Report No. SR2009-10-01

Effects of Gas Composition on Emissions from Heavy-Duty Natural Gas Engines

prepared for:

Southern California Gas Company

October 12, 2009

prepared by:

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1. EXECUTIVE SUMMARY

As is the case with other transportation fuels, changes in the composition of natural gas can impact motor vehicle engine performance and emissions. As a result, the California Air Resources Board (CARB) adopted regulations in March 1992 specifying the composition of compressed natural gas (CNG) used to fuel motor vehicles.[1][*] The CARB CNG motor vehicle fuel regulations are prescriptive in nature and set minimum and maximum levels of various components of natural gas (methane, ethane, propane, etc.). This differs from the standard currently used by CNG engine manufacturers that use a single performance-based standard known as the Methane Number (MN). The Southern California Gas Company (SoCalGas) and San Diego Gas & Electric Company (SDG&E) have recommended that the CARB CNG motor vehicle regulations be changed from the current prescriptive specification to a performance-based MN specification.

In order to assess the potential impact of the recommended changes to the CARB CNG motor vehicle regulations, SoCalGas and SDG&E conducted an engine testing program involving heavy-duty CNG engines that collected exhaust emissions data using a range of natural gas fuels. The goal of the testing program was to evaluate emissions performance as a function of natural gas quality. The data obtained from the testing program were analyzed using statistical methods and the analysis identified statistically significant relationships between MN, Wobbe Index (WI), and engine emissions, with MN generally having a greater effect on emissions than WI.

The relationships identified between MN, WI, and engine emissions were used to perform a theoretical assessment of the natural gas composition effects on emissions from CNG vehicles in the SoCal Gas and SDG&E service territories.[†] A key element in this assessment was the development of a complete list of all heavy-duty CNG engines in operation throughout Southern California that allowed quantification of the potential emissions impact from each CNG engine make and model in operation in the area.

The theoretical assessment of natural gas composition effects covered the years 2008 through 2018 and assumed that all gas used to fuel CNG vehicles was at the lowest allowable MN and highest allowable WI values under (a) the current CARB CNG motor vehicle fuel regulations and (b) the performance-based CNG composition regulation proposed by SoCalGas and SDG&E. These assumptions were made simply to establish the absolute limit of natural gas composition impacts that could theoretically occur in

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[*] Superscripted numerals denote references provided in Section 7.

[†] The combined service territory of both SoCalGas and SDG&E covers all or a significant portion of 13 California counties.

relation to current CNG composition. These assumptions were not intended to represent gas supply forecasts or to predict actual emissions under the current CARB CNG motor vehicle regulations or the performance-based regulation proposed by SoCal Gas and SDG&E.

As shown in Tables 1-1 and 1-2 for 2008 and 2018, respectively, the CNG composition assessment found—based on a theoretical assumption that natural gas has the lowest allowable MN and highest allowable WI values under the CARB CNG motor vehicle fuel regulation and the performance-based regulation proposed by SoCal Gas and SDG&E—that emissions of the ozone precursors non-methane hydrocarbons (NMHC) and oxides of nitrogen (NOx) from natural gas vehicles would be slightly higher than they are at present. In addition, the results show that the maximum theoretical increase in NMHC and NOx emissions under the current CARB CNG motor vehicle fuel regulation is larger than the maximum theoretical increase in NMHC and NOx emissions under the performance-based regulation proposed by SoCalGas and SDG&E. Finally, the results show that the magnitude of the theoretical impacts decline over time due to projected changes in the make and model of CNG engines in operation.

Table 1-1
Maximum Theoretical Change in 2008 NOx and NMHC Emissions
(Tons per Day)

County	Total NOx Inventory	NOx Change		Total NMHC Inventory	NMHC Change	
		Existing Reg[a]	Proposed Reg[b]		Existing Reg[a]	Proposed Reg[b]
San Diego	166	0.144	0.133	152	0.076	0.068
Los Angeles	482	0.346	0.325	336	0.381	0.340
Orange	136	0.067	0.062	117	0.085	0.076
Riverside	83	0.075	0.070	62	0.153	0.137
San Bernardino	91	0.019	0.018	72	0.038	0.034
Ventura	44	0.009	0.008	47	0.005	0.004
Santa Barbara	38	0.001	0.001	35	0.000	0.000
Kern	58	0.003	0.003	14	0.002	0.002
Kings	29	0.001	0.001	18	0.000	0.000
Tulare	45	0.016	0.014	45	0.015	0.013
Fresno	110	0.001	0.000	82	0.000	0.000
San Luis Obispo	21	0.001	0.001	23	0.001	0.001
Imperial	37	0.000	0.000	30	0.000	0.000
13-County Total	1340	0.683	0.636	1033	0.756	0.675

[a] MN = 72.4, WI = 1385.
[b] MN = 75, WI = 1385.

Table 1-2
Maximum Theoretical Change in 2018 NOx and NMHC Emissions
(Tons per Day)

County	Total NOx Inventory	NOx Change		Total NMHC Inventory	NMHC Change	
		Existing Reg[a]	Proposed Reg[b]		Existing Reg[a]	Proposed Reg[b]
San Diego	113	0.011	0.010	133	0.063	0.056
Los Angeles	330	0.050	0.045	277	0.350	0.312
Orange	95	0.060	0.055	102	0.075	0.067
Riverside	55	0.038	0.035	55	0.137	0.122
San Bernardino	66	0.007	0.006	65	0.026	0.023
Ventura	32	0.004	0.004	42	0.005	0.004
Santa Barbara	29	0.000	0.000	31	0.000	0.000
Kern	48	0.000	0.000	12	0.001	0.000
Kings	18	0.001	0.001	17	0.000	0.001
Tulare	31	0.008	0.007	42	0.013	0.012
Fresno	72	0.000	0.000	75	0.000	0.000
San Luis Obispo	15	0.000	0.000	21	0.001	0.000
Imperial	29	0.000	0.000	29	0.000	0.000
13-County Total	933	0.179	0.163	901	0.671	0.597

[a] MN = 72.4, WI = 1385.
[b] MN = 75, WI = 1385.

In summary, while the composition of future natural gas supplies in the SoCalGas and SDG&E service territory is not known, the assessment performed here shows that the performance-based regulations proposed by SoCalGas and SDG&E do not have the potential to increase emissions above the levels that could already occur under the existing CARB CNG motor vehicle fuel regulations.

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2. TECHNICAL SUMMARY

As is the case with other fuels, including gasoline and Diesel, changes in the composition of natural gas can impact engine performance and durability as well as cause changes in engine emissions. As a result of this, as is again the case with other fuels, industry standards and government regulations have been developed to specify the composition and properties of natural gas used as motor vehicle fuels. These include regulations adopted in March 1992 by the California Air Resources Board (CARB) specifying the composition of compressed natural gas used as commercial vehicle fuel[1] and in the emission certification of new vehicles and engines.[2]

The current CARB specifications for compressed natural gas sold commercially as a vehicle fuel and for use in new vehicle and engine certification are presented in Table 2-1. As shown, both the CARB certification and commercial fuel specifications set requirements in terms of required or allowed amounts of specific chemical compounds.

Table 2-1
CARB Certification and Commercial Specifications for Compressed Natural Gas Used as a Vehicular Fuel

Specification	Certification Fuel	Commercial Fuel[a]
Methane (mole %)	90.0 ± 1.0	88.0 (min)
Ethane (mole %)	4.0 ± 0.5	6.0 (max)
C_3 and Higher HC (mole %)	2.0 ± 0.3	3.0 (max)
C_6 and Higher HC (mole %)	-	0.2 (max)
Hydrogen (mole %)	-	0.1 (max)
Carbon Monoxide (mole %)	-	0.1 (max)
Oxygen (mole %)	0.5 (max)	1.0 (max)
Inert Gases ($CO_2 + N_2$)	3.5 ± 0.5 (vol. %)	1.5 – 4.5 (mole %)
Sulfur (ppmv)	-	16 (max)

[a] Commercial specifications include requirements for water, particulate matter, and odorant.

Because of their focus on chemical composition rather than natural gas performance characteristics, a number of parties have raised concerns about the lack of fuel supply flexibility provided by the CARB natural gas specifications.[3] Changes suggested to the CARB regulations have generally suggested that natural gas specifications should be cast in terms of performance metrics, foremost among these being MN and WI.[4]

The MN characterizes the propensity of a natural gas fuel to cause engine knock and is similar to the octane rating used to assess the potential of gasoline fuels to cause engine knock. MN can be calculated using equation 2-1 published by CARB:

$$MN = 1.624*(-406.14+508.04*H/C-173.55*H/C^2+20.17*H/C^3)-119.1 \qquad \text{(Eq. 2-1)}$$

where H/C is the ratio of reactive hydrogen atoms in the gas to carbon atoms in a mole of the gas. For example, the value of H/C for a gas that is composed of 90 mole % methane and 10 mole % ethane is 3.82 ((4*0.9+6*0.1)/(1*0.9+2*0.1)) and the MN value for this fuel would be 86.

As noted by CARB staff, with respect to natural gas used as vehicular fuels, the WI characterizes the gas with respect to its energy content and the impact that the gas would have on air-fuel ratio in an engine that does not use a closed-loop fuel control system. The WI is computed by dividing the higher heating value of the gas in units of British thermal units per standard cubic foot (Btu/SCF) by the square root of the specific gravity of the gas.

It should be noted that the MN and WI metrics are expected to be related to some degree given their relative dependencies on the specific hydrocarbon molecules and their concentrations in the natural gas being characterized. As shown by Equation 2-1, MN decreases as the number of carbon atoms present in a molecule or the number of double or triple carbon to carbon chemical bonds increases. In contrast, the higher heating value of hydrocarbons tends to increase with the number of carbon atoms.

Suggested changes to the CARB natural gas specifications vary, but generally include a minimum MN of approximately 70 and a maximum WI of approximately 1400. To put these values into perspective, it is possible to assess the approximate MN and WI values for fuels that comply with the CARB certification and commercial specifications. Given the allowable variations in the CARB certification fuel specification, there is a range of MN and WI values for compliant fuels. If one assumes that the specified values are achieved and that all of the C_3 and higher compounds are propane, the MN of the CARB certification fuel is 89. If one makes the same assumptions and further assumes that all of the inert gas present is nitrogen and that there is no oxygen in the fuel, the WI value of the CARB certification fuel is about 1320 Btu/SCF.

Similarly for the CARB commercial fuel specifications for natural gas, a gas that was pure methane would have a MN of 108 using Eq. 2-1 and a WI of 1357. At the other end of the commercial specifications, if one assumes the minimum allowable methane level, the maximum levels for ethane and $C_{3,}$ and higher hydrocarbons as propane, with the balance being nitrogen, the MN is 82 and the WI is 1354. However, because they are cast in broad compositional terms, CARB's commercial fuel specifications allow for a minimum MN value of approximately 72 and the WI is limited by the 1385 maximum value established by other regulations in California.[5] In addition, it should be noted that the MN and WI values of natural gas being used in California today vary considerably. For example, in a 2007 survey of natural gas samples taken throughout the Southern California Gas and San Diego Gas & Electric service territories, MN values were found to range from about 77 to 100, with WI values ranging from about 1135 to about 1385.

Based on the above, it is apparent that there is considerable variation in the characteristics of both natural gas allowed under the current CARB natural gas regulations and that being used in practice in California. In addition, it is clear that the characteristics of gas upon which heavy-duty natural gas engines are operating in California can differ substantially from that of the fuel used in the emissions certification of the engines. Given this, an important issue is what, if any, impact changes in gas characteristics have on emissions from existing and future natural gas engines.

To address this concern with respect to heavy-duty natural gas engines, Southern California Gas Company commissioned a study designed to collect emission test data suitable for use in investigating the relationships between natural gas composition and emissions. This test program, conducted by Southwest Research Institute (SwRI), involved emissions testing of five heavy-duty natural gas engines representative of those sold from the late 1990s through the present operating on test fuels spanning a wide range of MN and WI value; a report was then prepared that presented the results, details, and conclusions of the test program.[6]

The results of the statistical analysis of the data collected during the SwRI test program are illustrated in Tables 2-2 and 2-3. Table 2-2 presents the estimated percentage change in emissions of all the pollutants measured by SwRI for each engine during the testing program at the high and low ends of the range of MN and WI tested relative to operation on fuel meeting the CARB certification specifications. The results are also presented in order of engine age, with the oldest engine being on the left and the newest being on the right. Only those results where the changes in emissions are statistically significant at a 95% level of confidence are shown; results indicating a reduction in emissions relative to the CARB certification fuel are highlighted in blue. Table 2-3 presents the same results as Table 2-2, but cast in terms of changes in the rates of emissions relative to the CARB certification fuel, with the rate being expressed either in terms of grams, milligrams, or nanograms of pollutant emitted by the engine per brake-horsepower hour of work performed.

Table 2-2
Estimated Changes in Emissions with Changes in MN and WI Relative to MN89 WI 1333 CARB Certification Fuel
(% change relative to CARB certification fuel if statistically significant at 95% C.L.)

		1998 Cummins C Gas 275				1999 Detroit Diesel S50G TK				2005 John Deere 6081HFN04				2006 Cummins C Gas Plus 280				2007 Cummins ISL G 320			
		MN 78		MN 100		MN 75		MN 100		MN 75		MN 100		MN 75		MN 100		MN 75		MN 100	
Pollutant	Units	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI
		1363	1385	1302	1375	1353	1385	1302	1375	1363	1385	1302	1375	1363	1385	1302	1375	1363	1385	1302	1375
NOx	g/bhp-hr	11%	15%	-15%	-7%	9%	22%	-13%	N.S.	5%	5%	3%	4%	15%	20%	-15%	-4%	N.S.			
NMHC	g/bhp-hr	15%	18%	-20%	-15%	32%	36%	-28%	-15%	4%	4%	3%	3%	25%	28%	-22%	-12%	67%	63%	-55%	-68%
PM	g/bhp-hr	-13%	-12%	18%	22%	N.S.				N.S.				N.S.				51%	48%	-42%	-51%
THC	g/bhp-hr	-25%	-30%	34%	23%	-5%	-14%	9%	N.S.	-13%	-20%	16%	15%	-26%	-25%	21%	26%	N.S.			
CO	g/bhp-hr	28%	24%	-36%	-45%	7%	3%	-4%	-6%	N.S.				14%	13%	-12%	-14%	N.S.			
NO_2	g/bhp-hr	N.S.[a]				18%	21%	-16%	-4%	15%	14%	-12%	-15%	1%	10%	-6%	5%	N.S.			
CO_2	g/bhp-hr	Negligible (≤ ±1%)				Negligible (≤ ±1%)				N.S.				Negligible (≤ ±1%)				N.S.			
Benzene	mg/bhp-hr	Not Tested				N.S.				Not Tested				N.S.				N.S.			
1-3 Butadiene	mg/bhp-hr					58%	25%	-28%	-51%					N.D.				N.D.			
Ethylbenzene	mg/bhp-hr					N.S.								N.S.				N.S.			
Meta- & Para-Xylene	mg/bhp-hr					-67% (avg, all fuels)								N.S.				N.S.			
Ortho-Xylene	mg/bhp-hr					N.S.								N.S.				N.S.			
Acetaldehyde	mg/bhp-hr					657%	N.S.	-287%	-565%					49%	76%	-49%	N.S.	92%	86%	-75%	-92%
Formaldehyde	mg/bhp-hr					29660% (avg, all fuels)								N.S.				44% (avg, all fuels)			
Total PAH	mg/bhp-hr					N.S.								72% (avg, all fuels)				153% (avg, all fuels)			
Benzo(a)pyrene	ng/bhp-hr					N.S.								N.S.				N.S.			
Phenanthrene	ng/bhp-hr					-16%	-35%	26%	21%					-17%	17%	-8%	9%	-4%	-14%	7%	-25%

Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

[a] N.S. means that there was no statistically significant difference in emissions.

Table 2-3
Estimated Changes in Emissions with Changes in MN and WI Relative to MN89 WI 1333 CARB Certification Fuel
(change in physical units relative to CARB certification fuel where statistically significant at 95% C.L.)

Pollutant	Units	1998 Cummins C Gas 275				1999 Detroit Diesel S50G TK				2005 John Deere 6081HFN04				2006 Cummins C Gas Plus 280				2007 Cummins ISL G 320			
		MN 78		MN 100		MN 75		MN 100		MN 75		MN 100		MN 75		MN 100		MN 75		MN 100	
		LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI	LWI	HWI
		1363	1385	1302	1375	1353	1385	1302	1375	1363	1385	1302	1375	1363	1385	1302	1375	1363	1385	1302	1375
NOx	g/bhp-hr	0.25	0.33	-0.35	-0.16	0.08	0.19	-0.12	N.S.	0.06	0.06	0.05	0.05	0.23	0.31	-0.23	-0.06	N.S.			
NMHC	g/bhp-hr	0.05	0.06	-0.07	-0.05	0.16	0.18	-0.14	-0.08	0.00	0.00	0.00	0.00	0.04	0.05	-0.04	-0.02	0.06	0.05	-0.05	-0.06
PM	g/bhp-hr	-0.001	0.000	0.001	0.001	N.S.				N.S.				N.S.				0.002	0.002	-0.002	-0.002
THC	g/bhp-hr	-1.37	-1.64	1.86	1.29	-0.17	-0.51	0.33	N.S.	-0.39	-0.57	0.45	0.44	-0.92	-0.87	0.75	0.93	N.S.			
CO	g/bhp-hr	0.07	0.06	-0.10	-0.12	0.12	0.06	-0.07	-0.11	N.S.				0.03	0.03	-0.03	-0.03	N.S.			
NO_2	g/bhp-hr	N.S.[a].				0.07	0.08	-0.06	-0.02	0.02	0.02	-0.02	-0.02	0.00	0.02	-0.01	0.01	N.S.			
CO_2	g/bhp-hr	Negligible (≤ ±1%)				Negligible (≤ ±1%)				N.S.				Negligible (≤ ±1%)				N.S.			
Benzene	mg/bhp-hr	Not Tested				N.S.				Not Tested				N.S.				N.S.			
1-3 Butadiene	mg/bhp-hr					0.37	0.16	-0.18	-0.32					N.D.				N.D.			
Ethylbenzene	mg/bhp-hr					N.S.								N.S.				N.S.			
Meta- & Para-Xylene	mg/bhp-hr					-0.36 (avg, all fuels)								N.S.				N.S.			
Ortho-Xylene	mg/bhp-hr					N.S.								N.S.				N.S.			
Acetaldehyde	mg/bhp-hr					7.00	N.S.	-3.06	-6.02					0.76	1.18	-0.76	N.S.	1.43	1.34	-1.17	-1.44
Formaldehyde	mg/bhp-hr					+280 (avg, all fuels)								N.S.				+0.26 (avg, all fuels)			
Total PAH	mg/bhp-hr					N.S.								+1.86 (avg, all fuels)				+0.50 (avg, all fuels)			
Benzo(a)pyrene	ng/bhp-hr					N.S.								N.S.				N.S.			
Phenanthrene	ng/bhp-hr					-737	-1619	1221	985					-20197	20136	-9653	10145	-5148	-16759	7933	-29011

Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

[a] N.S. means that there was no statistically significant difference in emissions.

As shown in the tables, the impacts of changes in fuel specification generally vary from engine to engine and from pollutant to pollutant. This result also generally applied to pairs of engines designed to comply with the same emission standards. However, the statistical analysis did yield important results, key among which are those summarized below.

- Emissions of oxides of nitrogen (NOx), a key concern for heavy-duty engines, generally increase as MN decreases and as WI increases for the older engines tested. However, for the newest engine, the Cummins ISL G 320, which is designed to operate with a stoichiometric air-fuel ratio, there was no statistically significant relationship found between fuel composition and NOx emissions.
- For three of the five engines, there was no statistically significant relationship between PM emissions (another key factor for heavy-duty engines) and fuel composition. Further, for the two engines where statistically significant relationships were observed, the magnitude of the emission changes was small.
- Emissions of non-methane hydrocarbons (NMHC) increase as MN decreases.
- For those engines where emissions of non-regulated pollutants (including several compounds identified as toxic air contaminants) were measured, statistically significant relationships between fuel composition and emissions of non-regulated pollutants were, in general, not found. Of those relationships found between non-regulated pollutants and fuel composition, that for acetaldehyde was the most notable and showed that emissions of that compound increased with decreasing MN.

The results of the statistical analysis are also significant because the relationships between fuel composition and emissions that have been developed can be used to estimate the in-use emission impacts of changes in the composition of the fuel on which on-road heavy-duty natural gas engines operate. To accomplish this, however, data that define the population and usage patterns of heavy-duty natural gas vehicles operating in an area must be available in sufficient detail such that the fuel composition-emissions relationship for one of the five test engines can be assigned to each vehicle.

To assess the theoretical emission impacts associated with natural gas meeting the minimum allowable MN and maximum allowable WI requirements under the current CARB regulation as well as under revisions proposed by SoCalGas and SDG&E relative to gas with historical composition, an emission inventory analysis was performed. The emission inventory evaluation involved use of the engine-specific relationships from the statistical analysis, historical and theoretical natural gas fuel properties, and extremely detailed information regarding the make, model, and application of all heavy-duty CNG engines within the service territory. Key features of the emission inventory analysis are outlined below.

- Analysis period: Eleven years were analyzed, from 2008 through 2018.

- Pollutants: Six pollutants were quantified (methane, THC, NMHC, CO, NOx, and PM).

- Seasonal basis: Inventories were reported on annualized tons per day basis.

- Counties: Fresno, Imperial, Kern, Kings, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Tulare, and Ventura counties were evaluated.[*]

- CNG applications: Five distinct heavy-duty CNG applications were modeled—transit bus, school bus, street sweeper, solid waste collector, and other.

- Inventory methods: Activity levels and inventory calculation methods were those of CARB models (e.g., EMFAC2007) and other CARB references.

Additional assumptions for the inventory analysis are summarized below.

1. Unit work conversion factors (to convert emission factors from g/bhp-hr to g/mi) were taken from the 2008 update to the Carl Moyer Program guidelines.[7] These are specific to the applications of HHD transit buses, all other HHD applications, and all MHD applications.

2. An in-use factor adjustment was applied to account for the difference in typical in-use operation of each CNG application in each county versus operation based on standard reference conditions (e.g., those used in the SwRI test program). The in-use adjustment values applied (expressed as a unitless multiplier) were estimated from equivalent Diesel data because insufficient CNG data exist for this inventory correction. In-use operation characteristics for transit buses, school buses, and other MHD and HHD applications were those of the EMFAC2007 model for the specific county and calendar year being modeled. In-use operation characteristics for solid waste hauler and street sweeper applications were those from recent CARB regulatory support evaluations because these two applications are not distinctly modeled in EMFAC2007.[8,9]

3. Application-specific activity levels were taken from EMFAC2007 (for transit buses, school buses, and other MHD and HHD applications) and represent year-specific and county-specific values. Activity levels for solid waste hauler and street sweeper applications were also taken from CARB.

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[*] For Los Angeles, San Bernardino, and Riverside Counties, reported results include only the portion of the county within the South Coast Air Quality Management District; for Kern County, reported results include only the portion of the county within the Kern County Air Pollution Control District.

The total anthropogenic inventory for each county and district was also collected from CARB. This inventory represents all man-made emissions and was obtained to provide context for the magnitude of any emissions change estimated for the on-road heavy-duty CNG-fueled fleet. For the on-road portion of the anthropogenic inventory, these data were estimated using the EMFAC2007 model noted previously. For the remaining sources, the information was obtained from the CARB's "2009 Almanac Emission Projection Data" available on the CARB website.[*] The 2009 Almanac provides estimates for years 2008, 2010, 2015, and 2020. For years falling between the reported years, interpolation was used to estimate inventories for all years 2008 through 2018, inclusive.

As shown in Tables 2-4 and 2-5 for 2008 and 2018, respectively, the results of the CNG composition assessment show—based on a theoretical assumption that natural gas has the lowest allowable MN and highest allowable WI values under the CARB CNG motor vehicle fuel regulation and the performance-based regulation proposed by SoCal Gas and SDG&E—that emissions of the ozone precursors non-methane hydrocarbons (NMHC) and oxides of nitrogen (NOx) from natural gas vehicles would be slightly higher than they are at present.

Table 2-4
Maximum Theoretical Change in 2008 NOx and NMHC Emissions
(Tons per Day)

County	Total NOx Inventory	NOx Change		Total NMHC Inventory	NMHC Change	
		Existing Reg[a]	Proposed Reg[b]		Existing Reg[a]	Proposed Reg[b]
San Diego	166	0.144	0.133	152	0.076	0.068
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Riverside	83	0.075	0.070	62	0.153	0.137
San Bernardino	91	0.019	0.018	72	0.038	0.034
Ventura	44	0.009	0.008	47	0.005	0.004
Santa Barbara	38	0.001	0.001	35	0.000	0.000
Kern	58	0.003	0.003	14	0.002	0.002
Kings	29	0.001	0.001	18	0.000	0.000
Tulare	45	0.016	0.014	45	0.015	0.013
Fresno	110	0.001	0.000	82	0.000	0.000
San Luis Obispo	21	0.001	0.001	23	0.001	0.001
Imperial	37	0.000	0.000	30	0.000	0.000
13-County Total	1340	0.683	0.636	1033	0.756	0.675

[a] MN = 72.4, WI = 1385.
[b] MN = 75, WI = 1385.

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[*] See http://www.arb.ca.gov/app/emsinv/emssumcat.php.

Table 2-5
Maximum Theoretical Change in 2018 NOx and NMHC Emissions
(Tons per Day)

County	Total NOx Inventory	NOx Change		Total NMHC Inventory	NMHC Change	
		Existing Reg[a]	Proposed Reg[b]		Existing Reg[a]	Proposed Reg[b]
San Diego	113	0.011	0.010	133	0.063	0.056
Los Angeles	330	0.050	0.045	277	0.350	0.312
Orange	95	0.060	0.055	102	0.075	0.067
Riverside	55	0.038	0.035	55	0.137	0.122
San Bernardino	66	0.007	0.006	65	0.026	0.023
Ventura	32	0.004	0.004	42	0.005	0.004
Santa Barbara	29	0.000	0.000	31	0.000	0.000
Kern	48	0.000	0.000	12	0.001	0.000
Kings	18	0.001	0.001	17	0.000	0.001
Tulare	31	0.008	0.007	42	0.013	0.012
Fresno	72	0.000	0.000	75	0.000	0.000
San Luis Obispo	15	0.000	0.000	21	0.001	0.000
Imperial	29	0.000	0.000	29	0.000	0.000
13-County Total	933	0.179	0.163	901	0.671	0.597

[a] MN = 72.4, WI = 1385.
[b] MN = 75, WI = 1385.

In addition, the results show that the maximum theoretical increase in NMHC and NOx emissions under the current CARB CNG motor vehicle fuel regulation is larger than the maximum theoretical increase in NMHC and NOx emissions under the performance-based regulation proposed by SoCalGas and SDG&E. Finally, the results show that the magnitude of the theoretical impacts decline over time due to projected changes in the make and model of CNG engines in operation.

In summary, while the composition of future natural gas supplies in the SoCalGas and SDG&E service territory is not known, the assessment performed here shows that the performance-based regulations proposed by SoCalGas and SDG&E do not have the potential to increase emissions above the levels that could already occur under the existing CARB CNG motor vehicle fuel regulations.

###

3. REVIEW OF SWRI TEST PROGRAM

Because of the direct relation between the design and execution of the SwRI test program and the statistical analysis performed on the collected data, a summary of that program is provided in this section. For a detailed description of the SwRI test program, the reader is referred to reference 6.

3.1 Test Engines

Five heavy-duty natural gas engines with high sales were procured for testing at SwRI. The test engines and their basic technical specifications are summarized in Table 3-1. As shown, the test engines ranged in vintage from the 1998 to the 2007 model year. All of the engines except the 2007 model year ISL G 320 were designed to operate as lean-burn engines. The ISL G 320 was designed to operate with a stoichiometric air-fuel ratio. The test engines all displaced between 8 and 9 liters, with power ratings of between 275 and 320 horsepower.

Table 3-2 summarizes the certification emission standards and reported certification emissions levels for each engine during the CARB new engine certification process.* As shown, the S50G TK and C Gas 275 engines were certified to the same emission standards and had similar certification emission levels. Similarly, the John Deere and C Gas Plus engines were certified to the same standards and generally had the same certification emission levels—the one exception was the certification CO emission level for the John Deere engine, which was very low. It should be noted that the John Deere and C Gas Plus engines were certified to a combined NOx+NMHC emission standard and that the certification NOx+NMHC levels of these engines were approximately 40% below those of the older engines. Finally, the ISL G 320 engine was certified to the 0.2 g/bhp-hr NOx emission standard and had dramatically lower emissions of NMHC and NOx than the other engines.

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* The CARB certification documents for each engine can be found in Appendix A of the SwRI report (reference 6).

Table 3-1
Test Engines – Basic Characteristics

	Detroit Diesel S50G TK	Cummins C Gas 275	John Deere 6081HFN04	Cummins C Gas Plus 280	Cummins ISL G 320
Model Year	1999	1998	2005	2006	2007
Displacement (l)	8.5	8.3	8.1	8.3	8.9
Rated Power (hp)	275	275	280	280	320
Rated Torque (ft-lb)	890	750	900	850	1000
Design	lean-burn	lean-burn	lean-burn	lean-burn	stoichiometric

Table 3-2
Test Engines – FTP Emission Standards and Certification Emission Levels (g/bhp-hr)

Pollutant	Detroit Diesel S50G TK	Cummins C Gas 275	John Deere 6081HFN04	Cummins C Gas Plus 280	Cummins ISL G 320
NOx	2.5 (2.2)	2.5 (2.2)	-	-	0.2 (0.1)
NMHC	1.2 (0.6)	1.2 (0.5)	-	-	0.14 (0.13)
NOx+NMHC	- (2.8)	- (2.7)	1.8 (1.5)	1.8 (1.7)	- (0.23)
CO	15.5 (2.4)	15.5 (1.0)	15.5 (0.1)	15.5 (1.3)	15.5 (1.2)
PM	0.05 (0.01)	0.05 (0.02)	0.01 (0.01)	0.01 (0.01)	0.01 (0.009)

The emission control characteristics of the test engines are summarized in Table 3-3. As shown, all of the engines were electronically controlled, used closed-loop feedback air/fuel ratio control, were turbocharged, and had charge air coolers. In addition, all engines except the C Gas 275 engine had adaptive learning capability with respect to air-fuel ratio control. As noted above, the ISL G 320 engine was designed for stoichiometric operation and therefore was equipped with a three-way catalyst system. The ISL G 320 engine was also the only engine with an exhaust gas recirculation (EGR) system. Three other engines—C Gas 275, John Deere, and C Gas Plus—were equipped with oxidation catalysts, while the S50G TK had no catalyst.

Table 3-3
Test Engines – Emission Control Systems Characteristics

	Detroit Diesel S50G TK	Cummins C Gas 275	John Deere 6081HFN04	Cummins C Gas Plus 280	Cummins ISL G 320
Closed-Loop	X	X	X	X	X
Electronic Control	X	X	X	X	X
Adaptive A/F	X	-	X	X	X
EGR	-	-	-	-	X
Turbocharger	X	X	X	X	X
Charge cooling	X	X	X	X	X
Oxidation catalyst	-	X	X	X	-
Three-way catalyst	-	-	-	-	X

As discussed below, the emission test results for each engine were analyzed separately. However, the data were also analyzed for the following three engine groups, defined by certification emission standards, certification emission levels, and emissions control system characteristics:

- Group 1: S50G TK and C Gas 275;
- Group 2: John Deere and C Gas Plus; and
- Group 3: ISL G 320.

Because it is common practice to combine results from engines (or vehicles) of similar vintage, emission levels, and emission control systems for purposes of developing emission factors or assessing fuel composition, engine grouping (e.g., Groups 1 and 2) was performed to determine the impact of this effects on the results of the statistical analysis.

3.2 Test Fuels

The experimental fuel composition matrix consisted of blends of methane, ethane, propane, and nitrogen varied to achieve target levels of MN and WI. The eight fuels used in each test engine and the design targets for MN and WI were as follows:

- One test fuel of MN 89 and WI 1330 that complied with the CARB certification fuel specifications;

- A series of three test fuels of MN 75, 80, and 100 having “low WI values” for those MN values (e.g., higher nitrogen concentrations);

- A series of three test fuels of MN 75, 80, and 100 having "high WI values" for those MN values (e.g., lower nitrogen concentrations); and

- One test fuel of MN 100 with a "mid WI value."

It should be noted that the C Gas 275 engine was not tested with MN 75 fuel but rather with MN 78 fuel at high and low WI values. The target MN, WI, and compositions of all of the test fuels are presented in Table 3-4.

The suite of test fuels used in each of the test engines were blended at the time each engine was installed for testing at SwRI. Therefore, there were minor variations in the test fuels used in each engine. Figure 3-1 shows the MN and WI values for all of the actual test fuels. Also shown are upper and lower boundary lines, which are empirical trends drawn to emphasize the intent of the experiment to bracket a relatively wide range of MN and WI values. Note that the MN 89 fuels that comply with the CARB certification fuel specifications (CARB cert) can be viewed (at least approximately) as having a low WI value.

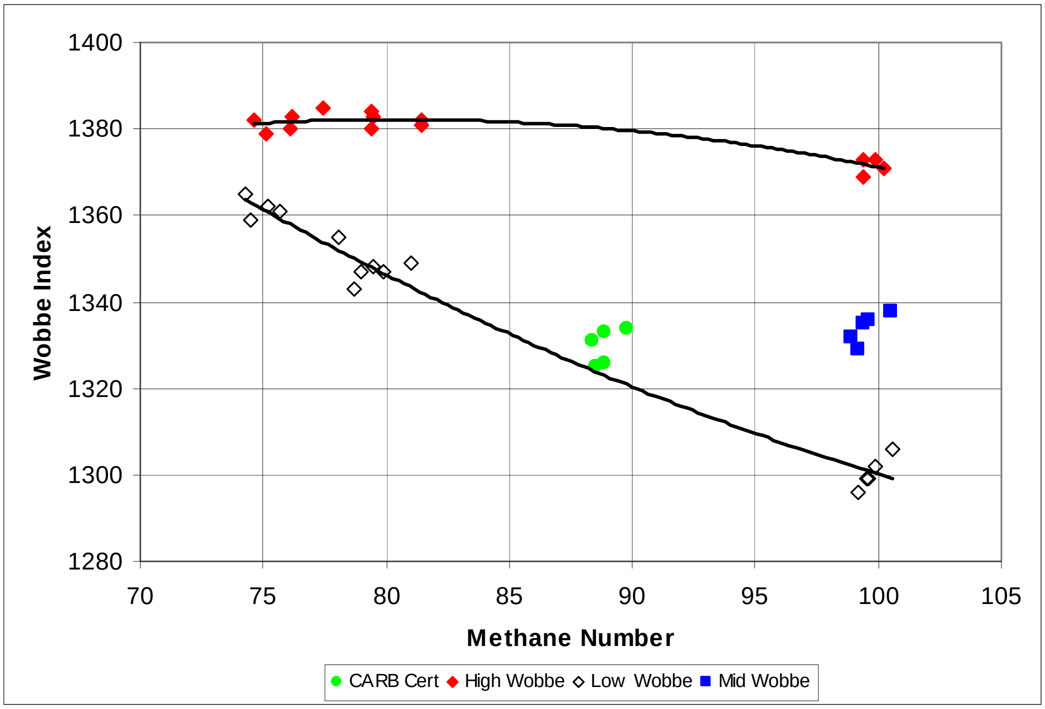
Table 3-4
Target Test Fuel MN and WI values and Target Compositions

MN Target	75		78[a]		80		89	100		
WI Target	Low 1363	High 1385	Low 1353	High 1386	Low 1347	High 1385	1333	Low 1302	Mid 1337	High 1375
Methane (vol%)	85.3	86.5	87.1	88.8	88.3	90.3	90.5	93.7	95.6	97.7
Ethane (vol%)	4.6	4.6	3.2	3.2	2.2	2.2	4.0	1.5	1.5	1.5
Propane (vol%)	6.1	6.2	5.7	5.8	5.5	5.7	2.0	0.8	0.8	0.9
Nitrogen (vol%)[b]	4.0	2.7	4.0	2.2	4.0	1.9	3.5	4.0	2.1	0.0

[a] MN 78 test fuel used only with C Gas 275 engine in lieu of MN 75 test fuel.

[b] Note that in practice limits are placed on the total diluents that can be contained in natural gas transported over interstate pipeline systems. For example, El Paso Interstate Pipeline Tariff Rule 5 provides that natural gas shall not at any time contain in excess of three percent (3%) total diluents (the total combined carbon dioxide, nitrogen, helium, oxygen, and any other diluent compound) by volume, with certain limited exceptions.

Figure 3-1
Test Fuel MN and WI Values



3.3 Emissions Testing

The emission testing program is discussed in detail in reference 6. In summary, each engine was subjected to one cold start and three hot start heavy-duty transient FTP* emission tests on each of the test fuels. Composite FTP results were computed using the cold-start emission result and the average of the three hot starts with the normal 1/7 cold start, 6/7 hot start weighting. A specific protocol was used after switching from one test fuel to another to ensure that there was an opportunity for adaptive air fuel ratio control learning to occur and to ensure proper engine performance on the test fuel.

Emissions results were reported for the following pollutants:

- Total hydrocarbons (THC);
- Non-methane hydrocarbons (NMHC);
- Carbon monoxide (CO);
- Oxides of nitrogen (NOx);
- Nitrogen dioxide (NO_2); and
- Particulate matter (PM).

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* Transient FTP testing was performed according to the procedures for heavy-duty on-highway engines specified in Code of Federal Regulations, Title 40, Part 86, Subpart N.

Also measured by SwRI were carbon dioxide (CO_2) emissions and brake specific fuel consumption.

In addition to the above, SwRI conducted measurements of speciated exhaust hydrocarbons, carbonyl compounds, and polycyclic aromatic hydrocarbons (PAHs). These measurements were made only on the S50G TK, C Gas Plus, and ISL G 320 engines.

###

4. STATISTICAL ANALYSIS OF SWRI PROGRAM DATA

4.1 Overview

As noted above, the emissions testing dataset consists of one FTP composite result for each of the five engines and each of the eight test fuels. Given this, the data set is somewhat limited in size for use in regression analysis as there are two statistical coefficients (emissions slopes with respect to MN and WI) to be estimated from the eight data points for each engine and, therefore, only five degrees of freedom are provided for the residual. Under these conditions, care is required to avoid the problem of "over-fitting" the data. Further, the analytical situation is complicated, as discussed above, because the fundamental relationships between MN and WI lead to a degree of correlation of the two variables.

The linear correlation coefficient between MN and WI is -0.57, which represents a high degree of correlation but not to the degree that it precludes successful analysis of the data. Conventional regression analysis handles data in which correlations exist between the independent variables by identifying the portion of the variation in each variable that occurs independently of the other variable(s). However, this leads to larger standard errors for the estimated regression coefficients (known as variance inflation) than would be observed if there were no correlation between variables and reduces the effective explanatory power of the dataset.

Given the small size of the dataset for each engine, a preliminary analysis was conducted for NOx and NMHC emissions to determine how well the data would support the determination of emission slopes for both MN and WI using conventional regression analysis. The analysis indicated that the correlation between MN and WI was sufficiently strong, in at least some cases, to confound the determination of statistically significant effects for changes in emissions due to changes in MN and WI. In other words, the observed emissions changes could be attributed to either MN or to WI in models that contained only that fuel variable, but neither effect could be estimated with statistical significance (or with only weakened statistical significance) when both variables were included in the regression analysis. As a result, the dataset for each engine is not fully adequate for a conventional regression analysis to identify the separate contributions of MN and WI.

Given the above, a Principal Components Analysis (PCA) was employed to understand the degrees of freedom present in the fuels data. PCA is a well known, multivariate statistical technique[*] that has been previously applied to the analysis of fuel property effects on emissions from heavy-duty Diesel engines.[10,11,12]

4.2 Principle Components Analysis of the Test Fuels

For a dataset consisting of observations of N variables, PCA performs a *singular value decomposition* of the X matrix (of independent variables) to produce a slate of N eigenvectors and N eigenvalues. The most common form of PCA involves decomposition of the correlation matrix so that the resulting eigenvectors are normalized to a vector length of unity and the eigenvalues sum to N. In this decomposition, each eigenvector expresses one way in which the N variables are related to each other, and the eigenvalues measure how much of the variation in the dataset is associated with each eigenvector. Essentially, the correlations among the N variables are broken down into N differing patterns of variation that make up the overall relationship of variables in the dataset. PCA works on the basis of variables standardized to a mean of zero and standard deviation of one. If there are N variables, then the standardized variance in the dataset is also N.

