (max.)	ASTM D 1945-81
C6 and higher HC	0.2 % (max.)	ASTM D 1945-81
Hydrogen	0.1 % (max.)	ASTM D 2650-88
Carbon Monoxide	0.1 % (max.)	ASTM D 2650-88
Oxygen	1.0 % (max.)	ASTM D 1945-81
Inert Gases: Sum of CO2 and N2	1.5 %-4.5 %	ASTM D 1945-81
Particulate Matter	The natural gas shall not contain dust, sand, dirt, gums, oils, or other substances in an amount sufficient to be injurious to fueling station equipment or the vehicle being fueled.	
Odorant	The natural gas at ambient conditions must have a distinctive odor potent enough for its presence to be detected down to a concentration in air of not over 1/5 (one-fifth) of the lower limit of flammability.	
Sulfur	16 ppm by vol. (max.)	Title 17 CCR Section 94112

* Expressed as mole percent unless otherwise indicated.

CARB adopted the current CNG fuel specification standard in 1992 and it is well recognized that an update is necessary. In fact, CARB itself proposed changes to the

[10] The CARB CNG fuel specification is located in California Code of Regulations Title 13, Division 3, Chapter 5, Article 3, Section 2292.5.

CNG fuel specification in 2002 that included an alternate Methane Number ("MN")[11/] standard but the proposed changes were ultimately suspended. CARB has granted SoCalGas two limited exemptions from the current CNG fuel specification, thereby allowing SoCalGas to meet an "MN 80" standard in particular geographical areas. These exemptions were granted to SoCalGas in 1999 for gas received from producers in the Los Angeles Basin and 2003 for gas received from producers in the San Joaquin Valley and the Central Coast. As far as SoCalGas is concerned, these limited exemptions show that the alternate MN 80 standard works just as well as the current multi-specification standard, especially because there have been no reported vehicle operational problems related to CNG that meet the MN 80 standard.

///

///

[11/] The Methane Number (MN) is a measure of the knock resistance of the fuel, calculated using the formula MN = 1.624*(MON)-119.1, where MON = -406.14+508.04(H/C)-173.55(H/C)2+20.17(H/C)3 and H/C is the reactive hydrogen/carbon ratio.

The anti-knock property of a natural gas fuel can be expressed as a methane number. Pure methane has a methane number of 100, and pure hydrogen has a methane number of 0. The percentage of methane in a methane-hydrogen mixture is the methane number of that mixture. This is similar to the scale used for the octane number of gasoline. Octane rating is not an appropriate scale for natural gas since the octane scale only goes up to 120, and methane has an octane rating in excess of 120. Since the methane number of various natural gas compositions can vary considerably, there may be a problem with knock on some engines.

The determination of the methane number of a fuel is conducted under a prescribed engine test. During the test, the compression ratio of the engine is increased until knock is detected. Mixtures of methane and hydrogen are then run in the engine. The mixture that produces knock at the same compression ratio as the fuel being tested determines the methane rating of that fuel. The time and cost associated with performing the test makes this approach impractical. Two mathematical alternative methods to determine methane number for the gas composition are the CARB method and the AVL method. The CARB method uses the equation developed in SAE Paper 922359, which is:

$$MN = 1.624*(-406.14+508.04*(H/C)-173.55*(H/C)^2+20.17*(H/C)^3)-119.1.$$

The AVL method uses a proprietary program to calculate methane number. The CARB method produces an average of 7% higher MN than the AVL method.

II.

NATURAL GAS QUALITY STANDARDS MUST ENSURE THAT UTILITY CUSTOMERS AND EMPLOYEES ARE PROTECTED AND THAT PIPELINE INTEGRITY IS MAINTAINED

The first and foremost priority in developing natural gas quality standards has been, and should continue to be, the protection of utility customers, utility employees, and the utility pipeline system. Existing natural gas quality standards contained in the utilities' tariffs have been developed over the years with these overriding priorities in mind. While existing gas quality specifications have worked well so far to protect utility customers, utility employees, and pipeline integrity, they are not the **only** quality specifications that achieve these goals. As noted above, significant work has been devoted to natural gas interchangeability so that new gas supplies can be accommodated safely and with minimal effects on emissions. SDG&E and SoCalGas believe that recent work in the area of natural gas interchangeability supports modification to current tariff gas quality specifications. For example, according to the data obtained from SoCalGas' Gas Quality And LNG Research Study,[12/] limiting the Wobbe Number to 1400 would result in no increase in NOx emissions in appliances that likely represent most of the gas consumption (water and space heaters). The data shows that, when such appliances are exposed to gas with a higher Wobbe Number and heating value, NOx emissions actually decrease. These results are consistent with the work of the NGC+ Task Group. SDG&E and SoCalGas intend to propose specific changes to their gas tariffs updating gas quality standards to reflect the results of such research.

[12/] A draft of this study is attached hereto as Attachment "A."

In addition, this research supports the ultimate elimination of CARB CNG standard,[13/] or at least the use of an "MN" standard lower than MN 80. SDG&E and SoCalGas strongly support the principle that there should be a single uniform gas quality standard. However, as an interim transitional approach, CARB should examine whether certain geographical areas, where there are few if any NGVs incapable of using gas with a lower MN, should have a lower MN standard or even no standard. Moreover, the MN specification for NGVs should be progressively lowered based on test results, upgrades to older engines so that they can operate on a wider range of gas quality, and the displacement of older NGV engines with newer engines designed to comply with manufacturing standards that require that they have the capability to burn gas with a higher heating value. SDG&E and SoCalGas urge California's administrative agencies to work cooperatively with stakeholders to modify air quality standards based on operating experience and sound scientific analysis.

///

///

[13/] Indeed, based upon testing performed by CARB, there is a significant question as to whether there is need for any gas quality specifications for NGVs. CARB Staff concluded that:

> Test results show that for dedicated light-duty NGVs, large variations in fuel composition produced only slight variations, both increases and decreases, in emissions and drivability. Also, bi-fuel vehicles had only modest changes in emissions and performance with changes in CNG quality. Heavy-duty vehicle test data shows that fueling advanced generation engine technologies with MN73 fuel produces no discernible impact on the particulate matter (PM) and oxides of nitrogen (NOx) emissions when compared to emissions from higher quality fuels with MN greater than 80. There were very small increases in carbon dioxide (CO_2) and non-methane hydrocarbon (NMHC) emissions.

"Proposed Amendments to the California Alternative Fuels for Motor Vehicles Regulation, STAFF REPORT: INITIAL STATEMENT OF REASONS" dated December 21, 2001.

III.

NATURAL GAS QUALITY STANDARDS SHOULD ALLOW THE INTRODUCTION OF NEW NATURAL GAS SUPPLIES

SDG&E/SoCalGas will not repeat here the conclusions reached by the CPUC and the CEC with respect to the need for new natural gas supplies in order to address projected shifts in the supply/demand balance that will exacerbate current high natural gas prices or, in the extreme case, cause shortages of natural gas leading to the use of more polluting fuels.

As both the CPUC and CEC are well aware, recent high natural gas prices have had an adverse effect on consumers in California. Gas commodity prices have shown increased volatility and a sustained price level significantly higher than those of only a few years ago. Even with aggressive conservation/efficiency efforts, it seems clear that additional natural gas supplies will substantially reduce natural gas commodity prices to the benefit of California as a whole.[14/]

The impact on California from significant natural gas shortages would be very costly. In the past, electric generation ("EG") facilities were owned by electric utilities that maintained fuel oil capability in the event of natural gas curtailment. Today, much gas-fired EG load does not have alternate fuel capability,[15/] meaning that a shortage of supply for EG customers could potentially affect electric grid reliability. While natural gas shortages would be expected to be more likely during the winter when there typically

---

14/ In their Phase I Proposals in R.04-01-025 at p. 10, SDG&E and SoCalGas presented the results of a study performed by Cambridge Energy Research Associates showing reductions in gas commodity prices from several hundred million dollars to a billion dollars per year from the construction of West Coast LNG terminals.

15/ SDG&E and SoCalGas estimate that approximately 14,000-15,000 MW of gas-fired EG capacity in their service territories is incapable of burning alternate fuels. This represents approximately 80% of the gas-fired EG capacity in their service territories.

is less EG gas demand than in the summer, the experience of the 2000-01 energy crisis, while unusual, showed that EG demand can also peak in the winter at the same time residential gas demand peaks. Any significant reduction in natural gas supply during another simultaneous residential and EG peak load scenario could be harmful indeed.[16/]

On the SDG&E/SoCalGas system, the only other single group of noncore customers with usage great enough that they could "free up" some measure of gas supply for residential and EG customers is the refinery group.[17/] Refinery shutdowns, however, are not an acceptable outcome to California given the tight supply/demand balance for refinery products such as gasoline. Refinery shutdowns of even a few days could have a significant upward effect on gasoline prices, harming residential and business consumers alike.

A supply shortage affecting NGVs would also be problematic. Today, there are 220 natural gas fueling stations and approximately 15,000 NGVs operating in southern California. Most of these vehicles are buses and, thanks to support from agencies like the South Coast Air Quality Management District and various local air districts, these vehicles make a contribution to improving air quality in the Los Angeles basin. Any inability of SoCalGas to provide gas supplies to NGV refueling stations, caused either by supply shortages or by an inability to meet CARB specifications, would have far-reaching ramifications for public transportation in the Los Angeles area and might force local transit districts to rely on more polluting alternatives.

16/ This does not even consider the effect on air quality if those EGs still retaining alternate fuel capability are required to burn fuel oil instead of natural gas during a supply shortage or the emissions of commercial/industrial customers using fuels other than natural gas.

17/ Approximately 6% of SoCalGas' total sendout is to oil refineries.

Accordingly, natural gas quality standards must be addressed in the context of ensuring that they permit the introduction of new natural gas supplies and do not discourage new sources of supply from seeking the California market. Since LNG is widely expected to become a significant part of the national natural gas mix, gas quality specifications should not be set at levels that impose large costs on LNG developers that always have the option of pursuing markets with less stringent gas quality specifications. This is not to say that natural gas quality standards should promote development of new gas supplies at the expense of pipeline integrity, the safety of utility customers and employees, or air quality. However, the proper balance must be struck in order to meet these objectives while still ensuring that new natural gas supplies will be delivered to California.

IV.

NATURAL GAS QUALITY STANDARDS SHOULD NOT BE CHANGED IN A MANNER THAT WOULD INHIBIT ATTAINMENT OF AIR QUALITY OBJECTIVES

SDG&E and SoCalGas support the efforts of air quality agencies to ensure that the region meets air quality objectives. Poor air quality has a clear adverse effect on both the quality of life in California and entails the real social and economic cost of health problems, particularly lung problems aggravated by poor air quality. As natural gas quality standards are examined, they must be analyzed with a view to ensuring that any modifications do not inhibit efforts to attain air quality objectives. In this discussion, however, responsible agencies must not ignore the fact that natural gas produces fewer emissions than fuel oil or diesel fuel. By adopting gas quality standards that permit the introduction of new supplies, California can avoid the significant air pollution that would occur should natural gas be less available due to supply shortages. SDG&E/SoCalGas believe that natural gas quality standards can permit the introduction of new supplies without inhibiting attainment of air quality objectives.

Natural gas has been a significant part of the solution for improving air quality in southern California. The 2003 South Coast Air Quality Management Plan indicates that 91% of the NOx emissions in the South Coast Basin are from mobile sources and only 9% are from stationary sources (see chart below).