When PCA is applied to an orthogonal dataset, the resulting eigenvectors reveal the experimental design. When PCA is applied to a non-orthogonal dataset, the eigenvectors reveal information on how the data were generated or sampled. The eigenvectors additionally provide a set of vector variables in which the data are orthogonal. The application of PCA to the dataset of 40 CNG fuels (8 target fuels produced 5 times for each of the 5 test engines) shows that three of the eigenvectors account for 99.9% of the variation present. The first two vectors are closely aligned with the design variables in this experiment, as explained below.

- Vector 1 represents the overall trend of MN and WI in the dataset and accounts for 65% of the variation among fuels. Figure 4-1 shows this trend line to correspond closely to the overall correlation of MN and WI in the data.

- Vector 2 represents the independent variation of WI at right angles to the overall MN/WI trend line as shown in Figure 4-1. This vector accounts for 27% of the variation among fuels.

- Vector 3 represents the substitution of ethane for propane and nitrogen during preparation of the test fuels at fixed ratios, with only a small effect on MN and essentially no effect on WI. This vector accounts for 8% of the fuel variation. Vector 3 is not shown in Figure 4-1 because its axis would be perpendicular to the page.

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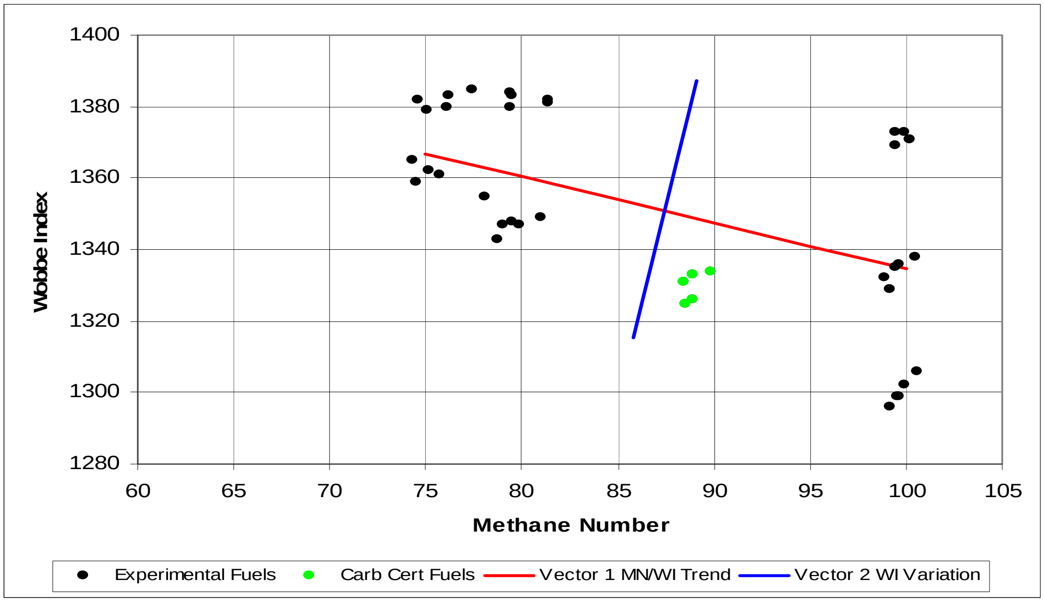
[*] See for example, Jackson, J.E., *A User's Guide to Principal Components*. Wiley Interscience. 1991.

Figure 4-1
Representation of Fuel Design Variables using PCA



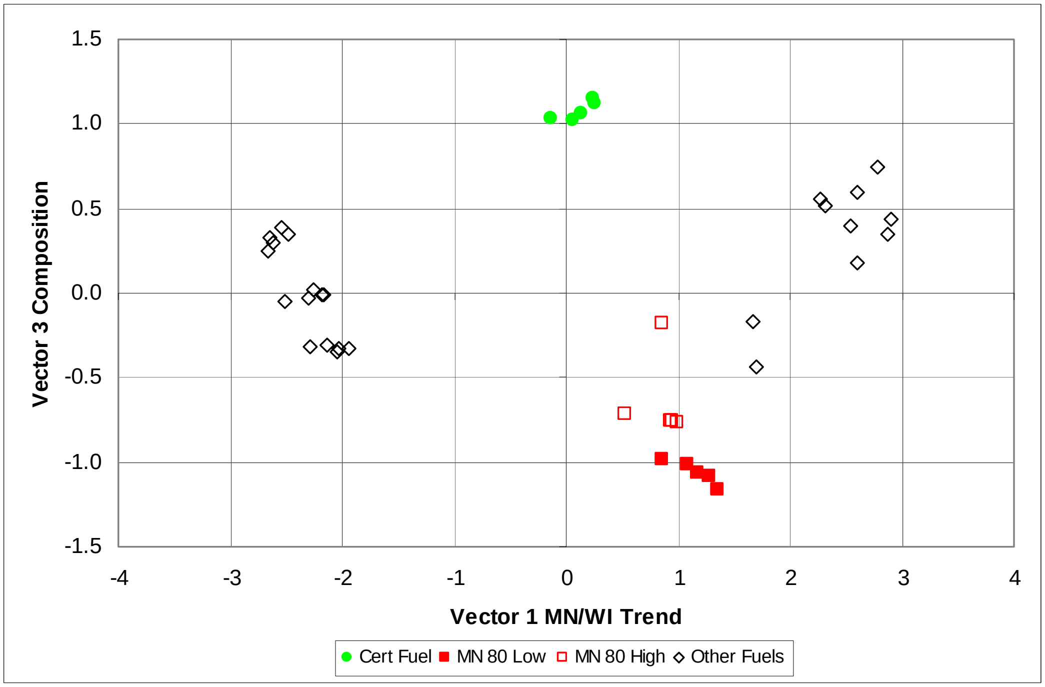
We interpret these vectors as reflecting important elements of the experiment design and the methods used in blending the fuels. Vector 1 represents the primary effect the experiment is designed to capture—the variation in MN in the range 75 to 100 with its associated variation in WI for the average fuel. Vector 2 represents an independent (and orthogonal) variation in WI among fuels away from the trend line representing the average fuel. Vector 3 represents a substitution that was used in fuel blending to trim MN values toward the specified targets without having an appreciable effect on WI.

Just as a fuel can be described by its MN and WI specifications, or by its hydrocarbon composition, the fuel can also be described by vector values ("scores") that quantify its expression of the eigenvectors. Because the first three vectors are sufficient to account for all of the systematic information in the fuels dataset, only three vector values are needed to define a fuel for analysis purposes. The procedure for computing fuel vector scores for any CNG fuel is documented in Appendix A. The scoring process is equivalent to locating each fuel numerically on the rotated axes seen in Figure 4-1 (and on the third axis that would be perpendicular to the page). Although the Vector 3 composition effect is present in the fuel composition data, that fact does not necessarily mean that it has an influence on engine emissions. A second preliminary analysis was conducted to test whether compositional effects could be detected in the data. The composition effect proved to be present for NOx emissions (as discussed in Section 5) for three of the engines, and it occurs for other pollutants as well. For NOx, the John Deere engine is most strongly affected, and its emissions were most often observed to be affected by the compositional effect. Given this, the composition effect appears to be engine specific and not a general fuel effect.

The Vector 3 composition effect is found to be associated with a tendency for emissions obtained using the MN89 fuel, which complied with the CARB certification fuel specification, to be offset from the lines otherwise formed by the experimental results. Because all the test fuels were blended at SwRI using the same high-purity source gases, there should be no reason why the MN 89 CARB certification fuels would be distinctive if the specifics of the composition dictated by the certification fuel specifications were not the causative factor.

Figure 4-2 shows the distribution of experimental test fuels in the parameter space defined by Vector 1 and Vector 3. The MN 89 CARB certification fuels are distinctive in having the highest Vector 3 composition effect, which is indicative of the shift toward ethane and away from propane and nitrogen dictated by the certification fuel specifications, compared to the average test fuel with comparable MN and WI. It happens that the neighboring MN 80 Low WI fuel has the lowest Vector 3 Composition effect (and some of the MN 80 High WI fuels are close). If an engine is sensitive to a departure of the ethane-propane-nitrogen ratio from the average, then emissions on the CARB certification fuel will be perturbed in one way and emissions on the MN 80 Low Wobbe fuel perturbed in the other way. This "kink" can be found in graphs of the experimental data in a number of cases.

Figure 4-2
Distribution of Test Fuels in the PCA Defined Vector Space



Because of the relatively small number of data points for each engine, care must be taken to avoid over-fitting the statistical models. The approach followed in this analysis was to fit linear regression models for the vector variables V1, V2, and V3, and then to reduce the models by dropping unnecessary terms based on statistical significance. The orthogonality of the vector variables is an important factor that allows this approach to be used. Because they are orthogonal (uncorrelated), the vector variables make best use of the available data without variance inflation.

Throughout the conduct of the analysis, attention has been given to the question of whether the third term (the Vector 3 composition effect) is a real effect present in the data, and not an artifact of over-fitting the data. In every instance where a statistically significant Vector 3 composition effect is identified, one can observe some offset of the results obtained using the MN CARB certification fuels from the other experimental fuels. Thus, Vector 3 is a real effect present in the data.

4.3 Form of the Statistical Analysis

As noted above, the statistical analysis involved fitting a linear regression model of the following form for each engine and pollutant:

$$\text{Emissions Impact} = A + B*V_1 + C*V_2 + D*V_3 \qquad \text{(Eq. 4- 1)}$$

where V_1, V_2, and V_3 are the vector scores associated with the three fuel eigenvectors described above and A, B, C, and D are the intercept term and emission slopes with respect to the fuel vectors. The models were then reduced to eliminate terms that were not statistically significant at the 90% confidence level.

The following pollutants were addressed in the statistical analysis:

- THC;
- NMHC;
- CO;
- NOx;
- NMHC+NOx;
- NO_2;
- PM;
- $CO_{2;}$
- Benzene;
- 1-3 Butadiene;
- Ethylbenzene;
- Meta- & Para-Xylene;
- Ortho-Xylene;
- Acetaldehyde;
- Formaldehyde;

- Total PAH;
- Benzo(a)pyrene; and
- Phenanthrene.

Again, the emission results analyzed were FTP composites based on the single cold start test and the average of three hot start tests weighted using factors of 1/7 and 6/7, respectively. The only exceptions were total PAH, benzo(a)pyrene, and phenanthrene, where emissions of these compounds were measured only during a single hot start test. It should again be noted that speciated exhaust emissions data were collected only for the ISL G 320, C Gas Plus, and S50G TK engines.

For most of the pollutants, the emissions impact variable was defined to be the percentage difference in emissions compared to the CARB certification fuel, i.e.:

$$\text{Emissions Impact} = E_{fuel} / E_{cert} - 1 \qquad \text{(Eq. 4-2)}$$

This choice was made so that the percentage changes estimated by the equations could be applied in varying circumstances where the use of a predicted absolute emission rate would be unhelpful. However, emissions of PM, total PAH, benzo(a)pyrene, and phenanthrene observed with the MN89 certification fuel were very low, so that computed percentage impacts could be subject to considerable uncertainty caused by poor precision in the denominator (i.e., the difficulty in measuring small quantities with high precision). For these pollutants, the emissions impact was defined as the change in emissions:

$$\text{Emissions Impact} = E_{fuel} - E_{cert} \qquad \text{(Eq. 4-3)}$$

Again, regression models of the form given by Equation 4-1 were estimated for each pollutant and engine. Terms shown to be statistically significant at the p=0.10 level (90% confidence) or better were retained in the model and used to assess emissions performance of the various fuels. The significance level was relaxed from the conventional choice of p=0.05 (95% confidence) to avoid dropping terms that clearly appeared to be present in graphical displays of the data, but which failed to achieve the p=0.05 level of significance (often just barely) due to the small dataset available for each engine.

The final regression models were evaluated for each of the test fuels using the target specifications, rather than the actual specifications realized in the testing. The choice to adjust predicted emissions to the target fuels places the comparisons on a consistent basis for all engines and removes the potential that small deviations from the test fuel targets could influence conclusions.

Two primary statistical tests were performed using the final regression models:

1. Emissions on each test fuel were compared to emissions on the CARB certification fuel, and a two-sided t-test was conducted to determine where

emissions on the test fuel were statistically different (increased or decreased) compared to the certification fuel at the 95% confidence level.

2. The models were evaluated for a series of fuels at integer steps in MN following the upper and lower trend lines in Figure 3-1. For each such fuel, a one-sided t-test was performed to determine if emissions on the fuel exceeded the applicable certification standard by a sufficient amount to achieve 95% statistical confidence. From this assessment, the MN level (for both Low and High WI fuels) was identified below (or above) which exceedance of the certification standard would be expected.

In assessing whether there would be an exceedance of certification emission standards, the predictive models were evaluated using only the Vector 1 and Vector 2 terms. At any given MN and WI, a large number of fuels are possible that differ in regard to hydrocarbon composition as measured by Vector 3. Because in-use effects will be determined by the average fuel at a given {MN,WI}, it is appropriate to set the value of Vector 3 to zero, after having determined values for Vectors 1 and 2 that match the {MN, WI} of interest. This is because PCA defines its vectors in such a way that the average fuel has vector values of zero, and the value of any vector can be set independently of the others.

Thus, whenever asking a question that is related to the effects that will occur under in-use conditions—and not directly related to the measurements made in the testing program—it is appropriate to set the Vector 3 Composition effect to zero. By doing so, the vector formulation represents an average fuel of the given MN and WI. This has been done both for assessing the potential for exceedance of the applicable certification standards and in computing emission effects for the fuels considered in the inventory analysis.

The analysis was conducted initially, and primarily, for each of the five engines, which are treated individually for inventory analysis. Secondarily, the engines sharing common certification standards for NOx and NMHC were combined for a comparable analysis of certification groups that could be used in the inventory analysis to represent engine lines that were not tested. In general, the test data indicate that emissions performance is frequently engine-specific. In the absence of additional test data, however, the best estimate that can be made for other engines is that given by the combined analysis for the certification group. Because the engine datasets are small (N=2), formal statistical tests were not conducted to determine whether engine behavior was distinctive.

###

5. RESULTS OF THE STATISTICAL ANALYSIS

The results of the statistical analysis to establish relationships between pollutant emissions and the fuel vectors are summarized in this section. Results for NOx emissions are addressed first and in more detail than the results for other pollutants for two reasons: (1) the relative importance of NOx emissions from heavy-duty engines; and (2) use as an example regarding interpretation of the statistical results for other pollutants.

Detailed tabular presentations of the results for NOx, NMHC, NOx+NMHC, PM, THC, CO, NO_2, and CO_2 can be found in Appendix B. Similar tabulations for the selected speciated hydrocarbons and PAH can be found in Appendices C and D, respectively.

5.1 NOx Emissions

Figure 5-1 plots NOx emissions from five engines as a function of the MN of the test fuel. As shown, for all engines except the ISL G 320 there is a relationship between NOx emissions and MN, with emissions increasing as MN decreases. As shown, NOx emissions from the stoichiometric ISL G 320 engine do not change as either a function of MN or WI. For the Group 1 engines, there is relatively little difference in emissions using the low and high WI fuels. However, for the Group 2 engines (John Deere and C Gas Plus), the WI effects can begin to approach the MN number effect in size.

Table 5-1 summarizes the results of the statistical analysis for the five individual engines based on the three-vector regression model. The dependent variable is again emissions impact as defined in Equation 4-2. Except for the ISL G 320 engine, for which no statistically significant changes in emissions were observed, we find the following:

- All four engines demonstrate a statistically significant emissions effect ($p \leq 0.05$) for the Vector 1 MN/WI Trend.
- Three of the lean-burn engines, excluding the John Deere, demonstrate a statistically significant emissions effect ($p \leq 0.05$) for the Vector 2 WI Variation.
- Three of the engines, excluding the C Gas 275, demonstrate at least a marginally significant emissions effect ($p \leq 0.10$) for the Vector 3 Composition term, although it is statistically significant ($p \leq 0.05$) only for the C Gas Plus engine.

Figure 5-1
NOx Emissions

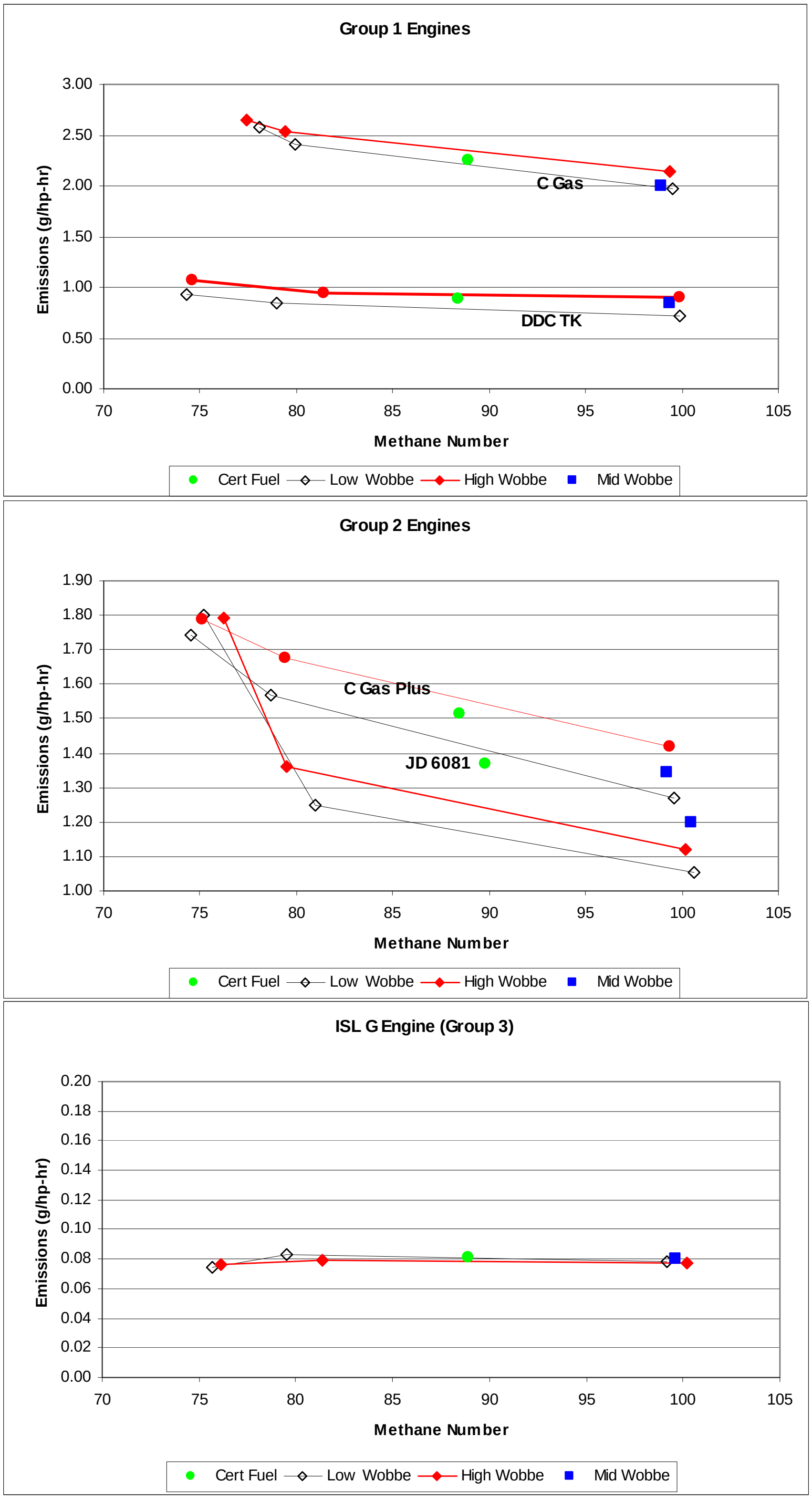


Table 5-1
NOx Emissions (g/hp-hr) by Engine
Model: $E/E_{cert} - 1 = A + B * \text{Vector 1} + C*\text{Vector 2} + D*\text{Vector 3}$

		C Gas 275	S50G TK	John Deere	C Gas Plus	ISL G 320
Statistical Analysis Results						
Model R^2		98.6%	93.3%	90.9%	99.8%	6.4%
Intercept		**0.0340**	0.0037	0.0096	**0.0150**	-0.0255
prob>|t|		0.00	0.80	0.74	0.01	0.09
Vector 1 (MN/WI Trend)		**0.0587**	**0.0325**	**0.0862**	**0.0538**	-0.0042
prob>|t|		0.00	0.01	0.00	0.00	0.55
Vector 2 (WI Variation)		**0.0272**	**0.0525**		**0.0313**	
prob>|t|		0.00	0.01		0.00	
Vector 3 (Composition)			0.0480	0.1069	**0.0137**	
prob>|t|			0.07	0.06	0.03	
Emissions Increase versus CARB Cert Fuel (95% Confidence)						
MN 75L		17%	9%	5%	15%	No statistically significant emissions changes detected
MN 75H		20%	22%	5%	20%	
MN 78L		11%	6%	3%	10%	
MN 78H		15%	17%	2%	15%	
MN 80L		7%			5%	
MN 80H		11%	13%		11%	
MN 100L		-15%	-13%	3%	-15%	
MN 100M		-12%		3%	-10%	
MN 100H		-7%		4%	-4%	
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (g/hp-hr)		2.50	2.50	NOx+NMHC	NOx+NMHC	0.20
Emissions on CARB Cert Fuel (g/hp-hr)		2.26	0.88	–	–	0.08
Increase to Reach Standard		11%	184%	–	–	150%
Standard Exceeded at Methane Number	Low WI	below 79	below 75	–	–	never
	High WI	below 82	below 75	–	–	never

Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

Intercept terms were estimated for each engine to account for any unexplained offset versus the CARB certification fuel, but these are small in all cases (± 3%) and their statistical significance is of no consequence.

Table 5-2 summarizes the range of emission effects for each fuel vector individually, which depends both on the estimated emissions slope (regression coefficient) and the full range of variation for the vector scores among the fuels (i.e., from lowest to highest values). For the four engines (excluding ISL G 320) with statistically significant emissions effects due to fuels, we find that NOx emissions increase (compared to the CARB certification fuel) by 8% to 21% for the values of Vector 1 that result in MN 75 fuels. Emissions decrease by 7% to 18% (compared to certification fuel) for the Vector 1 values that result in MN 100 fuels. These emission changes take place along the downward sloping Vector 1 axis found in Figure 4-1. The emissions effects estimated for the Vector 1 term represent the emission changes that would be expected for the otherwise average fuel within the experimental range, meaning the fuel located at a given point of MN and WI on the Vector 1 axis.

Table 5-2
Estimated Maximum Emissions Changes versus CARB Certification Fuel

Engine	Vector 1 MN/WI Trend		Vector 2 WI Variation		Vector 3 Composition	
	Low MN	High MN	Low WI	High WI	Low	High
C Gas 275	+14%	-12%	-8%	+4%	–	–
S50G TK	+ 8%	- 7%	-4%	+7%	- 4%	+ 5%
John Deere	+21%	-18%	–	–	-10%	+11%
C Gas Plus	+13%	-11%	-3%	+4%	- 1%	+ 1%
ISL G 320	-	-	–	–	–	–

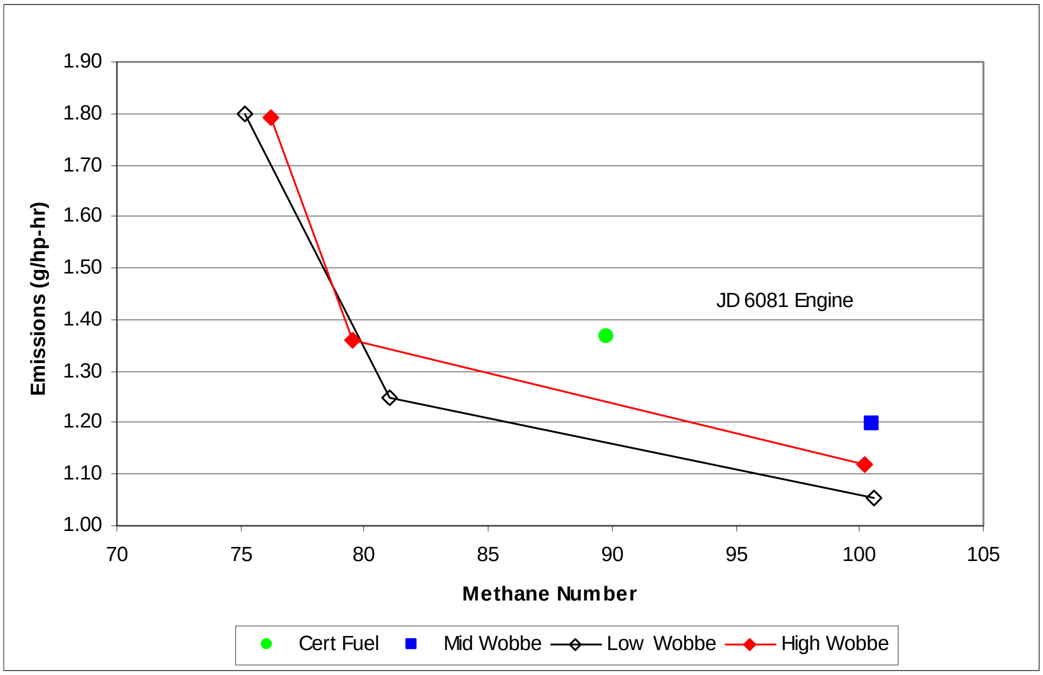
The effects of Vector 2 WI Variations are always smaller than the primary Vector 1 effect. The direction of the effect is that reducing WI below the Vector 1 trend line to its lowest values in the data (and lowest WI values) reduces NOx emissions by 3% to 8%, while increasing WI above the trend line increases NOx emissions by 4% to 8%. These emission changes take place along the upward sloping Vector 2 axis in Figure 4-1. Vector 1, and the MN/WI trend line it represents, exerts the primary effect on NOx emissions for the four engines, with WI variations away from this trend line having relatively smaller emissions effects across the full range of the experimental data.

The Vector 3 Composition effect is at least marginally significant for three of the Group 1 and 2 engines and is largest for the John Deere engine (although only marginally significant). Because this effect will re-occur at various points in the analysis, particularly for the John Deere engine, it is discussed here at some length. As explained in Section 4, the Vector 3 score represents a tradeoff between ethane content and propane/nitrogen content at essentially constant WI, with positive values for a fuel's Vector 3 score being associated with more ethane and less propane/nitrogen than the average fuel. The CARB certification fuels score highest on Vector 3, while all five adjacent MN 80 Low WI fuels and some of the adjacent MN 80 High WI fuels have the lowest scores.

The performance of some engines, and the John Deere in particular, appears to be sensitive to the ethane/propane/nitrogen composition difference represented by Vector 3. As seen in Figure 5-2 for the John Deere engine, the high Vector 3 value for the MN 89 CARB certification fuel appears to pull NOx emissions up, and the low Vector 3 values for the MN 80 Low and High WI fuels tends to push NOx emissions down, resulting in the "kink" that disturbs what might otherwise be a relatively straight line with MN. It is this effect that leads to the unexpected result that the CARB certification fuel lies outside the lines formed by the Low and High WI fuels. Such a result can be caused by the random variation in the experimental measurements, but it is observed a number of times in the data in regard to the certification fuel. The analysis indicates that sensitivity to the Vector 3 Composition effect is responsible for the empirical result that emissions on the CARB certification fuel sometimes do not lie within the boundaries formed by the Low and High WI fuels.

The statistical models summarized at the top of Table 5-1 were evaluated for the experimental fuels using the target fuel specifications in Table 3-4, rather than the specifications of the fuels as tested for each engine. Use of the targets, rather than actual

Figure 5-2
NOx Emissions from the John Deere Engine



fuel specifications as realized in the testing, removes the effect of somewhat varying fuels specifications by engine from the determination of emission changes relative to the MN89 CARB certification fuel. All terms in the statistical models were used, including the Vector 3 Composition effect, to estimate emissions as tested. A statistical test was then performed for each fuel to determine whether NOx emissions were significantly different ($p \leq 0.05$, 95% confidence) from emissions on the certification fuel. The statistically significant differences are tabulated in the middle portion of the table. In general, NOx emissions are increased on fuels with MN below that of the MN 89 CARB certification fuel, and decreased at higher MN numbers. The percentage change is largest for the C Gas 275, S50G TK and C Gas Plus engines, and is relatively small for the John Deere (where emissions changes are strongly affected by the ethane/propane composition).

The lower part of the table summarizes the determination of whether emissions from these engines may increase sufficiently within the MN/WI range tested such that emissions would be expected to exceed the applicable certification standard (with 95% confidence). This assessment, and similar assessments described below, was made only to illustrate the relative importance of emission increases associated with changes in fuel specifications. It has no meaning with respect to whether the engine would continue to meet the certification standards, as any direct comparison of engine emissions to the certification standards for engines operating on any fuel can be made only when the engine is operating on the appropriate certification fuel.

As shown in Table 3-3, the C Gas 275, S50G TK and ISL G 320 engines were certified to NOx emissions standards of 2.5 g/hp-hr (C Gas 275, S50G TK) and 0.20 g/hp-hr (ISL G 320). For these engines, the analysis finds the following:

- The C Gas 275 engine would exceed its NOx certification standard when MN is below 79 (Low WI) and when MN is below 82 (high WI).[*]

- The S50G TK engine would not exceed its NOx certification standard at any MN down to the minimum 75 value covered by the experiment. Exceedances would occur only at MN below 75.

- The ISL G 320 engine was found to be insensitive to fuel composition. Its emissions do not change with fuel specification, and varying fuel specifications will not lead to exceedance of its NOx standard.

A comparable analysis was also conducted for the engine groups, with the results summarized in Table 5-3. When grouped, neither Group 1 nor Group 3 engines would exceed their NOx certification standard within the MN 75-100 range of the data.

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[*] The MN thresholds (79 and 82) are cited as the lowest MN values that would not be expected to exceed certification standards with 95% confidence; exceedances would be expected only for lower MNs.

Table 5-3
NOx Emissions (g/hp-hr) by Certification Group
Model: E/E_{cert} - 1 = A + B * Vector 1 + C*Vector 2 + D*Vector 3

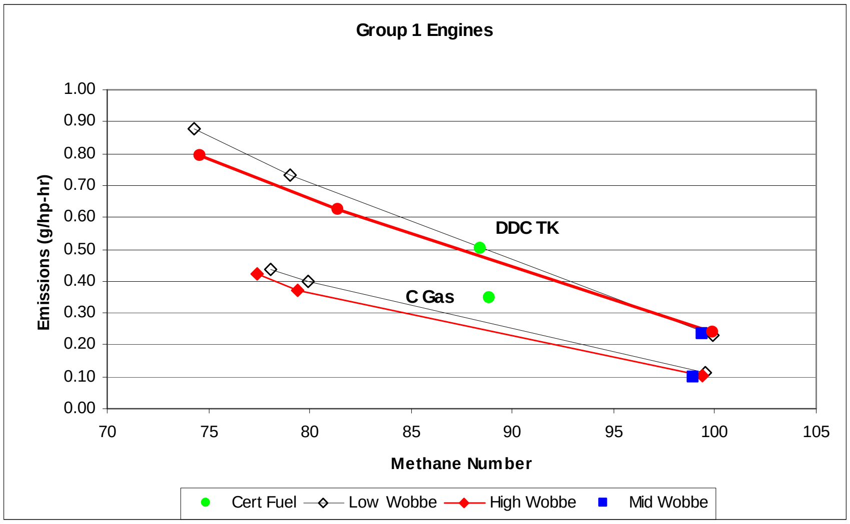
		Group 1: C Gas S50G TK	Group 2: John Deere C Gas +	Group 3: C ISL G
Statistical Analysis Results				
	Model R^2	83.3%	84.8%	6.4%
Intercept		0.0185	0.0066	-0.0255
	prob>|t|	0.15	0.72	0.09
Vector 1 (MN/WI Trend)		**0.0433**	**0.0697**	-0.0042
	prob>|t|	0.00	0.00	0.55
Vector 2 (WI Variation)		**0.0414**	0.0234	
	prob>|t|	0.00	0.14	
Vector 3 (Composition)			0.0546	
	prob>|t|		0.07	
Emissions Increase versus CARB Certification Fuel (95% Confidence)				
MN 75L		14%	17%	No statistically significant emissions changes detected
MN 75H		19%	26%	
MN 78L		9%	11%	
MN 78H		16%	15%	
MN 80L		6%		
MN 80H		14%		
MN 100L		-13%	-19%	
MN 100M		- 6%	-15%	
MN 100H				
Exceedance of Certification Standard (95% Confidence)				
Certification Standard (g/hp-hr)		2.50	NOx+NMHC	0.20
Emissions on CARB Cert Fuel (g/hp-hr)		1.57	1.44	0.08
Increase to Reach Standard		59%	–	150%
Standard Exceeded at MN	Low Wobbe	below 75	–	never
	High Wobbe	below 75	–	never

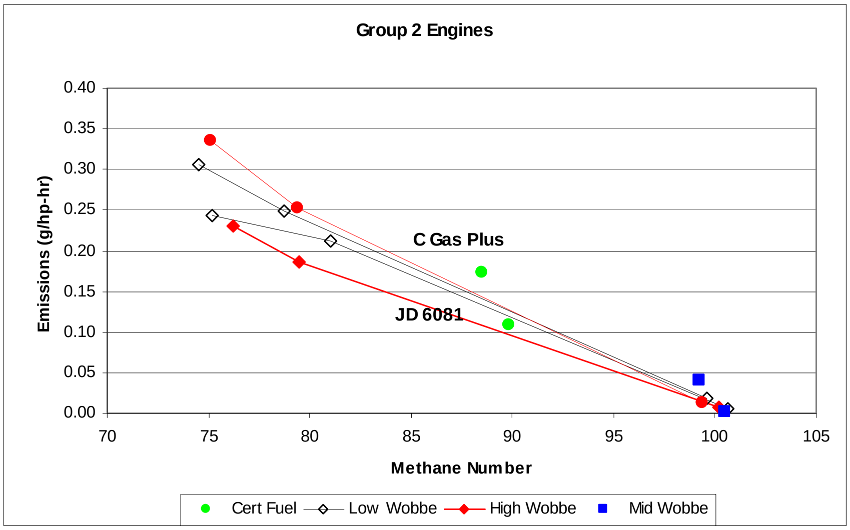
Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

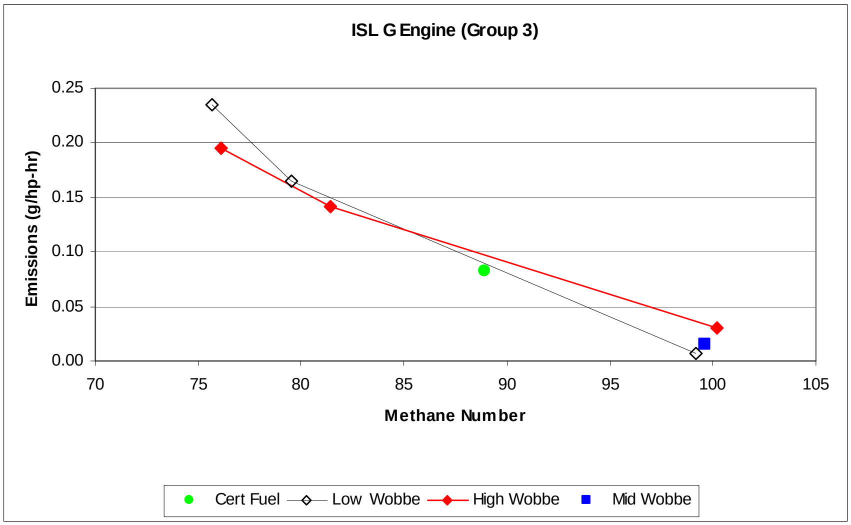
5.2 NMHC Emissions

Figure 5-3 shows the NMHC emissions of the five engines. Emissions are affected primarily by the MN/WI trend, with relatively little difference between the Low and High WI fuels. As indicated by the parallel slopes, all engines also appear to have similar sensitivity to fuels.

Figure 5-3
NMHC Emissions







The statistical analysis reported in Table B-5 of Appendix B finds that NHMC emissions are influenced by the Vector 1 MN/WI Trend and not by the Vector 2 WI Variation. There is marginal statistical evidence (p=≤0.10) that the C Gas 275, S50G TK, and John Deere engines are influenced by the compositional differences in the fuels represented by Vector 3 Composition.

Table 5-4 presents the estimated NMHC emissions changes relative to MN89 CARB certification fuel that are statistically significant at the 95% confidence level. Emissions increase as MN is reduced below the MN 89 average of the certification fuel, with the changes reaching 24-25% for the C Gas 275 engine, 32-36% for the S50G TK, 4% for the John Deere engine, 25-28% for the C Gas Plus engine, and 63-67% for the ISL G 320 engine (although measured from a very low base).

Table 5-4
Estimated NMHC Emissions Changes

		C Gas 275	S50G TK	John Deere	C Gas Plus	ISL G 320
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		24%	32%	4%	25%	67%
MN 75H		25%	36%	4%	28%	63%
MN 78L		15%	20%	3%	16%	42%
MN 78H		18%	26%	2%	20%	37%
MN 80L		9%	13%		10%	25%
MN 80H		12%	20%		15%	19%
MN 100L		-20%	-28%	3%	-22%	-55%
MN 100M		-18%	-22%	3%	-17%	-61%
MN 100H		-15%	-15%	3%	-12%	-68%
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (g/hp-hr)		1.20	1.20	NOx+NMHC	NOx+NMHC	0.14
Emissions on CARB Cert Fuel (g/hp-hr)		0.35	0.50	0.11	0.17	0.08
Increase to Reach Standard		244%	138%			71%
Standard Exceeded at Methane Number	Low WI	below 75	below 75	–	–	below 75
	High WI	below 75	below 75	–	–	below 75

Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

Only the C Gas 275, S50G TK, and ISL G 320 engines were certified to a separate NMHC standard. None of the engines would exceed their certification standard on any fuel within the range spanned by the testing. Exceedances would occur only below MN 75. The separate analysis by engine is reported in Table B-6 of Appendix B and the results are similar to those reported for the individual engines.

5.3 NOx+NMHC Emissions

Statistical analysis was performed for NOx+NMHC emissions because the Group 2 engines (John Deere and C Gas Plus) were certified on that basis. Complete results are summarized in Tables B-3 and B-4 of Appendix B; only selected results are discussed here.

The effect of fuel specification on NOx+NMHC emissions depends strongly (and significantly) on both the Vector 1 MN/WI Trend and Vector 2 WI Variation terms. For these engines, emissions are found to increase by 25-34% for MN 75 fuels, with low WI offsetting some of the emissions increase due to low MN. As shown in Table 5-5, the John Deere and C Gas Plus engines have relatively small margins between their emissions on CARB certification fuel and the applicable NOx+NHMC standard. Given this, emissions from the John Deere engine would exceed the NOx+NMHC standard when MN is below 76 (Low WI fuels) and when MN is below 75 (High WI fuels). The C Gas Plus engine would exceed its NOx + NMHC certification standard when MN is below 82 (Low WI fuels) and when MN is below 85 (High WI fuels).

When the two engines are combined to represent Engine Group 2, the results indicate that the standard would be exceeded for fuels with MN below 79, regardless of WI.

Table 5-5
Exceedance of NOx+NMHC Certification Standard
(95% Confidence)

		C Gas	S50G TK	John Deere	C Gas +	C ISL G
Certification Standard (g/hp-hr)		NOx	NOx	1.80	1.80	NOx x
Emissions on CARB Cert Fuel (g/hp-hr)		2.64	1.38	1.48	1.69	0.16
Increase to Reach Standard		–	–	22%	7%	–
Standard Exceeded at Methane Number	Low WI	–	–	below 76	below 82	–
	High WI	–	–	below 75	below 85	–

5.4 PM Emissions

The five engines tested emit very low levels of PM, both on an absolute basis and in relation to the applicable certification standard. The C Gas 275 and S50G TK engines were certified to a PM standard of 0.05 g/hp-hr, but emit only 0.004 g/hp-hr and <0.001 g/hp-hr, respectively, when tested on the MN 89 CARB certification fuel. The remaining three engines were certified to a lower standard of 0.005 gm/hp-hr, but PM emissions on the MN 89 certification fuel are never more than one-half the applicable standard.