The RECLAIM universe of emissions that includes emissions from power plants, refineries and other major facilities contribute approximately 3% of NOx to the L.A. Basin. RECLAIM is a "cap and trade" program and to a large degree is self-regulating. Thus, any emissions increase from RECLAIM facilities must be offset with either RECLAIM trading credits, additional emission controls, or new equipment. Residential gas appliances contribute only 3% to the NOx emissions in the L.A. Basin and the SoCalGas Gas Quality and LNG Research Study has demonstrated that by limiting the Wobbe Number to 1400 there would be minimal emissions impact while some equipment actually showed decreases in NOx emissions.

///

///

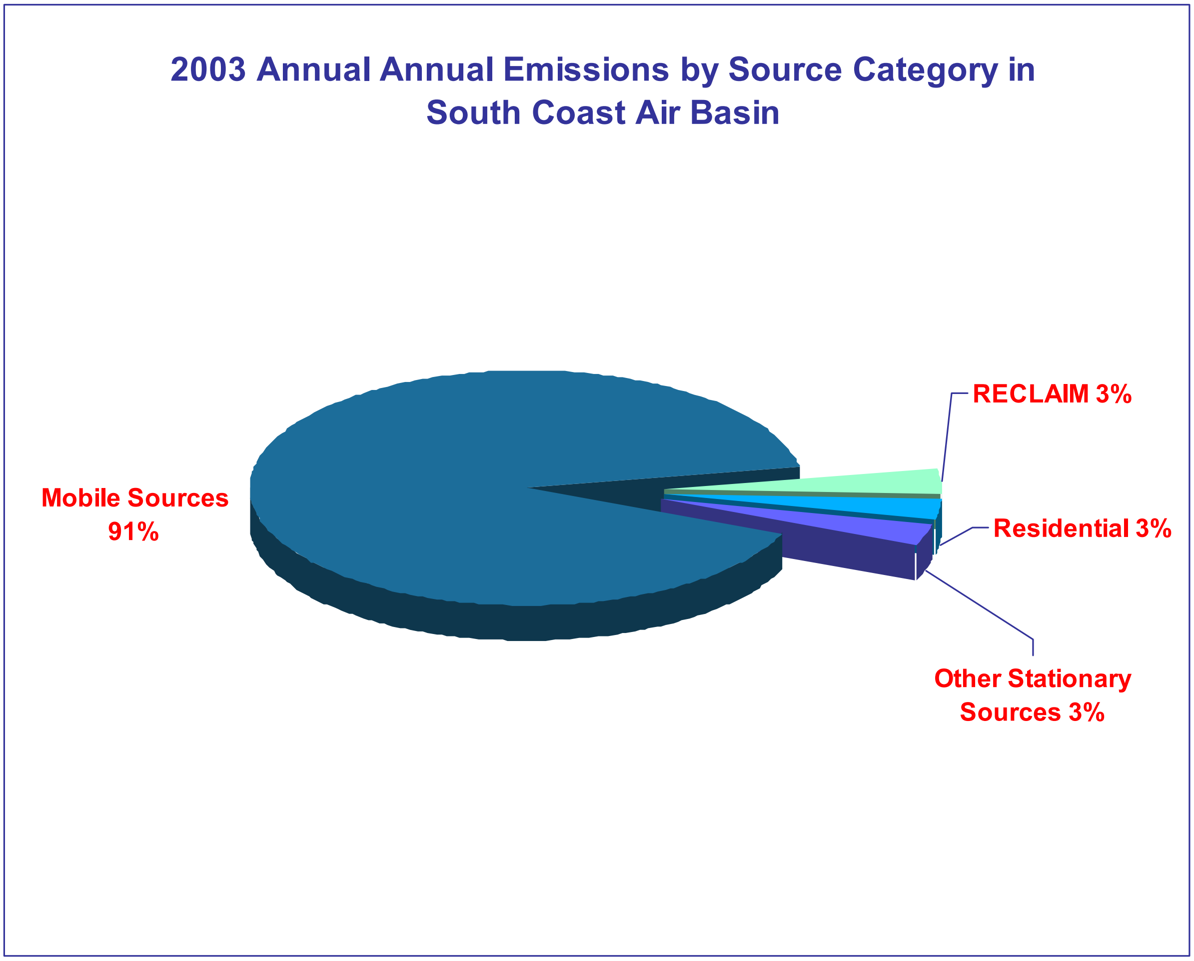
///

///

///

///

///



The Gas Quality and LNG Research Study indicated that newer Ultra Low NOx technology was able to manage swings in gas composition without material increases in NOx emissions better than earlier generation low NOx technology. As has been the case in the past, improved technology can solve potential emissions issues caused by changing gas compositions. Currently, equipment has been designed and set to operate on California-produced gas that has many similar characteristics to LNG. This equipment is able to meet the emission requirements in numerous air districts across the state. Finally, industry and regulators have achieved outstanding results in emission reductions from stationary sources, but for California to meet its air quality objectives the primary focus should be on the 91% of emissions from mobile sources.

V.

STATE GAS QUALITY STANDARDS SHOULD NOT BE MORE STRINGENT THAN FEDERAL STANDARDS

As noted above, the FERC has embarked upon an effort to develop gas interchangeability / gas quality standards that would apply to natural gas subject to its jurisdiction, *i.e.*, natural gas transported in interstate commerce.

As California decisionmakers consider gas quality standards, they should remain mindful of any standard adopted by the FERC. Currently, southern California receives approximately 88% of its natural gas from out-of-state sources. Even if LNG becomes a more significant part of the overall gas supply mix, it will be many years, if ever, before California materially reduces its dependence on gas supplies delivered to the utilities by interstate pipelines. Should California adopt interchangeability standards for gas consumed in California that are inconsistent FERC gas quality standards, such action could have the effect of potentially depriving California of necessary sources of natural gas at the time of a national production decline, thereby imposing costs on natural gas consumers.

In addition, there are legal issues surrounding the authority of California to adopt gas quality standards that are more stringent than federal standards. It might not be economically practical for interstate pipelines to meet stricter California standards without ensuring that all gas transported on the interstate pipeline system serving California meets such standards, including gas delivered to states other than California.

This, of course, would impose costs on natural gas consumers in other states merely for the purpose of meeting a standard that does not apply to their state (and one that may have been adopted to meet the needs of only a small percentage of consumers in California), raising significant Constitutional issues, including whether this would impose an undue burden on interstate commerce. SDG&E and SoCalGas are not attempting here to predict the legal outcome should California gas quality standards that are stricter than federal standards be challenged in court, but are merely noting that legal challenges might be undertaken.[18/]

Moreover, if California should adopt stricter gas quality standards than those adopted at some point by the FERC, this would likely increase costs to California consumers. Even if California ultimately is found to have the legal authority to adopt stricter gas quality standards than federal standards, there is a legal question as to whether California would be able to impose the cost of compliance with stricter California standards on either interstate pipelines or their shippers.[19/] If California utilities are required to construct the facilities necessary to meet stricter California gas quality standards, and are not able to recover the cost of such facilities from upstream pipelines or shippers, such costs will be borne by utility customers.

SDG&E/SoCalGas submit that it would be unwise public policy to take actions that would entail lengthy legal battles over state and federal jurisdiction. A better

---

18/ Any analysis of California's legal authority to adopt stricter gas quality standards than those that might be adopted by the FERC would require knowledge of facts presently unknown, such as the exact scope of FERC standards, the scope of California standards, and the effect of California standards on the flow of natural gas in interstate commerce.

19/ *See*, *e.g*., *Public Utilities Comm'n of California v. FERC*, 143 F.3d 610 (D.C. Cir. 1998) in which the Court of Appeals upheld the determination of the FERC that SoCalGas could not legally impose the costs of intrastate facilities on upstream interstate shippers.

solution is to determine whether federal standards can satisfactorily meet California's energy policy objectives. If so, then California should adopt federal standards as its own for all gas entering the utility system, regardless of source.

SDG&E and SoCalGas believe that it is important to establish a single set of durable natural gas quality standards that apply equally to all gas supplies regardless of their source. This means that new gas quality standards should apply to any source of supply interconnecting to the utility system regardless of whether such supply is from California production, an upstream intrastate or interstate pipeline, or an LNG terminal. This approach would support the CPUC's policy decision (D.04-09-022) in R.04-01-025 to treat all supplies equally.[20/]

In addition, SDG&E and SoCalGas cannot assure that they can process non-compliant gas supplies via "blending" with utility pipeline gas in order to deliver conforming gas to end-use customers. While SoCalGas has in the past provided blending service for certain California production, this service has become increasingly difficult operationally as gas flow and demand patterns change.[21/] In some instances, small volumes of local production flow directly into the SoCalGas distribution system without any "blending" with out-of-state supply. Clearly, any large volumes of new gas supply must meet all applicable gas quality specifications because large volumes cannot be blended with system gas in order to meet specifications. Large volumes of gas, such as

---

20/ *See*, *e.g.*, D.04-09-022, Conclusion of Law No. 18, *mimeo*, p. 91 ("New supplies … should be allowed to compete on an equal footing with existing supplies").

21/ Currently, "blending" occurs two ways. One way is for a SoCalGas fuel blending truck to deliver methane to individual NGV refueling stations. The other is for SoCalGas to manage the flow on its system to ensure that gas received from California producers is sufficiently blended with system gas before it is delivered to an NGV refueling station. Neither method allows blending of large gas volumes.

regasified LNG, far exceed local demand at and near the point of receipt and are therefore likely to be delivered to end-use customers without any dilution with system gas throughout a large area of the utility system. For these reasons, the processing via pipeline blending of nonconforming gas with system gas is no longer practical, and it should be clearly established that all natural gas entering the utility system must meet all applicable gas quality standards.

VI.

SUMMARY OF DRAFT SOCALGAS GAS QUALITY AND LNG RESEARCH STUDY

Prior to its participation on the NGC+ Task Group, SoCalGas undertook a study to analyze a variety of gas-fired equipment to test the safety and performance of such equipment, as well as to gather emissions data, under conditions of changing natural gas composition. SDG&E and SoCalGas expect that the findings and recommendations of this study will fully support the policy principles proposed above. The draft study report is attached hereto as Attachment "A."[22/] The following is a summary of this draft report:

This research study was designed to assess SoCalGas' current Gas Quality Standards (Rule 30) and the potential need to modify these standards in light of changing natural gas supplies and newer advanced combustion technologies. While the potential exists for gas-fired equipment to exhibit varied performance characteristics when supplied natural gas fuel that varies in composition, this study focused on safety and performance of selected commercial/industrial and residential natural gas-fired appliances. The major objectives of the Study were as follows:

1. Evaluate each selected unit to determine whether any issues exist relating to equipment safety and performance. Equipment safety includes changes in Carbon Monoxide (CO) levels, combustion stability and Lifting, Flashback, and Yellow Tipping.

22/ SDG&E and SoCalGas will supplement these Comments with the final report as soon as it is ready for publication.

2. Compare measured and observed results against the major natural gas Interchangeability Indices, including Wobbe Number, Lifting, Flashback, Yellow Tipping and Incomplete Combustion.

3. Collect NOx emission data during testing.

Thirteen different gas-fired appliances were tested in a formal test program that assessed the response of the devices to a range of natural gas compositions and characteristics. The gas compositions represented heating value and Wobbe Number boundaries of the current SoCalGas Gas Quality Standards (Rule 30).

This study concludes and recommends that SoCalGas needs to incorporate results of this study, national efforts on gas quality, and other resources to develop an "Interim Range of Acceptability" based on quality/composition for each end-use category. Other recommendations and findings are to update Gas Quality Standards and Rule 30 to include an interim Wobbe Number range from 1290 minimum to 1400 maximum. The test results were less clear on the need to adjust the 1150Btu/scf High Heating Value maximum limit. All equipment operated successfully on a 1150Btu/scf with a 1370 Wobbe Number but not on the 1150Btu/scf with a 1430 Wobbe Number.

- Update Gas Quality Standards and Rule 30.

- The Range of Acceptability concept may need to replace the current approach which utilizes AGA Interchangeability Indices: Lifting Index, Flashback Index, and Yellow Tip Index. These indices have performed well for appliances and equipment designed and installed up to the 1990s but may not be accurate for newer, more efficient, and less polluting equipment.

- Additional metrics need to be added for better predictions, such as Methane Number which is currently utilized by engine manufacturers for Internal Combustion Engine performance. Turbines or feedstock applications may also require metrics or compositional limits.

- Establish longer term goals for a wide "Range of Acceptability" based on national standards.

Long term, SoCalGas will work with industry, manufacturers and government on the development and implementation of national gas quality standards that allow for the broadest range of gas compositions. Further recommendations include:

- Develop a target "Range of Acceptability," provide a transition period and encourage equipment manufacturers to produce equipment that operates safely over the entire range.

- Simplify testing standards and protocols. Single standard testing/protocols should be adopted for certification, performance, safety and emission testing.

- Continue to work to promote testing of large equipment by manufacturers, possibly with Department of Energy sponsorship.

- Continue to work with manufacturers and agencies on development of testing protocols and test gas specifications.

- Determine if adjustment gas or gases could be used during equipment set-up to allow for the widest range of acceptable gas composition. This determination should be based on sound statistical methodologies.

VII.

SUMMARY OF SDG&E/SOCALGAS LEGACY FLEET STUDY

In addition to the work undertaken by SDG&E and SoCalGas to study gas quality effects for a variety of stationary gas-fired equipment, they have also initiated work to examine the impacts on NGVs. The following is a summary of a study recently completed by SDG&E and SoCalGas to catalog existing heavy-duty NGV engines in their service territories. The complete study is attached hereto as Attachment "B."

As part of the on-going efforts to understand the potential impact of changes in natural gas quality standards within California, SDG&E and SoCalGas have assessed how compressed natural gas (CNG) vehicles may react to fuel composition outside the current CARB CNG fuel specification. In particular, SDG&E and SoCalGas have focused on older, heavy-duty CNG vehicles, which have less adaptable control systems than newer heavy duty and light-duty CNG vehicles.

As of the end of October, 2003, SDG&E and SoCalGas had surveyed customers with known fleets of heavy-duty CNG vehicles as well as all customers billed under the G-NGV tariffs. The results of the survey are summarized in Exhibit 1 of Attachment "B," which shows the complete inventory of all heavy-duty CNG vehicles within SoCalGas and SDG&E service territory as of October, 2003.

Based upon the results of the survey, SDG&E and SoCalGas contacted heavy-duty CNG engine manufacturers to obtain fuel specification and performance data for each engine make and model operating in significant numbers. For the purpose of comparison, each of the manufacturer fuel specifications was reduced to a Methane Number (MN) as well as the current CARB CNG fuel specification, which ranges from MN 72.5 to MN 108.4. The results of the heavy-duty CNG engine manufacturer discussions are summarized in Exhibit 2 of Attachment "B," which shows that 17.8% of the engine makes and models in the inventory can operate on natural gas that is less than MN 80. However, more than half of the entire inventory is made up of engines manufactured by Detroit Diesel Corporation ("Detroit Diesel"). According to Detroit Diesel, a single CNG fuel specification was developed for the initial version of the Series 50G engine, but never updated as subsequent, more advanced versions of the engine were developed and commercialized. Since there are a large number of these more advanced versions of the Series 50G engine in operation, it is of great interest to all stakeholders to understand whether it is possible to update the Series 50G fuel specification.

Although most of the heavy-duty CNG engines produced today are capable of operating on natural gas below MN 73, this only represents a fraction of the engines in the inventory. The impact of this fact is illustrated in Exhibit 3 of Attachment "B," which shows how the inventory of heavy-duty CNG engines that may not operate on natural gas below MN 73 changes over time. The majority of these engines are forecasted to reach the end of their useful life by 2019.

SDG&E and SoCalGas subsequently contracted with a third-party heavy-duty CNG engine expert, the Southwest Research Institute ("SWRI"), to develop reports that include theoretical assessments of the fuel specification range that relevant Cummins and Detroit Diesel heavy-duty CNG engines could safely operate within. Further, each report was to provide options (engine retrofit, engine replacement) and estimated costs for engines incapable of operating on natural gas below MN 73. The SWRI "Cummins" report is included as Exhibit 4 of Attachment "B." The SWRI "Detroit Diesel" report is currently underway but was not completed by the date of this filing.[23/]

The SWRI "Cummins" report assesses the ability of Cummins heavy-duty engines no longer in production to operate on the lowest possible MN natural gas that still meets the SoCalGas Rule 30 natural gas quality standards (approximately MN 70). The Cummins engines evaluated include the L10 Phase 1, L10 Phase 2, L10 Phase 3, B5.9G, and C8.3G. The report recommends that all of the engines evaluated be retrofitted or replaced in order to operate reliably on varying natural gas composition. Based on the report cost estimates as well as the number of each engine make and model in the inventory, the following table shows the total costs estimated for each option:

23/ SDG&E and SoCalGas will file a supplement to these Comments attaching the SWRI Detroit Diesel report when it is available.

Cummins Engine Model	Estimated Number of Engines	Engine Retrofit	Engine Replacement
L10 Phase 1	81	$1,057,200	$3,315,000
L10 Phase 2	5	$206,000	$275,000
L10 Phase 3	618	$879,800	$24,795,000
B5.9G	95	$1,140,000	Not recommended
C8.3G	173	$2,076,000	Not recommended
Total	972	$5,359,000	$28,385,000

Although the engine retrofit option appears to be the lowest cost option, it should be noted that these costs assume no significant problems in developing and installing engine retrofits for each engine make and model. Further, the issue of manufacturer acceptance and potential impact of third party retrofits on manufacturer guarantees and/or warrantees have not been addressed. Since the cost estimate was based on theoretical studies and inventory data collected solely through SDG&E and SoCalGas records, it should be stressed that these figures are only an estimate that may change as more data is collected over time.

SDG&E and SoCalGas are currently working with SWRI to develop a set of heavy-duty CNG engine testing procedures that will be used to test engines currently in operation in southern California. These tests will serve to validate conclusions reached in the SWRI "Cummins" and "Detroit Diesel" reports. Regardless of the outcome of these engine tests, however, it is imperative that key stakeholders interested in changing natural gas quality specifications realize that heavy-duty CNG engine manufacturers must be receptive to any recommended changes in order to ensure engine warrantees (implicit or explicit) are not invalidated through the use of fuel that does not meet the manufacturer engine fuel specification or the use of engine retrofit equipment. This is particularly important with respect to Detroit Diesel, since Detroit Diesel engines make up over 50% of the existing inventory of CNG heavy-duty engines and Detroit Diesel has been unresponsive to requests to update their engine fuel specification.

VIII.

CONCLUSION

Now that significant additional research has been completed, the time has come to reassess the gas quality specifications contained in the tariffs of SDG&E and SoCalGas. These tariff specifications should be updated in a way that will allow the introduction of new natural gas supplies while still protecting utility customers and employees, maintaining the integrity of the pipeline system, and supporting efforts to attain air

These tariff specifications should be updated in a way that will allow the introduction of new natural gas supplies while still protecting utility customers and employees, maintaining the integrity of the pipeline system, and supporting efforts to attain air quality objectives. In addition, SDG&E and SoCalGas believe that the CARB specifications for NGVs should be revised immediately to adopt an "MN" standard. SDG&E and SoCalGas believe that the MN specification can be progressively reduced as further testing is completed, as older engines are modified to accept a wider range of gas quality, and as newer natural gas engines displace older engines in southern California. California administrative agencies should work cooperatively with stakeholders to modify gas quality standards in a manner that promotes the overall public interest. SDG&E/SoCalGas look forward to participating in the upcoming workshops and preparing filings with the CPUC to amend current gas quality specifications to reflect recent research.

DATED this 11th day of February, 2005, and Los Angeles, California.

Respectfully submitted,

By: ______________________________
David J. Gilmore

DAVID B. FOLLETT
DAVID J. GILMORE

Attorneys for
SAN DIEGO GAS & ELECTRIC COMPANY and
SOUTHERN CALIFORNIA GAS COMPANY
555 West Fifth Street, Suite 1400
Los Angeles, California 90013-1011
[Telephone: (213) 244-2945]
[Facsimile: (213) 629-9620]
[E-mail: dgilmore@sempra.com]

ATTACHMENT A

Southern California Gas Company

A Sempra Energy utility

Draft Final Report

Gas Quality

and

Liquefied Natural Gas Research Study

February 2005

Southern California Gas Company

PO Box 513249 SC723B

Los Angeles, CA 90051

DISCLAIMER

Testing protocols used in this study were derived from industry standards and regulatory test procedures. Note, however, that based on the needs of this program and the operating and design characteristics of equipment tested, adherence to the industry and regulatory testing standards was not literal. The reader is cautioned that no inference can nor should be drawn as regards certification of these devices to the industry standards or regulatory requirements as a result of this program.

Southern California Gas Company (SCG)

Larry Sasadeusz
Rod Schwedler
Kevin Shea
Jorge Gutierrez

Bourns College of Engineering – Center for Environmental Research and Technology - University of California, Riverside (CE-CERT)

Wayne Miller
William Welch

Consultants
William Raleigh
William Dennison
A. L. Wilson, Wilson Environmental Associates
Daryl Hosler, Wilson Environmental Associates
Howard Levinsky, Gasunie Research

ACKNOWLEDGEMENTS

The Southern California Gas Company expresses appreciation to the Air Emission Advisory Committee (AEAC)[1], Gas Appliance Manufacturers' Association (GAMA) and numerous gas equipment manufacturers, Natural Gas Council + Task Group on Interchangeability and industry experts who made significant contributions to the success of this study and to the extension of knowledge, related to Natural Gas-fired equipment performance and emissions.

[1] See Appendix E for Committee Members

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

This research study was designed to assess how residential and small commercial/industrial end-use equipment responded to changes in gas quality and to determine if Southern California Gas Company (SCG) needs to modify its current Gas Quality Standards (Rule 30). Furthermore, this assessment is important in light of changing natural gas supplies, both domestic and LNG, newer advanced combustion technologies and certification/testing procedures based on historic gas quality. While the potential exists for gas-fired equipment to exhibit varied performance characteristics when supplied natural gas fuel that varies in composition, this study focused on safety and performance of selected commercial/industrial and residential natural gas-fired appliances. The major objectives of the study were as follows:

1. Evaluate each selected unit to determine whether any issues exist relating to equipment safety and performance. Equipment safety includes changes in Carbon Monoxide (CO) levels, combustion stability and Lifting, Flashback, and Yellow Tipping.

2. Compare measured and observed results against the major natural gas Interchangeability Indices, including Wobbe Number, Lifting, Flashback, Yellow Tipping and Incomplete Combustion.