Figure 5-4 shows the trends in PM emissions. Only the C Gas 275 engine exhibits evidence of emissions sensitivity to MN number, and only the C Gas Plus engine exhibits evidence of sensitivity to the difference between Low and High WI fuels. The ISL G 320 engine may have a small emissions slope with respect to MN, but it is not statistically significant.

The statistical analysis is reported in Table B-7 of Appendix B. Only the C Gas 275 engine demonstrates a statistically significant effect ($p \leq 0.05$) of fuel specification on emissions. For this engine, PM emissions are estimated to decrease by 21% (relative to the CARB certification fuel) at values of the Vector 1 MN/WI Trend that yield MN 75, and to increase by 22% at values of Vector 1 that yield MN 100. No other engine shows evidence of statistically significant changes in emission levels with respect to fuel specification. When the engines are analyzed by Engine Group, no Engine Group exhibits statistically significant changes in PM emissions with fuel specification, as shown in Table B-8.

As shown in Table 5-6, because the C Gas 275 engine has a substantial margin versus the standard when tested on the certification fuel, its relatively small emissions effect due to fuels (± 22% with MN/WI Trend) does not lead to an exceedance of the PM certification standard within the range of the experimental fuels. It would reach the applicable PM standard only when extrapolated to MN well in excess of 100. The other engines are insensitive to fuel composition and will not exceed their applicable PM standard within the experimental range. Comparable results are obtained when the analysis is performed for Engine Groups, as shown in Table B-8 of Appendix B.

Figure 5-4
PM Emissions

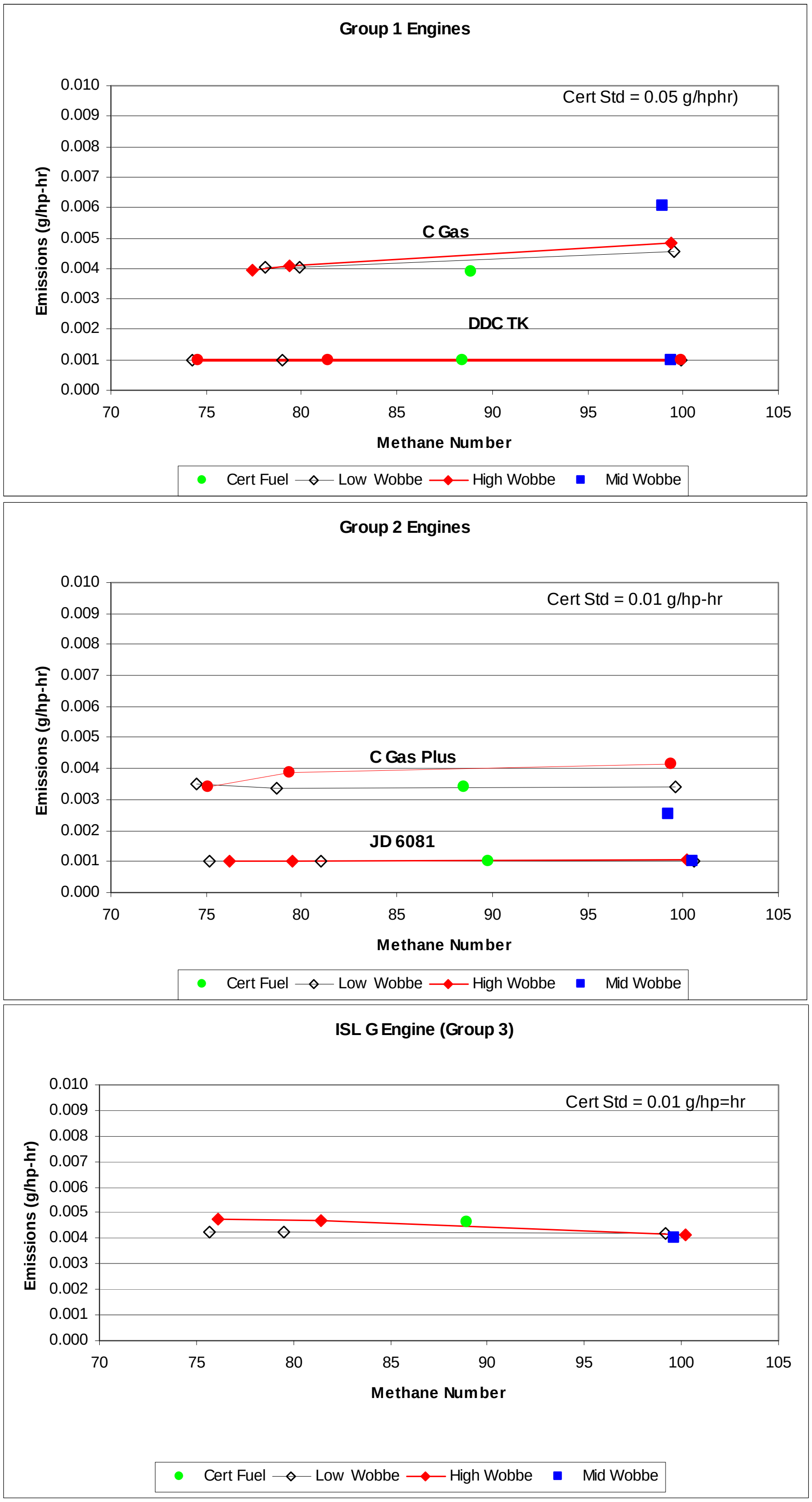


Table 5-6
Exceedance of PM Certification Standard (95% Confidence)

		C Gas	S50G TK	John Deere	C Gas +	C ISL G
Certification Standard (g/hp-hr)		0.05	0.05	0.010	0.010	0.010
Emissions on CARB Cert Fuel (g/hp-hr)		0.004	0.000	0.000	0.003	0.005
Increase to Reach Standard		1187%	48920%	3409%	193%	2062%
Standard Exceeded at Methane Number	Low WI	above 100	never	never	never	never
	High WI	above 100	never	never	never	never

5.5 Total HC Emissions (THC)

Figure 5-5 shows the trends in THC emissions. There is a general trend for THC emissions to increase with increasing MN, and for the differences between Low and High WI fuels to be small. However, there is considerable variation among the engines in these trends and there is some evidence, particularly for the John Deere and S50G engines, that a fuel composition effect comes into play. Only the ISL G 320 engine appears to be insensitive to fuel specification for THC emissions.

The full statistical analysis is reported in Table B-9 of Appendix B. Results of the regression model are outlined below.

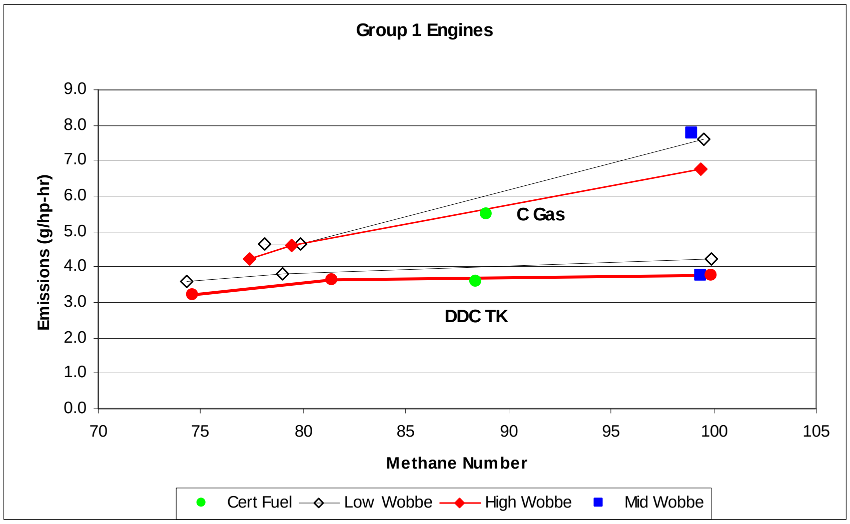
- A statistically significant emissions effect ($p \leq 0.05$) associated with the Vector 1 MN/WI Trend for all engines except the ISL G 320. THC emissions decrease by 5% to 43% depending on engine at Vector 1 scores that yield MN 75. THC emissions decrease by up to 34% when the Vector 1 scores yield MN 100.

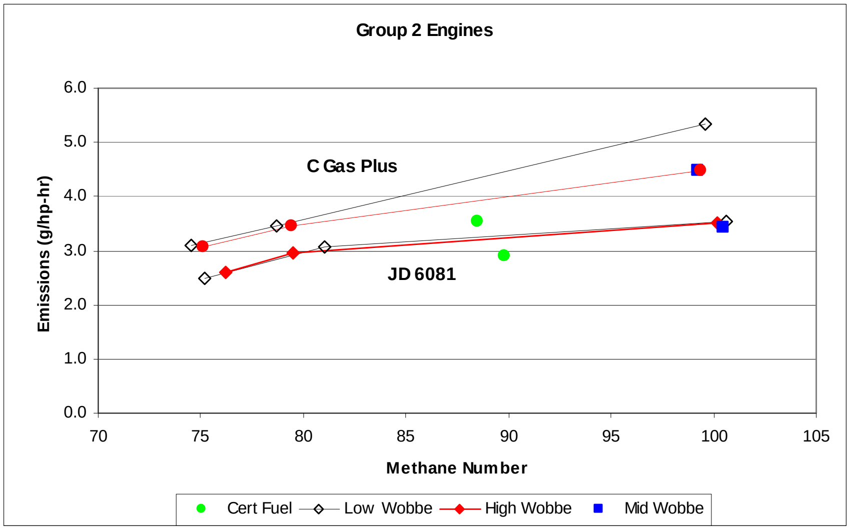
- The C Gas 275 and S50G TK engines exhibit an effect related to the Vector 2 WI Variation that is statistically significant ($p \leq 0.05$) for C Gas 275 and marginally significant ($p \leq 0.10$) for S50G TK. The magnitude of the effect is to increase THC emissions by 3-4% for the lowest WI fuel and to increase emissions by 4-6% for the highest WI fuels.

- The S50G TK and John Deere engines exhibit an emissions effect related to the Vector 3 Composition term that is marginally significant and statistically significant, respectively. The magnitude of this effect is on the order of ±4-6% relative to emissions on the certification fuel.

For the four engines showing fuel effects, change in MN number in conjunction with the corresponding trend in WI is the primary fuel effect, while variation in WI relative to this trend has a much smaller effect. The results for emissions changes are summarized in Table 5-7. Comparable results are obtained when the engines are grouped as shown in Table B-10.

Figure 5-5
THC Emissions





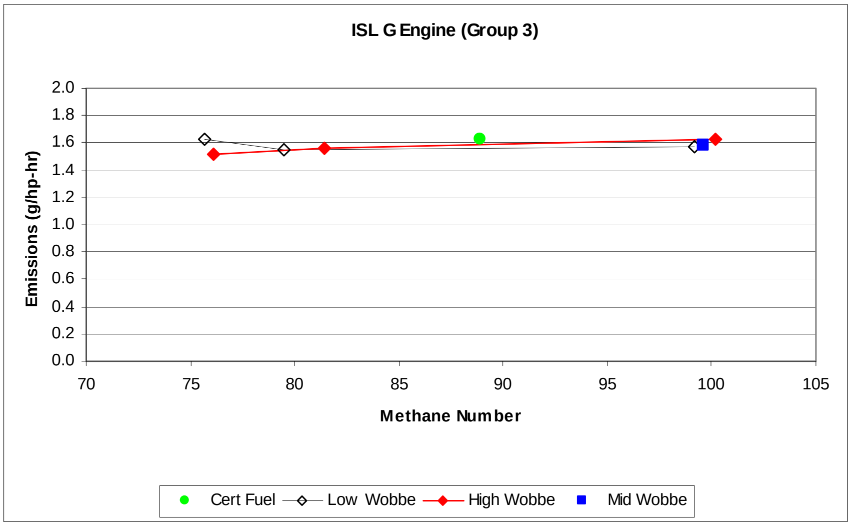


Table 5-7
THC Emissions Changes versus CARB Certification Fuel
(95% Confidence)

	C Gas	S50G TK	John Deere	C Gas +	C ISL G
MN 75L	-39%	-5%	-13%	-26%	No Statistically Significant Emissions Difference Detected (95% confidence level)
MN 75H	-43%	-14%	-20%	-25%	
MN 78L	-25%	-3%	-8%	-16%	
MN 78H	-30%	-9%	-9%	-14%	
MN 80L	-15%			-10%	
MN 80H	-21%			-7%	
MN 100L	34%	9%	16%	21%	
MN 100M	29%		16%	24%	
MN 100H	23%		15%	26%	

Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

5.6 CO Emissions

Figure 5-6 shows the CO emission trends for the five engines. There is a general tendency for CO emissions to decrease with increasing MN, and for the differences between Low and High WI fuels to be small. However, there are differences among the engines and some evidence, particularly for the S50G TK engine, that the fuel composition effect comes into play.

The full statistical analysis is reported in Table B-11 of Appendix B. The regression model demonstrates a consistent emissions effect for the Vector 1 MN/WI Trend in all of the engines, although this reaches statistical significance ($p \leq 0.05$) only for the C Gas 275, S50G TK, and C Gas Plus engines. Directionally, CO emissions are increased when the Vector 1 value moves toward low MN. The effect is present, but reaches only marginal statistical significance ($p \leq 0.10$) for the other two engines. The Vector 2 WI Variation term is not found to be significant for any engine, and the Vector 3 Composition term is statistically significant ($p \leq 0.05$) only for the S50G TK engine.

Table 5-8 shows the estimated emissions changes for the experimental fuels in relation to the CO emissions on the CARB certification fuel. The C Gas 275 engine shows the largest percentage increases, although this is exaggerated in comparison to the S50G TK engine by the low CO levels measured on CARB certification fuel. In addition, the certification standard CO (15.5 g/bhp-hr) applicable to all five test engines is approximately an order of magnitude higher than the CO emissions observed from operation on any test fuel.

The analysis by Engine Group reaches similar conclusions as shown in Table B-12 of Appendix B.

Figure 5-6
CO Emissions

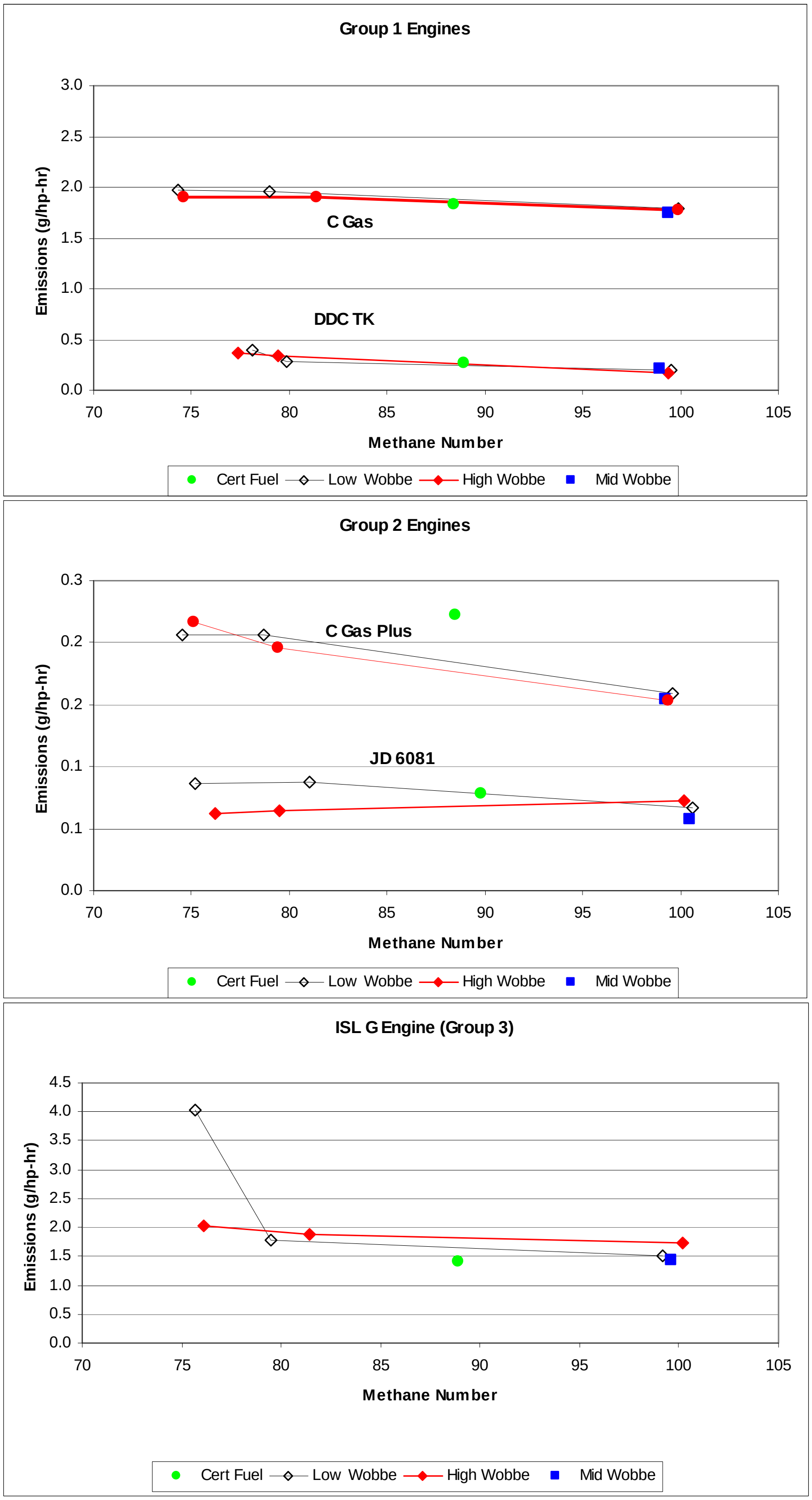


Table 5-8
CO Emissions Changes versus CARB Certification Fuel
(95% Confidence)

	C Gas	S50G TK	John Deere	C Gas Plus	ISL G 320
Emissions (g/hp-hr) on CARB Cert Fuel	0.26	1.83	0.08	0.22	1.40
MN 75L	44%	7%	No statistically significant emissions differences detected (95% confidence interval)	14%	No statistically significant emissions differences detected (95% confidence interval)
MN 75H	42%	3%		13%	
MN 78L	28%	4%		9%	
MN 78H	24%	3%		8%	
MN 80L	16%	4%		5%	
MN 80H	13%	3%		4%	
MN 100L	-36%	-4%		-12%	
MN 100M	-40%	-5%		-13%	
MN 100H	-45%	-6%		-14%	

Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

5.7 NO_2 Emissions

NO_2 emissions are of concern because although there is no NO_2 exhaust emission certification standard for heavy-duty engines, NO_2 is a criteria air pollutant for which California and federal ambient air quality standards have been established. As shown in Figure 5-7, trends of NO_2 are complicated and appear to vary substantially by engine. In Group 1, NO_2 emissions of the C Gas 275 engine appear to be insensitive to fuel specification, while emissions of the S50G TK engine slope downward with increasing MN number. In Group 2, NO_2 emissions of both engines appear to increase below MN 80 number, while the ISL G 320 engine has both very low NO_2 emissions and no clear trends with specification.

The full statistical analysis is reported in Table B-13 of Appendix B. A variety of terms are found to be significant depending on the engine. The Vector 1 MN/WI Trend is the dominant fuel effect, where one is present, except for the C Gas 275 Plus engine, which is a complex combination of all three effects. Of the estimated percentage changes, the variation in WI away from the primary MN/WI trend line accounts for only a 3-5% maximum difference in emissions over and above the primary effect.

Table 5-9 shows the estimated emissions changes for the experimental fuels in relation to the NO_2 emissions on the CARB certification fuel. The S50G TK C engine shows the largest percentage increases in NO_2 emissions relative to the CARB certification fuel, as well as the highest absolute emission levels.

Figure 5-7
NO$_2$ Emissions

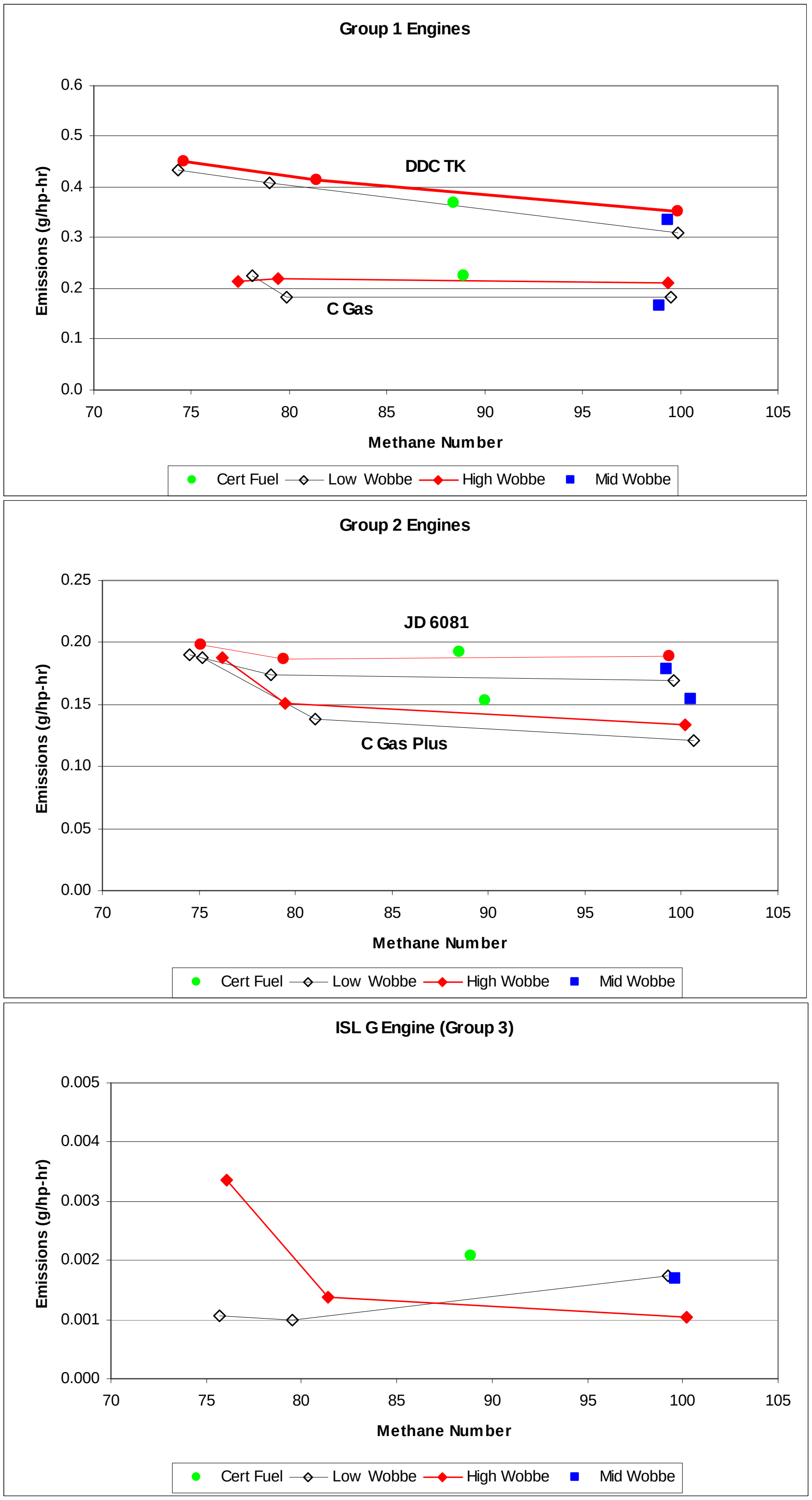


Table 5-9
NO_2 Emissions Changes versus CARB Certification Fuel
(Statistically Significant at 95% Confidence Level)

	C Gas 275	S50G TK	John Deere	C Gas Plus	ISL G 320
MN 75L	No Statistically Significant Emissions Change Detected (95% confidence level)	18%	15%	1%	No Statistically Significant Emissions Change Detected (95% confidence level)
MN 75H		21%	14%	10%	
MN 78L		11%	9%		
MN 78H		17%	8%	5%	
MN 80L		7%	6%	-3%	
MN 80H		14%	4%	2%	
MN 100L		-16%	-12%	-6%	
MN 100M		-10%	-14%		
MN 100H		-4%	-15%	5%	

Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

5.8 CO_2 Emissions

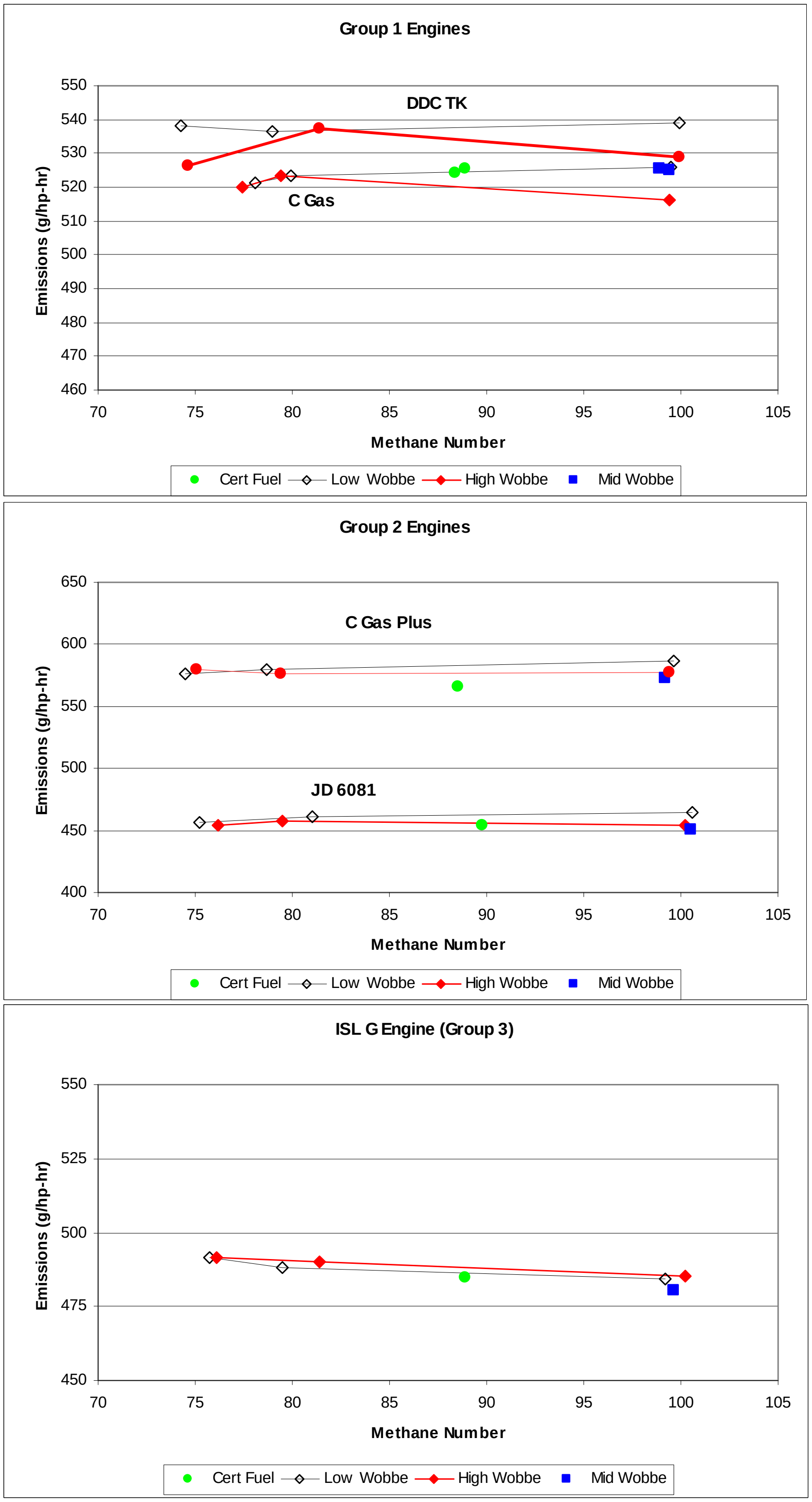
Although the engines differ in their fuel economy levels, and in CO_2 emissions on the CARB certification fuel, there is little evidence of emission effects related to fuel composition, as can be seen in Figure 5-8. Although the statistical analysis detects a statistically significant fuel effect for three of the engines, the implied emission changes are never more than ± 1% over the range of the experimental data. No meaningful difference in CO_2 emissions is associated with fuel specification.

5.9 Speciated Hydrocarbon Emissions

As noted previously, speciated HC emissions were collected for three of the test engines. Because only one engine was tested in each Engine Group, no group analysis was conducted. A complete statistical analysis was attempted for the following seven hydrocarbon species:

1. Benzene;
2. 1-3 Butadiene;
3. Acetaldehyde;
4. Formaldehyde;
5. Ethylbenzene;
6. m- & p-Xylene; and
7. o-Xylene.

Figure 5-8
CO_2 Emissions



There were sufficient data for the first four species listed above to conduct a complete statistical analysis of the type described in Sections 5.1 through 5.8. The remaining three species were not detected in a number of cases and there were insufficient data available for use in a complete statistical analysis. These latter species are examined on a case-by-case basis in the last subsection below.

Table 5-10 shows the emission rates, by engine, observed using the MN89 CARB certification fuel for the four hydrocarbon species that were routinely measured during the study. In the small number of cases where concentrations of one of these four species did not reach the detection threshold, the emissions level was set to zero.

Table 5-10
Summary of Emission Levels on CARB Certification Fuel
For Four HC Species

Engine	Emissions on Certification Fuel (mg/hp-hr)			
	Benzene	1-3 Butadiene	Acetaldehyde	Formaldehyde
C Gas 275	not tested			
S50G TK	0.05	0.63	1.07	0.94
John Deere	not tested			
C Gas Plus	0.22	ND	1.56	43.3
ISL G 320	0.11	ND	0.11	0.59

5.9.1 Benzene

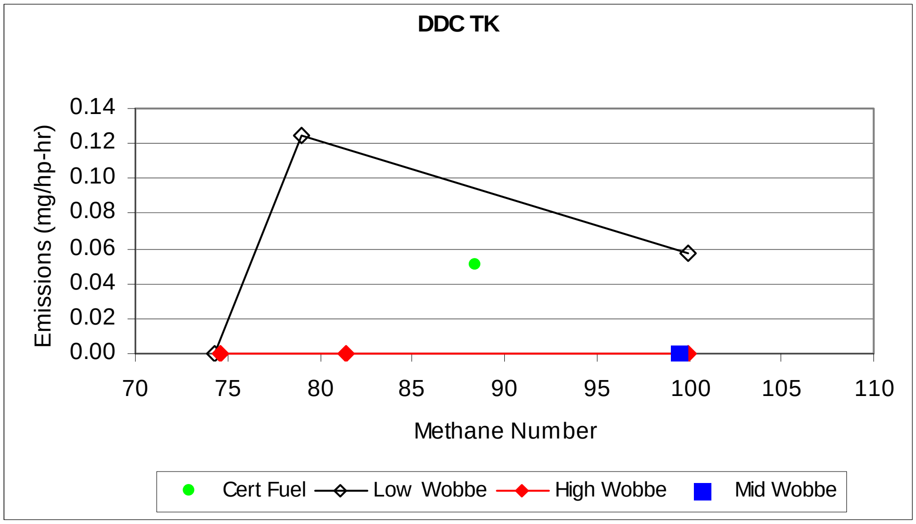
Figure 5-9 shows the trend in benzene emissions for the three engines tested. Except for the ISL G 320 engine, there is no indication of a systematic relationship between fuel specifications and benzene emissions. For the ISL G 320 engine, benzene emissions appear to increase as MN is decreased below the MN 89 level of the certification fuel. For the S50G TK and C Gas 275 Plus engines, there is no evidence of a statistically significant fuel effect on emissions. The intercept term in the models for these engines estimates the average percentage difference between benzene emissions for the experimental fuels and emissions on the CARB certification fuel.

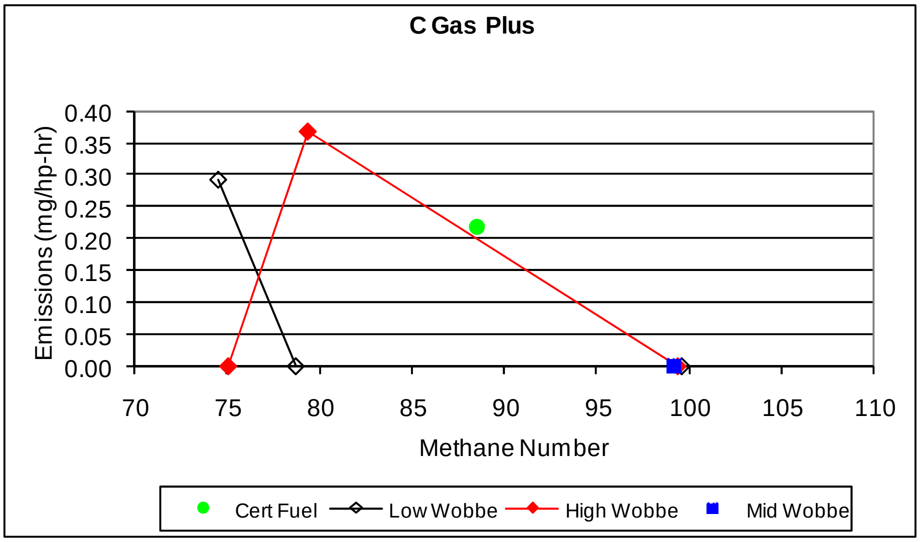
The statistical analysis reported for benzene in Table C-1 of Appendix C supports the following conclusions:

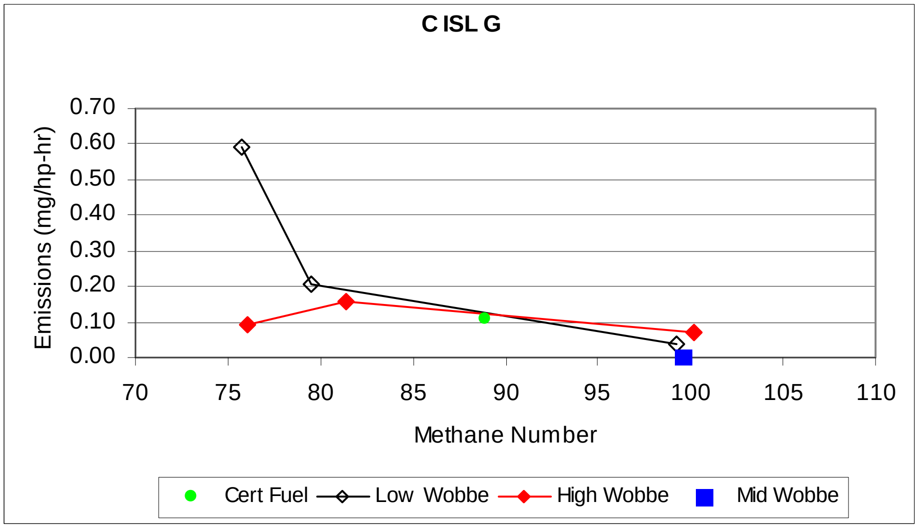
- For the S50G TK engine, emissions on experimental fuels are estimated to be 42% below the MN 89 CARB certification fuel (counting non-detections as zero emissions), but the difference is not statistically significant.

- For the C Gas 275 Plus engine, emissions on experimental fuels are estimated to be 49% below the MN 89 CARB certification fuel. This difference is marginally significant at the p=0.09 level.

Figure 5-9
Benzene Emissions







- For the C Gas 275 Plus engine, emissions on experimental fuels are estimated to be 49% below the MN 89 CARB certification fuel. This difference is marginally significant at the p=0.09 level.

The ISL G 320 engine exhibits a marginally significant relationship (p=0.07) to the Vector 1 MI/WI Trend that, directionally, would cause benzene emissions to increase by 138% to an estimated average of 0.26 mg/hp-hr at MN 75, while decreasing to zero at MN 100. This apparent trend is strongly influenced, however, by the one data point for the MN 75 High Wobbe fuel. Because of this and the fact that the trend fails to reach the conventional 95% confidence level for statistical significance, our conclusion is that the benzene emissions from ISL G 320 engine exhibited no statistically significant relationship to fuel specification.

The same result would be obtained for the ISL G 320 engine if reporting only the differences in average emissions. Mean benzene emissions on the experimental fuels are 0.16 mg/hp-hr ± 0.20 mg/hp-hr, which is not statistically different than zero and not statistically different than the 0.11 mg/hp-hr emission level on certification fuel.

5.9.2 1-3 Butadiene Emissions

1,3 Butadiene emissions were detected only with the S50G TK engine exhaust. As shown in Figure 5-10, it appears that 1-3 butadiene emissions increased with the use of low MN fuels. However, an offset is present with respect to the CARB certification fuel, which does not lie on or near the experimental fuel line and makes it difficult to draw a conclusion from the graphical evidence.

The full statistical analysis is reported in Table C-2 of Appendix C. A strong and statistically significant relationship is detected between 1-3 butadiene emissions and the Vector 1 MN/WI Trend, in addition to a Vector 3 Composition effect.

Table 5-11 summarizes the emissions changes on experimental fuels in comparison to the CARB certification fuel. This comparison considers all factors influencing the emissions measured during the testing including the composition effect. Emissions at MN 75 are estimated to increase 58% for Low Wobbe fuels and 25% for High Wobbe fuels, while decreasing by similar amounts at MN 100. The large emissions difference between the Low and High Wobbe fuels is the result of the apparent sensitivity to the Vector 3 Composition term. The Vector 1 term itself increases emissions by a maximum of 38% for MN 75 fuels, and decreases emissions by a maximum of 34% for MN 100 fuels. When the predictive equation for 1-3 butadiene emissions is evaluated for an average CNG composition (i.e., for Vector 3 = 0), fuel specifications influence emissions by approximately ±30-35% over the MN range 75-100.