3. Collect NOx emission data during testing.

Thirteen different gas-fired appliances were tested in a formal test program that assessed the response of the devices to a range of natural gas compositions and characteristics. The gas compositions represented heating value and Wobbe Number boundaries of the current SCG Gas Quality Standards (Rule 30).

This study concludes and recommends that SCG needs to incorporate results of this study, national efforts on gas quality and other resources to develop an “Interim Range of Acceptability” encompassing on quality/composition for various end-use category. Other recommendations and findings are:

- Update Gas Quality Standards and Rule 30.
- Include interim Wobbe Number range from 1290 minimum to 1400 maximum.
- The test results were less clear on the need to adjust the 1150 Btu/scf High Heating Value (HHV) maximum limit.
- Neither HHV nor Wobbe Number is an absolute predictor of equipment performance.
- The Range of Acceptability concept may need to replace the current approach which utilizes AGA Interchangeability Indices:

Lifting Index, Flashback Index, and Yellow Tip Index. These indices have performed well for appliances and equipment designed and installed up to the 1990's but may not be accurate for newer, more efficient, and less polluting equipment.

- Additional metrics need to be added for better predictions, such as Methane Number which is currently utilized by engine manufacturers for Internal Combustion (I.C.) Engine performance. Turbines or feedstock applications may also require metrics or compositional limits other than the AGA Interchangeability Indices.
- Establish longer term goals for a wide "Range of Acceptability" based on national standards.

Long term, SCG will work with industry, manufacturers and government on the development and implementation of national gas quality standards that allow for the broadest range of gas compositions without significant impact on utilization equipment. Further recommendations include:

- Develop a target "Range of Acceptability", provide a transition period and encourage equipment manufacturers to produce equipment that operates safely over the entire range.
- Simplify testing standards and protocols. Single standard testing/protocols should be adopted for certification, performance, safety and emission testing.
- Continue to work to promote testing of large equipment by manufacturers, possibly with DOE sponsorship.
- Continue to work with manufacturers and agencies on development of testing protocols and test gas specifications.
- Determine if adjustment gas or gases could be used during equipment set-up to allow for the widest range of acceptable gas composition. This determination should be based on sound statistical methodologies.

INTRODUCTION

During this study, laboratory tests on a variety of Natural Gas-fired residential, commercial, and industrial equipment were conducted to evaluate safety and performance and to gather emissions data. The evaluation focused on how equipment operating characteristics changed as a function of changes in natural gas composition.

Different gas compositions, which represented a range of potential gas compositions that could enter the Southern California Gas Company (SCG) distribution system from Liquefied Natural Gas (LNG) supplies, California-produced gas, traditional out-of-state gas supplies or supplies from non-traditional sources, were used in the study. Specific study objectives were to assess SCG's current Gas Quality Standards (Rule 30) to ensure they will continue to provide customer safety and equipment performance as it relates to:

1) Higher heat content and higher Wobbe Number natural gas supplies that may enter SCG's system;

2) Transient and steady state equipment performance changes through the range of gas compositions;

3) New and emerging end-use combustion technologies; and

4) The relationship between changing gas compositions and combustion performance.

SCG and the gas industry have identified a need to examine the effects of changing Natural Gas composition for each type of end use equipment and combustion technology in the residential, commercial and industrial service categories. End use equipment that needs to be assessed includes residential appliances, small and large Commercial/Industrial equipment, reciprocating engines, turbines and non-combustion applications. Within each end use equipment category there are older combustion technologies, current technologies still being installed and newer emerging combustion technologies. This study focused on end use equipment representing residential appliances and small commercial / industrial equipment.

Equipment tests were conducted at Bourns College of Engineering-Center for Environmental Research and Technology (CE-CERT), located at the University of

California, Riverside, the SCG's Engineering Analysis Center, located in Pico Rivera, California, and at several manufacturer locations.

An Air Emissions Advisory Committee (AEAC) was established by SCG to review, advise and provide oversight in the air emissions element of the study. The AEAC was composed of technical representatives from interested regulatory agencies and LNG terminal proponents. (See Appendix E)

BACKGROUND

SCG and San Diego Gas & Electric Company (SDG&E) provide gas distribution services to approximately six million customers in southern California. The largest portion of this area's current gas supply that reaches our customers originates from the Rocky Mountains, the Permian Basin, and the San Juan Basin. A smaller portion is produced within California.

While supplies have traditionally been adequate to meet demand, a nationwide natural gas supply imbalance is developing, as new gas reserves are not being discovered and developed at a rate matching the overall increase in demand. The rapid growth in natural gas demand and a slowdown in developing new North American gas supplies have led to increased gas commodity prices. At current and projected natural gas prices, importation of natural gas, shipped as LNG, has become an economically viable option. The US Department of Energy's (DOE) "Energy Outlook 2003" projects a ten-fold increase in LNG imports from 2001 to 2025. Five west coast LNG supply projects are in various stages of development. At this time, we cannot predict which projects will initiate operation. However, we believe that LNG will provide a substantial portion of future California natural gas supplies and will access end users through new receipt points close to load centers.

Supplies of LNG for the SCG system would originate primarily from Pacific Rim countries, such as Indonesia, Russia, and Australia. The respective chemical compositions and heating values of LNG supplies from these sources differ from natural gas supplied to southern California from out-of-state domestic sources as some ethane, propane and butanes have been removed from out-of-state domestic natural gas prior to shipment via interstate pipelines. Furthermore, gas components such as CO_2, N_2, and O_2 and heavier hydrocarbon components ($>C_4$), which are common in domestic natural gas supplies, are virtually nonexistent in LNG. California-produced gas can exhibit concentrations of higher ethane and propane similar to LNG.

Completion of just one proposed LNG terminal on the West Coast could deliver from 500MMscf to a 1Bscf of natural gas into the SCG and SDG&E gas distribution systems each day, replacing gas from sources currently supplying this region. Multiple terminals could deliver much more. Thus, significant numbers of SCG and SDG&E customers' utilization equipment could experience a change in gas composition from out-of-state domestic natural gas to gas supplies from LNG. Furthermore, given the operating characteristics of the SCG/SDG&E transmission and distribution systems and customer usage patterns, many customers may be subject to "swings" in gas composition from traditional interstate supplies to new supplies or vice versa in relatively short timeframes.

SCG has actively tested appliances and small industrial/commercial equipment to monitor equipment performance over broad ranges of gas composition. Extensive testing in the laboratory and field in the mid 90's led to the establishment of an upper Btu limit for SCG's Gas Quality Standards (Rule 30). During those tests, it was noted that for a few tested appliances test results were not consistent with the interchangeability indices calculations. Subsequent testing over the next several years confirmed that some newer end-use combustion technologies, such as premix/powered combustion, yielded results that were not predictable within the conventional interchangeability indices calculations. These combustion systems, although resulting in better efficiencies and lower NOx, seem to be more sensitive to changes in gas quality and rate of change in gas quality.

SCOPE

This research study was designed to assess current Gas Quality Standards (Rule 30) and the potential need to modify these standards based on safety and performance of selected, representative commercial/industrial and residential natural gas-fired appliances.

The major objectives of the study were as follows:

1. Evaluate each selected unit to determine any issues relating to equipment safety and performance. Equipment safety includes changes in Carbon Monoxide (CO) levels, combustion stability, lifting, flashback, and yellow tipping.
2. Compare measured and observed results against the major natural gas interchangeability indices, including Wobbe Number, Lifting, Flashback, Yellow Tipping and incomplete combustion.
3. Collect NOx emission data during testing.

Based upon earlier studies, a list of potentially sensitive equipment was drafted as a starting point. This list and a detailed questionnaire were provided to industry experts for review and comments. Manufacturer associations and more than 40 companies representing residential equipment manufacturers, burner manufacturers, boiler manufacturers and food service equipment manufacturers were contacted. Several industry consultants were retained to provide advice and SCG received valuable advice from these various external sources and on the list of candidate equipment types to be tested. Further input and guidance was provided through internal SCG surveys, meetings and discussions with SCG industrial service technicians, research managers and highly experienced industrial/customer service training instructors.

Combustion systems and equipment were categorized as residential, commercial or industrial equipment. In order to maximize the number of different combustion systems and equipment types to be tested, equipment represented in more than one equipment type category would only be tested in one of the categories.

Once the list of equipment to be tested was finalized (Table 1), significant assistance was provided by SCG field service personnel, the AEAC and industry participants by providing access to test equipment on a loan basis. SCG also purchased equipment either new or salvaged from homes. Brand name and model number anonymity have been maintained to encourage full participation of all.

The study approach was to test the selected natural gas-fired equipment at gas composition boundary conditions within the existing Gas Quality Standards (Rule 30) limits. Equipment selection and prioritization was based on surveys of SCG employees (Field Service and Applied Technology), input from equipment manufacturers, analysis of other technical studies and input from industry experts and the Air Emissions Advisory Committee. Equipment selection was reviewed against and guided by specific criteria:

1. Critical time-controlled processes with limited or no temperature control
2. Narrow air/fuel ratio operating band
3. Performance/safety possibly dependent on flame characteristics
4. Safety concerns related to flue gases
5. Existence of sophisticated heat exchanger/combustion system
6. Historical combustion system related safety concerns
7. High population density in southern California
8. Recommendations from credible industry experts
9. Information from background and industry research
10. Technology entering southern California marketplace

Table 1 below shows the equipment selected and tested during this study. In addition to the Service Type Categories, Burner Type, and Size, it also shows the selection criteria that were identified for each device.

Table 1 – List of Equipment Tested

Unit	Description	Service Categories	Burner Type	Rated Input (BTU/hr)	Selection Criteria[2]
1	Condensing Forced Air Furnace	Residential	Low NOX, induced combustion system with in shot burners firing into a tube-type heat exchanger	105,000	3,4,5,8,9,10
2	Flammable Vapor Ignition Resistant Water Heater	Residential	Atmospheric (with limited air)	36,000	3,4,8,9,10
3	Instantaneous Water Heater	Residential	Low NOX	117,000	2,3,4,5,8,10
4	Legacy Water Heater	Residential	Atmospheric	32,000	3,4,7
5	Legacy Floor Furnace	Residential	Atmospheric	32,000	3,4,6,7,8
6	Legacy Wall Furnace	Residential	Atmospheric	35,000	3,4,6,7,8
7	Pool Heater	Residential	Low NOX	250,000	2,3,5,10
8	Condensing Hot Water Boiler	Commercial	Low NOX	199,000	3,4,5,8,10
9	Hot Water Boiler	Commercial/ Industrial	Low NOX	500,000	3,4,5,7,8
10	Steam Boiler	Commercial/ Industrial	Low NOX	300,000	3,4,5,7,8
11	Steam Boiler	Commercial/ Industrial	Ultra Low NOX	660,000	3,4,5,7,8,10
12	Deep Fat Fryer	Commercial	Powered, surface-type	86,000	3,4,5,7,8
13	Chain-Driven Char Broiler	Commercial	Radiant tile operating in blue-flame mode	96,000/ 75,000	1,3,5,7,8

[2] The selection criteria were updated on the basis of the final equipment selected and additional information from manufacturers or industry experts.

For the purposes of this study, operational safety is defined primarily by CO concentration in the flue gas. Other parameters, such as lifting, flashback, yellow tipping, etc., are taken into account in the overall safety evaluation, but the main parameter is CO. The CO concentration used as this safety indicator is 400 ppmv air-free, although we recognize that some appliances have different levels of acceptable safety performance related to CO and combustion stability. Also, certification/acceptance is with a specific test gas composition at STP (Standard Temperature and Pressure) which may not be applicable to other natural gas compositions. However, as noted, this study used 400 ppmv air-free as the basis for safety performance with all test gases as a reference to "safe" performance.

Test gas compositions selected for this study were based on current SCG Gas Quality Standards (Rule 30) and the potential HHV and Wobbe Number of acceptable future natural gas supplies. The approach used in selecting these "test gases" was to develop compositions that reflected HHV and Wobbe at boundary conditions within the current SCG Gas Quality Standard utilizing minimum and maximum components within the current standard. Intermediate gas compositions were utilized to further test equipment that exhibited sensitivities at the boundary condition in order to determine upper operating ranges for safety and performance and to provide input on HHV and Wobbe Number impacts. In some cases the selected compositions reflect actual gas compositions that may be present currently in the SCG system. However, they were not specific to compositions in either existing supplies or known LNG gas supplies. The test gas matrix was developed in a multi-tier system: primary and secondary. Primary gas blends are:

- Baseline gas (BL) corresponding to the average gas quality in the SCG system. 1020 Btu HHV and 1330 Wobbe Number.

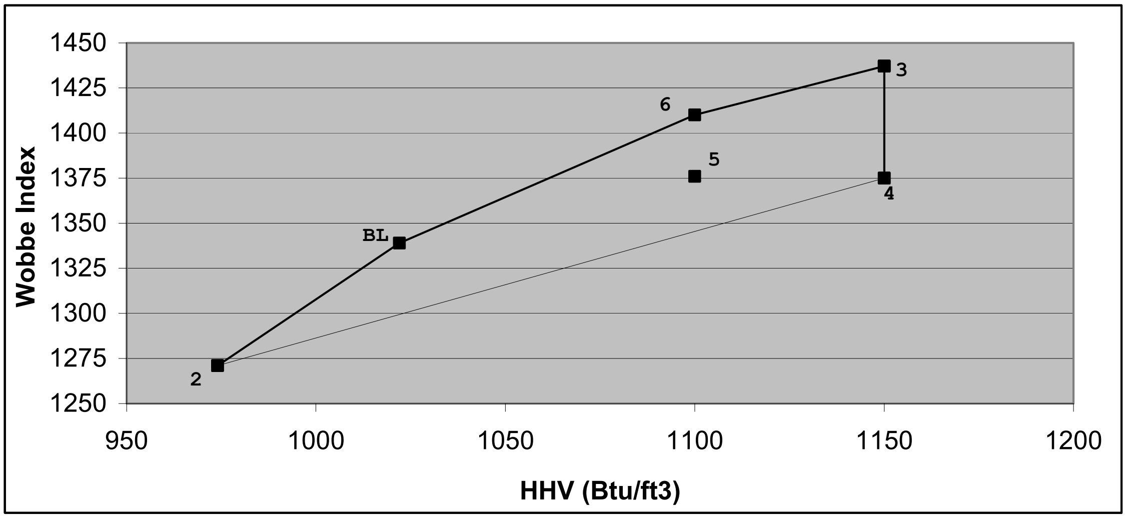
- Low Btu/Low Wobbe Number (Gas 2) – The lowest combination of higher heating value and Wobbe Number within current Gas Quality Standards (Rule 30). 970 Btu HHV and 1271 Wobbe Number.

- High Btu/High Wobbe (Gas 3) – The highest possible combination of HHV and Wobbe Number that complies with current Gas Quality Standards (Rule 30). 1150 Btu HHV and 1430 Wobbe Number.

- High Btu/Low Wobbe Number (Gas 4) – This is the lowest Wobbe Number for the highest heating value in the Gas Quality Standards (Rule 30). 1150 Btu HHV and 1375 Wobbe Number.

Secondary blends were selected to test any sensitivity observed while testing the Primary gas blends. These were blended by holding the Wobbe Number constant at 1375 (Gas 4) and lowering the HHV to 1100 Btu HHV (Gas 5). The other secondary gas blend held the 1100 Btu HHV and raised the Wobbe Number to 1400 (Gas 6).

FIGURE 1 - GAS COMPOSITION MATRIX



In order to ensure commonality between all tests, gas compositions were either blended with a mass-flow mixing system or supplied from pre-mixed bottled gases. Then, for each equipment test the respective test gases were supplied in a specified order. The units were first run on Baseline gas and then Gas 2 and Gas 3 in succession. If any sensitivities were observed, the remaining Gases 4 – 6 were tested, as necessary. Not only were changes in gas components noted for the various test gases, but the rate of change from one to the other was also observed. Gases 4a and 5a were subsets used to see if there was any influence resulting from the number of hydrocarbons used to prepare the mixtures (e.g., mixture of high heating value and Wobbe that contained a mixture of only three hydrocarbons -methane, ethane, and propane or five hydrocarbons – methane, ethane, propane, butanes, C5+).

Note that there were limitations in the mass-flow gas blending system used in this study, which precluded the use of Gases 6a, 7a and 7b. These gases had been identified in the original test design and were listed in the "White Paper" (Appendix D).

The specific test gas compositions used in this study are presented in Table 2. Table 3 presents the Gas Indices for each of the test gases.

Table 2 – Gas Composition[3]

Primary	METHANE	ETHANE	PROPANE	iso-BUTANE	n-BUTANE	iso-PENTANE	n-PENTANE	C6 plus	CARBON DIOXIDE	NITROGEN	MN	Wobbe#	HHV
1 Baseline, Line Gas	96.08	1.78	0.37	0.06	0.06	0.01		0.03	1.18	0.44	100	1338.9	1022
2 970 Btu Gas	96.00								3.00	1.00	108	1271	974
or 1000 Btu Gas	97.00	0.75	0.10						2.00	0.15	106	1315	1000
3 1150 Btu Gas, Hi Wobbe	87.03	9.23	2.76	0.99					0.00	0.00	75	1437	1150
4 1150 Btu Gas, Lo Wobbe	84.92	4.79	2.40	1.20	1.20	0.60	0.60	0.30	3.00	1.00	68	1375	1150
(w/Nitrogen)	84.92	4.79	2.40	1.20	1.20	0.60	0.60	0.30	0.00	4.00	68	1392	1150
4a or 4 component mix	84.45		11.55						3.00	1.00	68	1375	1150
Secondary													
If fails test gas 4													
5 1100 Btu Gas, Avg. Wobbe	88.88	5.28	2.61	0.34	0.50	0.11	0.06	0.06	1.40	0.75	79	1376	1100
5a or 4 component mix	90.85		7.00						1.40	0.75	79	1376	1099
6	91.83	5.81	1.74	0.31	0.31						84	1410	1100

[3] The study allowed for a +/- 1% in both heating value and Wobbe and individual components were targets not absolutes to reach the Btu / Wobbe numbers. Actual Btu and Wobbe Numbers are identified in individual reports.

Table 3 – Test Gas Indices

Test Gas	Base	2	3	4	5	6	Limits
Heating Value (Btu/cf)	1020	970	1150	1150	1100	1100	970 to 1150
Wobbe Number	1332	1270	1430	1375	1376	1400	5%
AGA Indexes							
Lifting	1	1.06	0.92	0.98	0.97	0.935	<= 1.06
Flashback	1.01	1.01	1.03	1.03	1.02	1.018	<= 1.2
Yellow Tipping	1	1.10	0.81	0.80	0.88	0.857	>= 0.8
Weaver Indexes							
Flashback	0	0.044	-0.065	-0.022	-0.024	-0.055	<= 0.26
Yellow tipping	0	-0.076	0.209	0.207	0.128	0.141	<= 0.3
Incomplete Combustion	0	-0.053	0.099	0.060	0.049	0.074	<= 0.05
Lifting	1	0.933	1.124	1.050	1.052	1.091	>= 0.64
Heat Rate	1	0.953	1.077	1.029	1.031	1.060	0.95 to 1.05
Primary Air Ratio	1	0.953	1.077	1.030	1.031	1.060	0.80 to 1.20

Historical Gas Interchangeability Indices, identified in Table 3, were developed for atmospheric type burners from data gathered from testing residential appliances and a specially developed AGA test burner[4]. The indices indicated that several of the test gases were not interchangeable with the Baseline gas as indicated by the highlighted numbers. Some equipment tested in this study would have been expected to demonstrate performance problems or sensitivity with Gases 3, 4 and 6. However, test results showed sensitivity only with Gas 3.

These indices do not apply to the engines, turbines, and feedstock equipment categories. Other indices or gas composition requirements are utilized for safety and performance, such as Methane Number for engines.

[4] AGA Bulletin 36

STANDARDS AND PROTOCOLS

Testing protocols used in this study were derived from industry standards and regulatory test procedures. However, based on the needs of this program and the operating and design characteristics of equipment tested, it should be noted that adherence to the industry and regulatory testing standards was not literal. The reader is cautioned that no inference can nor should be drawn with regard to certification of these devices to the industry or regulatory requirements as a result of this program.

Prior to testing each piece of equipment, a detailed test protocol was developed by SCG, CE-CERT and industry experts/consultants, who were either members of the AEAC or separately contacted to provide input and guidance. The approach used in developing the test protocols for each appliance type was largely to combine and simplify testing standards.

Deviations from the standards were included when specific sections were believed to be superfluous or inappropriate to specific appliances or operating/installation realities. While standard industry or regulatory certification test standards provide consistent test methodologies and a basis for comparing test results, they are not always valid for observing the operation of natural gas-fired equipment installed at an end user's location. For instance, many of the standards define that a specific ambient temperature range be maintained at the test site. While this is appropriate for ensuring comparable results between test units, it does not address equipment performance at ambient conditions encountered in the field. Thus, professional experience and engineering judgment were required to develop the appropriate tests for each unit tested.

As a final quality assurance control measure, all protocols were thoroughly reviewed by SCG, CE-CERT and industry experts prior to testing.

Various standards from the following organizations were used as inputs or as the basis for the test protocols used in this study:

- ANSI – American National Standards Institute.
- AOAC – Association of Official Analytical Chemists.
- ASHRAE – American Society of Heating, Refrigeration and Air Conditioning Engineers.
- ASTM – American Society of Testing and Materials.

- **SCAQMD** - South Coast Air Quality Management District.
- **UL** – Underwriters Laboratories.
- **Manufacturer Test Guidelines**

GENERAL TEST PROCEDURE

The testing of each natural gas-fired appliance was conducted according to the individual equipment-specific individual test protocols. Test objectives were to determine safety and performance, and to gather emissions data as a function of fuel composition. These objectives were met through a series of tests conducted at steady state and transient (sudden gas changing) conditions.

The general protocol incorporated in each equipment-specific test protocol is described below. Detailed test protocols for each piece of equipment can be found in the individual reports in Appendices A, B and C.

1. The end-user equipment was installed and set-up according to the appropriate test standard(s) and/or manufacturers' specifications.

2. Appliance testing at "as received" conditions was performed with Baseline Gas and/or Baseline and Primary Gases. Data were monitored and collected for each gas tested. These data included CO, CO_2, O_2 and NO_x emissions, flame lifting, flashback, yellow tipping, temperature fluctuations, smooth ignition and production output and quality.