Figure 5-10
1-3 Butadiene Emissions

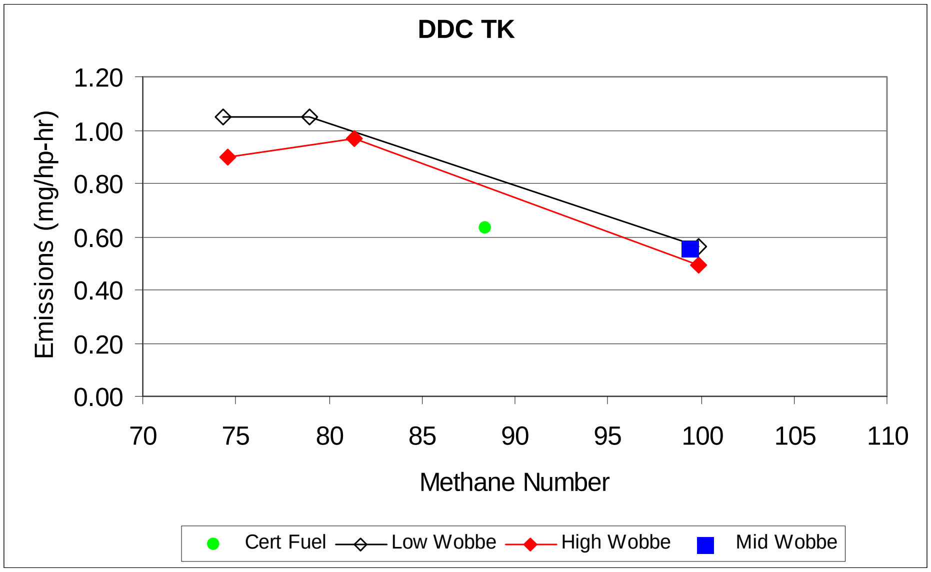


Table 5-11
1-3 Butadiene Emissions Changes versus CARB Certification Fuel
(95% Confidence)

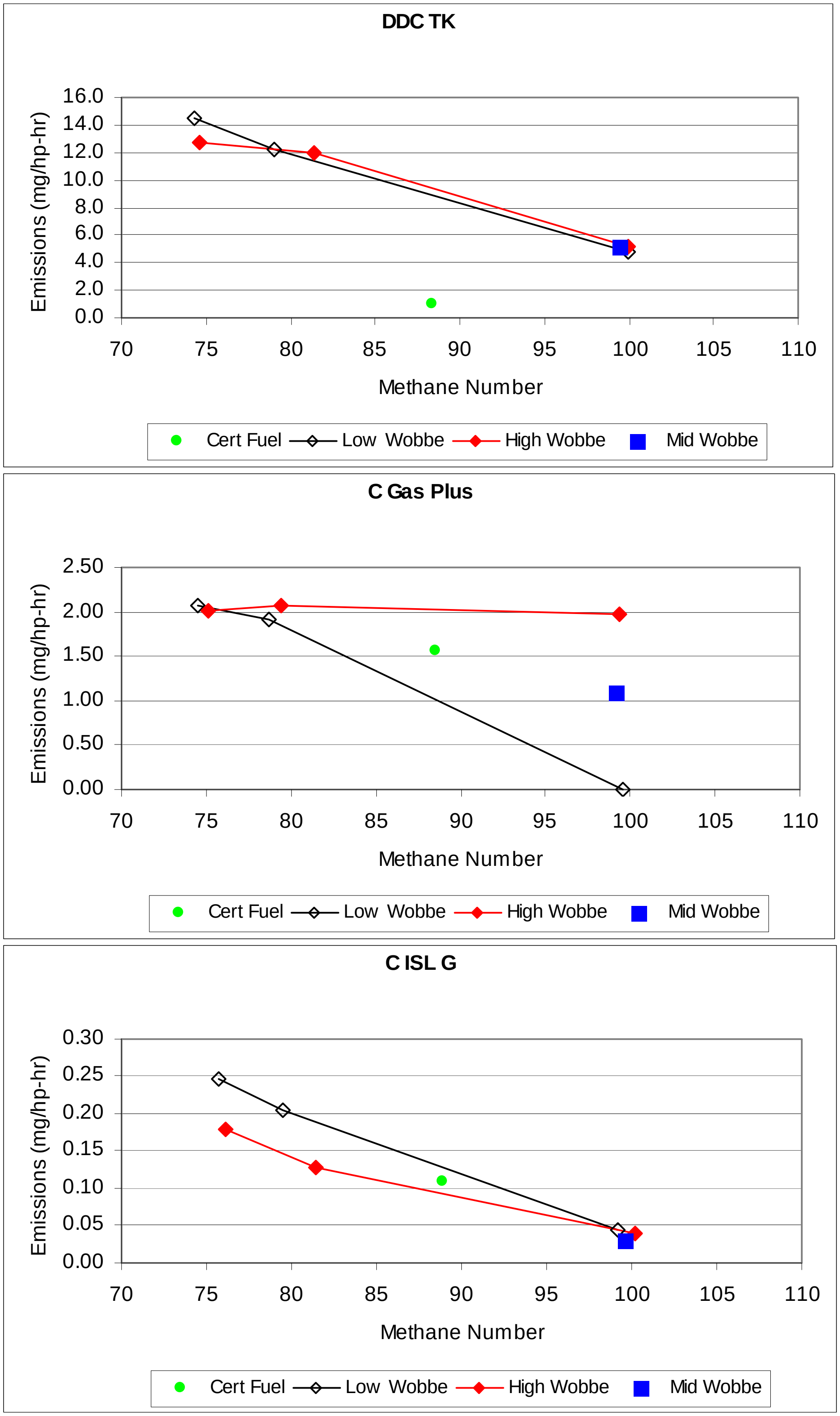
	C Gas 275	S50G TK	John Deere	C Gas Plus	ISL G 320
MN 75L	Not Tested	58%	Not Tested	Not Detected	Not Detected
MN 75H		25%			
MN 78L		36%			
MN 78H		26%			
MN 80L		40%			
MN 80H		29%			
MN 100L		-28%			
MN 100M		-39%			
MN 100H		-51%			

Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

5.9.3 Acetaldehyde Emissions

The test data show that acetaldehyde emissions varied as a function of fuel specification. As shown in Figure 5-11, emissions from all three engines decrease with increasing MN relative to the MN 89 CARB certification fuel. The difference between Low and High WI fuels is unclear and may vary among the engines, with the C Gas Plus and ISL G 320 engines showing the greatest differences.

Figure 5-11
Acetaldehyde Emissions



The S50G TK engine shows a large offset of the CARB certification fuel from the emissions line for the experimental fuels. The offset will be attributed, at least in part, to the Vector 3 Composition term in the statistical analysis, but its true cause is unclear. In addition to a sensitivity to fuel composition, other possible explanations include the result for the CARB certification fuel being an outlier due to any of a variety of unidentified changes in test conditions. Because of the large offset, all of the experimental fuels are found to increase acetaldehyde emissions and, because the base emission rate on certification fuel is very low, the percentage increases are large.

The full statistical analysis is reported in Table C-3 of Appendix C, and summarized in Table 5-12. All of the engines show a statistically significant emissions response to the Vector 1 MN/WI trend, with emissions increasing with decreasing Methane Number. The C Gas 275 Plus engine is the only one to show a statistically significant effect for Vector 2 WI Variation. The S50G TK engine is found to be sensitive to Vector 3 Composition vector.

The S50G TK engine shows significantly increased emissions on all test fuels as a result of the offset of the CARB certification fuel. If the compositional effect is removed using the statistical analysis, the engine shows increased emissions only for fuels below the MN 89 average for certification fuel.

Table 5-12
Acetaldehyde Emissions Changes versus CARB Certification Fuel
(95% Confidence)

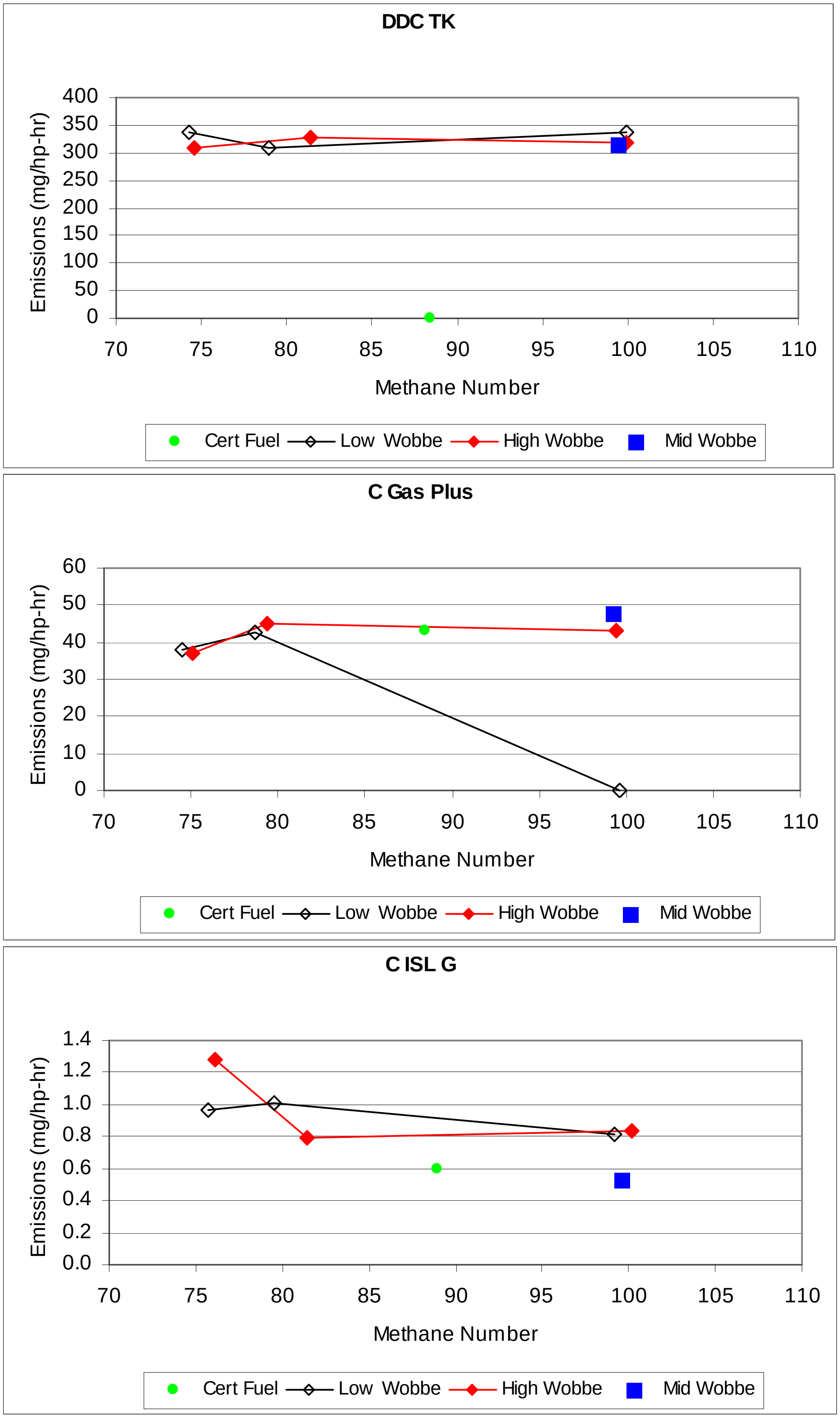
	C Gas 275	S50G TK	John Deere	C Gas Plus	ISL G 320
MN 75L	Not Tested	657%	Not Tested	49%	92%
MN 75H				76%	86%
MN 78H		288%		71%	50%
MN 78L		407%		33%	57%
MN 80L		477%		22%	34%
MN 80H		345%		67%	26%
MN 100L		-287%		-49%	-75%
MN 100M		-423%			-84%
MN 100H		-565%			-92%

Note: Blue shading is used to highlight emission reductions relative to the CARB certification fuel.

5.9.4 Formaldehyde Emissions

Figure 5-12 displays the experimental data on formaldehyde emissions. Varying trends with Methane Number are outlined below.

Figure 5-12
Formaldehyde Emissions



- Similar to the results for acetaldehyde, the S50G TK engine shows significantly higher formaldehyde emissions on all of the experimental fuels compared to the CARB certification fuel, but in this case it shows no trend of any kind with respect to fuel specification. That the offset occurs for both aldehyde species suggests either some issue with the measurement of formaldehyde during testing on certification fuel or some sensitivity in the S50G TK engine to details of the fuel specification that happen not to be encountered with the certification fuel. Except for this, varying fuel specifications have no effect on formaldehyde emissions.

- The C Gas 275 Plus engine generally shows no emissions response to fuel specification except for the MN 100 Low Wobbe test fuel. When subjected to a complete statistical analysis, no statistically significant emissions effect due to fuels can be detected.

- The ISL G 320 engine suggests the possibility of a downward trend of emissions with increasing Methane Number, although the trend is not confirmed by the high methane fuels. The statistical analysis does not detect a statistically significant response of formaldehyde with respect to fuel specification. However, a statistically significant positive intercept is detected, representing a mean emissions difference between the experimental and certification fuels.

The full statistical analysis is reported in Table C-4 of Appendix C. Based on this analysis, Table 5-13 summarizes the statistically significant emissions changes versus the CARB certification fuels.

Table 5-13
Formaldehyde Emissions Changes versus CARB Certification Fuel
(95% Confidence)

	C Gas 275	S50G TK	John Deere	C Gas Plus	ISL G 320
MN 75L	Not Tested	A statistically significant emissions difference of +281 mg/hp-hr is detected (all fuels)	Not Tested	No statistically significant emissions change detected (95% Confidence Level)	A statistically significant emissions difference of +0.26 mg/hp-hr (or 44%) is detected (all fuels)
MN 75H					
MN 78L					
MN 78H					
MN 80L					
MN 80H					
MN 100L					
MN 100M					
MN 100H					

5.9.5 Other Hydrocarbon Species

The analysis examined emissions of three additional hydrocarbon species: ethylbenzene, m- & p-xylene, and o-xylene. The statistical analysis methods used for the other pollutants cannot be applied in these cases due to the relatively large number of non-detections recorded in the test data. The species are examined on a case-by-case basis below.

As summarized in Table 5-14, ethylbenzene is not detected in the engine exhaust on CARB certification fuel and is detected only sporadically (one or two fuels per engine) on the experimental fuels. Treating non-detections as zero emissions, a simple analysis of mean emissions by engine demonstrates that mean emissions on the experimental fuels are not statistically different from zero.

Table 5-14
Ethylbenzene Emissions (mg/hp-hr) by Engine

	S50G TK	C Gas Plus	ISL G 320
Emissions (mg/hp-hr) on CARB Certification Fuel	Not Detected	Not Detected	Not Detected
Detections on Experimental Fuels	MN 79 Low WI MN 100 Mid WI	MN 100 Low WI	MN 100 High WI
Mean Emissions (mg/hp-hr) on Experimental Fuels	0.017 ± 0.030	0.010 ± 0.026	0.007 ± 0.019

As summarized in Table 5-15, m- & p-xylene is detected in the exhaust of all three engines on the CARB certification fuels. It is also detected in the engine exhaust for most of the experimental fuels, but most often at lower levels than for the certification fuels.

Table 5-15
m- & p-Xylene Emissions (mg/hp-hr) by Engine

	S50G TK	C Gas Plus	ISL G 320
Emissions (mg/hp-hr) on CARB Certification Fuel	0.30	0.15	0.38
Detections on Experimental Fuels	6 of 8 fuels	5 of 8 fuels	7 of 8 fuels
Mean Emissions (mg/hp-hr) on Experimental Fuels	0.057 ± 0.053	0.117 ± 0.112	0.168 ± 0.088

For all three engines, a simple analysis of mean emissions indicates that emissions on the experimental fuels are not statistically different from zero at the 95% confidence level or better ($p \leq 0.05$). We do not have standard deviations to assign to the non-zero emissions on the certification fuels for the purpose of conducting a t-test for the difference of means. However, we can draw the following conclusions based on comparison of the certification result to the 95% confidence interval for mean emissions on the experimental fuels:

- For S50G TK, the certification fuel result of 0.30 mg/hp-hr falls above 0.21 mg/hp-hr, which is the upper end of the 95% confidence interval for the experimental mean. We conclude that m- & p-xylene emissions were lower on fuels other than the CARB certification fuel at the 95% confidence level.
- For C Gas 275 Plus, the MN 89 CARB certification fuel result of 0.15 mg/hp-hr falls near the center of the 95% confidence interval for mean emissions on the experimental fuels. We conclude that m- & p-xylene emissions are not statistically different from emissions on the CARB certification fuel at the 95% confidence level.
- For ISL G 320, the MN 89 CARB certification fuel result of 0.38 mg/hp-hr falls near the upper end of the 95% confidence interval for mean emissions on the experimental fuels. We conclude that m- & p-xylene emissions are not statistically different from emissions on the CARB certification fuel at the 95% confidence level. At a relaxed 90% confidence level, emissions would be lower than on the certification fuel by a statistically significant amount.

As summarized in Table 5-16, o-xylene is not detected in the exhaust of the engines using the MN 89 CARB certification fuel. It is frequently detected in the engine exhaust on experimental fuels for the S50G TK engine, but seldom detected for the other engines. Based on a simplified analysis of mean emission for the experimental fuels, and counting non-detections as zero emissions, our conclusion is that emissions of o-xylene are not statistically different from zero or from emissions using the CARB certification fuels.

Table 5-16
o-Xylene Emissions (mg/hp-hr) by Engine

	S50G TK	C Gas 275 Plus	ISL G 320
Emissions (mg/hp-hr) on CARB Certification Fuel	ND	ND	ND
Detections on Experimental Fuels	6 of 8 fuels	3 of 8 fuels	1of 8 fuels
Mean Emissions (mg/hp-hr) on Experimental Fuels	0.06 ± 0.21	0.08 ± 0.43	0.08 ± 0.26

5.10 PAH Emissions

With respect to PAH, the statistical analysis examined total PAH emissions, as well as emissions of benzo(a)pyrene, which was considered a marker for high molecular weight PAH, and of phenanthrene, which was considered as a marker for low molecular weight PAH. PAH emissions were measured for S50G TK, C Gas Plus, and ISL G 320 engines during one of the three hot starts tests conducted on each engine. Being the result of a single emissions test, the experimental results are subject to greater random error due to test-to-test variation compared to the other pollutants which reflected composite emissions. As a result, the PAH data are less powerful for the detection of emission trends with respect to fuel specification, and the interpretation of the experimental data given here is more limited.

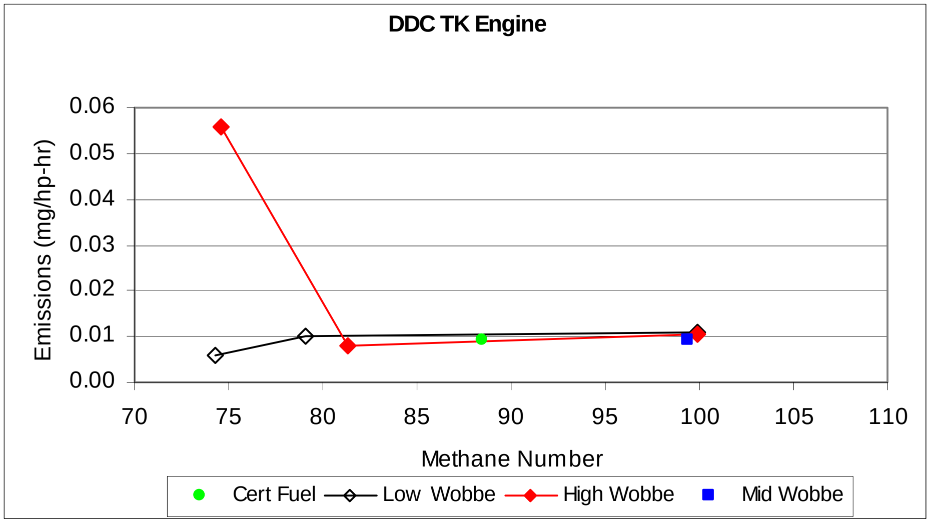
As shown in Table 5-17, there are substantial differences among the engines in the emission levels on certification fuel. As a result of the very low base emission levels for some engines, the statistical analysis was conducted using the absolute (rather than percentage) change in emissions from certification fuel as the dependent variable. Percentage differences can be computed by dividing the predicted emissions change by base emissions on the certification fuel.

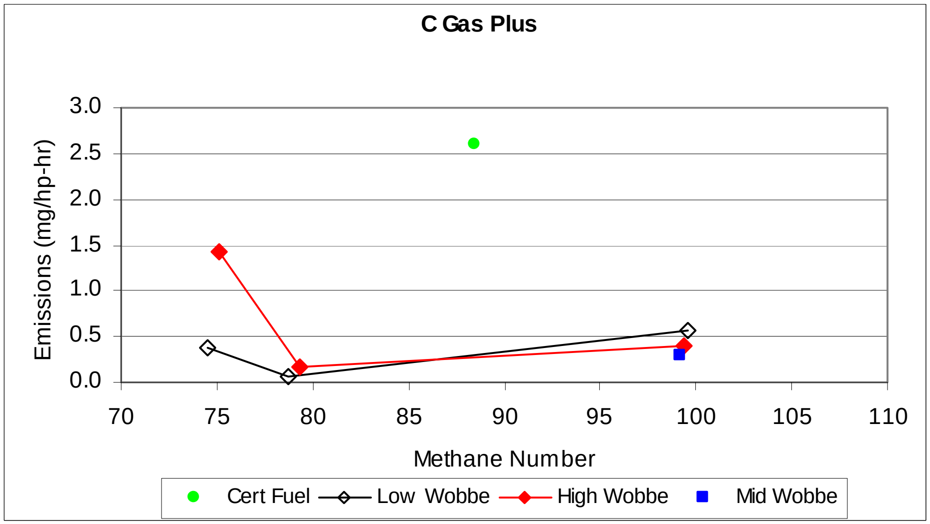
Table 5-17
PAH Emissions on CARB Certification Fuel

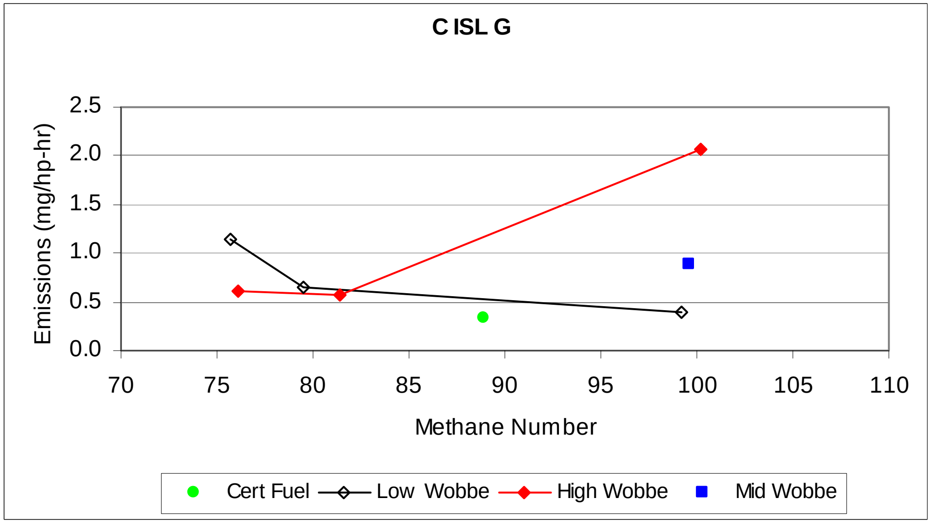
	Emissions on Certification Fuel		
	Total PAH (mg/hp-hr)	Benzo(a)pyrene (ng/hp-hr)	Phenanthrene (ng/hp-hr)
C Gas 275	not tested		
S50G TK	0.009	4	4,660
JD 8081	not tested		
C Gas 275 Plus	2.59	293	166,000
C ISG L	0.33	24	24,800

As shown in Figure 5-13, there is little evidence in the experimental data that total PAH emissions vary consistently with fuel specification. For the S50G TK engine, emissions are generally unchanged compared to the CARB certification fuel except for the MN 75 High Wobbe fuel. For the C Gas Plus engines, emissions on the experimental fuels are consistently below emissions on CARB certification fuel and display no clear trend with fuel specification. For the ISL G 320 engine, emissions on experimental fuels appear to be slightly above that on the certification fuel and, again, display no clear trend with fuel specification.

Figure 5-13
Total PAH Emissions







The full statistical analysis is reported in Table D-1 of Appendix D. In no instance is a statistically significant trend found with respect to fuel specification, whether measured by the Vector 1 MN/WI Trend or the Vector 2 WI Variation. For the S50G TK, we find no statistically significant emissions difference compared to the CARB certification fuel.

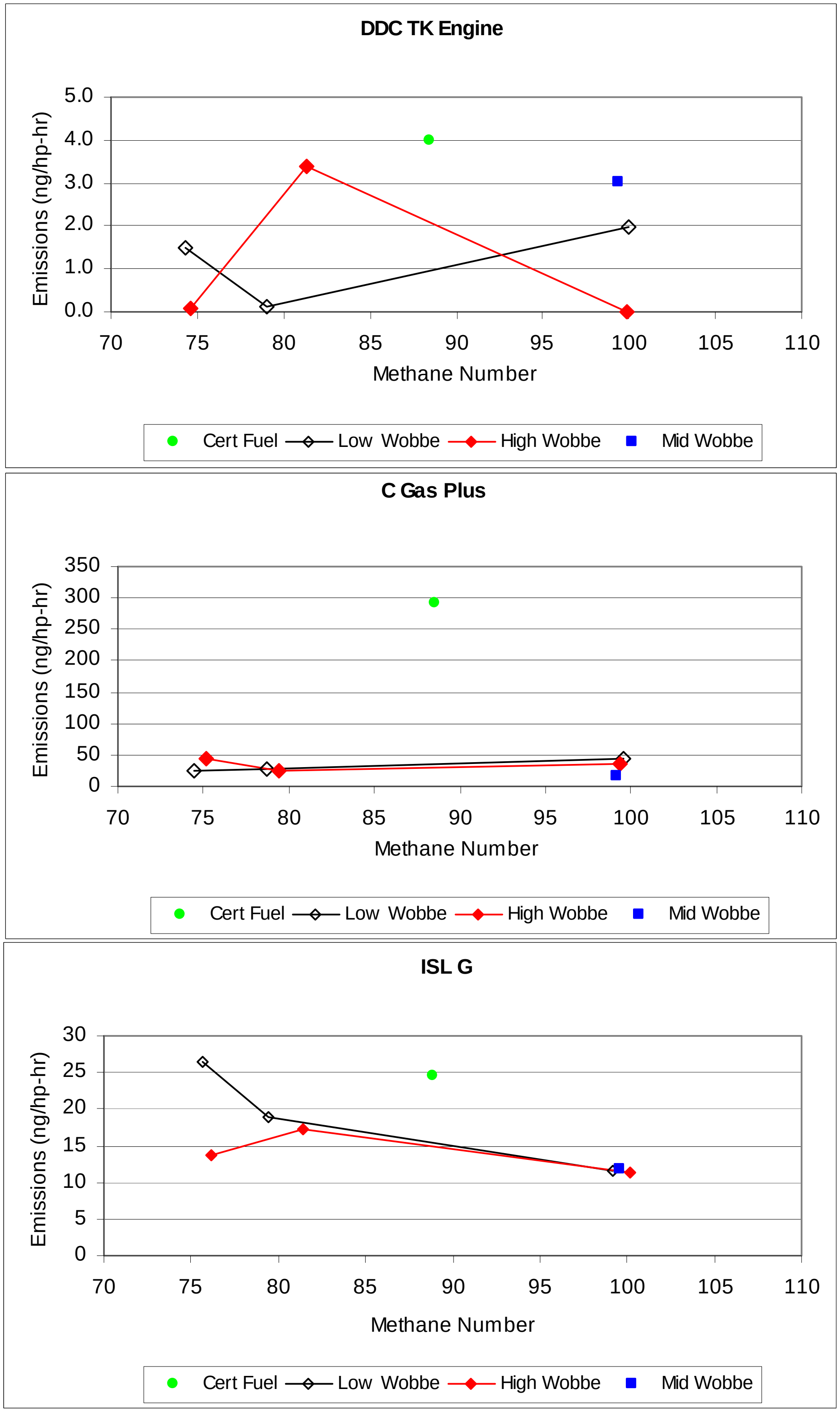
For the C Gas Plus engine, the statistical analysis estimates a statistically significant Vector 3 Composition term that accounts for the observed offset of the CARB certification fuel. However, no statistically significant emissions trend is found related to fuel specification. Because each data point represents a single test, we are reluctant to conclude that the C Gas Plus engine is truly sensitive to fuel composition. Instead, we conclude that total PAH emissions are reduced by a constant 1.87 mg/hp-hr or 72% on the experimental fuels. For the ISL G 320 engine, we find no emissions effect related to fuel specification, but instead a constant emissions increase of 0.51 ng/hp-hr or 154% on the experimental fuels. These results are summarized in Table 5-18.

Table 5-18
Emissions Changes versus CARB Certification Fuel
(95% Confidence)

	C Gas 275	S50G TK	John Deere	C Gas Plus	ISL G 320
MN 75L	Not Tested	No statistically significant emissions change detected (95% confidence level)	Not Tested	Constant -1.87 mg/hp-hr emissions change or 72% decrease (95% confidence level)	Constant +0.51 mg/hp-hr emissions change or 154% increase (95% confidence level)
MN 75H					
MN 78L					
MN 78H					
MN 80L					
MN 80H					
MN 100L					
MN 100M					
MN 100H					

The experimental data on benzo(a)pyrene emissions are shown in Figure 5-14. Except for the ISL G 320 engine, there is no clear-cut evidence of an emissions trend with fuel specification. The S50G TK engine suggests that benzo(a)pyrene emissions are generally lower on the experimental fuels compared to the CARB certification fuels but are quite variable. C Gas Plus engine emissions on the experimental fuels are substantially below the level observed using the MN 89 CARB certification fuel. Emissions from the ISL G 320 engine suggest a trend with Methane Number, and all experimental fuels are below the level with the MN 89 certification fuel except for the MN 75 Low WI fuel.

Figure 5-14
Benzo(a)pyrene Emissions



The full statistical analysis is reported in Table D-2 of Appendix D and supports the qualitative trends seen in the figure. Table 5-19 summarizes the results for emissions changes relative to the CARB certification fuel. In the S50G TK and C Gas Plus, the experimental fuels are found to significantly reduce benzo(a)pyrene emissions compared to the MN 89 CARB certification fuel. For the ISL G 320 engine, the analysis finds a marginally significant slope (p=0.06) for the Vector 1 MN/WI Trend. Because the slope is strengthened by the one test result for the MN 75 Low WI fuel and yet fails to reach the 95% confidence level of significance, we have chosen to discount the result. Therefore, we find that there is no statistically significant overall reduction in emissions for this engine.

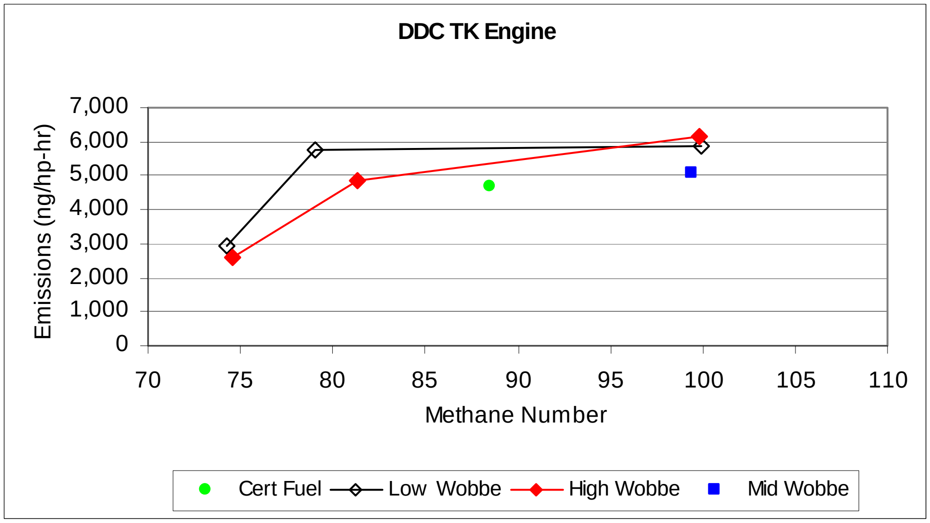
Table 5-19
Benzo(a)pyrene Emissions Changes versus CARB Certification Fuel
(95% Confidence)

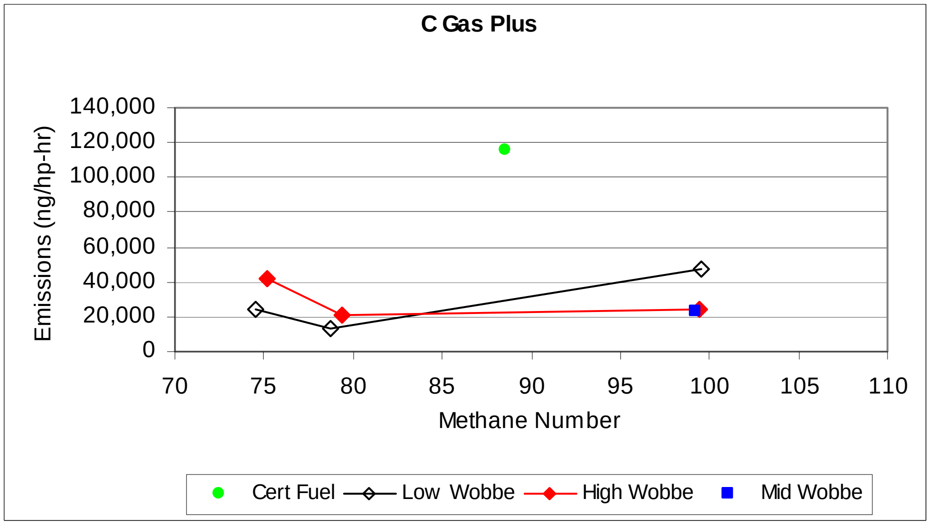
	C Gas 275	S50G TK	John Deere	C Gas Plus	ISL G 320
MN 75L	Not Tested	Constant -2.38 ng/hp-hr emissions difference or 59% decrease (95% confidence level)	Not Tested	Constant -229 ng/hp-hr emissions change or 78% decrease (95% confidence level)	Constant -7 ng/hp-hr emissions change or 29% decrease (95% confidence level)
MN 75H					
MN 78L					
MN 78H					
MN 80L					
MN 80H					
MN 100L					
MN 100M					
MN 100H					

The experimental data on phenanthrene emissions is shown in Figure 5-15. Both the S50G TK and ISL G 320 engines suggest some emissions effect related to fuel specification. For the C Gas Plus engine, phenanthrene emissions on the experimental fuels are substantially below the level observed using the CARB certification fuel, but display no trend with fuel specification.

The full statistical analysis is reported in Table D-3 of Appendix D. Table 5-20 summarizes the results for emissions changes relative to the MN 89 CARB certification fuel. Emissions effects related to fuel specification are found for the S50G TK engine (the Vector 1 MN/WI Trend) and for the ISL G 320 engine (Vector 2 WI Variation). No statistically significant fuel effects were detected for the C Gas 275 engine, although a large (and significant) intercept term is present related to the emissions offset versus CARB certification fuel.

Figure 5-15
Phenanthrene Emissions





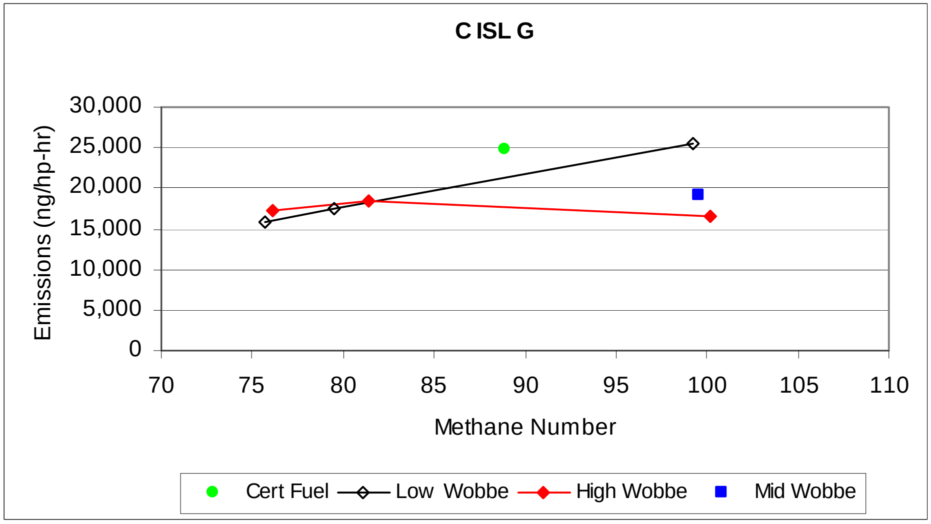


Table 5-20
Phenanthrene Emissions Changes versus CARB Certification Fuel
(95% Confidence)

	C Gas 275	S50G TK	John Deere	C Gas Plus	ISL G 320
MN 75L	Not Tested	-16%	Not Tested	Constant -77662 ng/hp-hr emissions change or 67% decrease (95% confidence level)	- 4%
MN 75H		-10%			- 3%
MN 78L					- 3%
MN 78H		26%			7%
MN 80L		24%			- 8%
MN 80H		-35%			-14%
MN 100L		-12%			-18%
MN 100M					-20%
MN 100H		21%			-25%

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6. EMISSION INVENTORY ANALYSIS

Based on the results of the SwRI test program and subsequent statistical analysis, an emission inventory analysis was conducted to assess the theoretical impact that changes in natural gas composition could have on emissions from CNG vehicles in the SoCal Gas and SDG&E service territories.[*] In addition to the relationships between fuel composition and emissions discussed in the previous section of this report, another key element in this assessment was the development of a complete inventory of all heavy-duty CNG engines in operation throughout the service territories. The assessment evaluated theoretical changes in natural gas vehicle emissions under the current CARB CNG prescriptive motor vehicle fuel regulations and the performance-based CNG composition regulation proposed by SoCalGas and SDG&E at the lowest allowable MN and highest allowable WI values. The emission changes under these conditions were evaluated relative to emissions estimated for natural gas vehicle operation on natural gas with properties consistent with historical data over the period from 2008 through 2018. The analytical methodology used to perform this assessment and the results are documented below.

6.1 Fuel Composition Scenarios

As noted above, four fuel composition scenarios were evaluated in this analysis: the first is a baseline scenario that defines “historical” fuel compositions for each county based on 2007 survey data; the second assumes fuels with the minimum MN and maximum WI fuel composition allowed under CARB’s current prescriptive regulations; and the third and fourth fuel composition scenarios reflect minimum MN and maximum WI values associated with a SoCal Gas and SDG&E proposed two-phase change to the CARB regulations that would transform them to a performance-based standard set in terms of minimum MN and a maximum WI. The MN and WI values for the historical fuel and the theoretical values for the minimum MN and maximum WI under the three regulatory scenarios are presented in Table 6-1.

As shown in Table 6-1, historical CNG fuel composition data in the 13-county service area are generally characterized by higher MN and lower WI values than are assumed under any of the regulatory scenarios. With respect to the regulatory scenarios, all three would allow a maximum WI value of 1,385, but there are different allowable minimums for MN, as shown in Table 6-1.

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[*] The combined service territory of both SoCalGas and SDG&E covers all or a significant portion of 13 California counties.

Table 6-1
CNG Properties of Four Fuel Scenarios Used for the Emission Inventory Analysis[a]

Fuel Scenario	County	Methane Number (MN)	Wobbe Index (WI)
1. Historical (Baseline) Fuel Based on 2007 Survey Data	Los Angeles	99.2	1341
	Orange	100.0	1336
	San Diego	100.0	1337
	Riverside	99.2	1341
	San Bernardino	99.2	1341
	Ventura	91.0	1353
	Santa Barbara	90.6	1355
	Kern	96.5	1347
	Kings	80.6	1351
	Tulare	96.5	1347
	San Luis Obispo	77.3	1382
	Imperial	100.0	1337
	Fresno	81.6	1352
2. Current CARB Regulation	All	72.4	1385
3. SoCal Gas/SDG&E Proposal – Phase 1	All	80.0	1385
4. SoCal Gas/SDG&E Proposal – Phase 2	All	75.0	1385

[a] Values provided by Ed Harte via e-mail, December 2008. CARB fuel requirements were defined as the composition with the lowest possible methane number and highest, SoCalGas Rule 30 compliant, Wobbe Index.

6.2 Heavy-Duty CNG Vehicle Population and Engine Data

The CNG engine populations assumed here to be operating in the service territories are summarized by engine type and vehicle application in Tables 6-2 and 6-3 for 2008 and 2018, respectively.[*] Over the whole territory in 2008, 6,056 CNG engines were estimated to be in operation, of which 4,289 were transit buses, 867 were school buses, 567 were solid waste haulers, 264 were street sweepers, and 69 were not otherwise classified. The primary difference between the 2008 and 2018 population estimates is that engines slated for retirement would be replaced by ISL-G engines (the only test engine meeting 2010 model year standards), and thereby the 2018 calendar year engine inventory contains a greater proportion of ISL-G engines.

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[*] CNG fleets operating within each county by engine make and model (for each calendar year) were provided in an email communication from Ed Harte (March 2009) and were derived from survey data.

Table 6-2 (Calendar Year 2008) CNG Engines Served by the SDG&E and SoCal Gas Territories (13-County Total)					
Engine Make	Transit Bus	School Bus	Waste Hauler	Street Sweeper	Other
DDC TK	1,479	0	0	0	0
CGas	95	23	47	0	0
CGPlus	548	1	189	22	22
ISL-G	657	0	162	0	18
JD6081H	85	781	78	0	4
Group 1 (HHD)	632	9	33	0	2
Group 2 (HHD)	677	0	58	0	7
Group 1 (MHD)	48	28	0	13	13
Group 2 (MHD)	68	25	0	229	3
Total	**4,289**	**867**	**567**	**264**	**69**

Table 6-3 (Calendar Year 2018) CNG Engines Served by the SDG&E and SoCal Gas Territories (13-County Total)					
Engine Make	Transit Bus	School Bus	Waste Hauler	Street Sweeper	Other
DDC TK	20	0	0	0	0
CGas	0	5	26	0	0
CGPlus	276	1	57	2	16
ISL-G	3,413	204	414	196	50
JD6081H	22	622	39	0	2
Group 1 (HHD)	0	0	14	0	0
Group 2 (HHD)	516	0	17	0	1
Group 1 (MHD)	0	10	0	0	0
Group 2 (MHD)	42	25	0	66	0
Total	**4,289**	**867**	**567**	**264**	**69**

Engines other than the five types specifically tested in the SwRI study were assigned, as shown in Tables 6-2 and 6-3, to either Engine Group 1 or 2 based on their vintage and were also further classified by heavy-heavy-duty (HHD) and medium-heavy-duty (MHD), as some of the inventory modeling assumptions (described below) differ by these weight classes. It is important to note that the total number of CNG engines by application remained constant for all calendar years modeled, and only the distribution by engine type varied from one year to the next. Table 6-4 presents the distribution of CNG engines (by application) for each of the 13 counties. The engine distributions shown in Table 6-4 are valid for all 11 calendar years modeled.

Table 6-4
CNG Engine Applications by District and County

Air District	County	Application Type Transit	School Bus	Waste Hauler	Street Sweeper	Other
SDCAPCD	San Diego	537	100	0	0	5
SCAQMD	Los Angeles	2,961	322	177	159	32
	Orange	429	88	68	16	27
	Riverside	230	166	216	85	5
	San Bernardino	9	80	66	0	0
	Total	3,629	656	527	260	64
VCAPCD	Ventura	68	25	0	3	0
SBAPCD	Santa Barbara	2	11	0	0	0
KCAPCD	Kern	7	4	1	1	0
SJVUAPCD	Kings	10	1	0	0	0
	Tulare	20	34	30	0	0
	Fresno	0	21	0	0	0
	Total	30	56	30	0	0
SLOAPCD	San Luis Obispo	16	12	9	0	0
ICAPCD	Imperial	0	3	0	0	0
13-County Total		4,289	867	567	264	69

6.3 Emission Inventory Analysis

The emission inventory evaluation involved use of the engine-specific relationships discussed in Section 5, the natural gas fuel properties for the four fuel scenarios, and the vehicle population and engine data discussed above. Key inventory modeling parameters and resources are summarized below.

- Years: Eleven years, from 2008 through 2018, were modeled.

- Pollutants: Six pollutants were quantified (methane, THC, NMHC, CO, NOx, and PM).

- Seasonal basis: Inventories were reported on annualized tons per day basis.

- Counties: Fresno, Imperial, Kern, Kings, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Tulare, and Ventura counties were evaluated.*

- CNG applications: Five distinct heavy-duty CNG applications were modeled—transit bus, school bus, street sweeper, solid waste collector, and other.

- Inventory methods: Activity levels and inventory calculation methods were those of CARB models (e.g., EMFAC2007) and other CARB references.

Additional assumptions for the inventory analysis are outlined below.

- Unit work conversion factors (to convert emission factors from g/bhp-hr to g/mi) were taken from the 2008 update to the Carl Moyer Program guidelines.[13] These are specific to the applications of HHD transit buses, all other HHD applications, and all MHD applications.

- An in-use factor adjustment was applied to account for the difference in typical in-use operation of each CNG application in each county versus operation based on standard reference conditions (e.g., those used in the SwRI test program). The in-use adjustment values applied (expressed as a unitless multiplier) were estimated from equivalent Diesel data because insufficient CNG data exist for this inventory correction. In-use operation characteristics for transit buses, school buses, and other MHD and HHD applications were those of the EMFAC2007 model for the specific county and calendar year being modeled. In-use operation characteristics for solid waste hauler and street sweeper applications were those from recent CARB regulatory support evaluations because these two applications are not distinctly modeled in EMFAC2007.[14,15]

- Application-specific activity levels were taken from EMFAC2007 (for transit buses, school buses, and other MHD and HHD applications) and represent year-specific and county-specific values. Activity levels for solid waste hauler and street sweeper applications were also taken from CARB.

The total anthropogenic inventory for each county and district was also collected from CARB. This inventory represents all man-made emissions and was obtained to provide context for the magnitude of any emissions change estimated for the on-road heavy-duty CNG-fueled fleet. For the on-road portion of the anthropogenic inventory, these data were estimated using the EMFAC2007 model noted previously. For the remaining sources, the information was obtained from the CARB's "2009 Almanac Emission

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[*] For Los Angeles, San Bernardino, and Riverside Counties, reported results include only the portion of the county within the South Coast Air Quality Management District; for Kern County, reported results include only the portion of the county within the Kern County Air Pollution Control District.

Projection Data" available on the CARB website.[*] The 2009 Almanac provides estimates for years 2008, 2010, 2015, and 2020. For years falling between the reported years, interpolation was used to estimate inventories for all years 2008 through 2018, inclusive.

6.3 Summary of Results

In this section, the results of the inventory analysis are summarized first for 2008 and then for the entire analysis period. Beginning with the anthropogenic emissions inventory, the 2008 is presented by county and air basin in Table 6-5. Analogous tables are included for all calendar years in Appendix E.

Table 6-5
2008 Anthropogenic Emission Inventory by County

		Pollutant[a] (annual tons per day)				
Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	516.79	151.53	822.25	165.78	31.52
SCAQMD	Los Angeles	408.28	335.85	1,877.77	482.37	56.00
	Orange	154.36	117.30	656.90	135.53	17.70
	Riverside	103.70	61.69	348.29	83.40	12.65
	San Bernardino	132.81	72.16	365.04	90.84	15.87
	Total	799.15	586.99	3,248.00	792.13	102.23
VCAPCD	Ventura	101.19	46.86	208.21	44.36	8.25
SBAPCD	Santa Barbara	75.81	35.21	171.30	37.54	8.88
KCAPCD	Kern	25.33	13.96	96.87	58.16	9.92
SJVUAPCD	Kings	114.23	17.87	60.45	29.13	6.91
	Tulare	243.09	44.97	160.38	45.45	14.06
	Fresno	454.94	81.82	350.61	110.36	28.07
	Total	812.26	144.66	571.43	184.94	49.04
SLOAPCD	San Luis Obispo	56.73	23.16	135.60	21.13	8.98
ICAPCD	Imperial	127.53	30.06	91.61	37.27	39.49
13-County Total		2,514.79	1,032.42	5,345.27	1,341.30	258.30

[a] The on-road hydrocarbon (HC) inventory is expressed as either THC or NMHC; the remaining sources are expressed as either Total Organic Gas (TOG) or Reactive Organic Gas (ROG). The differences between these relate to how the minor HC species of ethane and carbonyl compounds are counted.

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[*] See http://www.arb.ca.gov/app/emsinv/emssumcat.php.

Tables 6-6 through 6-9 summarize the 2008 emission inventory results from this analysis for the four fuel scenarios, again by air basin and county. Inventory totals represent annual average ton per day (tpd) emissions levels from the heavy-duty CNG vehicle fleet operating in the county; the magnitude of the county-level inventory totals generally tracks the number of CNG applications (see Table 6-4 for vehicle populations by county). Again, analogous tables for all calendar years of the analysis period are included in Appendix F.

Table 6-6
2008 CNG Engine Emission Inventory – Historical Fuel Scenario
(annual average tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	1.136	0.041	0.208	0.423	0.0008
SCAQMD	Los Angeles	5.527	0.295	1.463	1.833	0.0020
	Orange	0.953	0.005	0.193	0.210	0.0008
	Riverside	1.910	0.048	0.220	0.290	0.0004
	San Bernardino	0.478	0.004	0.023	0.053	0.0001
	Total	8.869	0.352	1.899	2.386	0.0034
VCAPCD	Ventura	0.094	0.006	0.017	0.046	0.0001
SBAPCD	Santa Barbara	0.006	0.000	0.001	0.003	0.0000
KCAPCD	Kern	0.022	0.000	0.001	0.008	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.199	0.001	0.004	0.035	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.219	0.004	0.007	0.048	0.0000
SLOAPCD	San Luis Obispo	0.047	0.005	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		10.395	0.408	2.147	2.933	0.0042

Table 6-7
2008 CNG Engine Emission Inventory – Current CARB Fuel Regulations Scenario (annual average tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.739	0.117	0.240	0.567	0.0007
SCAQMD	Los Angeles	4.196	0.676	1.675	2.179	0.0021
	Orange	0.652	0.091	0.202	0.277	0.0009
	Riverside	1.242	0.201	0.263	0.365	0.0004
	San Bernardino	0.293	0.042	0.028	0.073	0.0001
	Total	6.383	1.009	2.168	2.893	0.0034
VCAPCD	Ventura	0.069	0.011	0.019	0.054	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.016	0.002	0.002	0.011	0.0000
SJVUAPCD	Kings	0.011	0.002	0.003	0.008	0.0000
	Tulare	0.147	0.017	0.004	0.051	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.165	0.020	0.008	0.066	0.0000
SLOAPCD	San Luis Obispo	0.045	0.006	0.013	0.020	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.422	1.166	2.450	3.616	0.0042

Table 6-8
2008 CNG Engine Emission Inventory – Proposed CARB Phase 1 Scenario (annual average tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.847	0.094	0.230	0.536	0.0007
SCAQMD	Los Angeles	4.568	0.558	1.610	2.117	0.0021
	Orange	0.740	0.064	0.199	0.261	0.0008
	Riverside	1.435	0.154	0.250	0.348	0.0004
	San Bernardino	0.349	0.030	0.026	0.068	0.0001
	Total	7.092	0.806	2.085	2.795	0.0034
VCAPCD	Ventura	0.079	0.009	0.018	0.052	0.0001
SBAPCD	Santa Barbara	0.005	0.000	0.001	0.003	0.0000
KCAPCD	Kern	0.018	0.002	0.002	0.010	0.0000
SJVUAPCD	Kings	0.013	0.002	0.003	0.008	0.0000
	Tulare	0.165	0.012	0.004	0.046	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.185	0.014	0.007	0.059	0.0000
SLOAPCD	San Luis Obispo	0.049	0.004	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		8.275	0.928	2.356	3.473	0.0042

Table 6-9
2008 CNG Engine Emission Inventory – Proposed CARB Phase 2 Scenario
(annual average tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.776	0.109	0.237	0.556	0.0007
SCAQMD	Los Angeles	4.323	0.636	1.653	2.158	0.0021
	Orange	0.682	0.082	0.201	0.271	0.0009
	Riverside	1.308	0.185	0.258	0.359	0.0004
	San Bernardino	0.312	0.038	0.027	0.071	0.0001
	Total	6.625	0.940	2.139	2.860	0.0034
VCAPCD	Ventura	0.072	0.010	0.018	0.053	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.016	0.002	0.002	0.011	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.153	0.015	0.004	0.049	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.172	0.018	0.008	0.064	0.0000
SLOAPCD	San Luis Obispo	0.046	0.005	0.013	0.019	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.714	1.085	2.418	3.567	0.0042

The data presented in Tables 6-6 through 6-9 were used to estimate the change in emissions for each of the regulatory fuel scenarios relative to the baseline fuel scenario. These results are shown in Tables 6-10 through 6-12, where the estimated emission changes are presented both in absolute terms—e.g., changes in emissions in units of tons of pollutant emitted per day—as well as in terms of the percent change relative to the total anthropogenic emission inventory for that pollutant in that county. It should also be noted, as is discussed in more detail below, that 2008 was the calendar year in which the absolute changes in emissions were greatest for most pollutants.

Table 6-10
2008 CNG Engine Emission Inventory, Difference Relative to Historical Fuel Scenario, Current CARB Fuel Regulations Scenario[a]

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.397	0.076	0.031	0.144	0.0000	-0.08%	0.05%	0.00%	0.09%	0.00%
SCAQMD	Los Angeles	-1.331	0.381	0.212	0.346	0.0000	-0.33%	0.11%	0.01%	0.07%	0.00%
	Orange	-0.301	0.085	0.009	0.067	0.0000	-0.20%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.669	0.153	0.043	0.075	0.0000	-0.64%	0.25%	0.01%	0.09%	0.00%
	San Bernardino	-0.185	0.038	0.005	0.019	0.0000	-0.14%	0.05%	0.00%	0.02%	0.00%
	Total	-2.486	0.657	0.269	0.507	0.0000	-0.31%	0.11%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.026	0.005	0.002	0.009	0.0000	-0.03%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.007	0.002	0.000	0.003	0.0000	-0.03%	0.01%	0.00%	0.01%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.052	0.015	0.000	0.016	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.054	0.016	0.001	0.018	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.002	0.001	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.01%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.973	0.758	0.303	0.683	0.0000	-0.12%	0.07%	0.01%	0.05%	0.00%

[a] Positive values reflect emission increases; negative values, emission decreases.

Table 6-11
2008 CNG Engine Emission Inventory, Difference Relative to Historical Fuel Scenario, Proposed CARB Phase 1 Scenario[a]

		Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.289	0.053	0.022	0.113	0.0000	-0.06%	0.04%	0.00%	0.07%	0.00%
SCAQMD	Los Angeles	-0.959	0.263	0.147	0.284	0.0000	-0.23%	0.08%	0.01%	0.06%	0.00%
	Orange	-0.214	0.059	0.006	0.052	0.0000	-0.14%	0.05%	0.00%	0.04%	0.00%
	Riverside	-0.476	0.106	0.030	0.059	0.0000	-0.46%	0.17%	0.01%	0.07%	0.00%
	San Bernardino	-0.130	0.026	0.003	0.014	0.0000	-0.10%	0.04%	0.00%	0.02%	0.00%
	Total	-1.778	0.454	0.186	0.408	0.0000	-0.22%	0.08%	0.01%	0.05%	0.00%
VCAPCD	Ventura	-0.015	0.003	0.001	0.006	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.001	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.010	0.000	0.011	0.0000	-0.01%	0.02%	0.00%	0.02%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.034	0.010	0.000	0.011	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.001	-0.001	0.000	-0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.120	0.521	0.210	0.540	0.0000	-0.08%	0.05%	0.00%	0.04%	0.00%

[a] Positive values reflect emission increases; negative values, emission decreases.

Table 6-12
2008 CNG Engine Emission Inventory, Difference Relative to Historical Fuel Scenario, Proposed CARB Phase 2 Scenario[a]

		Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.360	0.068	0.028	0.133	0.0000	-0.07%	0.05%	0.00%	0.08%	0.00%
SCAQMD	Los Angeles	-1.204	0.340	0.190	0.325	0.0000	-0.29%	0.10%	0.01%	0.07%	0.00%
	Orange	-0.271	0.076	0.008	0.062	0.0000	-0.18%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.603	0.137	0.038	0.070	0.0000	-0.58%	0.22%	0.01%	0.08%	0.00%
	San Bernardino	-0.166	0.034	0.004	0.018	0.0000	-0.13%	0.05%	0.00%	0.02%	0.00%
	Total	-2.244	0.588	0.240	0.473	0.0000	-0.28%	0.10%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.022	0.004	0.002	0.008	0.0000	-0.02%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.046	0.013	0.000	0.014	0.0000	-0.02%	0.03%	0.00%	0.03%	0.00%
	Fresno	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.047	0.014	0.000	0.015	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.001	0.001	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.681	0.677	0.271	0.634	0.0000	-0.11%	0.07%	0.01%	0.05%	0.00%

[a] Positive values reflect emission increases; negative values, emission decreases.

Observations from the 2008 calendar year results shown in Tables 6-10 through 6-12 are outlined below.

1. Generally, the results show that relative to the baseline, the emission inventories for NOx, NMHC, and CO from heavy-duty CNG vehicles increase, while the THC[*] emission inventory decreases.

2. The heavy-duty CNG vehicle PM emission inventory is not significantly affected.

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[*] The difference between THC and NMHC is methane; for CNG applications, THC emissions levels are generally much greater than NMHC emissions levels owing to the fact that methane is by far the largest constituent of natural gas.

3. The magnitude of the changes reported by county generally reflects the number of CNG engines operating in that county.

4. For all 13 counties in the service area in 2008, NOx emissions were estimated to increase in the range of 0.540 tpd[*] to 0.683 tpd.[†] This range equates to a 0.04 to 0.05 percent increase in the total anthropogenic NOx inventory for the 13 counties.

5. For all 13 counties in the service area, exhaust NMHC emissions were estimated to increase in the range of 0.521 tpd[3] to 0.758 tpd.[‡] This range equates to a 0.05 to 0.07 percent increase in the total anthropogenic NMHC inventory for the 13 counties.

6. For all 13 counties in the service area, CO emissions were estimated to increase in the range of 0.210 tpd[3] to 0.303 tpd.[‡] This range equates to a 0.01 percent increase in the total anthropogenic CO inventory for the 13 counties.

Tables analogous to Tables 6-10 through 6-12 for all years of the inventory analysis are provided in Appendix G. Note that in the reported changes in emissions, positive values reflect emission increases; negative values reflect emission decreases relative to the baseline inventory

Analysis results for the entire analysis period are presented in Table 6-13, which shows the estimated inventory change for the 13-county total region for every calendar year for each of the three regulatory scenarios. Observations from these results are as follows.

1. For all pollutants but PM, the largest absolute change in emissions occurs in 2008.

2. For THC, NOx, and CO, the estimated absolute impact declines over time, reaching the lowest levels in 2018. For NMHC, the absolute impact declines over time until 2015 and increases again thereafter.

3. For PM, a small change in emissions is estimated that increases over time but never amounts to more than one one-hundredth of a ton per day.

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[*] As shown in Table 6-11 for the fuel composition associated with the proposed Phase 1 CARB standard.

[†] As shown in Table 6-10 for the fuel composition associated with the current CARB commercial fuel standards.

[‡] CNG fleets operating within each county by engine make and model (for each calendar year) were provided in an email communication from Ed Harte (March 2009) and were derived from survey data.

Table 6-13
13-County CNG Engine Emission Inventory, Difference Relative to Historical Fuel Scenario, Calendar Years 2008 through 2018

		Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
Fuel Scenario	Year	THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
Current CARB Regulations	2008	-2.973	0.758	0.303	0.683	0.0000	-0.12%	0.07%	0.01%	0.05%	0.00%
	2009	-2.957	0.757	0.299	0.677	0.0000	-0.12%	0.07%	0.01%	0.05%	0.00%
	2010	-2.877	0.755	0.289	0.664	0.0000	-0.12%	0.08%	0.01%	0.05%	0.00%
	2011	-2.613	0.731	0.237	0.592	0.0001	-0.11%	0.07%	0.01%	0.05%	0.00%
	2012	-2.374	0.704	0.214	0.555	0.0001	-0.10%	0.07%	0.00%	0.05%	0.00%
	2013	-1.997	0.652	0.155	0.441	0.0002	-0.08%	0.07%	0.00%	0.04%	0.00%
	2014	-1.817	0.644	0.144	0.396	0.0002	-0.07%	0.07%	0.00%	0.04%	0.00%
	2015	-1.628	0.640	0.126	0.365	0.0003	-0.07%	0.07%	0.00%	0.04%	0.00%
	2016	-1.456	0.661	0.091	0.311	0.0003	-0.06%	0.07%	0.00%	0.03%	0.00%
	2017	-1.198	0.684	0.042	0.227	0.0004	-0.05%	0.08%	0.00%	0.02%	0.00%
	2018	-1.016	0.672	0.036	0.179	0.0004	-0.04%	0.07%	0.00%	0.02%	0.00%
SoCal Gas /SDG&E Proposal – Phase 1	2008	-2.120	0.521	0.210	0.540	0.0000	-0.08%	0.05%	0.00%	0.04%	0.00%
	2009	-2.109	0.520	0.207	0.536	0.0000	-0.09%	0.05%	0.00%	0.04%	0.00%
	2010	-2.049	0.518	0.200	0.524	0.0000	-0.08%	0.05%	0.00%	0.04%	0.00%
	2011	-1.860	0.500	0.164	0.465	0.0000	-0.08%	0.05%	0.00%	0.04%	0.00%
	2012	-1.695	0.481	0.148	0.437	0.0000	-0.07%	0.05%	0.00%	0.04%	0.00%
	2013	-1.427	0.444	0.107	0.348	0.0001	-0.06%	0.05%	0.00%	0.03%	0.00%
	2014	-1.299	0.438	0.100	0.312	0.0001	-0.05%	0.05%	0.00%	0.03%	0.00%
	2015	-1.164	0.435	0.087	0.286	0.0001	-0.05%	0.05%	0.00%	0.03%	0.00%
	2016	-1.033	0.448	0.063	0.239	0.0001	-0.04%	0.05%	0.00%	0.02%	0.00%
	2017	-0.836	0.463	0.029	0.169	0.0002	-0.03%	0.05%	0.00%	0.02%	0.00%
	2018	-0.710	0.454	0.025	0.133	0.0002	-0.03%	0.05%	0.00%	0.01%	0.00%
SoCal Gas /SDG&E Proposal – Phase 2	2008	-2.681	0.677	0.271	0.634	0.0000	-0.11%	0.07%	0.01%	0.05%	0.00%
	2009	-2.667	0.676	0.268	0.629	0.0000	-0.11%	0.07%	0.01%	0.05%	0.00%
	2010	-2.594	0.674	0.259	0.616	0.0000	-0.11%	0.07%	0.01%	0.05%	0.00%
	2011	-2.355	0.652	0.212	0.548	0.0000	-0.10%	0.07%	0.00%	0.05%	0.00%
	2012	-2.142	0.628	0.192	0.515	0.0001	-0.09%	0.07%	0.00%	0.04%	0.00%
	2013	-1.802	0.581	0.138	0.409	0.0002	-0.07%	0.06%	0.00%	0.04%	0.00%
	2014	-1.640	0.573	0.129	0.367	0.0002	-0.07%	0.06%	0.00%	0.04%	0.00%
	2015	-1.469	0.570	0.113	0.338	0.0002	-0.06%	0.06%	0.00%	0.03%	0.00%
	2016	-1.311	0.588	0.082	0.286	0.0002	-0.05%	0.06%	0.00%	0.03%	0.00%
	2017	-1.075	0.608	0.038	0.207	0.0003	-0.04%	0.07%	0.00%	0.02%	0.00%
	2018	-0.912	0.598	0.032	0.163	0.0003	-0.04%	0.07%	0.00%	0.02%	0.00%

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APPENDIX A

Background on Principal Components Analysis

A.1 Introduction

This appendix discusses Principal Components Analysis (PCA), and provides examples of the mathematical calculations involved, as a reference for users of the analysis presented in this report. As described previously, PCA is a well known, multivariate statistical technique that is not often used in engineering studies, but is better known in the physical sciences. For a dataset consisting of observations on N variables, PCA performs a *singular value decomposition* of the X matrix (of independent variables) to produce a slate of N eigenvectors and N eigenvalues.

The most common form of PCA involves decomposition of the correlation matrix; the resulting eigenvectors are normalized to a vector length of unity and the eigenvalues sum to N. In this decomposition, each eigenvector expresses one way in which the N variables are related to each other, and the eigenvalues measure how much of the variation in the dataset is associated with each eigenvector. Essentially, the correlations among the N variables are broken down into N differing patterns of variation that make up the overall relationship of variables in the dataset. PCA works on the basis of variables standardized to a mean of zero and standard deviation of one. If there are N variables, then the standardized variance in the dataset is also N.

When PCA is applied to an orthogonal dataset, the resulting eigenvectors reveal the experimental design. When PCA is applied to a non-orthogonal dataset, the eigenvectors reveal information on how the data were generated (or sampled). The eigenvectors additionally provide a set of vector variables in which the data are orthogonal. PCA has been applied extensively to the analysis of diesel engine emissions by one of the authors and has proved to offer reliable insight into the underlying structures of fuel datasets.

A.2 Application to CNG Fuels

The use of PCA begins with the process of normalizing the variables to a mean value of 0 and a standard deviation of 1. Table A-1 shows the means and standard deviations of the six variables in the dataset of 40 CNG fuels (8 target fuels times 5 realizations). When normalized, a fuel is expressed as a slate of standardized property values, each of which measures the deviation of the fuel from the mean property value in the dataset in units of standard deviations. The property values stated in units of standard deviations from the mean are called standardized scores.

As an example, the CARB certification fuel in the experimental design has nominal values of 89 MN, 1333 WI, 90.5% methane, 4.0% ethane, 2.0% propane, and 3.5% nitrogen. Its MN property is normalized as (89 – 87.41) / 10.42 = 0.153. The full slate of normalized properties are MN = 0.153, WI = -0.654, Methane = -0.132, Ethane = 1.091, Propane = -0.622, and Nitrogen = 0.557. These values say that, compared to all fuels in the CNG dataset, the CARB certification fuel is more than 1 standard deviation from the mean in its ethane content, and more than 0.5 standard deviation from the mean for WI, propane, and ethane content. It is close to the mean in the data set only for MN and methane content.

Table A-1
Normalization Values for Fuel Variables in CNG Dataset

Variable	Units	Mean Value	Standard Deviation
MN	number	87.41	10.42
WI	number	1350.8	27.2
Methane	vol %	91.02	3.94
Ethane	vol %	2.68	1.21
Propane	vol %	3.50	2.41
Nitrogen	vol %	2.77	1.31

As conducted in this report, PCA is applied to the correlation matrix formed from the variables in the dataset. It is actually this choice that causes PCA to work with variables normalized to mean 0 and standard deviation 1. Other forms of PCA exist, in which other normalizations are used or the data may be used without normalization, but these forms are not commonly encountered in multivariate analysis outside specialized areas.

When applied to the dataset of 40 CNG fuels with its six variables, the outputs of the PCA procedure consist of six eigenvectors and six corresponding eigenvalues. By definition, a dataset of N variables will produce N eigenvectors and N non-zero eigenvalues, unless one or more variables are a linear combination of other variables. If n linear dependencies are present, then N – n non-zero eigenvalues and corresponding eigenvectors will be obtained. In the terminology of linear algebra, the eigenvectors form a complete vector basis for the space of the data, meaning that any fuel in the dataset can be exactly expressed in terms of a weighted sum of the eigenvectors.

Table A-2 shows the eigenvalues of the CNG dataset. The eigenvalues partition the total variance in the dataset into the parts associated with each of the eigenvectors. The total variance in the dataset is 6.0 (because there are six variables, each having a variance of 1 in normalized form). A variance of 3.92 (or 65% of the total) is associated with Vector 1 and lesser amounts for subsequent vectors. Vectors 4 through 6 have very small non-zero eigenvalues, which are shown as zero in the table. To say that the variance associated with Vector 1 is 3.92 means that the Vector 1 scores have a variance of 3.92 across the fuels in the dataset. (The calculation of vector scores is explained below.) Thus, Vector 1 represents the characteristic that varies most widely among the fuels in the dataset, Vector 2 is the characteristic that varies next most widely, and so forth.

A total of 99.9% of the variance in the CNG fuel dataset is associated with Vectors 1, 2, and 3. This means that essentially all of the systematic variation in the fuels is associated with those vectors. The near-zero Vectors 4, 5, and 6 must be present for the eigenvectors to be a complete vector basis, but they represent little more than noise sources in the data (such as measurement error and rounding).

Table A-2
Eigenvalues of the CNG Dataset

	Eigenvalue (Variance)	Percent of Total Variance	Cumulative Percent
Vector 1	3.92	65.3%	65.3%
Vector 2	1.64	27.4%	92.7%
Vector 3	0.44	7.3%	99.9%
Vector 4	0.00	0.1%	100.0%
Vector 5	0.00	0.0%	100.0%
Vector 6	0.00	0.0%	100.0%
Total	6.00		

Table A-3 gives the internal coefficients of the three primary eigenvectors in the CNG fuel dataset. As can be seen, each vector is expressed as a slate of internal coefficients or weights associated with the (normalized) variables. Vector 1 can be read as stating that a MN change of -0.50 standard deviations (s.d.) is associated with a change of +0.25 s.d. in WI, -0.49 s.d. in methane content, +0.41 s.d. in ethane content, +0.48 s.d. in propane content, and +0.23 s.d. in nitrogen content. This is the downward-sloping MN/WI axis shown in red in Figure 4-1 of this report and represents the largest (or most prevalent) pattern of variation in the data. Vector 2 corresponds to the upward-sloping perpendicular axis shown in blue in Figure 4-1 and represents the second largest pattern of variation. Vector 3 would be an axis perpendicular to the plane of Figure 4-1 if it could be shown.

Table A-3
Primary Eigenvectors of the CNG Dataset
(Internal Coefficients by Variable)

	Vector 1	Vector 2	Vector 3
MN	-0.498	-0.081	0.178
WI	0.247	0.680	0.013
Methane	-0.493	0.169	0.054
Ethane	0.411	-0.085	0.867
Propane	0.476	0.141	-0.422
Nitrogen	0.228	-0.689	-0.188

In general, any fuel may be represented as a weighted sum of the eigenvectors:

$$F_i = s_{i,1} \cdot V_1 + s_{i,2} \cdot V_2 + s_{i,3} \cdot V_3 + s_{i,4} \cdot V_4 + s_{i,5} \cdot V_5 + s_{i,6} \cdot V_6 \qquad \text{(Eq. A-1)}$$

Here, the coefficients $s_{i,j}$ are the vector scores that define the extent to which fuel i expresses the characteristics (or pattern) represented by vector j. A fuel i is completely defined by the set of six scores { $s_{i,j}$ }, and the mean fuel in the dataset is (by definition) the fuel whose scores are identically zero. All six vectors must be used if one is to replicate the original data exactly, but three vectors are adequate to describe fully the systematic variation among fuels in the CNG dataset.

A.3 Calculation of Vector Scores

Determining the vector scores that correspond to a given fuel is a basic calculation encountered in working with principal components. This process is shown in Table A-4 for the CARB certification fuel. As can be seen, the properties of the fuel are first normalized to mean 0 and standard deviation 1. Then, the standardized property values are weighted according to the internal coefficients of each vector, and the score is calculated by summing the weighted values across the variables (column-wise). To two decimal places, the CARB certification fuel can be expressed as having a Vector 1 score of 0.10, a Vector 2 score of -0.45, and a Vector 3 score of 1.12.

Table A-4
Example Vector Score Calculation for the CARB Certification Fuel

			Vector 1 Score Computation								
		Fuel Formulation	Vector Coefficient		Fuel		Mean		Std		Score
MN	number	**89.0**	-0.498	* (	89.0	-	87.41	) /	10.42	=	-0.08
WI	number	**1,333**	0.247	* (	1333	-	1350.8	) /	27.2	=	-0.16
Methane	vol %	**90.5**	-0.493	* (	90.5	-	91.02	) /	3.94	=	0.07
Ethane	vol %	**4.0**	0.411	* (	4.0	-	2.68	) /	1.21	=	0.45
Propane	vol %	**2.0**	0.476	* (	2.0	-	3.50	) /	2.41	=	-0.30
Nitrogen	vol %	**3.5**	0.228	* (	3.5	-	2.77	) /	1.31	=	0.13
									Vector 1 Score	=	**0.10**

			Vector 2 Score Computation								
		Fuel Formulation	Vector Coefficient		Fuel		Mean		Std		Score
MN	number	89.0	-0.498	* (	89.0	-	87.41	) /	10.42	=	-0.01
WI	number	1333.0	0.247	* (	1333.0	-	1350.8	) /	27.2	=	-0.45
Methane	vol %	90.5	-0.493	* (	90.5	-	91.02	) /	3.94	=	-0.02
Ethane	vol %	4.0	0.411	* (	4.0	-	2.68	) /	1.21	=	-0.09
Propane	vol %	2.0	0.476	* (	2.0	-	3.50	) /	2.41	=	-0.09
Nitrogen	vol %	3.5	0.228	* (	3.5	-	2.77	) /	1.31	=	-0.38
									Vector 2 Score	=	**-0.45**

			Vector 3 Score Computation								
		Fuel Formulation	Vector Coefficient		Fuel		Mean		Std		Score
MN	number	89.0	-0.498	* (	89.0	-	87.41	) /	10.42	=	0.03
WI	number	1333.0	0.247	* (	1333.0	-	1350.8	) /	27.2	=	-0.01
Methane	vol %	90.5	-0.493	* (	90.5	-	91.02	) /	3.94	=	-0.01
Ethane	vol %	4.0	0.411	* (	4.0	-	2.68	) /	1.21	=	0.95
Propane	vol %	2.0	0.476	* (	2.0	-	3.50	) /	2.41	=	0.26
Nitrogen	vol %	3.5	0.228	* (	3.5	-	2.77	) /	1.31	=	-0.10
									Vector 3 Score	=	**1.12**

A.3 Calculation of Fuel Properties from Vector Scores

A second basic calculation encountered in working with principle components is the need to compute the fuel properties that are implied by a set of vector scores. This calculation is the inverse of that shown in the preceding section and involves expansion of Eq. A-1 on a row-by-row basis.

This process is shown in Table A-5 using only the first three vectors that account for essentially all of the systematic variation in the fuels. Here, the score values (to 2 decimals) taken from Table A-4 are used as multipliers of the internal coefficients in the vectors, and then summed row-wise across the vectors, to produce the properties (in normalized form) for the corresponding fuel. The physical properties are recovered by first multiplying by the standard deviation and then adding the mean value of each property (found in Table A-1). The direction of calculation is row-wise for each variable, whereas the calculation in Table A-4 is column-wise.

Table A-5
Computation of Fuel Properties from Vector Scores

	Vector 1	Vector 2	Vector 3	Normalized Fuel Properties	Multiply by Standard Deviation	Add the Mean
Scores	0.10	-1.04	1.12			
Internal Components						
MN	-0.498	-0.081	0.178	0.23	2.4	89.8
WI	0.247	0.680	0.013	-0.67	-18.2	1332.6
Methane	-0.493	0.169	0.054	-0.16	-0.7	90.4
Ethane	0.411	-0.085	0.867	1.10	1.3	4.0
Propane	0.476	0.141	-0.422	-0.57	-1.4	2.1
Nitrogen	0.228	-0.689	-0.188	0.53	0.7	3.5

One should note that the CARB certification fuel is not recovered exactly by the calculation shown in the table. Two sources of imprecision are involved:

- The vector scores were entered only to 2 decimal places, causing a degree of truncation error in the calculation.
- Only Vectors 1-3 were considered. Although the first three vectors represent essentially all of the systematic variation in the data, all six vectors must be carried in order to exactly represent fuels.

A.4 Determination of Fuels based on MN/WI Targets

A final calculation to be shown is the determination of fuels that meet given targets for MN and WI. As has been explained, three vectors are needed to characterize the systematic variation of fuels in the dataset. Section 2 of the report characterized the vectors as follows:

- Vector 1 represents the overall trend of MN and WI in the dataset. Figure 4-1 shows this trend line to correspond closely to the overall correlation of MN and WI in the data.
- Vector 2 represents the independent variation of WI at right angles to the overall MN/WI trend line defined by Vector 1.
- Vector 3 represents a substitution of ethane for propane and nitrogen at fixed ratios, with only a small effect on MN and essentially no effect on WI.

Properly combined, Vectors 1, 2, and 3 can produce a range of fuels with varying ethane/propane/nitrogen composition that all share the same values for MN and WI.

In applying the analysis presented here to solve problems in the real world, it will often be necessary to work with fuels specified only in terms of MN and WI and without further information on the hydrocarbon composition. Because there can be a range of compositions consistent with any given MN and WI values, such fuels are not fully specified with respect to this analysis. Therefore, one must define such problems in terms of the average fuel having the given MN/WI values.

In vector terms, a mean value corresponds to a vector score of zero. The overall average fuel has scores of zero for all six vectors, and the fuel effect of any one vector can be set to the average condition by setting its score to zero (while allowing scores for the other vectors to vary). To define a fuel with given MN and WI index, but with what is otherwise an average composition in the dataset, we set the Vector 3 score to zero and then solve for Vector 1 and 2 scores that yield the desired MN and WI values. This process yields a fuel having the desired MN and WI values and an overall average ratio for ethane/propane/nitrogen content that is consistent both with the MN and WI values and with the compositional variations among the fuels in the dataset.

The mathematics of the solution are to write out the first two rows of the calculation shown in Table A-5 using the symbols s_1 and s_2 for the unknown scores for Vectors 1 and 2 and with $s_3 = 0$ assumed for Vector 3. For MN, the calculation is as follows, where the constants are the internal coefficients for MN in Vectors 1-3:

$$MN = -0.498 * s_1 + -0.081 * s_2 + 0.178 * 0 \qquad \text{(Eq. A-2)}$$

For WI, the calculation is as follows, where the constants are now the internal coefficients for WI in the vectors:

$$WI = +0.247 * s_1 + 0.680 * s_2 + 0.013 * 0 \qquad \text{(Eq. A-3)}$$

This produces a system of two equations in two unknowns (s_1 and s_2) that are parameterized by the target values MN and WI of interest to the analyst. The system is solved by letting the variable R equal the ratio of the internal coefficients for MN in vectors 1 and 2. Therefore, R = -0.498/0.247 = -2.0195. Multiplying Eq. A-3 by R and then subtracting Eq. A-2 gives the following equation:

$$R * WI - MN = (R * 0.680 + 0.081) * s_2 \qquad \text{(Eq. A-4)}$$

Solving Eq. A-4 for s_2 gives:

$$s_2 = (R * WI - MN) / (R * 0.680 + 0.081) \qquad \text{(Eq. A-5)}$$

Solving Eq. A-3 for s_2 gives:

$$s_1 = (WI - 0.680 * s_2) / 0.247 \qquad \text{(Eq. A-6)}$$

Under the assumption that the Vector 3 score is zero, the Vector 1 and 2 scores can be determined for any desired MN and WI values using Equations A-5 and A-6. For example, let us find the Vector 1 and 2 scores that yield a fuel having MN = 100 and WI = 1337 and otherwise of average composition. Such an average fuel could be compared to the MN 100 mid-WI fuel in the CNG dataset, which is one specific fuel in the same class.

First, we computed normalized MN and WI numbers:

$$MN = (100 - 87.41) / 10.42 = +1.208$$
$$WI = (1337 - 1350.8) / 27.2 = -0.507$$

From Equation A-5, we have:

$$s_2 = (-2.0195 * -0.507 - 1.208) / (-2.0195 * 0.680 + 0.081) = 0.142$$

From Equation A-6, we have:

$$s_1 = (-.507 - 0.680 * 0.142) / 0.247 = -2.444$$

For comparison, the scores of the MN 100 mid-WI fuels in the dataset have Vector 1 scores ranging from -2.16 to -2.50, Vector 2 scores ranging from +0.01 to -0.38, and Vector 3 scores ranging from +0.02 to -0.05. The average MN 100 mid-WI fuel defined by the procedure above is, in fact, a good representation of the average for the class of similar fuels.

One can check the accuracy of the solution by performing the calculation given in Table A-4 using the scores $s_1 = -2.444$, $s_2 = 0.142$ and all other scores identically zero. The result is given in Table A-6 and shows that the calculated fuel does in fact meet the specified targets for MN and WI.