3. After testing at "as received" conditions, the gas input rate was adjusted to "rated input" conditions, if necessary. Then, appliances were tested at "rated input" conditions with Baseline Gas. High speed switching was used as test gases were changed. Data were monitored and collected for each gas tested. These data included CO, CO_2, O_2 and NO_x emissions, flame lifting, flashback, yellow tipping, temperature fluctuations, smooth ignition and production output and quality.

4. After testing at "rated input" conditions, additional tests, as required by the equipment-specific test protocol, were performed (i.e., over -fire and under-fire testing with Baseline Gas and/or Baseline and Primary Gases). Data were monitored and collected for each gas tested. These data included CO, CO_2, O_2 and NO_x emissions, flame lifting, flashback, yellow tipping, temperature fluctuations, smooth ignition and production output and quality.

5. Hot and/or cold ignition tests with Baseline and Secondary Gases at rated input, under fired or over-fired conditions were performed. During this time, visual observation of the flame, ignition delays and other observed phenomena were documented.

SUMMARY OF FINDINGS

The research study was designed to assess current Gas Quality Standards (Rule 30) and the potential need to modify these standards due to changing gas supplies and newer advanced combustion technologies. The following findings were identified relative to the stated objectives identified in the Scope section of this document. The numbering scheme is for reference only and does not indicate level of importance.

Objective 1 – Safety and Performance

1. There were no performance issues observed in the equipment tested that might have resulted from rapid changes in gas composition through the range of test gases.

2. All equipment tested operated safely within the context of this study and performed satisfactorily when set up to Baseline gas (BL) and operated with 970 HHV/ 1270 Wobbe Number (Gas 2), 1150 HHV / 1375 Wobbe Number (Gas 4), 1100 HHV / 1375 Wobbe Number (Gas 5) and 1100 HHV / 1400 Wobbe Number (Gas 6).

3. Most of the equipment operated satisfactorily on the 1150 HHV/ 1437 Wobbe Number (Gas 3), however, safety problems were encountered on some equipment.

   - The wall furnace showed significant CO emission level sensitivity to the High HHV / High Wobbe Number. However, the other legacy (used) residential indoor appliances tested were quite forgiving with respect to gas composition changes.

   - The deep fat fryer produced elevated CO levels when operating with the highest HHV and Wobbe Number gas. However, it maintained consistent food quality over all test conditions.

4. The CO levels for two other units, condensing boiler and pool heater, neared the Critical Point with 1150 HHV / 1430 Wobbe Number (Gas 3). (For purposes of this study the Critical Point is assessed as a change in CO concentration of 75 ppmv between baseline gas and other gas mixtures.) (See Figure 2).

5. The temperature changes for all units, except the deep fat fryer, increased when burning gases with higher HHV and higher Wobbe Number than baseline gas. This exception is believed to be the result of incomplete combustion due to limited air supply. (The actual combustion or flame temperatures could not be measured on all of the test units. For these units, either the stack temperature or heat exchanger temperature was used as the temperature change.) (See Figure 3).

6. The chain driven charbroiler (time-based cooking) exhibited several product quality problems. When the equipment was tuned to the high HHV/high Wobbe Gas (Gas 3) and switched to baseline gas, the meat sometimes came out undercooked. When tuned to baseline gas and switched to high HHV/high Wobbe Number gas, meat patties were sometimes overcooked.

7. Overall, neither HHV value nor Wobbe Number of the gas consistently correlated with equipment performance.

Objective 2– Interchangeability Indices

1. Interchangeability Indices in Table 3 indicated a potential for problems with three of the gas blends. However, with the exception of the 1150 HHV/ 1430 Wobbe Gas (Gas 3), when combusted in the wall furnace and the deep fat fryer the historic gas interchangeability analysis techniques did not always provide a means for predicting the acceptability of a fuel composition for the equipment tested.

Objective 3 – Emissions Data

1. HHV and Wobbe Number generally showed positive correlation with NOx emissions with Wobbe Number having the higher correlation.

2. All Low-NOx units showed higher NOx emission levels with the higher HHV / higher Wobbe Number gases, except for the horizontal condensing forced air unit. (See Figure 4).

3. Several of the units tested exhibited more NOx sensitivities with a greater number of hydrocarbon species in a given HHV / Wobbe Number gas.

4. Of the boilers tested in this study, one, the ultra Low-NOx boiler (the

newest technology and meeting one of the tightest emissions standards) showed little NOx emissions sensitivity over the range of gases. This unit also showed the least CO sensitivity.

5. Indoor residential appliances did not exhibit significant NOx sensitivities to gas composition changes. Some appliances showed small increases and others showed small decreases in NOx emissions concentration between study gas blends.

<u>Other Key Findings</u>

1. During this study, it was apparent from contacts with manufacturers and industry experts that there is a general lack of awareness regarding the wide range of gas compositions and characteristics distributed within SCG's territory and throughout the nation.

2. The "as-received" fuel input rates for several of the new, residential units tested in this study were at less than 90% of the nameplate rating values.

3. Initial testing of the instantaneous hot water heater indicated elevated CO levels when supplied with all study gases. During subsequent testing, it was discovered that the burner was extremely sensitive to slight gas supply pressure pulsations caused by an upstream regulator. The unit was retested with a different regulator and this test sequence did not indicate elevated CO levels.

Note: The individual equipment test reports are contained in Appendices A, B and C. The test reports contain detailed test results for each equipment unit tested at CE-CERT laboratory in Riverside, California and at the SCG Engineering Analysis Center in Pico Rivera, California.

Figure 2 - Changes in CO Emissions Relative to Baseline Gas

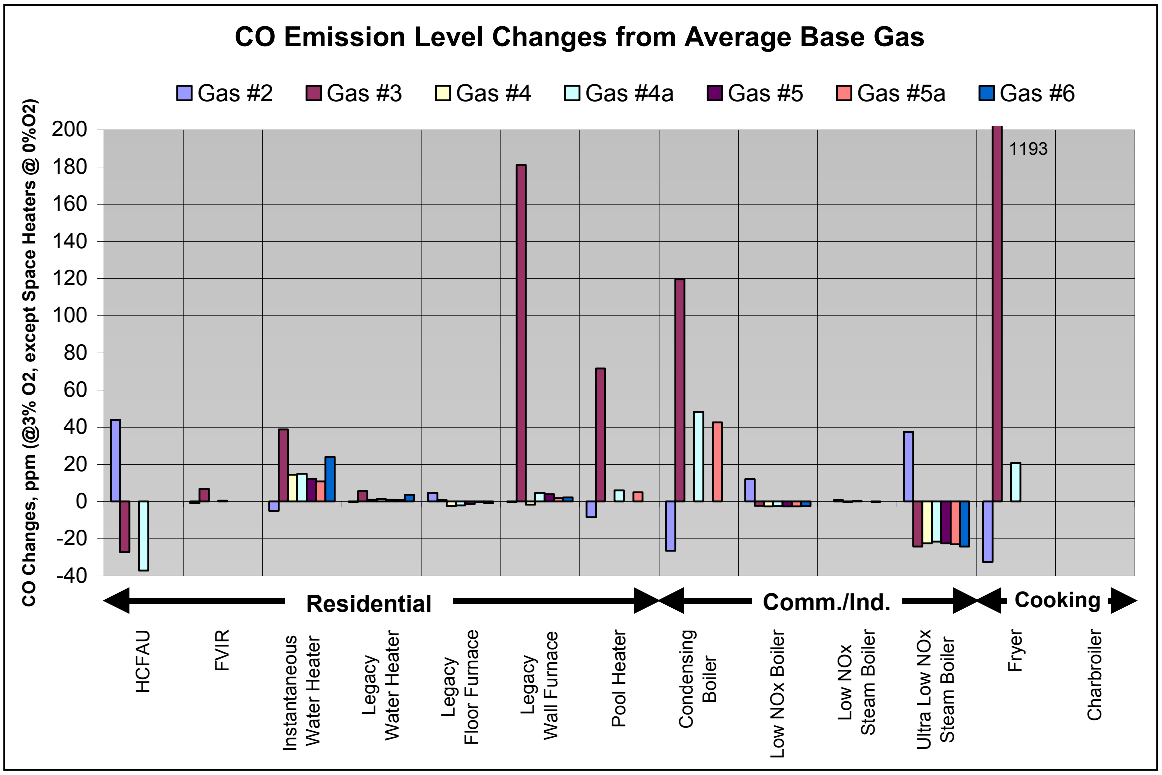


Figure 3 – Changes in Indicative Temperatures Relative to Baseline Gas

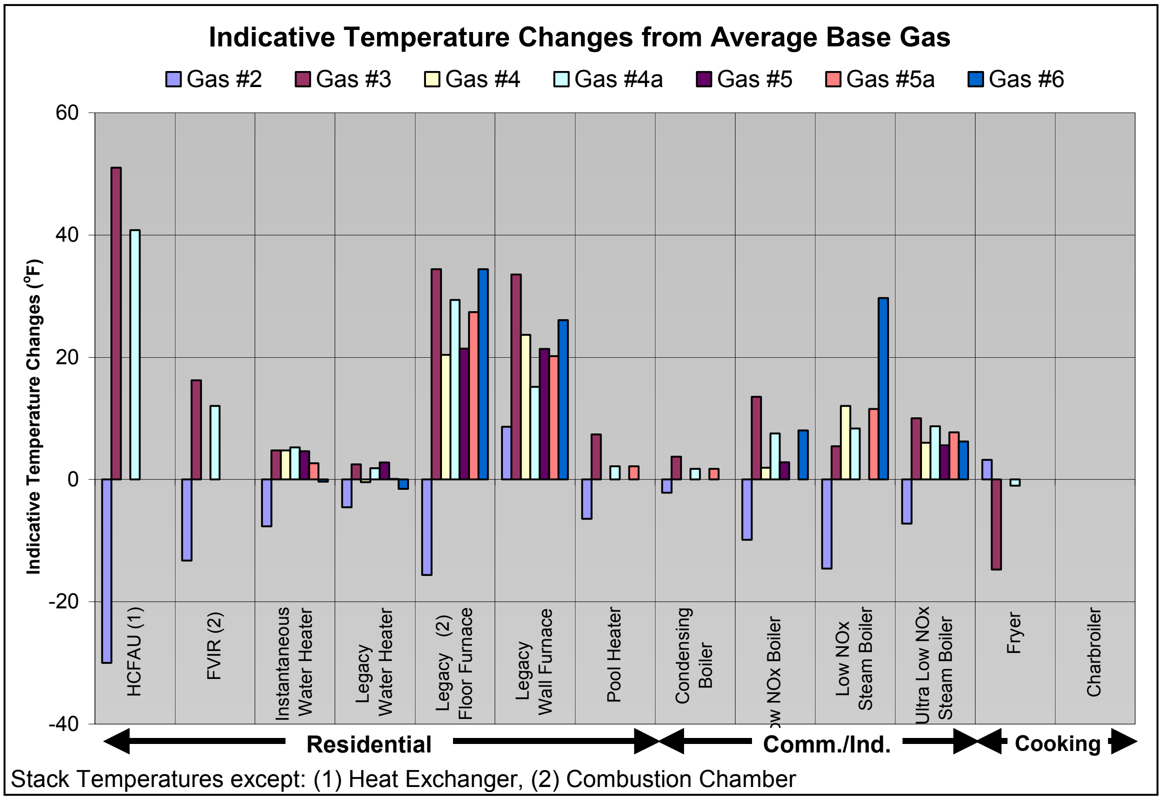
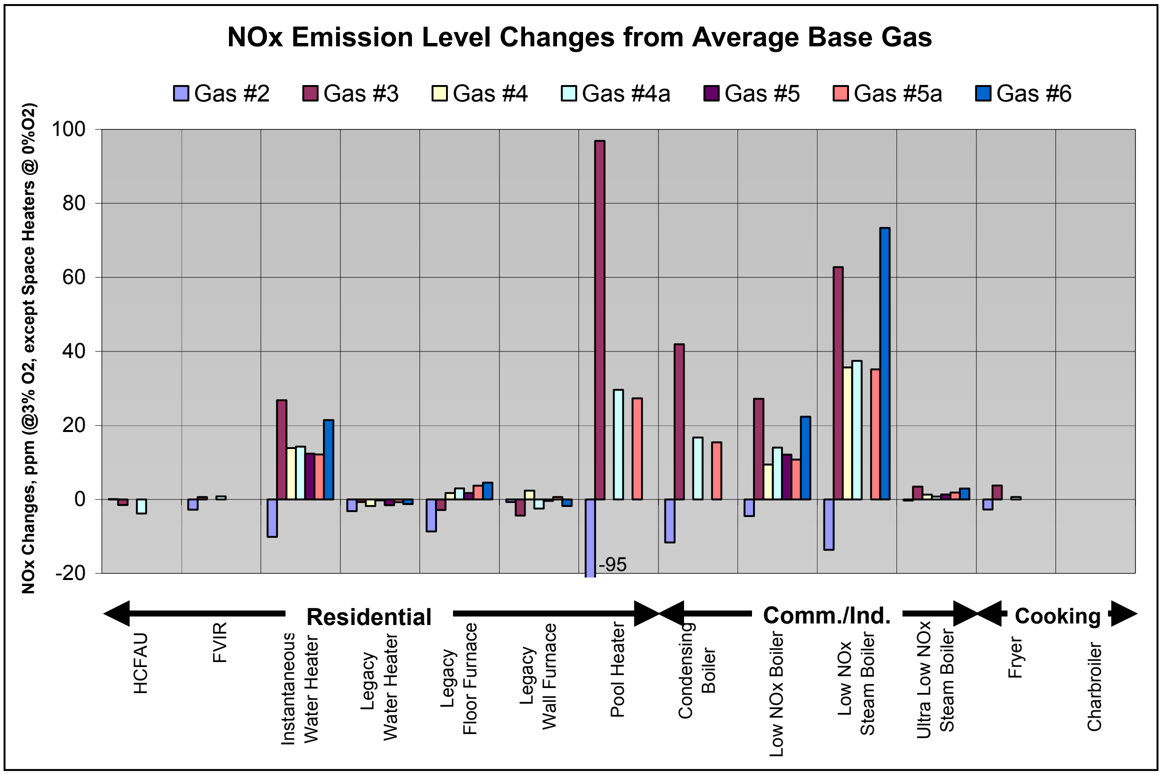