Table A-6
Properties of MN 100 mid-WI Fuel Determined by Calculation

	Specified	Computed
MN	100	100.0
WI	1337	1337.0
Methane	C	95.9
Ethane	C	1.4
Propane	C	0.7
Nitrogen	C	1.9

APPENDIX B

Complete Results of Statistical Analysis for Criteria Pollutants and CO_2

Table B-1
NOx Emissions (g/hp-hr) by Engine

Model: $E/E_{cert} - 1 = A + B * \text{Vector } 1 + C*\text{Vector } 2 + D*\text{Vector } 3$

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		98.6%	93.3%	90.9%	99.8%	6.4%
Intercept		**0.0340**	0.0037	0.0096	**0.0150**	-0.0255
prob>|t|		0.00	0.80	0.74	0.01	0.09
Vector 1 (MN/WI Trend)		**0.0587**	**0.0325**	**0.0862**	**0.0538**	-0.0042
prob>|t|		0.00	0.01	0.00	0.00	0.55
Vector 2 (WI Variation)		**0.0272**	**0.0525**		**0.0313**	
prob>|t|		0.00	0.01		0.00	
Vector 3 (Composition)			0.0480	0.1069	**0.0137**	
prob>|t|			0.07	0.06	0.03	
Emissions Increase versus CARB Cert Fuel (95% Confidence)						
MN 75L		17%	9%	5%	15%	No statistically significant emissions change detected
MN 75H		20%	22%	5%	20%	
MN 78L		11%	6%	3%	10%	
MN 78H		15%	17%	2%	15%	
MN 80L		7%			5%	
MN 80H		11%	13%		11%	
MN 100L		-15%	-13%	3%	-15%	
MN 100M		-12%		3%	-10%	
MN 100H		-7%		4%	-4%	
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (g/hp-hr)		2.50	2.50	NOx+NMHC	NOx+NMHC	0.20
Emissions on CARB Cert Fuel (g/hp-hr)		2.26	0.88	–	–	0.08
Increase to Reach Standard		11%	184%	–	–	150%
Standard Exceeded at Methane Number	Low WI	below 79	below 75	–	–	never
	High WI	below 82	below 75	–	–	never

Table B-2

NOx Emissions (g/hp-hr) by Certification Group

Model: $E/E_{cert} - 1 = A + B * \text{Vector 1} + C*\text{Vector 2} + D*\text{Vector 3}$

		Group 1: C Gas DDC TK	**Group 2: JD 6081 C Gas +**	**Group 3: C ISL G**
Statistical Analysis Results				
Model R^2		83.3%	84.8%	6.4%
Intercept		0.0185	0.0066	-0.0255
prob>|t|		0.15	0.72	0.09
Vector 1 (MN/WI Trend)		**0.0433**	**0.0697**	-0.0042
prob>|t|		0.00	0.00	0.55
Vector 2 (WI Variation)		**0.0414**	0.0234	
prob>|t|		0.00	0.14	
Vector 3 (Composition)			0.0546	
prob>|t|			0.07	
Emissions Increase versus CARB Certification Fuel (95% Confidence)				
MN 75L		14%	17%	No statistically significant emissions change detected
MN 75H		19%	26%	
MN 78L		9%	11%	
MN 78H		16%	15%	
MN 80L		6%		
MN 80H		14%		
MN 100L		-13%	-19%	
MN 100M		- 6%	-15%	
MN 100H				
Exceedance of Certification Standard (95% Confidence)				
Certification Standard (g/hp-hr)		2.50	NOx+NMHC	0.20
Emissions on CARB Cert Fuel (g/hp-hr)		1.57	1.44	0.08
Increase to Reach Standard		59%	–	150%
Standard Exceeded at MN	Low Wobbe	below 75	–	never
	High Wobbe	below 75	–	never

Table B-3
NOx + NMHC Emissions (g/hp-hr) by Engine

Model: $E/E_{cert} - 1 = A + B * \text{Vector } 1 + C*\text{Vector } 2 + D*\text{Vector } 3$

		C Gas	**DDC TK**	**JD 6081**	**C Gas +**	**C ISL G**
Statistical Analysis Results						
Model R^2		99.3%	99.8%	95.1%	99.5%	94.4%
Intercept		0.0105	**0.0149**	0.0228	0.0090	**0.1481**
prob>|t|		0.11	0.02	0.38	0.18	0.02
Vector 1 (MN/WI Trend)		**0.0831**	**0.1085**	**0.1132**	**0.0845**	**0.2503**
prob>|t|		0.00	0.00	0.00	0.00	0.00
Vector 2 (WI Variation)		**0.0235**	**0.0444**	0.0853	**0.0332**	
prob>|t|		0.00	0.00	0.07	0.00	
Vector 3 (Composition)						
prob>|t|						
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		24%	32%	25%	25%	67%
MN 75H		25%	36%	34%	28%	63%
MN 78L		15%	20%	16%	16%	42%
MN 78H		18%	26%	16%	20%	37%
MN 80L		9%	13%		10%	25%
MN 80H		12%	20%		15%	19%
MN 100L		-20%	-28%	-28%	-22%	-55%
MN 100M		-18%	-22%	-28%	-17%	-61%
MN 100H		-15%	-15%	-28%	-12%	-68%
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (g/hp-hr)		NOx	NOx	1.80	1.80	NOx
Emissions on CARB Cert Fuel (g/hp-hr)		2.64	1.38	1.48	1.69	0.16
Increase to Reach Standard		–	–	22%	7%	–
Standard Exceeded at Methane Number	Low WI	–	–	below 76	below 82	–
	High WI	–	–	below 75	below 85	–

Table B-4
NOx + NMHC Emissions (g/hp-hr) by Certification Group

Model: E/E_{cert} - 1 = A + B * Vector 1 + C*Vector 2 + D*Vector 3

		Group 1: C Gas DDC TK	Group 2: JD 6081 C Gas +	Group 3: C ISL G
Statistical Analysis Results				
	Model R^2	97.7%	91.5%	94.4%
Intercept		0.0143	0.0107	**0.1481**
	prob>|t|	0.10	0.54	0.02
Vector 1 (MN/WI Trend)		**0.0980**	**0.0985**	**0.2503**
	prob>|t|	0.00	0.00	0.00
Vector 2 (WI Variation)		**0.0322**	0.0262	
	prob>|t|	0.00	0.08	
Vector 3 (Composition)				
	prob>|t|			
Emissions Increase versus CARB Certification Fuel (95% Confidence)				
MN 75L		28%	28%	67%
MN 75H		31%	30%	63%
MN 78L		18%	18%	42%
MN 78H		22%	20%	37%
MN 80L		11%	11%	25%
MN 80H		16%	14%	19%
MN 100L		-24%	-24%	-55%
MN 100M		-21%	-21%	-61%
MN 100H		-16%	-18%	-68%
Exceedance of Certification Standard (95% Confidence)				
Certification Standard (g/hp-hr)		NOx	1.80	NOx
Emissions on CARB Cert Fuel (g/hp-hr)		2.01	1.58	0.16
Increase to Reach Standard		–	14%	–
Standard Exceeded at MN	Low WI	–	below 79	–
	High WI	–	below 79	–

Table B-5
NMHC Emissions (g/hp-hr) by Engine

Model: $E/E_{cert} - 1 = A + B * \text{Vector } 1 + C*\text{Vector } 2 + D*\text{Vector } 3$

		C Gas	**DDC TK**	**JD 6081**	**C Gas +**	**C ISL G**
Statistical Analysis Results						
Model R^2		98.9%	98.7%	98.6%	97.9%	94.1%
Intercept		**-0.1275**	0.0355	**0.1909**	-0.0553	**0.3194**
prob>|t|		0.00	0.22	0.01	0.25	0.02
Vector 1 (MN/WI Trend)		**0.2513**	**0.0241**	**0.4506**	**0.3520**	**0.5007**
prob>|t|		0.00	0.00	0.00	0.00	0.00
Vector 2 (WI Variation)						
prob>|t|						
Vector 3 (Composition)		0.0737	-0.0841	-0.1850		
prob>|t|		0.08	0.07	0.07		
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		24%	32%	4%	25%	67%
MN 75H		25%	36%	4%	28%	63%
MN 78L		15%	20%	3%	16%	42%
MN 78H		18%	26%	2%	20%	37%
MN 80L		9%	13%		10%	25%
MN 80H		12%	20%		15%	19%
MN 100L		-20%	-28%	3%	-22%	-55%
MN 100M		-18%	-22%	3%	-17%	-61%
MN 100H		-15%	-15%	3%	-12%	-68%
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (g/hp-hr)		1.20	1.20	NOx+NMHC	NOx+NMHC	0.14
Emissions on CARB Cert Fuel (g/hp-hr)		0.35	0.50	0.11	0.17	0.08
Increase to Reach Standard		244%	138%			71%
Standard Exceeded at Methane Number	Low WI	below 75	below 75	–	–	below 75
	HighWI	below 75	below 75	–	–	below 75

Table B-6
NMHC Emissions (g/hp-hr) by Certification Group

Model: $E/E_{cert} - 1 = A + B * \text{Vector 1} + C*\text{Vector 2} + D*\text{Vector 3}$

		Group 1: C Gas DDC TK	Group 2: JD 6081 C Gas +	Group 3: C ISL G
Statistical Analysis Results				
Model R^2		94.4%	93.6%	94.1%
Intercept		-0.0558	0.0609	**0.3194**
prob>|t|		0.08	0.29	0.02
Vector 1 (MN/WI Trend)		**0.2412**	**0.3962**	**0.5007**
prob>|t|		0.00	0.00	0.00
Vector 2 (WI Variation)				
prob>|t|				
Vector 3 (Composition)				
prob>|t|				
Emissions Increase versus CARB Certification Fuel (95% Confidence)				
MN 75L		28%	28%	67%
MN 75H		31%	30%	63%
MN 78L		18%	18%	42%
MN 78H		22%	20%	37%
MN 80L		11%	11%	25%
MN 80H		16%	14%	19%
MN 100L		-24%	-24%	-55%
MN 100M		-21%	-21%	-61%
MN 100H		-16%	-18%	-68%
Exceedance of Certification Standard (95% Confidence)				
Certification Standard (g/hp-hr)		1.20	NOx+NMHC	0.14
Emissions on CARB Cert Fuel (g/hp-hr)		0.43	0.14	0.08
Increase to Reach Standard		182%	–	71%
Standard Exceeded at MN	Low WI	below 75	–	below 75
	High WI	below 75	–	below 75

Table B-7
PM Emissions (g/hp-hr) by Engine

Model: $E-E_{cert}$ = A + B * Vector 1 + C*Vector 2 + D*Vector 3

<table>
<tr><th colspan="2"></th><th>C Gas</th><th>DDC TK</th><th>JD 6081</th><th>C Gas +</th><th>C ISL G</th></tr>
<tr><td colspan="7">Statistical Analysis Results</td></tr>
<tr><td colspan="2">Model R^2</td><td>57.8%</td><td>18.2%</td><td>1.8%</td><td>0.9%</td><td>42.3%</td></tr>
<tr><td colspan="2">Intercept</td><td>0.0005</td><td>0.0002</td><td>0.0002</td><td>0.0001</td><td>-0.0003</td></tr>
<tr><td colspan="2">prob>|t|</td><td>0.04</td><td>0.02</td><td>0.00</td><td>0.78</td><td>0.02</td></tr>
<tr><td colspan="2">Vector 1 (MN/WI Trend)</td><td>-0.00031</td><td>0.00003</td><td>-0.00001</td><td>0.00002</td><td>0.00009</td></tr>
<tr><td colspan="2">prob>|t|</td><td>0.03</td><td>0.29</td><td>0.75</td><td>0.83</td><td>0.08</td></tr>
<tr><td colspan="2">Vector 2 (WI Variation)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">prob>|t|</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Vector 3 (Composition)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">prob>|t|</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">Emissions Increase versus CARB Certification Fuel (95% Confidence)</td></tr>
<tr><td colspan="2">MN 75L</td><td>-21%</td><td rowspan="9">No statistically significant emissions change detected (95% confidence level)</td><td rowspan="9">No statistically significant emissions change detected (95% confidence level)</td><td rowspan="9">No statistically significant emissions change detected (95% confidence level)</td><td rowspan="9">No statistically significant emissions change detected (95% confidence level)</td></tr>
<tr><td colspan="2">MN 75H</td><td>-20%</td></tr>
<tr><td colspan="2">MN 78L</td><td>-13%</td></tr>
<tr><td colspan="2">MN 78H</td><td>-12%</td></tr>
<tr><td colspan="2">MN 80L</td><td>-8%</td></tr>
<tr><td colspan="2">MN 80H</td><td>-6%</td></tr>
<tr><td colspan="2">MN 100L</td><td>18%</td></tr>
<tr><td colspan="2">MN 100M</td><td>20%</td></tr>
<tr><td colspan="2">MN 100H</td><td>22%</td></tr>
<tr><td colspan="7">Exceedance of Certification Standard (95% Confidence)</td></tr>
<tr><td colspan="2">Certification Standard (g/hp-hr)</td><td>0.05</td><td>0.05</td><td>0.010</td><td>0.010</td><td>0.010</td></tr>
<tr><td colspan="2">Emissions on CARB Cert Fuel (g/hp-hr)</td><td>0.004</td><td>0.000</td><td>0.000</td><td>0.003</td><td>0.005</td></tr>
<tr><td colspan="2">Increase to Reach Standard</td><td>1187%</td><td>48920%</td><td>3409%</td><td>193%</td><td>2062%</td></tr>
<tr><td rowspan="2">Standard Exceeded at Methane Number</td><td>Low WI</td><td>above 100</td><td>never</td><td>never</td><td>never</td><td>never</td></tr>
<tr><td>High WI</td><td>above 100</td><td>never</td><td>never</td><td>never</td><td>never</td></tr>
</table>

Table B-8

PM Emissions (g/hp-hr) by Certification Group

Model: $E-E_{cert} = A + B * \text{Vector 1} + C*\text{Vector 2} + D*\text{Vector 3}$

		Group 1: C Gas DDC TK	**Group 2: JD 6081 C Gas +**	**Group 3: C ISL G**
Statistical Analysis Results				
Model R^2		16.7%	0.0%	42.3%
Intercept		**0.0003**	0.0001	**-0.0003**
prob>|t|		0.02	0.12	0.02
Vector 1 (MN/WI Trend)		-0.00011	0.00000	0.00009
prob>|t|		0.12	0.96	0.08
Vector 2 (WI Variation)				
prob>|t|				
Vector 3 (Composition)				
prob>|t|				
Emissions Increase versus CARB Certification Fuel (95% Confidence)				
MN 75L		No statistically significant emissions change detected (95% confidence level)	No statistically significant emissions change detected (95% confidence level)	No statistically significant emissions change detected (95% confidence level)
MN 75H				
MN 78L				
MN 78H				
MN 80L				
MN 80H				
MN 100L				
MN 100M				
MN 100H				
Exceedance of Certification Standard (95% Confidence)				
Certification Standard (g/hp-hr)		0.05	0.010	0.010
Emissions on CARB Cert Fuel (g/hp-hr)		0.002	0.002	0.005
Increase to Reach Standard		2408%	441%	-88%
Standard Exceeded at MN	Low WI	never	never	never
	High WI	never	never	never

Table B-9
Total HC Emissions (g/hp-hr) by Engine

Model: E/E_{cert} - 1 = A + B * Vector 1 + C*Vector 2 + D*Vector 3

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		96.4%	87.1%	98.6%	83.3%	9.1%
Intercept		0.0226	**0.0412**	**0.0510**	**0.1119**	**-0.0260**
prob>|t|		0.33	0.04	0.00	0.02	0.03
Vector 1 (MN/WI Trend)		**-0.1370**	**-0.0235**	**-0.0632**	**-0.0969**	-0.0037
prob>|t|		0.00	0.02	0.00	0.00	0.47
Vector 2 (WI Variation)		**-0.0427**	-0.0279			
prob>|t|		0.04	0.06			
Vector 3 (Composition)			-0.0465	**-0.0551**		
prob>|t|			0.08	0.00		
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		-39%	-5%	-13%	-26%	No statistically significant emissions change detected (95% confidence level)
MN 75H		-43%	-14%	-20%	-25%	
MN 78L		-25%	-3%	-8%	-16%	
MN 78H		-30%	-9%	-9%	-14%	
MN 80L		-15%			-10%	
MN 80H		-21%			-7%	
MN 100L		34%	9%	16%	21%	
MN 100M		29%		16%	24%	
MN 100H		23%		15%	26%	
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (g/hp-hr)		none	none	none	none	none
Emissions on CARB Cert Fuel (g/hp-hr)		5.49	3.57	2.89	3.53	1.62
Increase to Reach Standard		–	–	–	–	–
Standard Exceeded at Methane Number	Low WI	–	–	–	–	–
	High WI	–	–	–	–	–

Table B-10
Total HC Emissions (g/hp-hr) by Certification Group

Model: $E/E_{cert} - 1 = A + B * \text{Vector } 1 + C * \text{Vector } 2 + D * \text{Vector } 3$

		Group 1: C Gas DDC TK	**Group 2: JD 6081 C Gas +**	**Group 3: C ISL G**
Statistical Analysis Results				
Model R^2		53.6%	79.4%	9.1%
Intercept		0.0357	**0.0790**	**-0.0250**
prob>|t|		0.30	0.00	0.03
Vector 1 (MN/WI Trend)		**-0.0704**	**-0.0792**	-0.0037
prob>|t|		0.00	0.00	0.47
Vector 2 (WI Variation)				
prob>|t|				
Vector 3 (Composition)				
prob>|t|				
Emissions Increase versus CARB Certification Fuel (95% Confidence)				
MN 75L		-19%	-21%	No statistically significant emissions change detected (95% confidence level)
MN 75H		-18%	-20%	
MN 78L		-12%	-13%	
MN 78H		-10%	-12%	
MN 80L		-7%	-8%	
MN 80H		-5%	-6%	
MN 100L		15%	17%	
MN 100M		17%	19%	
MN 100H		19%	22%	
Exceedance of Certification Standard (95% Confidence)				
Certification Standard (g/hp-hr)		none	none	none
Emissions on CARB Cert Fuel (g/hp-hr)		4.53	3.21	0.08
Increase to Reach Standard				
Standard Exceeded at MN	Low WI			
	High WI			

Table B-11
CO Emissions (g/hp-hr) by Engine

Model: E/E_{cert} - 1 = A + B * Vector 1 + C*Vector 2 + D*Vector 3

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		91.2%	93.3%	16.0%	77.0%	38.8%
Intercept		0.0802	**0.0179**	-0.0780	**-0.1588**	0.4118
prob>|t|		0.06	0.02	0.18	0.00	0.07
Vector 1 (MN/WI Trend)		**0.1641**	**0.0194**	0.0270	**0.0528**	0.1861
prob>|t|		0.00	0.00	0.10	0.00	0.10
Vector 2 (WI Variation)						
prob>|t|						
Vector 3 (Composition)			**-0.0228**			
prob>|t|			0.02			
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		44%	7%	No statistically significant emissions change detected (95% confidence interval)	14%	No statistically significant emissions change detected (95% confidence interval)
MN 75H		42%	3%		13%	
MN 78L		28%	4%		9%	
MN 78H		24%	3%		8%	
MN 80L		16%	4%		5%	
MN 80H		13%	3%		4%	
MN 100L		-36%	-4%		-12%	
MN 100M		-40%	-5%		-13%	
MN 100H		-45%	-6%		-14%	
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (g/hp-hr)		none	none	none	none	none
Emissions on CARB Cert Fuel (g/hp-hr)		0.26	1.83	0.08	0.22	1.40
Increase to Reach Standard		–	–	–	–	–
Standard Exceeded at Methane Number	Low WI	–	–	–	–	–
	High WI	–	–	–	–	–

<table>
<tr><th colspan="5">Table B-12
CO Emissions (g/hp-hr) by Certification Group
Model: $E/E_{cert} - 1 = A + B * \text{Vector } 1 + C*\text{Vector } 2 + D*\text{Vector } 3$</th></tr>
<tr><th colspan="2"></th><th>Group 1:
C Gas
DDC TK</th><th>Group 2:
JD 6081
C Gas +</th><th>Group 3:
C ISL G</th></tr>
<tr><td colspan="5">Statistical Analysis Results</td></tr>
<tr><td colspan="2">Model R^2</td><td>47.2%</td><td>34.3%</td><td>38.8%</td></tr>
<tr><td colspan="2">Intercept</td><td>0.0387</td><td>-0.1165</td><td>0.4118</td></tr>
<tr><td colspan="2">prob>|t|</td><td>0.34</td><td>0.00</td><td>0.07</td></tr>
<tr><td colspan="2">Vector 1 (MN/WI Trend)</td><td>0.0754</td><td>0.0386</td><td>0.1861</td></tr>
<tr><td colspan="2">prob>|t|</td><td>0.00</td><td>0.02</td><td>0.10</td></tr>
<tr><td colspan="2">Vector 2 (WI Variation)</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">prob>|t|</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Vector 3 (Composition)</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">prob>|t|</td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Emissions Increase versus CARB Certification Fuel (95% Confidence)</td></tr>
<tr><td colspan="2">MN 75L</td><td>20%</td><td>10%</td><td rowspan="9">No statistically significant emissions change detected (95% confidence interval)</td></tr>
<tr><td colspan="2">MN 75H</td><td>19%</td><td>10%</td></tr>
<tr><td colspan="2">MN 78L</td><td>13%</td><td>6%</td></tr>
<tr><td colspan="2">MN 78H</td><td>11%</td><td>6%</td></tr>
<tr><td colspan="2">MN 80L</td><td>8%</td><td>4%</td></tr>
<tr><td colspan="2">MN 80H</td><td>6%</td><td>3%</td></tr>
<tr><td colspan="2">MN 100L</td><td>-17%</td><td>-9%</td></tr>
<tr><td colspan="2">MN 100M</td><td>-18%</td><td>-9%</td></tr>
<tr><td colspan="2">MN 100H</td><td>-20%</td><td>-10%</td></tr>
<tr><td colspan="5">Exceedance of Certification Standard (95% Confidence)</td></tr>
<tr><td colspan="2">Certification Standard (g/hp-hr)</td><td>none</td><td>none</td><td>none</td></tr>
<tr><td colspan="2">Emissions on CARB Cert Fuel (g/hp-hr)</td><td>1.04</td><td>0.15</td><td>4.40</td></tr>
<tr><td colspan="2">Increase to Reach Standard</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td rowspan="2">Standard Exceeded at MN</td><td>Low WI</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>High WI</td><td>–</td><td>–</td><td>–</td></tr>
</table>

Table B-13
NO_2 Emissions (g/hp-hr) by Engine

Model: E/E_{cert} - 1 = A + B * Vector 1 + C*Vector 2 + D*Vector 3

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		26.7%	99.4%	58.8%	98.5%	6.3%
Intercept		**-0.0935**	**0.0311**	0.0096	**-0.0393**	-0.1963
prob>|t|		0.03	0.00	0.81	0.00	0.21
Vector 1 (MN/WI Trend)		0.0287	**0.0583**	**0.0559**	**0.0118**	0.0458
prob>|t|		0.19	0.00	0.03	0.00	0.55
Vector 2 (WI Variation)			**0.0356**		**0.0191**	
prob>|t|			0.00		0.00	
Vector 3 (Composition)					**0.0493**	
prob>|t|					0.00	
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		No statistically significant emissions change detected (95% confidence level)	18%	15%	1%	No statistically significant emissions change detected (95% confidence level)
MN 75H			21%	14%	10%	
MN 78L			11%	9%		
MN 78H			17%	8%	5%	
MN 80L			7%	6%	-3%	
MN 80H			14%	4%	2%	
MN 100L			-16%	-12%	-6%	
MN 100M			-10%	-14%		
MN 100H			-4%	-15%	5%	
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (g/hp-hr)		none	none	none	none	none
Emissions on CARB Cert Fuel (g/hp-hr)		0.23	0.30	0.15	0.19	0.00
Increase to Reach Standard		–	–	–	–	–
Standard Exceeded at Methane Number	Low WI	–	–	–	–	
	−High WI	–	–	–	–	

Table B-14
NO_2 Emissions (g/hp-hr) by Certification Group

Model: $E/E_{cert} - 1 = A + B * \text{Vector 1} + C*\text{Vector 2} + D*\text{Vector 3}$

		Group 1: C Gas DDC TK	**Group 2: JD 6081 C Gas +**	**Group 3: C ISL G**
Statistical Analysis Results				
Model R^2		48.6%	51.9%	6.3%
Intercept		-0.0286	-0.0203	-0.1963
prob>|t|		0.27	0.36	0.21
Vector 1 (MN/WI Trend)		**0.0481**	**0.0325**	0.0458
prob>|t|		0.00	0.01	0.55
Vector 2 (WI Variation)				
prob>|t|				
Vector 3 (Composition)			0.0672	
prob>|t|			0.06	
Emissions Increase versus CARB Certification Fuel (95% Confidence)				
MN 75L		13%		No statistically significant emissions change detected (95% confidence level)
MN 75H		8%		
MN 78L		5%		
MN 78H		-11%	-9%	
MN 80L		-12%	-8%	
MN 80H		12%	13%	
MN 100L		7%		
MN 100M		4%	-2%	
MN 100H		-13%	-7%	
Exceedance of Certification Standard (95% Confidence)				
Certification Standard (g/hp-hr)		none	none	none
Emissions on CARB Cert Fuel (g/hp-hr)		0.30	0.17	0.00
Increase to Reach Standard		–	–	–
Standard Exceeded at MN	Low WI	–	–	
	High WI\	–	–	

Table B-15
CO_2 Emissions (g/hp-hr) by Engine

Model: $E/E_{cert} - 1 = A + B * \text{Vector } 1 + C*\text{Vector } 2 + D*\text{Vector } 3$

		C Gas	**DDC TK**	**JD 6081**	**C Gas +**	**C ISL G**
Statistical Analysis Results						
Model R^2		61.5%	45.4%	0.0%	77.9%	0.0%
Intercept		**-0.0048**	**0.0154**	**0.0200**	**0.0042**	**0.0125**
prob>|t|		0.02	0.00	0.00	0.03	0.00
Vector 1 (MN/WI Trend)					**0.0034**	
prob>|t|					0.00	
Vector 2 (WI Variation)		-0.0035				
prob>|t|		**0.02**				
Vector 3 (Composition)			-0.0109			
prob>|t|			0.07			
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		Negligible emissions change (not more than ± 1% over range of data)	Negligible emissions change (not more than ± 1% over range of data)	No statistically significant emissions change detected (95% confidence level)	Negligible emissions change (not more than ± 1% over range of data)	No statistically significant emissions change detected (95% confidence level)
MN 75H						
MN 78L						
MN 78H						
MN 80L						
MN 80H						
MN 100L						
MN 100M						
MN 100H						
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (g/hp-hr)		none	none	none	none	none
Emissions on CARB Cert Fuel (g/hp-hr)		525	524	454	565	485
Increase to Reach Standard		–	–	–	–	–
Standard Exceeded at Methane Number	Low WI	–	–	–	–	–
	High WI	–	–	–	–	–

Table B-16

CO_2 Emissions (g/hp-hr) by Certification Group

Model: $E/E_{cert} - 1 = A + B * \text{Vector } 1 + C * \text{Vector } 2 + D * \text{Vector } 3$

		Group 1: C Gas DDC TK	Group 2: JD 6081 C Gas +	Group 3: C ISL G
Statistical Analysis Results				
	Model R^2	0.0%	0.0%	0.0%
Intercept		0.0048	**0.0125**	**0.0125**
	prob>|t|	0.08	0.00	0.00
Vector 1 (MN/WI Trend)				
	prob>|t|			
Vector 2 (WI Variation)				
	prob>|t|			
Vector 3 (Composition)				
	prob>|t|			
Emissions Increase versus CARB Certification Fuel (95% Confidence)				
MN 75L		No statistically significant emissions change detected (95% confidence level)	No statistically significant emissions change detected (95% confidence level)	No statistically significant emissions change detected (95% confidence level)
MN 75H				
MN 78L				
MN 78H				
MN 80L				
MN 80H				
MN 100L				
MN 100M				
MN 100H				
Exceedance of Certification Standard (95% Confidence)				
Certification Standard (g/hp-hr)		none	none	none
Emissions on CARB Cert Fuel (g/hp-hr)		525	510	485
Increase to Reach Standard		–	–	–
Standard Exceeded at MN	Low WI	–	–	–
	High WI	–	–	–

APPENDIX C

Complete Results of Statistical Analysis for Speciated HC Emissions

Table C-1
Benzene Emissions (mg/hp-hr) by Engine

Model: $E/E_{cert} - 1 = A + B * \text{Vector } 1 + C*\text{Vector } 2 + D*\text{Vector } 3$

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		Not Tested	0.0%	Not Tested	0.0%	0.5%
Intercept			-0.4210		-0.4949	0.4751
prob>|t|			0.23		0.09	0.38
Vector 1 (MN/WI Trend)						0.5745
prob>|t|						0.07
Vector 2 (WI Variation)						
prob>|t|						
Vector 3 (Composition)						
prob>|t|						
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		Not Tested	No statistically significant emissions change detected (95% confidence level)	Not Tested	No statistically significant emissions change detected (95% confidence level)	No statistically significant emissions change detected (95% confidence level)
MN 75H						
MN 78L						
MN 78H						
MN 80L						
MN 80H						
MN 100L						
MN 100M						
MN 100H						
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (mg/hp-hr)		Not Tested	None	Not Tested	None	None
Emissions on CARB Cert Fuel (mg/hp-hr)			0.05		0.22	0.11
Increase to Reach Standard			–		–	–
Standard Exceeded at Methane Number	Low WI		–		–	
	High WI				–	

Table C-2
1-3 Butadiene Emissions (mg/hp-hr) by Engine

Model: E/E_{cert} - 1 = A + B * Vector 1 + C*Vector 2 + D*Vector 3

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		Not Tested	98.0%	Not Tested	Not Detected	Not Detected
Intercept			**0.2273**			
prob>|t|			0.00			
Vector 1 (MN/WI Trend)			**0.1597**			
prob>|t|			0.00			
Vector 2 (WI Variation)						
prob>|t|						
Vector 3 (Composition)			**-0.2319**			
prob>|t|			0.00			
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		Not Tested	58%	Not Tested	Not Detected	Not Detected
MN 75H			25%			
MN 78L			36%			
MN 78H			26%			
MN 80L			40%			
MN 80H			29%			
MN 100L			-28%			
MN 100M			-39%			
MN 100H			-51%			
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (mg/hp-hr)		Not Tested	None	Not Tested	None	None
Emissions on CARB Cert Fuel (mg/hp-hr)			0.63		ND	ND
Increase to Reach Standard			–		–	–
Standard Exceeded at Methane Number	Low WI		–		–	
	High WI				–	

Table C-3
Acetaldehyde Emissions (mg/hp-hr) by Engine

Model: E/E_{cert} - 1 = A + B * Vector 1 + C*Vector 2 + D*Vector 3

		C Gas	**DDC TK**	**JD 6081**	**C Gas +**	**C ISL G**
Statistical Analysis Results						
Model R^2		Not Tested	79.6%	Not Tested	80.8%	90.2%
Intercept			**6.9783**		0.0464	0.1127
prob>|t|			0.00		0.62	0.25
Vector 1 (MN/WI Trend)			**1.7224**		**0.1332**	**0.3404**
prob>|t|			0.01		0.03	0.00
Vector 2 (WI Variation)					**0.2248**	
prob>|t|					0.02	
Vector 3 (Composition)			-2.9453			
prob>|t|			0.07			
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		Not Tested	657%	Not Tested	49%	92%
MN 75H					76%	86%
MN 78L			288%		71%	50%
MN 78H			407%		33%	57%
MN 80L			477%		22%	34%
MN 80H			345%		67%	26%
MN 100L			-287%		-49%	-75%
MN 100M			-423%			-84%
MN 100H			-565%			-92%
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (mg/hp-hr)		Not Tested	None	Not Tested	None	None
Emissions on CARB Cert Fuel (mg/hp-hr)			1.07		1.56	.0.11
Increase to Reach Standard			–		–	–
Standard Exceeded at Methane Number	Low WI		–		–	
	High WI				–	

Table C-4
Formaldehyde Emissions (mg/hp-hr) by Engine

Model: $E/E_{cert} - 1 = A + B * \text{Vector } 1 + C*\text{Vector } 2 + D*\text{Vector } 3$

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		Not Tested	0.0%	Not Tested	0.0%	0.0%
Intercept			**281.0**		-6.2110	**0.2584**
prob>|t|			0.00		0.29	0.01
Vector 1 (MN/WI Trend)						
prob>|t|						
Vector 2 (WI Variation)						
prob>|t|						
Vector 3 (Composition)						
prob>|t|						
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		Not Tested	A statistically significant emissions change of +281 mg/hp-hr is detected (all fuels)	Not Tested	No statistically significant emissions change detected (95% Confidence Level)	A statistically significant emissions change of +0.26 mg/hp-hr is detected (all fuels)
MN 75H						
MN 78L						
MN 78H						
MN 80L						
MN 80H						
MN 100L						
MN 100M						
MN 100H						
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (mg/hp-hr)		Not Tested	None	Not Tested	None	None
Emissions on CARB Cert Fuel (mg/hp-hr)			0.94		43.3	0.59
Increase to Reach Standard			–		–	–
Standard Exceeded at Methane Number	Low WI		–		–	
	High WI				–	

APPENDIX D

Complete Results of Statistical Analysis for Poly-Cyclic Aromatic Hydrocarbon Emissions

Table D-1
Total PAH Emissions (mg/hp-hr) by Engine

Model: $E\text{-}E_{cert}$ = A + B * Vector 1 + C*Vector 2 + D*Vector 3

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		Not Tested	0.0%	Not Tested	61.5%	0.0%
Intercept			0.0060		**-1.8725**	**0.5079**
prob>|t|			0.34		0.00	0.04
Vector 1 (MN/WI Trend)						
prob>|t|						
Vector 2 (WI Variation)						
prob>|t|						
Vector 3 (Composition)					**0.9054**	
prob>|t|					0.02	
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		Not Tested	No statistically significant emissions change detected (95% confidence level)	Not Tested	Constant -1.87 mg/hp-hr emissions change or 72% decrease (95% confidence level)	Constant +0.51 mg/hp-hr emissions change or 154% increase (95% confidence level)
MN 75H						
MN 78L						
MN 78H						
MN 80L						
MN 80H						
MN 100L						
MN 100M						
MN 100H						
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (mg/hp-hr)		Not Tested	None	Not Tested	None	None
Emissions on CARB Cert Fuel (mg/hp-hr)			0.01		2.59	0.33
Increase to Reach Standard			–		–	–
Standard Exceeded at Methane Number	Low WI		–		–	
	High WI				–	

Table D-2
Benzo(a)pyrene Emissions (ng/hp-hr) by Engine

Model: $E\text{-}E_{cert}$ = A + B * Vector 1 + C*Vector 2 + D*Vector 3

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		Not Tested	0.0%	Not Tested	0.0%	46.7%
Intercept			**-2.3800**		**-229.0**	**-7.030**
prob>|t|			0.00		0.00	0.01
Vector 1 (MN/WI Trend)						1.960
prob>|t|						0.06
Vector 2 (WI Variation)						
prob>|t|						
Vector 3 (Composition)						
prob>|t|						
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		Not Tested	Constant -2.38 ng/hp-hr emissions difference or 59% decrease (95% confidence level)	Not Tested	Constant -229 ng/hp-hr emissions change or 78% decrease (95% confidence level)	Constant -7 ng/hp-hr emissions change or 29% decrease (95% confidence level)
MN 75H						
MN 78L						
MN 78H						
MN 80L						
MN 80H						
MN 100L						
MN 100M						
MN 100H						
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (ng/hp-hr)		Not Tested	None	Not Tested	None	None
Emissions on CARB Cert Fuel (ng/hp-hr)			4		293	24
Increase to Reach Standard			–		–	–
Standard Exceeded at Methane Number	Low WI		–		–	
	High WI				–	

Table D-3
Phenanthrene Emissions (ng/hp-hr) by Engine

Model: $E-E_{cert}$ = A + B * Vector 1 + C*Vector 2 + D*Vector 3

		C Gas	DDC TK	JD 6081	C Gas +	C ISL G
Statistical Analysis Results						
Model R^2		Not Tested	82.6%	Not Tested	47.6%	55.4%
Intercept			173.4		**-77662**	**-5513**
prob>|t|			0.49		0.00	0.00
Vector 1 (MN/WI Trend)			**-450.8**			
prob>|t|			0.01			
Vector 2 (WI Variation)						**-1927**
prob>|t|						0.03
Vector 3 (Composition)			-725.7		30742	
prob>|t|			0.08		0.06	
Emissions Increase versus CARB Certification Fuel (95% Confidence)						
MN 75L		Not Tested	-16%	Not Tested	Constant -77662 ng/hp-hr emissions change or 67% decrease (95% confidence level)	- 4%
MN 75H			-10%			- 3%
MN 78L						- 3%
MN 78H			26%			7%
MN 80L			24%			- 8%
MN 80H			-35%			-14%
MN 100L			-12%			-18%
MN 100M						-20%
MN 100H			21%			-25%
Exceedance of Certification Standard (95% Confidence)						
Certification Standard (ng/hp-hr)		Not Tested	None	Not Tested	None	None
Emissions on CARB Cert Fuel (ng/hp-hr)			4660		116000	24800
Increase to Reach Standard			–		–	–
Standard Exceeded at Methane Number	Low WI		–		–	
	High WI				–	

APPENDIX E

Anthropogenic Emissions Inventories for Southern California Counties (2008–2018)

2008 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	516.79	151.53	822.25	165.78	31.52
SCAQMD	Los Angeles	408.28	335.85	1,877.77	482.37	56.00
	Orange	154.36	117.30	656.90	135.53	17.70
	Riverside	103.70	61.69	348.29	83.40	12.65
	San Bernardino	132.81	72.16	365.04	90.84	15.87
	Total	799.15	586.99	3,248.00	792.13	102.23
VCAPCD	Ventura	101.19	46.86	208.21	44.36	8.25
SBAPCD	Santa Barbara	75.81	35.21	171.30	37.54	8.88
KCAPCD	Kern	25.33	13.96	96.87	58.16	9.92
SJVUAPCD	Kings	114.23	17.87	60.45	29.13	6.91
	Tulare	243.09	44.97	160.38	45.45	14.06
	Fresno	454.94	81.82	350.61	110.36	28.07
	Total	812.26	144.66	571.43	184.94	49.04
SLOAPCD	San Luis Obispo	56.73	23.16	135.60	21.13	8.98
ICAPCD	Imperial	127.53	30.06	91.61	37.27	39.49
13-County Total		2,514.79	1,032.42	5,345.27	1,341.30	258.30

2009 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	508.89	148.71	783.42	161.08	31.20
SCAQMD	Los Angeles	401.82	329.54	1,779.93	476.06	56.10
	Orange	153.15	115.91	632.29	134.97	17.68
	Riverside	104.44	60.25	331.34	81.97	12.43
	San Bernardino	135.02	71.12	350.06	89.87	15.70
	Total	794.43	576.82	3,093.61	782.86	101.91
VCAPCD	Ventura	92.48	45.34	198.05	43.16	7.99
SBAPCD	Santa Barbara	75.31	34.90	165.39	37.48	8.88
KCAPCD	Kern	24.76	13.53	91.14	57.23	9.85
SJVUAPCD	Kings	112.32	17.85	59.18	28.72	6.89
	Tulare	238.90	44.35	156.06	45.49	13.98
	Fresno	448.76	80.83	340.39	107.90	28.04
	Total	799.98	143.03	555.63	182.11	48.91
SLOAPCD	San Luis Obispo	56.43	22.88	131.65	20.97	8.96
ICAPCD	Imperial	127.15	29.68	88.78	36.59	39.37
13-County Total		2,479.43	1,014.90	5,107.67	1,321.48	257.06

2010 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	501.25	146.12	747.30	156.11	30.88
SCAQMD	Los Angeles	396.37	324.17	1,691.52	467.93	56.19
	Orange	152.13	114.69	609.07	133.96	17.66
	Riverside	105.23	58.85	315.09	79.88	12.20
	San Bernardino	137.26	70.11	335.44	88.24	15.51
	Total	790.98	567.82	2,951.12	770.01	101.57
VCAPCD	Ventura	83.77	43.83	188.05	41.75	7.72
SBAPCD	Santa Barbara	74.84	34.62	159.91	37.39	8.88
KCAPCD	Kern	24.38	13.27	87.82	56.07	9.78
SJVUAPCD	Kings	110.39	17.81	57.78	27.99	6.87
	Tulare	234.68	43.70	151.65	45.13	13.89
	Fresno	442.56	79.83	330.19	104.39	28.02
	Total	787.63	141.35	539.62	177.51	48.78
SLOAPCD	San Luis Obispo	56.12	22.59	127.50	20.71	8.94
ICAPCD	Imperial	126.79	29.32	86.12	35.63	39.25
13-County Total		2,445.77	998.92	4,887.44	1,295.18	255.81

2011 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	512.49	143.28	717.76	145.89	31.55
SCAQMD	Los Angeles	381.08	310.81	1,622.76	429.98	55.54
	Orange	147.60	110.96	586.73	121.67	17.74
	Riverside	99.71	58.58	303.21	73.37	12.87
	San Bernardino	129.22	69.21	327.86	82.15	15.98
	Total	757.61	549.55	2,840.55	707.16	102.12
VCAPCD	Ventura	99.97	44.90	186.66	39.94	8.26
SBAPCD	Santa Barbara	74.44	33.75	154.35	34.52	8.87
KCAPCD	Kern	24.93	13.05	86.12	54.47	9.94
SJVUAPCD	Kings	116.13	17.61	55.91	26.35	6.85
	Tulare	246.86	44.02	145.88	41.40	14.06
	Fresno	457.66	79.17	319.72	96.66	27.64
	Total	820.64	140.81	521.51	164.42	48.55
SLOAPCD	San Luis Obispo	55.80	22.13	123.83	19.01	9.00
ICAPCD	Imperial	126.88	29.45	84.56	34.06	39.41
13-County Total		2,472.77	976.91	4,715.34	1,199.46	257.69

2012 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	514.97	141.23	690.53	138.82	31.69
SCAQMD	Los Angeles	373.04	303.46	1,559.41	408.65	55.27
	Orange	145.53	108.91	566.75	115.64	17.71
	Riverside	98.57	58.09	291.29	69.91	13.08
	San Bernardino	128.26	68.71	318.92	79.31	16.12
	Total	745.41	539.16	2,736.36	673.51	102.17
VCAPCD	Ventura	100.32	44.41	180.98	38.04	8.27
SBAPCD	Santa Barbara	74.14	33.29	149.00	33.21	8.86
KCAPCD	Kern	25.32	12.86	84.05	54.18	10.08
SJVUAPCD	Kings	118.30	17.61	54.29	24.89	6.83
	Tulare	251.52	43.92	140.86	38.98	14.08
	Fresno	462.53	78.52	310.59	91.29	27.44
	Total	832.35	140.05	505.74	155.16	48.35
SLOAPCD	San Luis Obispo	55.66	21.84	120.33	18.14	9.02
ICAPCD	Imperial	126.79	29.36	82.65	33.25	39.42
13-County Total		2,474.96	962.20	4,549.63	1,144.32	257.87

2013 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	517.72	139.43	666.05	132.02	31.84
SCAQMD	Los Angeles	365.65	296.71	1,501.29	387.70	54.99
	Orange	143.66	107.04	548.45	109.80	17.67
	Riverside	97.54	57.70	280.54	66.57	13.28
	San Bernardino	127.41	68.29	310.89	76.60	16.25
	Total	734.25	529.74	2,641.18	640.67	102.20
VCAPCD	Ventura	100.73	43.97	175.80	36.22	8.28
SBAPCD	Santa Barbara	73.88	32.87	144.03	31.95	8.85
KCAPCD	Kern	25.73	12.70	82.32	53.91	10.23
SJVUAPCD	Kings	120.48	17.61	52.80	23.44	6.81
	Tulare	256.22	43.84	136.21	36.62	14.10
	Fresno	467.48	77.95	302.27	86.23	27.26
	Total	844.18	139.41	491.28	146.29	48.17
SLOAPCD	San Luis Obispo	55.56	21.58	117.13	17.31	9.04
ICAPCD	Imperial	126.73	29.31	81.05	32.41	39.44
13-County Total		2,478.78	949.00	4,398.83	1,090.77	258.05

2014 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	520.66	137.81	643.51	125.67	31.99
SCAQMD	Los Angeles	358.81	290.47	1,448.83	367.91	54.73
	Orange	141.88	105.26	531.37	104.09	17.63
	Riverside	96.65	57.43	271.24	63.40	13.50
	San Bernardino	126.62	67.94	303.72	74.04	16.39
	Total	723.96	521.10	2,555.16	609.44	102.26
VCAPCD	Ventura	101.19	43.57	171.10	34.60	8.30
SBAPCD	Santa Barbara	73.66	32.49	139.49	30.75	8.84
KCAPCD	Kern	26.15	12.54	80.70	53.68	10.38
SJVUAPCD	Kings	122.67	17.62	51.44	22.05	6.80
	Tulare	260.96	43.80	131.97	34.39	14.12
	Fresno	472.50	77.45	294.68	81.45	27.08
	Total	856.13	138.87	478.09	137.88	48.00
SLOAPCD	San Luis Obispo	55.47	21.33	114.13	16.50	9.06
ICAPCD	Imperial	126.67	29.25	79.50	31.56	39.46
13-County Total		2,483.87	936.97	4,261.68	1,040.09	258.28

2015 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	523.85	136.42	623.61	119.67	32.14
SCAQMD	Los Angeles	352.48	284.74	1,400.36	348.93	54.46
	Orange	140.27	103.63	515.56	98.66	17.58
	Riverside	95.83	57.24	262.67	60.36	13.71
	San Bernardino	125.92	67.68	297.19	71.66	16.53
	Total	714.51	513.29	2,475.78	579.61	102.28
VCAPCD	Ventura	101.71	43.24	166.93	33.05	8.32
SBAPCD	Santa Barbara	73.50	32.16	135.53	29.60	8.84
KCAPCD	Kern	26.59	12.41	79.38	53.54	10.53
SJVUAPCD	Kings	124.88	17.65	50.23	20.72	6.79
	Tulare	265.76	43.82	128.16	32.31	14.15
	Fresno	477.61	77.03	287.78	77.04	26.91
	Total	868.24	138.49	466.17	130.08	47.85
SLOAPCD	San Luis Obispo	55.42	21.12	111.38	15.74	9.08
ICAPCD	Imperial	126.63	29.22	78.17	30.73	39.47
13-County Total		2,490.45	926.35	4,136.95	992.01	258.52

2016 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	503.06	134.76	600.92	123.21	31.45
SCAQMD	Los Angeles	355.59	287.54	1,338.08	363.49	54.90
	Orange	140.43	104.53	496.95	104.42	17.75
	Riverside	95.76	55.00	250.48	60.33	12.90
	San Bernardino	125.48	65.80	282.90	70.15	15.90
	Total	717.25	512.87	2,368.41	598.40	101.45
VCAPCD	Ventura	97.62	42.75	160.37	35.28	8.25
SBAPCD	Santa Barbara	72.37	31.85	130.54	30.59	8.87
KCAPCD	Kern	23.95	12.13	75.05	48.04	9.75
SJVUAPCD	Kings	115.32	16.87	48.08	20.46	6.67
	Tulare	244.76	42.08	124.67	34.26	13.92
	Fresno	471.85	75.81	282.50	79.68	27.24
	Total	831.94	134.76	455.25	134.40	47.82
SLOAPCD	San Luis Obispo	54.43	20.87	108.27	16.34	9.00
ICAPCD	Imperial	126.02	28.65	75.84	29.98	39.29
13-County Total		2,426.65	918.64	3,974.65	1,016.23	255.88

2017 Anthropogenic Total Emission Inventory by Air District and County
(annual tons per day)

Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	506.57	133.66	584.59	117.96	31.61
SCAQMD	Los Angeles	349.90	282.38	1,296.99	346.20	54.63
	Orange	138.99	103.06	483.37	99.42	17.70
	Riverside	95.02	54.88	243.07	57.40	13.09
	San Bernardino	124.86	65.61	277.54	67.77	16.03
	Total	708.77	505.93	2,300.97	570.79	101.45
VCAPCD	Ventura	98.19	42.46	156.75	33.71	8.27
SBAPCD	Santa Barbara	72.25	31.56	127.02	29.54	8.86
KCAPCD	Kern	24.41	12.02	73.97	48.17	9.91
SJVUAPCD	Kings	117.56	16.92	47.15	19.39	6.66
	Tulare	249.63	42.16	121.61	32.45	13.95
	Fresno	477.11	75.50	276.93	75.89	27.09
	Total	844.30	134.58	445.68	127.73	47.70
SLOAPCD	San Luis Obispo	54.42	20.69	105.96	15.65	9.02
ICAPCD	Imperial	126.01	28.64	74.76	29.26	39.31
13-County Total		2,434.93	909.54	3,869.70	972.82	256.14

2018 Anthropogenic Total Emission Inventory by Air District and County (annual tons per day)						
Air District	County	TOG/THC	ROG/NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	510.17	132.64	569.74	112.97	31.78
SCAQMD	Los Angeles	344.50	277.49	1,259.55	329.70	54.38
	Orange	137.64	101.67	470.99	94.65	17.65
	Riverside	94.36	54.83	236.62	54.74	13.29
	San Bernardino	124.30	65.47	272.89	65.63	16.16
	Total	700.80	499.45	2,240.06	544.72	101.48
VCAPCD	Ventura	98.79	42.20	153.59	32.23	8.28
SBAPCD	Santa Barbara	72.17	31.30	123.94	28.56	8.86
KCAPCD	Kern	24.90	11.93	73.15	48.42	10.07
SJVUAPCD	Kings	119.81	16.99	46.34	18.43	6.66
	Tulare	254.53	42.28	118.95	30.75	13.99
	Fresno	482.41	75.23	271.91	72.37	26.94
	Total	856.76	134.50	437.21	121.56	47.59
SLOAPCD	San Luis Obispo	54.42	20.53	103.93	15.00	9.04
ICAPCD	Imperial	126.01	28.63	73.69	28.64	39.34
13-County Total		2,444.02	901.18	3,775.30	932.10	256.45

APPENDIX F

HD CNG Engine Emissions Inventory by Fuel Scenario (2008–2018)

2008 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	1.136	0.041	0.208	0.423	0.0008
SCAQMD	Los Angeles	5.527	0.295	1.463	1.833	0.0020
	Orange	0.953	0.005	0.193	0.210	0.0008
	Riverside	1.910	0.048	0.220	0.290	0.0004
	San Bernardino	0.478	0.004	0.023	0.053	0.0001
	Total	8.869	0.352	1.899	2.386	0.0034
VCAPCD	Ventura	0.094	0.006	0.017	0.046	0.0001
SBAPCD	Santa Barbara	0.006	0.000	0.001	0.003	0.0000
KCAPCD	Kern	0.022	0.000	0.001	0.008	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.199	0.001	0.004	0.035	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.219	0.004	0.007	0.048	0.0000
SLOAPCD	San Luis Obispo	0.047	0.005	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		10.395	0.408	2.147	2.933	0.0042

2009 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	1.133	0.040	0.210	0.422	0.0008
SCAQMD	Los Angeles	5.519	0.293	1.462	1.829	0.0021
	Orange	0.953	0.005	0.194	0.210	0.0008
	Riverside	1.887	0.046	0.226	0.276	0.0005
	San Bernardino	0.479	0.004	0.023	0.053	0.0001
	Total	8.838	0.349	1.904	2.368	0.0034
VCAPCD	Ventura	0.092	0.006	0.017	0.047	0.0001
SBAPCD	Santa Barbara	0.006	0.000	0.001	0.003	0.0000
KCAPCD	Kern	0.022	0.000	0.002	0.008	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.199	0.002	0.004	0.035	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.219	0.004	0.007	0.048	0.0000
SLOAPCD	San Luis Obispo	0.047	0.005	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		10.359	0.404	2.155	2.914	0.0043

2010 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	1.125	0.039	0.212	0.417	0.0008
SCAQMD	Los Angeles	5.433	0.279	1.457	1.793	0.0022
	Orange	0.927	0.005	0.198	0.207	0.0008
	Riverside	1.880	0.046	0.228	0.272	0.0005
	San Bernardino	0.445	0.003	0.028	0.050	0.0001
	Total	8.685	0.332	1.911	2.322	0.0036
VCAPCD	Ventura	0.092	0.006	0.017	0.046	0.0001
SBAPCD	Santa Barbara	0.007	0.000	0.001	0.003	0.0000
KCAPCD	Kern	0.022	0.000	0.002	0.008	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.199	0.001	0.004	0.035	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.219	0.004	0.007	0.048	0.0000
SLOAPCD	San Luis Obispo	0.047	0.005	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		10.199	0.386	2.164	2.863	0.0045

2011 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.998	0.009	0.190	0.351	0.0011
SCAQMD	Los Angeles	5.059	0.259	1.535	1.588	0.0025
	Orange	0.927	0.004	0.198	0.207	0.0008
	Riverside	1.842	0.044	0.235	0.256	0.0005
	San Bernardino	0.392	0.002	0.043	0.043	0.0001
	Total	8.220	0.309	2.011	2.094	0.0040
VCAPCD	Ventura	0.078	0.004	0.018	0.037	0.0001
SBAPCD	Santa Barbara	0.007	0.000	0.001	0.003	0.0000
KCAPCD	Kern	0.022	0.000	0.003	0.008	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.199	0.001	0.004	0.035	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.219	0.004	0.007	0.048	0.0000
SLOAPCD	San Luis Obispo	0.048	0.005	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		9.593	0.332	2.242	2.560	0.0051

2012 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.997	0.009	0.193	0.350	0.0011
SCAQMD	Los Angeles	4.832	0.250	1.600	1.451	0.0027
	Orange	0.840	0.003	0.217	0.198	0.0008
	Riverside	1.821	0.043	0.238	0.251	0.0005
	San Bernardino	0.314	0.001	0.064	0.031	0.0001
	Total	7.807	0.297	2.119	1.931	0.0042
VCAPCD	Ventura	0.078	0.004	0.018	0.036	0.0001
SBAPCD	Santa Barbara	0.005	0.000	0.003	0.001	0.0000
KCAPCD	Kern	0.020	0.000	0.002	0.006	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.007	0.0000
	Tulare	0.199	0.001	0.004	0.035	0.0000
	Fresno	0.007	0.000	0.001	0.004	0.0000
	Total	0.218	0.004	0.008	0.047	0.0000
SLOAPCD	San Luis Obispo	0.041	0.005	0.022	0.004	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		9.167	0.319	2.365	2.376	0.0054

2013 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.800	0.004	0.246	0.250	0.0011
SCAQMD	Los Angeles	4.383	0.226	1.674	1.207	0.0031
	Orange	0.825	0.003	0.222	0.196	0.0009
	Riverside	1.801	0.043	0.243	0.248	0.0005
	San Bernardino	0.313	0.001	0.065	0.030	0.0001
	Total	7.322	0.273	2.205	1.680	0.0045
VCAPCD	Ventura	0.071	0.004	0.020	0.031	0.0001
SBAPCD	Santa Barbara	0.005	0.000	0.003	0.001	0.0000
KCAPCD	Kern	0.020	0.000	0.002	0.006	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.198	0.001	0.005	0.034	0.0000
	Fresno	0.007	0.000	0.001	0.004	0.0000
	Total	0.216	0.004	0.010	0.045	0.0000
SLOAPCD	San Luis Obispo	0.040	0.004	0.023	0.004	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		8.475	0.289	2.509	2.017	0.0058

2014 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.670	0.003	0.305	0.167	0.0012
SCAQMD	Los Angeles	4.332	0.225	1.707	1.169	0.0031
	Orange	0.807	0.002	0.226	0.193	0.0009
	Riverside	1.753	0.033	0.238	0.223	0.0006
	San Bernardino	0.257	0.001	0.081	0.023	0.0001
	Total	7.149	0.261	2.252	1.609	0.0047
VCAPCD	Ventura	0.071	0.004	0.020	0.030	0.0001
SBAPCD	Santa Barbara	0.005	0.000	0.003	0.001	0.0000
KCAPCD	Kern	0.019	0.000	0.004	0.005	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.198	0.001	0.005	0.034	0.0000
	Fresno	0.007	0.000	0.001	0.004	0.0000
	Total	0.216	0.004	0.010	0.045	0.0000
SLOAPCD	San Luis Obispo	0.039	0.004	0.023	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		8.170	0.275	2.619	1.861	0.0061

2015 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.663	0.002	0.312	0.161	0.0012
SCAQMD	Los Angeles	4.141	0.203	1.727	1.102	0.0034
	Orange	0.779	0.002	0.238	0.189	0.0009
	Riverside	1.648	0.021	0.246	0.192	0.0007
	San Bernardino	0.226	0.000	0.090	0.019	0.0001
	Total	6.795	0.227	2.301	1.502	0.0051
VCAPCD	Ventura	0.068	0.003	0.020	0.028	0.0001
SBAPCD	Santa Barbara	0.004	0.000	0.003	0.000	0.0000
KCAPCD	Kern	0.018	0.000	0.005	0.004	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.175	0.001	0.017	0.030	0.0000
	Fresno	0.006	0.000	0.001	0.004	0.0000
	Total	0.193	0.003	0.022	0.040	0.0000
SLOAPCD	San Luis Obispo	0.039	0.004	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		7.782	0.240	2.688	1.740	0.0065

2016 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.650	0.002	0.320	0.152	0.0012
SCAQMD	Los Angeles	3.709	0.119	1.693	0.895	0.0042
	Orange	0.767	0.002	0.243	0.187	0.0009
	Riverside	1.639	0.021	0.250	0.190	0.0007
	San Bernardino	0.209	0.000	0.096	0.016	0.0001
	Total	6.325	0.142	2.282	1.288	0.0059
VCAPCD	Ventura	0.066	0.002	0.020	0.027	0.0001
SBAPCD	Santa Barbara	0.004	0.000	0.003	0.000	0.0000
KCAPCD	Kern	0.012	0.000	0.007	0.002	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.174	0.001	0.017	0.030	0.0000
	Fresno	0.006	0.000	0.001	0.004	0.0000
	Total	0.193	0.003	0.022	0.040	0.0000
SLOAPCD	San Luis Obispo	0.039	0.004	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		7.290	0.155	2.679	1.513	0.0073

2017 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.615	0.002	0.337	0.129	0.0012
SCAQMD	Los Angeles	3.222	0.008	1.630	0.628	0.0053
	Orange	0.733	0.002	0.257	0.180	0.0009
	Riverside	1.514	0.018	0.277	0.170	0.0008
	San Bernardino	0.209	0.000	0.096	0.016	0.0001
	Total	5.678	0.028	2.260	0.995	0.0071
VCAPCD	Ventura	0.063	0.002	0.023	0.023	0.0001
SBAPCD	Santa Barbara	0.004	0.000	0.003	0.000	0.0000
KCAPCD	Kern	0.011	0.000	0.008	0.001	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.159	0.001	0.025	0.027	0.0000
	Fresno	0.006	0.000	0.002	0.003	0.0000
	Total	0.177	0.003	0.031	0.037	0.0001
SLOAPCD	San Luis Obispo	0.039	0.004	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		6.588	0.040	2.686	1.189	0.0085

2018 CNG Engine Emission Inventory by Air District and County
Historical County Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.501	0.001	0.392	0.055	0.0013
SCAQMD	Los Angeles	3.139	0.007	1.668	0.597	0.0054
	Orange	0.731	0.002	0.258	0.179	0.0009
	Riverside	1.469	0.016	0.292	0.159	0.0008
	San Bernardino	0.207	0.000	0.098	0.015	0.0001
	Total	5.546	0.026	2.317	0.950	0.0072
VCAPCD	Ventura	0.062	0.002	0.024	0.021	0.0001
SBAPCD	Santa Barbara	0.004	0.000	0.004	0.000	0.0000
KCAPCD	Kern	0.011	0.000	0.009	0.001	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.120	0.001	0.045	0.020	0.0001
	Fresno	0.006	0.000	0.002	0.003	0.0000
	Total	0.137	0.003	0.051	0.029	0.0001
SLOAPCD	San Luis Obispo	0.037	0.004	0.024	0.001	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		6.299	0.035	2.820	1.058	0.0087

2008 CNG Engine Emission Inventory by Air District and County
Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.739	0.117	0.240	0.567	0.0007
SCAQMD	Los Angeles	4.196	0.676	1.675	2.179	0.0021
	Orange	0.652	0.091	0.202	0.277	0.0009
	Riverside	1.242	0.201	0.263	0.365	0.0004
	San Bernardino	0.293	0.042	0.028	0.073	0.0001
	Total	6.383	1.009	2.168	2.893	0.0034
VCAPCD	Ventura	0.069	0.011	0.019	0.054	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.016	0.002	0.002	0.011	0.0000
SJVUAPCD	Kings	0.011	0.002	0.003	0.008	0.0000
	Tulare	0.147	0.017	0.004	0.051	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.165	0.020	0.008	0.066	0.0000
SLOAPCD	San Luis Obispo	0.045	0.006	0.013	0.020	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.422	1.166	2.450	3.616	0.0042

2009 CNG Engine Emission Inventory by Air District and County
Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.738	0.117	0.241	0.565	0.0007
SCAQMD	Los Angeles	4.190	0.675	1.673	2.174	0.0021
	Orange	0.652	0.091	0.202	0.277	0.0009
	Riverside	1.230	0.198	0.266	0.348	0.0004
	San Bernardino	0.293	0.042	0.028	0.073	0.0001
	Total	6.365	1.005	2.169	2.870	0.0035
VCAPCD	Ventura	0.067	0.011	0.019	0.056	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.001	0.003	0.0000
KCAPCD	Kern	0.016	0.002	0.003	0.011	0.0000
SJVUAPCD	Kings	0.011	0.002	0.003	0.008	0.0000
	Tulare	0.147	0.017	0.004	0.051	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.165	0.020	0.008	0.066	0.0000
SLOAPCD	San Luis Obispo	0.045	0.006	0.013	0.019	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.402	1.161	2.455	3.591	0.0043

2010 CNG Engine Emission Inventory by Air District and County
Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.733	0.116	0.243	0.558	0.0007
SCAQMD	Los Angeles	4.133	0.662	1.661	2.129	0.0022
	Orange	0.645	0.089	0.206	0.273	0.0009
	Riverside	1.227	0.197	0.267	0.342	0.0004
	San Bernardino	0.284	0.039	0.032	0.068	0.0001
	Total	6.289	0.986	2.166	2.812	0.0036
VCAPCD	Ventura	0.067	0.011	0.019	0.055	0.0001
SBAPCD	Santa Barbara	0.006	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.016	0.002	0.003	0.011	0.0000
SJVUAPCD	Kings	0.011	0.002	0.003	0.008	0.0000
	Tulare	0.147	0.017	0.004	0.051	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.165	0.019	0.008	0.066	0.0000
SLOAPCD	San Luis Obispo	0.045	0.006	0.013	0.019	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.321	1.141	2.453	3.527	0.0045

2011 CNG Engine Emission Inventory by Air District and County Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)						
Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.637	0.095	0.208	0.477	0.0010
SCAQMD	Los Angeles	3.936	0.614	1.703	1.878	0.0026
	Orange	0.645	0.089	0.207	0.273	0.0009
	Riverside	1.206	0.191	0.271	0.322	0.0005
	San Bernardino	0.266	0.036	0.046	0.058	0.0001
	Total	6.053	0.930	2.226	2.531	0.0040
VCAPCD	Ventura	0.059	0.009	0.019	0.044	0.0001
SBAPCD	Santa Barbara	0.006	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.016	0.002	0.003	0.011	0.0000
SJVUAPCD	Kings	0.011	0.002	0.003	0.009	0.0000
	Tulare	0.147	0.017	0.004	0.051	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.165	0.019	0.008	0.066	0.0000
SLOAPCD	San Luis Obispo	0.045	0.006	0.013	0.019	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.981	1.062	2.479	3.152	0.0052

2012 CNG Engine Emission Inventory by Air District and County Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)						
Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.637	0.095	0.211	0.474	0.0010
SCAQMD	Los Angeles	3.821	0.587	1.750	1.716	0.0028
	Orange	0.618	0.083	0.223	0.260	0.0009
	Riverside	1.196	0.189	0.273	0.315	0.0005
	San Bernardino	0.239	0.032	0.066	0.043	0.0001
	Total	5.873	0.891	2.312	2.335	0.0043
VCAPCD	Ventura	0.059	0.009	0.020	0.043	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.003	0.002	0.0000
KCAPCD	Kern	0.014	0.002	0.002	0.009	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.008	0.0000
	Tulare	0.147	0.017	0.004	0.051	0.0000
	Fresno	0.006	0.001	0.001	0.005	0.0000
	Total	0.164	0.019	0.009	0.064	0.0000
SLOAPCD	San Luis Obispo	0.041	0.006	0.022	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.793	1.023	2.579	2.931	0.0055

2013 CNG Engine Emission Inventory by Air District and County Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)						
Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.582	0.081	0.256	0.333	0.0011
SCAQMD	Los Angeles	3.579	0.523	1.774	1.403	0.0032
	Orange	0.612	0.082	0.229	0.258	0.0009
	Riverside	1.188	0.188	0.277	0.311	0.0005
	San Bernardino	0.239	0.032	0.067	0.041	0.0001
	Total	5.617	0.825	2.347	2.013	0.0047
VCAPCD	Ventura	0.056	0.008	0.021	0.036	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.003	0.002	0.0000
KCAPCD	Kern	0.014	0.002	0.002	0.009	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.007	0.0000
	Tulare	0.147	0.017	0.005	0.050	0.0000
	Fresno	0.006	0.001	0.001	0.005	0.0000
	Total	0.163	0.019	0.011	0.062	0.0000
SLOAPCD	San Luis Obispo	0.039	0.005	0.023	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.478	0.941	2.663	2.459	0.0060

2014 CNG Engine Emission Inventory by Air District and County Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)						
Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.537	0.073	0.312	0.219	0.0012
SCAQMD	Los Angeles	3.559	0.520	1.805	1.361	0.0033
	Orange	0.607	0.081	0.232	0.255	0.0009
	Riverside	1.153	0.181	0.269	0.280	0.0006
	San Bernardino	0.219	0.028	0.081	0.032	0.0001
	Total	5.539	0.810	2.388	1.927	0.0049
VCAPCD	Ventura	0.056	0.008	0.021	0.036	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.003	0.001	0.0000
KCAPCD	Kern	0.014	0.002	0.004	0.007	0.0000
SJVUAPCD	Kings	0.010	0.002	0.004	0.007	0.0000
	Tulare	0.147	0.017	0.005	0.050	0.0000
	Fresno	0.006	0.001	0.001	0.005	0.0000
	Total	0.163	0.019	0.011	0.061	0.0000
SLOAPCD	San Luis Obispo	0.039	0.005	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.353	0.919	2.763	2.257	0.0063

2015 CNG Engine Emission Inventory by Air District and County
Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.536	0.072	0.318	0.212	0.0012
SCAQMD	Los Angeles	3.458	0.500	1.816	1.275	0.0035
	Orange	0.597	0.080	0.243	0.250	0.0009
	Riverside	1.091	0.168	0.271	0.243	0.0007
	San Bernardino	0.208	0.027	0.090	0.026	0.0001
	Total	5.355	0.775	2.420	1.795	0.0053
VCAPCD	Ventura	0.054	0.007	0.021	0.033	0.0001
SBAPCD	Santa Barbara	0.004	0.001	0.003	0.000	0.0000
KCAPCD	Kern	0.014	0.002	0.005	0.006	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.007	0.0000
	Tulare	0.136	0.016	0.017	0.043	0.0000
	Fresno	0.006	0.001	0.001	0.004	0.0000
	Total	0.152	0.019	0.023	0.054	0.0000
SLOAPCD	San Luis Obispo	0.039	0.005	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.154	0.881	2.814	2.105	0.0067

2016 CNG Engine Emission Inventory by Air District and County
Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.532	0.072	0.325	0.199	0.0013
SCAQMD	Los Angeles	3.161	0.438	1.747	1.019	0.0044
	Orange	0.592	0.079	0.248	0.248	0.0009
	Riverside	1.088	0.168	0.275	0.240	0.0007
	San Bernardino	0.201	0.026	0.096	0.024	0.0001
	Total	5.042	0.711	2.367	1.531	0.0062
VCAPCD	Ventura	0.053	0.007	0.021	0.031	0.0001
SBAPCD	Santa Barbara	0.004	0.001	0.003	0.000	0.0000
KCAPCD	Kern	0.010	0.001	0.007	0.003	0.0000
SJVUAPCD	Kings	0.010	0.002	0.004	0.007	0.0000
	Tulare	0.136	0.016	0.017	0.043	0.0000
	Fresno	0.006	0.001	0.001	0.004	0.0000
	Total	0.152	0.019	0.023	0.054	0.0000
SLOAPCD	San Luis Obispo	0.039	0.005	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		5.834	0.815	2.770	1.824	0.0077

2017 CNG Engine Emission Inventory by Air District and County
Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.519	0.070	0.342	0.167	0.0013
SCAQMD	Los Angeles	2.798	0.362	1.641	0.689	0.0056
	Orange	0.579	0.077	0.262	0.240	0.0009
	Riverside	1.042	0.157	0.298	0.212	0.0008
	San Bernardino	0.201	0.026	0.096	0.024	0.0001
	Total	4.620	0.622	2.297	1.165	0.0074
VCAPCD	Ventura	0.051	0.007	0.023	0.028	0.0001
SBAPCD	Santa Barbara	0.004	0.001	0.003	0.000	0.0000
KCAPCD	Kern	0.010	0.001	0.008	0.002	0.0000
SJVUAPCD	Kings	0.010	0.002	0.004	0.007	0.0000
	Tulare	0.128	0.015	0.025	0.039	0.0000
	Fresno	0.006	0.001	0.002	0.004	0.0000
	Total	0.145	0.018	0.031	0.050	0.0001
SLOAPCD	San Luis Obispo	0.039	0.005	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		5.389	0.724	2.728	1.416	0.0089

2018 CNG Engine Emission Inventory by Air District and County
Current CARB Prescriptive Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.481	0.063	0.393	0.065	0.0014
SCAQMD	Los Angeles	2.768	0.358	1.678	0.647	0.0056
	Orange	0.578	0.077	0.264	0.239	0.0009
	Riverside	1.027	0.153	0.311	0.197	0.0008
	San Bernardino	0.200	0.026	0.098	0.022	0.0002
	Total	4.574	0.614	2.351	1.105	0.0075
VCAPCD	Ventura	0.050	0.007	0.024	0.026	0.0001
SBAPCD	Santa Barbara	0.004	0.001	0.004	0.000	0.0000
KCAPCD	Kern	0.010	0.001	0.009	0.002	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.007	0.0000
	Tulare	0.110	0.014	0.045	0.028	0.0001
	Fresno	0.006	0.001	0.002	0.003	0.0000
	Total	0.126	0.017	0.052	0.038	0.0001
SLOAPCD	San Luis Obispo	0.037	0.005	0.024	0.001	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		5.282	0.708	2.856	1.237	0.0091

2008 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.847	0.094	0.230	0.536	0.0007
SCAQMD	Los Angeles	4.568	0.558	1.610	2.117	0.0021
	Orange	0.740	0.064	0.199	0.261	0.0008
	Riverside	1.435	0.154	0.250	0.348	0.0004
	San Bernardino	0.349	0.030	0.026	0.068	0.0001
	Total	7.092	0.806	2.085	2.795	0.0034
VCAPCD	Ventura	0.079	0.009	0.018	0.052	0.0001
SBAPCD	Santa Barbara	0.005	0.000	0.001	0.003	0.0000
KCAPCD	Kern	0.018	0.002	0.002	0.010	0.0000
SJVUAPCD	Kings	0.013	0.002	0.003	0.008	0.0000
	Tulare	0.165	0.012	0.004	0.046	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.185	0.014	0.007	0.059	0.0000
SLOAPCD	San Luis Obispo	0.049	0.004	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		8.275	0.928	2.356	3.473	0.0042

2009 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.845	0.094	0.232	0.534	0.0007
SCAQMD	Los Angeles	4.562	0.557	1.608	2.112	0.0021
	Orange	0.740	0.064	0.200	0.261	0.0008
	Riverside	1.420	0.151	0.254	0.332	0.0004
	San Bernardino	0.349	0.030	0.026	0.068	0.0001
	Total	7.070	0.802	2.088	2.772	0.0035
VCAPCD	Ventura	0.077	0.009	0.018	0.053	0.0001
SBAPCD	Santa Barbara	0.005	0.000	0.001	0.003	0.0000
KCAPCD	Kern	0.018	0.002	0.002	0.010	0.0000
SJVUAPCD	Kings	0.013	0.002	0.003	0.008	0.0000
	Tulare	0.165	0.012	0.004	0.046	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.185	0.014	0.007	0.059	0.0000
SLOAPCD	San Luis Obispo	0.049	0.004	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		8.250	0.924	2.362	3.450	0.0043

2010 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.839	0.092	0.234	0.528	0.0007
SCAQMD	Los Angeles	4.498	0.543	1.599	2.068	0.0022
	Orange	0.727	0.062	0.203	0.258	0.0008
	Riverside	1.415	0.150	0.255	0.326	0.0005
	San Bernardino	0.333	0.028	0.031	0.064	0.0001
	Total	6.974	0.783	2.088	2.716	0.0036
VCAPCD	Ventura	0.077	0.009	0.018	0.052	0.0001
SBAPCD	Santa Barbara	0.006	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.018	0.002	0.003	0.010	0.0000
SJVUAPCD	Kings	0.013	0.002	0.003	0.008	0.0000
	Tulare	0.165	0.011	0.004	0.046	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.185	0.014	0.007	0.059	0.0000
SLOAPCD	San Luis Obispo	0.049	0.004	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		8.149	0.904	2.364	3.388	0.0045

2011 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.739	0.069	0.203	0.448	0.0010
SCAQMD	Los Angeles	4.247	0.503	1.652	1.825	0.0025
	Orange	0.728	0.063	0.204	0.258	0.0009
	Riverside	1.389	0.146	0.260	0.307	0.0005
	San Bernardino	0.304	0.026	0.045	0.054	0.0001
	Total	6.668	0.737	2.160	2.444	0.0040
VCAPCD	Ventura	0.067	0.007	0.018	0.041	0.0001
SBAPCD	Santa Barbara	0.006	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.018	0.002	0.003	0.010	0.0000
SJVUAPCD	Kings	0.013	0.002	0.003	0.008	0.0000
	Tulare	0.165	0.011	0.004	0.046	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.185	0.014	0.007	0.059	0.0000
SLOAPCD	San Luis Obispo	0.049	0.004	0.013	0.018	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.733	0.832	2.406	3.025	0.0051

2012 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.739	0.069	0.206	0.445	0.0010
SCAQMD	Los Angeles	4.098	0.481	1.704	1.669	0.0028
	Orange	0.684	0.058	0.221	0.246	0.0009
	Riverside	1.375	0.144	0.262	0.301	0.0005
	San Bernardino	0.262	0.022	0.065	0.040	0.0001
	Total	6.419	0.705	2.253	2.255	0.0042
VCAPCD	Ventura	0.067	0.007	0.019	0.040	0.0001
SBAPCD	Santa Barbara	0.005	0.000	0.003	0.002	0.0000
KCAPCD	Kern	0.016	0.001	0.002	0.008	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.165	0.011	0.004	0.046	0.0000
	Fresno	0.007	0.000	0.001	0.004	0.0000
	Total	0.184	0.014	0.009	0.058	0.0000
SLOAPCD	San Luis Obispo	0.042	0.004	0.022	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.472	0.800	2.513	2.813	0.0054

2013 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.647	0.057	0.253	0.315	0.0011
SCAQMD	Los Angeles	3.793	0.429	1.744	1.368	0.0031
	Orange	0.675	0.057	0.227	0.244	0.0009
	Riverside	1.364	0.143	0.267	0.297	0.0005
	San Bernardino	0.261	0.022	0.066	0.038	0.0001
	Total	6.094	0.651	2.304	1.947	0.0046
VCAPCD	Ventura	0.063	0.006	0.021	0.034	0.0001
SBAPCD	Santa Barbara	0.005	0.000	0.003	0.002	0.0000
KCAPCD	Kern	0.016	0.001	0.002	0.008	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.164	0.011	0.005	0.045	0.0000
	Fresno	0.007	0.000	0.001	0.004	0.0000
	Total	0.183	0.014	0.010	0.056	0.0000
SLOAPCD	San Luis Obispo	0.040	0.004	0.023	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.048	0.733	2.616	2.365	0.0059

2014 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.577	0.051	0.310	0.207	0.0012
SCAQMD	Los Angeles	3.764	0.427	1.775	1.327	0.0032
	Orange	0.667	0.056	0.230	0.241	0.0009
	Riverside	1.327	0.135	0.259	0.267	0.0006
	San Bernardino	0.230	0.019	0.081	0.029	0.0001
	Total	5.988	0.637	2.346	1.864	0.0048
VCAPCD	Ventura	0.062	0.006	0.021	0.034	0.0001
SBAPCD	Santa Barbara	0.005	0.000	0.003	0.001	0.0000
KCAPCD	Kern	0.015	0.001	0.004	0.006	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.164	0.011	0.005	0.044	0.0000
	Fresno	0.007	0.000	0.001	0.004	0.0000
	Total	0.183	0.013	0.010	0.055	0.0000
SLOAPCD	San Luis Obispo	0.039	0.004	0.023	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.871	0.713	2.718	2.173	0.0062

2015 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.574	0.050	0.316	0.200	0.0012
SCAQMD	Los Angeles	3.639	0.406	1.788	1.245	0.0034
	Orange	0.652	0.055	0.242	0.236	0.0009
	Riverside	1.253	0.122	0.264	0.231	0.0007
	San Bernardino	0.213	0.018	0.090	0.024	0.0001
	Total	5.757	0.601	2.384	1.735	0.0052
VCAPCD	Ventura	0.060	0.005	0.021	0.031	0.0001
SBAPCD	Santa Barbara	0.004	0.000	0.003	0.000	0.0000
KCAPCD	Kern	0.015	0.001	0.005	0.005	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.149	0.011	0.017	0.039	0.0000
	Fresno	0.006	0.000	0.001	0.004	0.0000
	Total	0.167	0.013	0.022	0.049	0.0000
SLOAPCD	San Luis Obispo	0.039	0.004	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.618	0.675	2.775	2.026	0.0066

2016 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.567	0.050	0.324	0.188	0.0012
SCAQMD	Los Angeles	3.312	0.336	1.731	0.994	0.0043
	Orange	0.645	0.055	0.246	0.234	0.0009
	Riverside	1.248	0.122	0.268	0.228	0.0007
	San Bernardino	0.203	0.017	0.096	0.021	0.0001
	Total	5.408	0.530	2.341	1.478	0.0060
VCAPCD	Ventura	0.059	0.005	0.021	0.030	0.0001
SBAPCD	Santa Barbara	0.004	0.000	0.003	0.000	0.0000
KCAPCD	Kern	0.011	0.001	0.007	0.003	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.149	0.011	0.017	0.039	0.0000
	Fresno	0.006	0.000	0.001	0.004	0.0000
	Total	0.167	0.013	0.023	0.049	0.0000
SLOAPCD	San Luis Obispo	0.040	0.004	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.257	0.603	2.741	1.753	0.0075

2017 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.548	0.048	0.340	0.158	0.0012
SCAQMD	Los Angeles	2.928	0.248	1.637	0.672	0.0054
	Orange	0.625	0.054	0.260	0.227	0.0009
	Riverside	1.179	0.113	0.292	0.202	0.0008
	San Bernardino	0.203	0.017	0.096	0.022	0.0001
	Total	4.936	0.432	2.286	1.122	0.0072
VCAPCD	Ventura	0.057	0.005	0.023	0.027	0.0001
SBAPCD	Santa Barbara	0.004	0.000	0.003	0.000	0.0000
KCAPCD	Kern	0.010	0.001	0.008	0.002	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.139	0.010	0.025	0.035	0.0000
	Fresno	0.006	0.000	0.002	0.003	0.0000
	Total	0.157	0.013	0.031	0.045	0.0001
SLOAPCD	San Luis Obispo	0.039	0.004	0.023	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		5.751	0.502	2.715	1.358	0.0087

2018 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.487	0.043	0.393	0.063	0.0013
SCAQMD	Los Angeles	2.881	0.245	1.675	0.633	0.0055
	Orange	0.624	0.053	0.262	0.225	0.0009
	Riverside	1.156	0.110	0.306	0.188	0.0008
	San Bernardino	0.202	0.017	0.098	0.020	0.0001
	Total	4.863	0.426	2.341	1.066	0.0073
VCAPCD	Ventura	0.055	0.005	0.024	0.024	0.0001
SBAPCD	Santa Barbara	0.004	0.000	0.004	0.000	0.0000
KCAPCD	Kern	0.010	0.001	0.009	0.002	0.0000
SJVUAPCD	Kings	0.012	0.002	0.004	0.006	0.0000
	Tulare	0.113	0.010	0.045	0.025	0.0001
	Fresno	0.006	0.000	0.002	0.003	0.0000
	Total	0.131	0.012	0.051	0.035	0.0001
SLOAPCD	San Luis Obispo	0.037	0.003	0.024	0.001	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		5.588	0.489	2.845	1.191	0.0089

2008 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.776	0.109	0.237	0.556	0.0007
SCAQMD	Los Angeles	4.323	0.636	1.653	2.158	0.0021
	Orange	0.682	0.082	0.201	0.271	0.0009
	Riverside	1.308	0.185	0.258	0.359	0.0004
	San Bernardino	0.312	0.038	0.027	0.071	0.0001
	Total	6.625	0.940	2.139	2.860	0.0034
VCAPCD	Ventura	0.072	0.010	0.018	0.053	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.016	0.002	0.002	0.011	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.153	0.015	0.004	0.049	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.172	0.018	0.008	0.064	0.0000
SLOAPCD	San Luis Obispo	0.046	0.005	0.013	0.019	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.714	1.085	2.418	3.567	0.0042

2009 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.774	0.109	0.238	0.554	0.0007
SCAQMD	Los Angeles	4.317	0.635	1.651	2.152	0.0021
	Orange	0.682	0.082	0.202	0.271	0.0009
	Riverside	1.295	0.182	0.262	0.342	0.0004
	San Bernardino	0.312	0.038	0.027	0.071	0.0001
	Total	6.606	0.936	2.142	2.837	0.0035
VCAPCD	Ventura	0.071	0.010	0.019	0.055	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.001	0.003	0.0000
KCAPCD	Kern	0.017	0.002	0.002	0.010	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.153	0.015	0.004	0.049	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.172	0.018	0.008	0.064	0.0000
SLOAPCD	San Luis Obispo	0.046	0.005	0.013	0.019	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.692	1.080	2.423	3.543	0.0043