Figure 4 - Changes in NOx Emissions Relative to Baseline Gas



CONCLUSIONS

The following conclusions are based on data gathered during tests of the individual pieces of equipment. Global generalizations should not be extrapolated without more statistically based results, since other end-use equipment may have different parameters.

1. SCG Gas Quality Standard has an allowable range of 970 - 1150 HVV and allows for the Wobbe Number to be within +/- 10% of the typical composition of gas within the system. Theoretically, within the current Standard the Wobbe Number Limit could reach 1430 +. Based on the results of this study, SCG needs to modify the Gas Quality Standard to include a maximum and minimum numeric Wobbe Number limit. All units tested performed satisfactorily over a wide range of gas compositions and characteristics up to the 1150 HHV and 1400 Wobbe Number study limits.
2. The test results were less clear on the need to adjust the 1150 Btu HHV maximum limit. All units tested performed satisfactorily on an 1150 Btu HHV / 1375 Wobbe Gas (Gas 4) composition while some experienced problems with the 1150 Btu HHV / 1437 Wobbe Number Gas (Gas 3).
3. Other aspects of the SCG Gas Quality Standard need to be reviewed and updated:
   - Additional metrics need to be added for better predictions. Neither HHV nor Wobbe Number is an absolute predictor of equipment performance.
   - A “Range of Acceptability” concept may need to replace current approach utilizing AGA Interchangeability Indices: Lifting Index, Flashback Index, and Yellow Tip Index. These indices generally have performed well for appliances and equipment designed and installed up to the 1990’s but may not be not good predictors for newer, more efficient, less polluting equipment.
   - Engine manufacturers currently utilize Methane Number as an I.C. Engine performance indicator. But gas turbines or feedstock applications require metrics or compositional limits other than AGA Interchangeability Indices
4. Standard safety and NOx emission testing procedures/protocols that use specific test gas compositions may not be applicable nor are they a true indicator of performance in actual end use installations. Testing or certifying over a range of gas compositions may be more appropriate. Differences in building codes, and safety and environmental regulations in different geographic locations may also necessitate changes to acceptance protocols in different geographical locations.

RECOMMENDATIONS

1. SCG needs to incorporate results of this study, national efforts on gas quality and other inputs to develop an "Interim Range of Acceptability" based on quality/composition for each end-use category.
   - Update Gas Quality Standards and Rule 30.
   - Include interim Wobbe Number range from 1290 minimum to 1400 maximum.
   - Establish longer term goals for wide "Range of Acceptability" based on national standards.

2. SCG will work with industry, manufacturers and government to develop and implement new, nationally applicable gas quality standards that allow for the broadest range of gas compositions that may reasonably be encountered.
   - Develop a target "Range of Acceptability", provide a transition period and require equipment manufacturers to produce equipment that operates safely over the entire range.
   - Simplify the testing standards and protocols. Single standard testing/protocols should be adopted for certification, performance, safety and emission testing.
   - Continue to promote testing of large equipment by manufacturers, possibly with DOE sponsorship.
   - Work with manufacturers and agencies to develop testing protocols and standardize a range of test gases.
   - Determine, based on sound statistical methodologies, if an adjustment gas or gases could be used for equipment set-up to allow for the widest range of acceptable gas compositions.

ATTACHMENT B

Heavy-Duty CNG Vehicle Natural Gas Quality Study

As part of the on-going efforts to understand the potential impact of changes in natural gas quality standards within California, SDG&E and SoCalGas have assessed how compressed natural gas (CNG) vehicles may react to fuel composition outside the current CARB CNG fuel specification[1]. In particular, SDG&E and SoCalGas have focused on older, heavy-duty CNG vehicles, which have less adaptable control systems than light-duty CNG vehicles.

As of the end of October, 2003, SDG&E and SoCalGas had surveyed customers with known fleets of heavy-duty CNG vehicles as well as all customers billed under the G-NGV tariffs. These surveys collected the following information:

- Number of heavy-duty, CNG engines by manufacturer make and model
- Engine production year
- Engine expected life (based on customer feedback).
- Fleet type (transit, school bus, waste hauler, street sweeper, other)

The results of the survey are summarized in Exhibit 1, which shows the complete inventory of all heavy-duty CNG vehicles within Southern California as of October, 2003.

Based upon the results of the survey, SDG&E and SoCalGas began to contact heavy-duty CNG engine manufacturers to obtain fuel specification and performance data for each engine make and model operating in significant numbers. For the purpose of comparison, each of the manufacturer fuel specifications was reduced to a Methane Number (MN) as well as the current CARB CNG fuel specification, which ranges from MN 72.5 to MN 108.4[2]. The results of the heavy-duty CNG engine

---

[1] The CARB CNG fuel specification is located in California Code of Regulations Title 13, Division 3, Chapter 5, Article 3, Section 2292.5.

[2] The Methane Number (MN) is a measure of the knock resistance of the fuel, calculated using the formula MN = 1.624*(MON)-119.1, where MON = -406.14+508.04(H/C)-173.55(H/C)2+20.17(H/C)3 and H/C is the reactive hydrogen/carbon ratio.

manufacturer discussions are summarized in Exhibit 2, which shows that only 17.8% of the engine makes and models in the inventory can operate on natural gas that is less than MN 80. However, more than half of the entire inventory is made up of engines manufactured by Detroit Diesel Corporation ("Detroit Diesel"). According to discussions with Detroit Diesel, a single CNG fuel specification was developed for the initial version of the Series 50G engine, but never updated as subsequent, more advanced versions of the engine were developed and commercialized. Since there are a large number of these more advanced versions of the Series 50G engine in operation, it is of great interest to all stakeholders to understand whether it is possible to update the Series 50G fuel specification. Unfortunately, all efforts by SDG&E and SoCalGas to engage Detroit Diesel in this effort have been met with little or no response.

Although most of the heavy-duty CNG engines produced today are capable of operating on natural gas below MN 73, this only represents a small fraction of the engines in the inventory. The impact of this fact is illustrated in Exhibit 3, which shows how the inventory of heavy-duty CNG engines that cannot operate on natural gas below MN 73 changes over time. The majority of these engines are forecast to the end of their useful life by 2019.

SDG&E and SoCalGas subsequently contracted with a third-party heavy-duty CNG engine expert, the Southwest Research Institute (SWRI), to develop reports that include theoretical assessments of the fuel specification range that relevant Cummins and Detroit Diesel heavy-duty CNG engines could safely operate within. Further, each report was to provide options (engine retrofit, engine replacement) and estimated costs for engines incapable of operating on natural gas below MN 73. The SWRI "Cummins" report can be found at http://www.arb.ca.gov/regact/cng-lpg/isor.pdf.

The SWRI "Cummins" report assesses the ability of Cummins heavy-duty engines no longer in production to operate on the lowest possible MN natural gas that still meets the SoCalGas Rule 30 natural gas quality standards (approximately MN 70). The Cummins engines evaluated include the L10 Phase 1, L10 Phase 2, L10 Phase 3, B5.9G, and C8.3G. The report recommends that all of the engines evaluated be retrofitted or replaced in order to operate reliably on varying natural gas composition. Based on the report cost estimates as well as the number of each engine make and model in the inventory, the following table shows the total costs estimated for each option:

Cummins Engine Model	Estimated Number of Engines	Engine Retrofit	Engine Replacement
L10 Phase 1	81	$1,057,200	$3,315,000
L10 Phase 2	5	$206,000	$275,000
L10 Phase 3	618	$879,800	$24,795,000
B5.9G	95	$1,140,000	Not recommended
C8.3G	173	$2,076,000	Not recommended
Total	972	$5,359,000	$28,385,000

Although the engine retrofit option appears to be the lowest cost option, it should be noted that these costs assume no significant problems in developing and installing engine retrofits for each engine make and model. Further, the issue of manufacturer acceptance and potential impact of third party retrofits on manufacturer guarantees and/or warrantees have not been addressed. Lastly, since the cost estimate was based on theoretical studies and inventory data collected solely through SDG&E and SoCalGas records, it should be stressed that these figures are only an estimate that may change as more data is collected over time.

A CARB Staff Report released on December 21, 2001 entitled “Proposed Amendments to the California Alternative Fuels for Motor Vehicle Regulations” offers several insights on the impact of changing natural gas fuel composition on various heavy-duty CNG engines and can be found at http://www.arb.ca.gov/regact/cng-lpg/isor.pdf. Page I-3, Part 2d of the report offers the following response to the question “How will these proposed amendments affect engine performance?”

> “Engine manufacturers recommend that open loop and first generation closed loop technology CNG engines utilize fuel that meets a minimum MN of 80. This specification allows these engines to properly operate and maintain performance. Advanced technology closed loop engines are equipped with improved feedback controls which allow these engines to operate on a broader range of fuel quality. Engine manufacturers believe that advanced technology engines can properly operate on CNG with a MN of 73.”

Page I-6 of the report offers the following response to the question “How will the proposed amendments affect exhaust emissions?”

> “Test results show that for dedicated light-duty NGVs, large variations in fuel composition produced only slight variations, both increases and decreases, in emissions and driveability. Also bi-fuel vehicles had only modest changes in emissions and performance with changes in CNG quality. Heavy-duty vehicle test data shows that fueling advanced generation engine technologies with MN 73 fuel produced no discernible impact on the particulate matter (PM) and oxides of nitrogen (NO_X) emissions when compared to emissions from higher quality fuels with MN greater than 80. There were very small increases in carbon dioxide (CO_2) and non-methane hydrocarbon (NMHC) emissions.”

Although the engine testing in the report did not include every make and model of heavy-duty CNG engine currently in operation throughout Southern California, the test results suggest that changing the CARB CNG fuel specification to a Methane Number standard as low as MN 73 will not affect the emissions and performance of modern heavy-duty CNG engines.

SDG&E and SoCalGas are currently working with SWRI to develop a set of heavy-duty CNG engine testing procedures that will be used to test engines currently in operation in Southern California. These tests will serve to validate conclusions reached in the SWRI “Cummins” and “Detroit Diesel” reports as well as the CARB Staff Report entitled “Proposed Amendments to the California Alternative Fuels for Motor Vehicle Regulations.” Regardless of the outcome of these engine tests, however, it is imperative that key stakeholders interested in changing natural gas quality specifications realize that heavy-duty CNG engine manufacturers must be receptive to any recommended changes in order to ensure engine warrantees (implicit or explicit) are not invalidated through the use of fuel that does not meet the manufacturer engine fuel specification or the use of engine retrofit equipment. This is particularly important with respect to Detroit Diesel, since Detroit Diesel engines make up over 50% of the existing inventory of CNG heavy-duty engines and Detroit Diesel has been unresponsive to requests to update their engine fuel specification.

Exhibit 1

Engine Type	SoCalGas	%	SDG&E	%	Total	%	Cumulative %
Detroit Diesel - 50G Series (Oct 1998 through Sep 2002)	1,567	53.4%	128	28.6%	1,695	50.1%	50.1%
Cummins - L10 Phase 3	618	21.1%	0	0.0%	618	18.3%	68.4%
John Deere - 6081H	301	10.3%	102	22.8%	403	11.9%	80.4%
Cummins - C8.3G	103	3.5%	70	15.6%	173	5.1%	85.5%
Cummins - C8.3G Plus	53	1.8%	105	23.4%	158	4.7%	90.1%
Cummins - B5.9G	81	2.8%	14	3.1%	95	2.8%	93.0%
Cummins - L10 Phase 1	74	2.5%	7	1.6%	81	2.4%	95.4%
Detroit Diesel - 50G Series (Oct 2002 to present)	76	2.6%	0	0.0%	76	2.2%	97.6%
Cummins - B5.9G Plus	13	0.4%	13	2.9%	26	0.8%	98.4%
John Deere - 6068H	6	0.2%	9	2.0%	15	0.4%	98.8%
Tecogen	14	0.5%	0	0.0%	14	0.4%	99.2%
Mack - E7G Series	10	0.3%	0	0.0%	10	0.3%	99.5%
Caterpillar - Dual Fuel	10	0.3%	0	0.0%	10	0.3%	99.8%
Cummins - L10 Phase 2	5	0.2%	0	0.0%	5	0.1%	100.0%
Detroit Diesel - 50G Series (1994 through Sep 1998)	1	0.0%	0	0.0%	1	0.0%	100.0%
Total	2,932	100.0%	448	100.0%	3,380	100.0%	

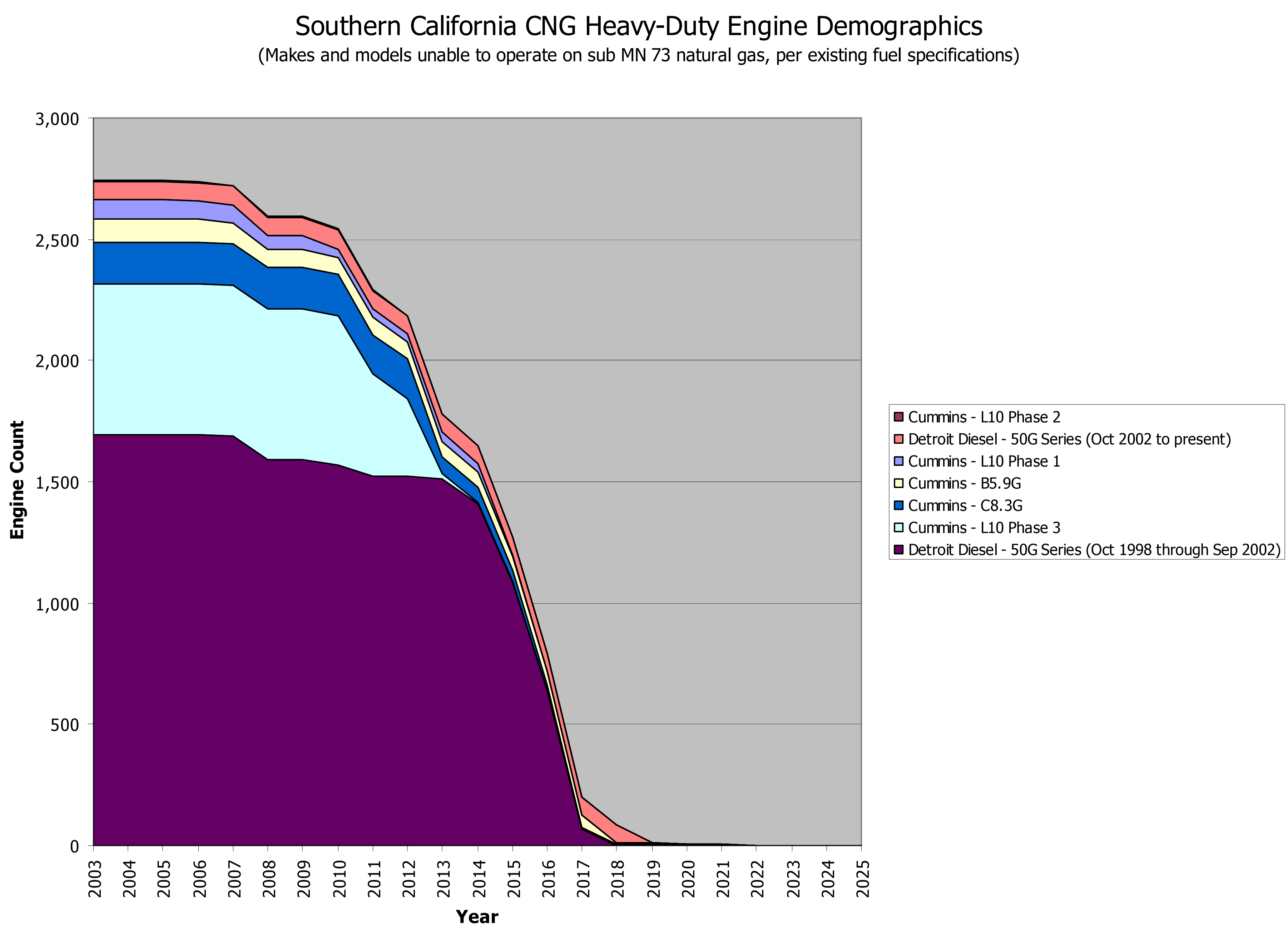
Fleet Type	SoCalGas	%	SDG&E	%	Total	%	Cumulative %
Transit	2,425	82.7%	344	76.8%	2,769	81.9%	81.9%
School Bus	259	8.8%	104	23.2%	363	10.7%	92.7%
Waste Hauler	179	6.1%	0	0.0%	179	5.3%	98.0%
Street Sweeper	37	1.3%	0	0.0%	37	1.1%	99.1%
Other	32	1.1%	0	0.0%	32	0.9%	100.0%
Total	2,932	100.0%	448	100.0%	3,380	100.0%	

Exhibit 2

Engine Manufacturer	Engine Model	Inventory		Manufacturer Fuel Requirements	Minimum Methane Number[1]	Notes
		count	%			
Cummins	L10 Phase 1	81	2.4%	Cummins Engineering Standard (CES) 20067, which is a prescriptive specification for natural gas composition. The Wobbe index must be between 1300 and 1377 as measured by ASTM D 3588.	83.8	Engine no longer produced.
	L10 Phase 2	5	0.1%			Engine no longer produced.
	L10 Phase 3	618	18.3%	Cummins Engineering Standard (CES) 14604. The methane number based on SAE 922359 must not be below 80 and the higher heating value must not be below 975 BTU/scf.	80	Engine no longer produced.
	B5.9G	95	2.8%			Engine no longer produced.
	C8.3G	173	5.1%			Engine no longer produced.
	B+5.9G	26	0.8%	Cummings Engineering Standard (CES) 14608. The methane number based on SAE 922359 must not be below 65 and the lower heating value must not be below 18,800 BTU/lbm.	65	-
	C+8.3G	158	4.7%			-
Detroit Diesel	50G (manufactured from 1994 through September, 1998)	1	0.0%	Detroit Diesel provided a prescriptive specification for natural gas composition. The Wobbe index must be between 1290 and 1380 as measured by ASTM D 3588.	83.7	Engine no longer produced.
	50G (manufactured from October, 1998 through September, 2002)	1,695	50.1%			Engine no longer produced.
	50G (manufactured after September, 2002)	76	2.2%			-
John Deere	6068H	15	0.4%	John Deere provided a minimum Motor Octane number of 118.	72.5	Engine no longer produced.
	6081H	403	11.9%			Discussions with John Deere indicate the 6081-HFN04 engine currently in production can operate on a minimum Octane number of 116 (implies a minimum Methane Number of 69.3).
All		3,346	99.0%	-	-	-

[1] Minimum methane number was calculated, if not explicitly specified, using "worst case" gas composition data from the manufacturer fuel requirements.

Exhibit 3



Southern California CNG Heavy-Duty Engine Demographics
(Makes and models unable to operate on sub MN 73 natural gas, per existing fuel specifications)
Engine Count
3,000
2,500
2,000
1,500
1,000
500
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year
Cummins - L10 Phase 2
Detroit Diesel - 50G Series (Oct 2002 to present)
Cummins - L10 Phase 1
Cummins - B5.9G
Cummins - C8.3G
Cummins - L10 Phase 3
Detroit Diesel - 50G Series (Oct 1998 through Sep 2002)

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a copy of the foregoing **COMMENTS OF SAN DIEGO GAS & ELECTRIC COMPANY (U 902 G) AND SOUTHERN CALIFORNIA GAS COMPANY (U 904 G) ON NATURAL GAS QUALITY ISSUES** on all known interested parties of record in R.04-01-025 by electronic mail a copy thereof properly addressed to all parties included on the list appended to the original document filed with the Commission.

Dated at Los Angeles, California, this 11th day of February, 2005.

Becky Roberts

Becky Roberts

S:LAW/DATA/DGILMORE/R.04-01-025 (GAS OIR)/COMM-NATLGAS-2.11.05