2010 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.769	0.108	0.240	0.548	0.0007
SCAQMD	Los Angeles	4.258	0.621	1.640	2.108	0.0022
	Orange	0.673	0.080	0.205	0.268	0.0009
	Riverside	1.291	0.181	0.263	0.337	0.0004
	San Bernardino	0.301	0.035	0.031	0.067	0.0001
	Total	6.523	0.917	2.140	2.780	0.0036
VCAPCD	Ventura	0.071	0.010	0.019	0.054	0.0001
SBAPCD	Santa Barbara	0.006	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.017	0.002	0.003	0.010	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.153	0.015	0.004	0.049	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.172	0.017	0.008	0.064	0.0000
SLOAPCD	San Luis Obispo	0.046	0.005	0.013	0.019	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.604	1.060	2.423	3.480	0.0045

2011 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.672	0.086	0.206	0.467	0.0010
SCAQMD	Los Angeles	4.042	0.576	1.686	1.860	0.0026
	Orange	0.674	0.080	0.206	0.268	0.0009
	Riverside	1.268	0.176	0.267	0.317	0.0005
	San Bernardino	0.279	0.033	0.046	0.057	0.0001
	Total	6.263	0.864	2.204	2.501	0.0040
VCAPCD	Ventura	0.062	0.008	0.019	0.043	0.0001
SBAPCD	Santa Barbara	0.006	0.001	0.001	0.004	0.0000
KCAPCD	Kern	0.017	0.002	0.003	0.010	0.0000
SJVUAPCD	Kings	0.012	0.002	0.003	0.008	0.0000
	Tulare	0.153	0.015	0.004	0.049	0.0000
	Fresno	0.007	0.001	0.000	0.006	0.0000
	Total	0.172	0.017	0.008	0.064	0.0000
SLOAPCD	San Luis Obispo	0.047	0.005	0.013	0.019	0.0000
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.238	0.984	2.454	3.108	0.0052

2012 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.672	0.086	0.209	0.464	0.0010
SCAQMD	Los Angeles	3.915	0.551	1.735	1.700	0.0028
	Orange	0.641	0.074	0.223	0.255	0.0009
	Riverside	1.257	0.173	0.269	0.310	0.0005
	San Bernardino	0.246	0.028	0.065	0.042	0.0001
	Total	6.060	0.827	2.292	2.307	0.0043
VCAPCD	Ventura	0.061	0.008	0.019	0.042	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.003	0.002	0.0000
KCAPCD	Kern	0.015	0.002	0.002	0.008	0.0000
SJVUAPCD	Kings	0.011	0.002	0.003	0.008	0.0000
	Tulare	0.153	0.015	0.004	0.049	0.0000
	Fresno	0.006	0.001	0.001	0.005	0.0000
	Total	0.171	0.017	0.009	0.062	0.0000
SLOAPCD	San Luis Obispo	0.041	0.005	0.022	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		7.025	0.946	2.557	2.891	0.0055

2013 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.605	0.072	0.255	0.327	0.0011
SCAQMD	Los Angeles	3.652	0.491	1.764	1.391	0.0032
	Orange	0.634	0.074	0.228	0.253	0.0009
	Riverside	1.248	0.173	0.274	0.306	0.0005
	San Bernardino	0.246	0.028	0.067	0.040	0.0001
	Total	5.780	0.766	2.332	1.990	0.0047
VCAPCD	Ventura	0.058	0.007	0.021	0.036	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.003	0.002	0.0000
KCAPCD	Kern	0.015	0.002	0.002	0.009	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.007	0.0000
	Tulare	0.153	0.015	0.005	0.048	0.0000
	Fresno	0.006	0.001	0.001	0.005	0.0000
	Total	0.170	0.017	0.010	0.060	0.0000
SLOAPCD	San Luis Obispo	0.039	0.005	0.023	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.673	0.870	2.647	2.427	0.0060

2014 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.551	0.066	0.311	0.215	0.0012
SCAQMD	Los Angeles	3.629	0.488	1.795	1.349	0.0033
	Orange	0.628	0.072	0.232	0.250	0.0009
	Riverside	1.213	0.165	0.265	0.276	0.0006
	San Bernardino	0.223	0.025	0.081	0.031	0.0001
	Total	5.692	0.751	2.373	1.906	0.0049
VCAPCD	Ventura	0.058	0.007	0.021	0.035	0.0001
SBAPCD	Santa Barbara	0.005	0.001	0.003	0.001	0.0000
KCAPCD	Kern	0.014	0.002	0.004	0.007	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.007	0.0000
	Tulare	0.153	0.015	0.005	0.048	0.0000
	Fresno	0.006	0.001	0.001	0.005	0.0000
	Total	0.170	0.017	0.011	0.059	0.0000
SLOAPCD	San Luis Obispo	0.039	0.005	0.023	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.530	0.848	2.747	2.228	0.0063

2015 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.549	0.065	0.317	0.208	0.0012
SCAQMD	Los Angeles	3.520	0.468	1.806	1.265	0.0035
	Orange	0.616	0.071	0.243	0.245	0.0009
	Riverside	1.147	0.153	0.269	0.239	0.0007
	San Bernardino	0.210	0.024	0.090	0.026	0.0001
	Total	5.492	0.715	2.408	1.774	0.0052
VCAPCD	Ventura	0.056	0.007	0.021	0.033	0.0001
SBAPCD	Santa Barbara	0.004	0.001	0.003	0.000	0.0000
KCAPCD	Kern	0.014	0.002	0.005	0.006	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.007	0.0000
	Tulare	0.140	0.014	0.017	0.042	0.0000
	Fresno	0.006	0.001	0.001	0.004	0.0000
	Total	0.157	0.017	0.023	0.053	0.0000
SLOAPCD	San Luis Obispo	0.039	0.005	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		6.313	0.810	2.801	2.078	0.0067

2016 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	0.544	0.064	0.325	0.195	0.0012
SCAQMD	Los Angeles	3.213	0.403	1.742	1.011	0.0044
	Orange	0.610	0.071	0.248	0.243	0.0009
	Riverside	1.143	0.152	0.273	0.236	0.0007
	San Bernardino	0.202	0.023	0.096	0.023	0.0001
	Total	5.168	0.649	2.358	1.513	0.0061
VCAPCD	Ventura	0.055	0.006	0.021	0.031	0.0001
SBAPCD	Santa Barbara	0.004	0.001	0.003	0.000	0.0000
KCAPCD	Kern	0.010	0.001	0.007	0.003	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.007	0.0000
	Tulare	0.140	0.014	0.017	0.042	0.0000
	Fresno	0.006	0.001	0.001	0.004	0.0000
	Total	0.157	0.017	0.023	0.053	0.0000
SLOAPCD	San Luis Obispo	0.039	0.005	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		5.978	0.743	2.760	1.800	0.0076

2017 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.529	0.062	0.341	0.164	0.0013
SCAQMD	Los Angeles	2.843	0.323	1.640	0.683	0.0055
	Orange	0.595	0.069	0.261	0.236	0.0009
	Riverside	1.089	0.142	0.296	0.208	0.0008
	San Bernardino	0.202	0.023	0.096	0.023	0.0001
	Total	4.728	0.557	2.293	1.150	0.0073
VCAPCD	Ventura	0.053	0.006	0.023	0.028	0.0001
SBAPCD	Santa Barbara	0.004	0.001	0.003	0.000	0.0000
KCAPCD	Kern	0.010	0.001	0.008	0.002	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.007	0.0000
	Tulare	0.132	0.014	0.025	0.038	0.0000
	Fresno	0.006	0.001	0.002	0.004	0.0000
	Total	0.149	0.016	0.031	0.048	0.0001
SLOAPCD	San Luis Obispo	0.039	0.005	0.024	0.004	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.001	0.0000
13-County Total		5.513	0.648	2.724	1.396	0.0088

2018 CNG Engine Emission Inventory by Air District and County
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario (annual tons per day)

Air District	County	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	0.483	0.056	0.393	0.065	0.0013
SCAQMD	Los Angeles	2.807	0.319	1.677	0.642	0.0056
	Orange	0.594	0.069	0.263	0.234	0.0009
	Riverside	1.071	0.139	0.309	0.194	0.0008
	San Bernardino	0.201	0.023	0.098	0.021	0.0002
	Total	4.673	0.550	2.347	1.091	0.0074
VCAPCD	Ventura	0.052	0.006	0.024	0.025	0.0001
SBAPCD	Santa Barbara	0.004	0.000	0.004	0.000	0.0000
KCAPCD	Kern	0.010	0.001	0.009	0.002	0.0000
SJVUAPCD	Kings	0.011	0.002	0.004	0.007	0.0000
	Tulare	0.111	0.012	0.045	0.027	0.0001
	Fresno	0.006	0.001	0.002	0.003	0.0000
	Total	0.128	0.015	0.051	0.037	0.0001
SLOAPCD	San Luis Obispo	0.037	0.004	0.024	0.001	0.0001
ICAPCD	Imperial	0.001	0.000	0.000	0.000	0.0000
13-County Total		5.387	0.633	2.852	1.221	0.0091

APPENDIX G

HD CNG Engine Inventories for the Three Regulatory Scenarios Differences Relative to Historical Fuel Scenario (2008–2018)

2008 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.397	0.076	0.031	0.144	0.0000	-0.08%	0.05%	0.00%	0.09%	0.00%
SCAQMD	Los Angeles	-1.331	0.381	0.212	0.346	0.0000	-0.33%	0.11%	0.01%	0.07%	0.00%
	Orange	-0.301	0.085	0.009	0.067	0.0000	-0.20%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.669	0.153	0.043	0.075	0.0000	-0.64%	0.25%	0.01%	0.09%	0.00%
	San Bernardino	-0.185	0.038	0.005	0.019	0.0000	-0.14%	0.05%	0.00%	0.02%	0.00%
	Total	-2.486	0.657	0.269	0.507	0.0000	-0.31%	0.11%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.026	0.005	0.002	0.009	0.0000	-0.03%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.007	0.002	0.000	0.003	0.0000	-0.03%	0.01%	0.00%	0.01%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.052	0.015	0.000	0.016	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.054	0.016	0.001	0.018	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.002	0.001	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.01%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.973	0.758	0.303	0.683	0.0000	-0.12%	0.07%	0.01%	0.05%	0.00%

2009 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.396	0.076	0.031	0.143	0.0000	-0.08%	0.05%	0.00%	0.09%	0.00%
SCAQMD	Los Angeles	-1.330	0.382	0.211	0.345	0.0000	-0.33%	0.12%	0.01%	0.07%	0.00%
	Orange	-0.301	0.085	0.009	0.067	0.0000	-0.20%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.657	0.152	0.040	0.071	0.0000	-0.63%	0.25%	0.01%	0.09%	0.00%
	San Bernardino	-0.185	0.038	0.005	0.019	0.0000	-0.14%	0.05%	0.00%	0.02%	0.00%
	Total	-2.473	0.657	0.265	0.502	0.0000	-0.31%	0.11%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.025	0.005	0.002	0.009	0.0000	-0.03%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.03%	0.01%	0.00%	0.01%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.052	0.015	0.000	0.016	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.054	0.016	0.001	0.018	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.002	0.001	0.000	0.001	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.957	0.757	0.299	0.677	0.0000	-0.12%	0.07%	0.01%	0.05%	0.00%

2010 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.392	0.076	0.030	0.141	0.0000	-0.08%	0.05%	0.00%	0.09%	0.00%
SCAQMD	Los Angeles	-1.300	0.383	0.204	0.336	0.0000	-0.33%	0.12%	0.01%	0.07%	0.00%
	Orange	-0.282	0.084	0.008	0.066	0.0000	-0.19%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.654	0.151	0.039	0.070	0.0000	-0.62%	0.26%	0.01%	0.09%	0.00%
	San Bernardino	-0.161	0.036	0.004	0.018	0.0000	-0.12%	0.05%	0.00%	0.02%	0.00%
	Total	-2.397	0.654	0.256	0.491	0.0001	-0.30%	0.12%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.025	0.005	0.002	0.009	0.0000	-0.03%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.03%	0.01%	0.00%	0.01%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.052	0.015	0.000	0.016	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.054	0.016	0.001	0.018	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.002	0.001	0.000	0.001	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.877	0.755	0.289	0.664	0.0000	-0.12%	0.08%	0.01%	0.05%	0.00%

2011 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.362	0.086	0.019	0.125	0.0000	-0.07%	0.06%	0.00%	0.09%	0.00%
SCAQMD	Los Angeles	-1.123	0.355	0.169	0.290	0.0001	-0.29%	0.11%	0.01%	0.07%	0.00%
	Orange	-0.282	0.084	0.008	0.066	0.0000	-0.19%	0.08%	0.00%	0.05%	0.00%
	Riverside	-0.637	0.148	0.036	0.066	0.0000	-0.64%	0.25%	0.01%	0.09%	0.00%
	San Bernardino	-0.126	0.034	0.003	0.016	0.0000	-0.10%	0.05%	0.00%	0.02%	0.00%
	Total	-2.168	0.621	0.216	0.437	0.0001	-0.29%	0.11%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.020	0.005	0.001	0.007	0.0000	-0.02%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.03%	0.01%	0.00%	0.01%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.052	0.015	0.000	0.016	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.054	0.016	0.001	0.018	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.002	0.001	0.000	0.001	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.613	0.731	0.237	0.592	0.0001	-0.11%	0.07%	0.01%	0.05%	0.00%

2012 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.360	0.086	0.018	0.124	0.0000	-0.07%	0.06%	0.00%	0.09%	0.00%
SCAQMD	Los Angeles	-1.012	0.338	0.150	0.266	0.0001	-0.27%	0.11%	0.01%	0.06%	0.00%
	Orange	-0.221	0.080	0.006	0.062	0.0000	-0.15%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.625	0.146	0.035	0.064	0.0000	-0.63%	0.25%	0.01%	0.09%	0.00%
	San Bernardino	-0.076	0.030	0.002	0.011	0.0000	-0.06%	0.04%	0.00%	0.01%	0.00%
	Total	-1.934	0.594	0.194	0.403	0.0001	-0.26%	0.11%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.019	0.005	0.001	0.007	0.0000	-0.02%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.052	0.015	0.000	0.016	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.053	0.016	0.001	0.017	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.001	0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.374	0.704	0.214	0.555	0.0001	-0.10%	0.07%	0.00%	0.05%	0.00%

2013 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.217	0.076	0.010	0.083	0.0000	-0.04%	0.05%	0.00%	0.06%	0.00%
SCAQMD	Los Angeles	-0.805	0.297	0.100	0.196	0.0001	-0.22%	0.10%	0.01%	0.05%	0.00%
	Orange	-0.213	0.079	0.006	0.062	0.0000	-0.15%	0.07%	0.00%	0.06%	0.00%
	Riverside	-0.613	0.146	0.035	0.063	0.0000	-0.63%	0.25%	0.01%	0.09%	0.00%
	San Bernardino	-0.075	0.030	0.001	0.011	0.0000	-0.06%	0.04%	0.00%	0.01%	0.00%
	Total	-1.705	0.553	0.143	0.333	0.0002	-0.23%	0.10%	0.01%	0.05%	0.00%
VCAPCD	Ventura	-0.015	0.004	0.001	0.006	0.0000	-0.01%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.051	0.015	0.000	0.016	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.053	0.016	0.001	0.017	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.997	0.652	0.155	0.441	0.0002	-0.08%	0.07%	0.00%	0.04%	0.00%

2014 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.133	0.070	0.007	0.053	0.0001	-0.03%	0.05%	0.00%	0.04%	0.00%
SCAQMD	Los Angeles	-0.773	0.295	0.098	0.191	0.0001	-0.22%	0.10%	0.01%	0.05%	0.00%
	Orange	-0.199	0.078	0.006	0.061	0.0000	-0.14%	0.07%	0.00%	0.06%	0.00%
	Riverside	-0.600	0.148	0.031	0.057	0.0000	-0.62%	0.26%	0.01%	0.09%	0.00%
	San Bernardino	-0.038	0.028	0.001	0.009	0.0000	-0.03%	0.04%	0.00%	0.01%	0.00%
	Total	-1.611	0.550	0.136	0.318	0.0002	-0.22%	0.11%	0.01%	0.05%	0.00%
VCAPCD	Ventura	-0.015	0.004	0.001	0.006	0.0000	-0.01%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.005	0.002	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.051	0.015	0.000	0.016	0.0000	-0.02%	0.03%	0.00%	0.05%	0.00%
	Fresno	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.053	0.016	0.001	0.017	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.817	0.644	0.144	0.396	0.0002	-0.07%	0.07%	0.00%	0.04%	0.00%

2015 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.127	0.070	0.006	0.051	0.0001	-0.02%	0.05%	0.00%	0.04%	0.00%
SCAQMD	Los Angeles	-0.683	0.297	0.088	0.173	0.0002	-0.19%	0.10%	0.01%	0.05%	0.00%
	Orange	-0.182	0.077	0.006	0.061	0.0000	-0.13%	0.07%	0.00%	0.06%	0.00%
	Riverside	-0.557	0.147	0.025	0.051	0.0000	-0.58%	0.26%	0.01%	0.08%	0.00%
	San Bernardino	-0.018	0.027	0.000	0.007	0.0000	-0.01%	0.04%	0.00%	0.01%	0.00%
	Total	-1.440	0.548	0.119	0.293	0.0002	-0.20%	0.11%	0.00%	0.05%	0.00%
VCAPCD	Ventura	-0.014	0.005	0.001	0.005	0.0000	-0.01%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.002	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.039	0.015	0.000	0.013	0.0000	-0.01%	0.03%	0.00%	0.04%	0.00%
	Fresno	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.040	0.015	0.001	0.015	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.001	0.000	0.000	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.628	0.640	0.126	0.365	0.0003	-0.07%	0.07%	0.00%	0.04%	0.00%

2016 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.118	0.069	0.005	0.047	0.0001	-0.02%	0.05%	0.00%	0.04%	0.00%
SCAQMD	Los Angeles	-0.549	0.320	0.054	0.124	0.0002	-0.15%	0.11%	0.00%	0.03%	0.00%
	Orange	-0.175	0.077	0.006	0.061	0.0000	-0.12%	0.07%	0.00%	0.06%	0.00%
	Riverside	-0.551	0.147	0.025	0.050	0.0000	-0.58%	0.27%	0.01%	0.08%	0.00%
	San Bernardino	-0.008	0.026	0.000	0.007	0.0000	-0.01%	0.04%	0.00%	0.01%	0.00%
	Total	-1.282	0.569	0.085	0.243	0.0002	-0.18%	0.11%	0.00%	0.04%	0.00%
VCAPCD	Ventura	-0.014	0.005	0.000	0.005	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.001	0.001	0.000	0.001	0.0000	-0.01%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.039	0.015	0.000	0.013	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.040	0.015	0.001	0.015	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.001	0.000	0.000	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.456	0.661	0.091	0.311	0.0003	-0.06%	0.07%	0.00%	0.03%	0.00%

2017 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.096	0.068	0.005	0.038	0.0001	-0.02%	0.05%	0.00%	0.03%	0.00%
SCAQMD	Los Angeles	-0.424	0.353	0.011	0.061	0.0003	-0.12%	0.13%	0.00%	0.02%	0.00%
	Orange	-0.154	0.075	0.005	0.061	0.0000	-0.11%	0.07%	0.00%	0.06%	0.00%
	Riverside	-0.472	0.139	0.021	0.042	0.0000	-0.50%	0.25%	0.01%	0.07%	0.00%
	San Bernardino	-0.008	0.026	0.000	0.007	0.0000	-0.01%	0.04%	0.00%	0.01%	0.00%
	Total	-1.057	0.594	0.037	0.170	0.0003	-0.15%	0.12%	0.00%	0.03%	0.00%
VCAPCD	Ventura	-0.012	0.005	0.000	0.005	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.001	0.001	0.000	0.000	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.030	0.014	0.000	0.012	0.0000	-0.01%	0.03%	0.00%	0.04%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.032	0.015	0.001	0.013	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.001	0.000	0.000	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.198	0.684	0.042	0.227	0.0004	-0.05%	0.08%	0.00%	0.02%	0.00%

2018 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Current CARB Prescriptive Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.021	0.063	0.001	0.011	0.0001	0.00%	0.05%	0.00%	0.01%	0.00%
SCAQMD	Los Angeles	-0.371	0.350	0.010	0.050	0.0003	-0.11%	0.13%	0.00%	0.02%	0.00%
	Orange	-0.153	0.075	0.005	0.060	0.0000	-0.11%	0.07%	0.00%	0.06%	0.00%
	Riverside	-0.441	0.137	0.019	0.038	0.0000	-0.47%	0.25%	0.01%	0.07%	0.00%
	San Bernardino	-0.007	0.026	0.000	0.007	0.0000	-0.01%	0.04%	0.00%	0.01%	0.00%
	Total	-0.972	0.588	0.034	0.154	0.0003	-0.14%	0.12%	0.00%	0.03%	0.00%
VCAPCD	Ventura	-0.011	0.005	0.000	0.004	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.001	0.001	0.000	0.000	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.010	0.013	0.000	0.008	0.0000	0.00%	0.03%	0.00%	0.03%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.011	0.014	0.001	0.009	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.016	0.672	0.036	0.179	0.0004	-0.04%	0.07%	0.00%	0.02%	0.00%

2008 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.289	0.053	0.022	0.113	0.0000	-0.06%	0.04%	0.00%	0.07%	0.00%
SCAQMD	Los Angeles	-0.959	0.263	0.147	0.284	0.0000	-0.23%	0.08%	0.01%	0.06%	0.00%
	Orange	-0.214	0.059	0.006	0.052	0.0000	-0.14%	0.05%	0.00%	0.04%	0.00%
	Riverside	-0.476	0.106	0.030	0.059	0.0000	-0.46%	0.17%	0.01%	0.07%	0.00%
	San Bernardino	-0.130	0.026	0.003	0.014	0.0000	-0.10%	0.04%	0.00%	0.02%	0.00%
	Total	-1.778	0.454	0.186	0.408	0.0000	-0.22%	0.08%	0.01%	0.05%	0.00%
VCAPCD	Ventura	-0.015	0.003	0.001	0.006	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.001	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.010	0.000	0.011	0.0000	-0.01%	0.02%	0.00%	0.02%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.034	0.010	0.000	0.011	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.001	-0.001	0.000	-0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.120	0.521	0.210	0.540	0.0000	-0.08%	0.05%	0.00%	0.04%	0.00%

2009 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.288	0.053	0.022	0.112	0.0000	-0.06%	0.04%	0.00%	0.07%	0.00%
SCAQMD	Los Angeles	-0.957	0.264	0.147	0.283	0.0000	-0.24%	0.08%	0.01%	0.06%	0.00%
	Orange	-0.214	0.059	0.006	0.052	0.0000	-0.14%	0.05%	0.00%	0.04%	0.00%
	Riverside	-0.468	0.105	0.028	0.056	0.0000	-0.45%	0.17%	0.01%	0.07%	0.00%
	San Bernardino	-0.130	0.026	0.003	0.014	0.0000	-0.10%	0.04%	0.00%	0.02%	0.00%
	Total	-1.768	0.453	0.184	0.404	0.0000	-0.22%	0.08%	0.01%	0.05%	0.00%
VCAPCD	Ventura	-0.015	0.003	0.001	0.006	0.0000	-0.02%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.001	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.010	0.000	0.011	0.0000	-0.01%	0.02%	0.00%	0.02%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.034	0.010	0.000	0.011	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.001	-0.001	0.000	-0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.109	0.520	0.207	0.536	0.0000	-0.09%	0.05%	0.00%	0.04%	0.00%

2010 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.285	0.053	0.021	0.111	0.0000	-0.06%	0.04%	0.00%	0.07%	0.00%
SCAQMD	Los Angeles	-0.935	0.264	0.142	0.275	0.0000	-0.24%	0.08%	0.01%	0.06%	0.00%
	Orange	-0.199	0.058	0.006	0.051	0.0000	-0.13%	0.05%	0.00%	0.04%	0.00%
	Riverside	-0.465	0.104	0.027	0.055	0.0000	-0.44%	0.18%	0.01%	0.07%	0.00%
	San Bernardino	-0.112	0.025	0.003	0.013	0.0000	-0.08%	0.04%	0.00%	0.02%	0.00%
	Total	-1.711	0.451	0.177	0.395	0.0000	-0.22%	0.08%	0.01%	0.05%	0.00%
VCAPCD	Ventura	-0.015	0.003	0.001	0.006	0.0000	-0.02%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.001	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.010	0.000	0.011	0.0000	-0.01%	0.02%	0.00%	0.02%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.034	0.010	0.000	0.011	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.001	-0.001	0.000	-0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.049	0.518	0.200	0.524	0.0000	-0.08%	0.05%	0.00%	0.04%	0.00%

2011 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.259	0.059	0.013	0.096	0.0000	-0.05%	0.04%	0.00%	0.07%	0.00%
SCAQMD	Los Angeles	-0.811	0.244	0.117	0.237	0.0000	-0.21%	0.08%	0.01%	0.06%	0.00%
	Orange	-0.199	0.058	0.006	0.051	0.0000	-0.14%	0.05%	0.00%	0.04%	0.00%
	Riverside	-0.454	0.102	0.025	0.051	0.0000	-0.45%	0.17%	0.01%	0.07%	0.00%
	San Bernardino	-0.088	0.023	0.002	0.011	0.0000	-0.07%	0.03%	0.00%	0.01%	0.00%
	Total	-1.552	0.427	0.150	0.350	0.0000	-0.20%	0.08%	0.01%	0.05%	0.00%
VCAPCD	Ventura	-0.011	0.003	0.001	0.005	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.001	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.010	0.000	0.011	0.0000	-0.01%	0.02%	0.00%	0.03%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.034	0.010	0.000	0.011	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.001	-0.001	0.000	-0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.860	0.500	0.164	0.465	0.0000	-0.08%	0.05%	0.00%	0.04%	0.00%

2012 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.258	0.059	0.013	0.096	0.0000	-0.05%	0.04%	0.00%	0.07%	0.00%
SCAQMD	Los Angeles	-0.734	0.232	0.104	0.218	0.0000	-0.20%	0.08%	0.01%	0.05%	0.00%
	Orange	-0.156	0.055	0.005	0.048	0.0000	-0.11%	0.05%	0.00%	0.04%	0.00%
	Riverside	-0.445	0.101	0.024	0.050	0.0000	-0.45%	0.17%	0.01%	0.07%	0.00%
	San Bernardino	-0.052	0.021	0.001	0.008	0.0000	-0.04%	0.03%	0.00%	0.01%	0.00%
	Total	-1.388	0.408	0.134	0.324	0.0000	-0.19%	0.08%	0.00%	0.05%	0.00%
VCAPCD	Ventura	-0.011	0.003	0.001	0.005	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.001	0.000	0.002	0.0000	-0.01%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.010	0.000	0.011	0.0000	-0.01%	0.02%	0.00%	0.03%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.034	0.010	0.000	0.011	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.001	-0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.695	0.481	0.148	0.437	0.0000	-0.07%	0.05%	0.00%	0.04%	0.00%

2013 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.152	0.052	0.007	0.065	0.0000	-0.03%	0.04%	0.00%	0.05%	0.00%
SCAQMD	Los Angeles	-0.590	0.203	0.069	0.161	0.0001	-0.16%	0.07%	0.00%	0.04%	0.00%
	Orange	-0.150	0.055	0.004	0.048	0.0000	-0.10%	0.05%	0.00%	0.04%	0.00%
	Riverside	-0.437	0.100	0.024	0.049	0.0000	-0.45%	0.17%	0.01%	0.07%	0.00%
	San Bernardino	-0.052	0.021	0.001	0.008	0.0000	-0.04%	0.03%	0.00%	0.01%	0.00%
	Total	-1.228	0.379	0.099	0.266	0.0001	-0.17%	0.07%	0.00%	0.04%	0.00%
VCAPCD	Ventura	-0.008	0.002	0.000	0.004	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.001	0.000	0.002	0.0000	-0.01%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.010	0.000	0.010	0.0000	-0.01%	0.02%	0.00%	0.03%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.034	0.010	0.000	0.011	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	-0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.427	0.444	0.107	0.348	0.0001	-0.06%	0.05%	0.00%	0.03%	0.00%

2014 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.093	0.048	0.005	0.041	0.0000	-0.02%	0.03%	0.00%	0.03%	0.00%
SCAQMD	Los Angeles	-0.568	0.202	0.068	0.158	0.0001	-0.16%	0.07%	0.00%	0.04%	0.00%
	Orange	-0.140	0.054	0.004	0.047	0.0000	-0.10%	0.05%	0.00%	0.05%	0.00%
	Riverside	-0.427	0.102	0.021	0.044	0.0000	-0.44%	0.18%	0.01%	0.07%	0.00%
	San Bernardino	-0.026	0.019	0.000	0.006	0.0000	-0.02%	0.03%	0.00%	0.01%	0.00%
	Total	-1.161	0.377	0.094	0.255	0.0001	-0.16%	0.07%	0.00%	0.04%	0.00%
VCAPCD	Ventura	-0.008	0.002	0.000	0.004	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.003	0.001	0.000	0.001	0.0000	-0.01%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.010	0.000	0.010	0.0000	-0.01%	0.02%	0.00%	0.03%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.033	0.010	0.000	0.011	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	-0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.299	0.438	0.100	0.312	0.0001	-0.05%	0.05%	0.00%	0.03%	0.00%

2015 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.089	0.048	0.004	0.039	0.0000	-0.02%	0.03%	0.00%	0.03%	0.00%
SCAQMD	Los Angeles	-0.503	0.202	0.061	0.143	0.0001	-0.14%	0.07%	0.00%	0.04%	0.00%
	Orange	-0.128	0.053	0.004	0.047	0.0000	-0.09%	0.05%	0.00%	0.05%	0.00%
	Riverside	-0.395	0.101	0.017	0.038	0.0000	-0.41%	0.18%	0.01%	0.06%	0.00%
	San Bernardino	-0.013	0.018	0.000	0.005	0.0000	-0.01%	0.03%	0.00%	0.01%	0.00%
	Total	-1.038	0.374	0.083	0.233	0.0001	-0.15%	0.07%	0.00%	0.04%	0.00%
VCAPCD	Ventura	-0.008	0.003	0.000	0.003	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.003	0.001	0.000	0.001	0.0000	-0.01%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.026	0.010	0.000	0.009	0.0000	-0.01%	0.02%	0.00%	0.03%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.025	0.010	0.000	0.009	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	-0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.164	0.435	0.087	0.286	0.0001	-0.05%	0.05%	0.00%	0.03%	0.00%

2016 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.083	0.047	0.004	0.036	0.0000	-0.02%	0.04%	0.00%	0.03%	0.00%
SCAQMD	Los Angeles	-0.397	0.217	0.038	0.100	0.0001	-0.11%	0.08%	0.00%	0.03%	0.00%
	Orange	-0.123	0.053	0.004	0.047	0.0000	-0.09%	0.05%	0.00%	0.05%	0.00%
	Riverside	-0.391	0.101	0.017	0.038	0.0000	-0.41%	0.18%	0.01%	0.06%	0.00%
	San Bernardino	-0.005	0.017	0.000	0.005	0.0000	0.00%	0.03%	0.00%	0.01%	0.00%
	Total	-0.916	0.388	0.059	0.190	0.0001	-0.13%	0.08%	0.00%	0.03%	0.00%
VCAPCD	Ventura	-0.008	0.003	0.000	0.003	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.001	0.001	0.000	0.001	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.026	0.010	0.000	0.009	0.0000	-0.01%	0.02%	0.00%	0.03%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.025	0.010	0.000	0.009	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	-0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.033	0.448	0.063	0.239	0.0001	-0.04%	0.05%	0.00%	0.02%	0.00%

2017 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.067	0.046	0.003	0.029	0.0000	-0.01%	0.03%	0.00%	0.02%	0.00%
SCAQMD	Los Angeles	-0.294	0.240	0.007	0.044	0.0001	-0.08%	0.08%	0.00%	0.01%	0.00%
	Orange	-0.108	0.051	0.004	0.047	0.0000	-0.08%	0.05%	0.00%	0.05%	0.00%
	Riverside	-0.334	0.096	0.014	0.032	0.0000	-0.35%	0.17%	0.01%	0.06%	0.00%
	San Bernardino	-0.005	0.017	0.000	0.005	0.0000	0.00%	0.03%	0.00%	0.01%	0.00%
	Total	-0.742	0.404	0.026	0.128	0.0001	-0.10%	0.08%	0.00%	0.02%	0.00%
VCAPCD	Ventura	-0.007	0.003	0.000	0.003	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	0.000	0.001	0.000	0.000	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.020	0.009	0.000	0.008	0.0000	-0.01%	0.02%	0.00%	0.02%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.020	0.009	0.000	0.008	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	-0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-0.836	0.463	0.029	0.169	0.0002	-0.03%	0.05%	0.00%	0.02%	0.00%

2018 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 1 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.015	0.042	0.001	0.008	0.0000	0.00%	0.03%	0.00%	0.01%	0.00%
SCAQMD	Los Angeles	-0.258	0.237	0.007	0.036	0.0001	-0.07%	0.09%	0.00%	0.01%	0.00%
	Orange	-0.107	0.051	0.004	0.046	0.0000	-0.08%	0.05%	0.00%	0.05%	0.00%
	Riverside	-0.313	0.094	0.013	0.029	0.0000	-0.33%	0.17%	0.01%	0.05%	0.00%
	San Bernardino	-0.005	0.017	0.000	0.005	0.0000	0.00%	0.03%	0.00%	0.01%	0.00%
	Total	-0.683	0.400	0.023	0.115	0.0001	-0.10%	0.08%	0.00%	0.02%	0.00%
VCAPCD	Ventura	-0.006	0.003	0.000	0.003	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	0.000	0.001	0.000	0.000	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.006	0.009	0.000	0.006	0.0000	0.00%	0.02%	0.00%	0.02%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.006	0.009	0.000	0.006	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
SLOAPCD	San Luis Obispo	0.000	-0.001	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-0.710	0.454	0.025	0.133	0.0002	-0.03%	0.05%	0.00%	0.01%	0.00%

2008 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.360	0.068	0.028	0.133	0.0000	-0.07%	0.05%	0.00%	0.08%	0.00%
SCAQMD	Los Angeles	-1.204	0.340	0.190	0.325	0.0000	-0.29%	0.10%	0.01%	0.07%	0.00%
	Orange	-0.271	0.076	0.008	0.062	0.0000	-0.18%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.603	0.137	0.038	0.070	0.0000	-0.58%	0.22%	0.01%	0.08%	0.00%
	San Bernardino	-0.166	0.034	0.004	0.018	0.0000	-0.13%	0.05%	0.00%	0.02%	0.00%
	Total	-2.244	0.588	0.240	0.473	0.0000	-0.28%	0.10%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.022	0.004	0.002	0.008	0.0000	-0.02%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.046	0.013	0.000	0.014	0.0000	-0.02%	0.03%	0.00%	0.03%	0.00%
	Fresno	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.047	0.014	0.000	0.015	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.001	0.001	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.681	0.677	0.271	0.634	0.0000	-0.11%	0.07%	0.01%	0.05%	0.00%

2009 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.359	0.068	0.028	0.132	0.0000	-0.07%	0.05%	0.00%	0.08%	0.00%
SCAQMD	Los Angeles	-1.202	0.341	0.189	0.324	0.0000	-0.30%	0.10%	0.01%	0.07%	0.00%
	Orange	-0.271	0.076	0.008	0.062	0.0000	-0.18%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.592	0.136	0.036	0.066	0.0000	-0.57%	0.22%	0.01%	0.08%	0.00%
	San Bernardino	-0.166	0.034	0.004	0.018	0.0000	-0.12%	0.05%	0.00%	0.02%	0.00%
	Total	-2.232	0.587	0.237	0.469	0.0000	-0.28%	0.10%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.022	0.004	0.002	0.008	0.0000	-0.02%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.046	0.013	0.000	0.014	0.0000	-0.02%	0.03%	0.00%	0.03%	0.00%
	Fresno	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.047	0.014	0.000	0.015	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.001	0.001	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.667	0.676	0.268	0.629	0.0000	-0.11%	0.07%	0.01%	0.05%	0.00%

2010 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.356	0.068	0.027	0.131	0.0000	-0.07%	0.05%	0.00%	0.08%	0.00%
SCAQMD	Los Angeles	-1.175	0.342	0.183	0.315	0.0000	-0.30%	0.11%	0.01%	0.07%	0.00%
	Orange	-0.254	0.075	0.007	0.061	0.0000	-0.17%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.589	0.135	0.035	0.065	0.0000	-0.56%	0.23%	0.01%	0.08%	0.00%
	San Bernardino	-0.144	0.032	0.003	0.016	0.0000	-0.10%	0.05%	0.00%	0.02%	0.00%
	Total	-2.162	0.585	0.229	0.458	0.0000	-0.27%	0.10%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.021	0.004	0.002	0.008	0.0000	-0.03%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.046	0.013	0.000	0.014	0.0000	-0.02%	0.03%	0.00%	0.03%	0.00%
	Fresno	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.047	0.014	0.000	0.015	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.001	0.001	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.594	0.674	0.259	0.616	0.0000	-0.11%	0.07%	0.01%	0.05%	0.00%

2011 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.327	0.077	0.017	0.115	0.0000	-0.06%	0.05%	0.00%	0.08%	0.00%
SCAQMD	Los Angeles	-1.016	0.317	0.151	0.272	0.0001	-0.27%	0.10%	0.01%	0.06%	0.00%
	Orange	-0.254	0.075	0.007	0.061	0.0000	-0.17%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.574	0.132	0.032	0.061	0.0000	-0.58%	0.23%	0.01%	0.08%	0.00%
	San Bernardino	-0.113	0.030	0.003	0.014	0.0000	-0.09%	0.04%	0.00%	0.02%	0.00%
	Total	-1.957	0.555	0.193	0.407	0.0001	-0.26%	0.10%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.017	0.004	0.001	0.006	0.0000	-0.02%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.006	0.002	0.000	0.003	0.0000	-0.02%	0.01%	0.00%	0.01%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.046	0.013	0.000	0.014	0.0000	-0.02%	0.03%	0.00%	0.03%	0.00%
	Fresno	-0.001	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.047	0.014	0.000	0.015	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	-0.001	0.001	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.355	0.652	0.212	0.548	0.0000	-0.10%	0.07%	0.00%	0.05%	0.00%

2012 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	PM$_{2.5}$	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	-0.325	0.077	0.017	0.114	0.0000	-0.06%	0.05%	0.00%	0.08%	0.00%
SCAQMD	Los Angeles	-0.917	0.301	0.135	0.249	0.0001	-0.25%	0.10%	0.01%	0.06%	0.00%
	Orange	-0.199	0.072	0.006	0.057	0.0000	-0.14%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.564	0.131	0.031	0.059	0.0000	-0.57%	0.23%	0.01%	0.08%	0.00%
	San Bernardino	-0.068	0.027	0.001	0.010	0.0000	-0.05%	0.04%	0.00%	0.01%	0.00%
	Total	-1.747	0.531	0.173	0.376	0.0001	-0.23%	0.10%	0.01%	0.06%	0.00%
VCAPCD	Ventura	-0.017	0.004	0.001	0.006	0.0000	-0.02%	0.01%	0.00%	0.02%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.005	0.001	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.046	0.013	0.000	0.014	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.047	0.014	0.000	0.015	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-2.142	0.628	0.192	0.515	0.0001	-0.09%	0.07%	0.00%	0.04%	0.00%

2013 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	PM$_{2.5}$	THC	NMHC	CO	NOx	PM$_{2.5}$
SDCAPCD	San Diego	-0.195	0.068	0.009	0.077	0.0000	-0.04%	0.05%	0.00%	0.06%	0.00%
SCAQMD	Los Angeles	-0.731	0.265	0.090	0.184	0.0001	-0.20%	0.09%	0.01%	0.05%	0.00%
	Orange	-0.191	0.071	0.006	0.057	0.0000	-0.13%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.553	0.130	0.031	0.058	0.0000	-0.57%	0.23%	0.01%	0.09%	0.00%
	San Bernardino	-0.067	0.027	0.001	0.010	0.0000	-0.05%	0.04%	0.00%	0.01%	0.00%
	Total	-1.542	0.493	0.128	0.310	0.0001	-0.21%	0.09%	0.00%	0.05%	0.00%
VCAPCD	Ventura	-0.013	0.004	0.001	0.005	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.005	0.001	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.045	0.013	0.000	0.014	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.046	0.014	0.000	0.015	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.802	0.581	0.138	0.409	0.0002	-0.07%	0.06%	0.00%	0.04%	0.00%

2014 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.119	0.063	0.006	0.049	0.0000	-0.02%	0.05%	0.00%	0.04%	0.00%
SCAQMD	Los Angeles	-0.703	0.263	0.088	0.180	0.0001	-0.20%	0.09%	0.01%	0.05%	0.00%
	Orange	-0.179	0.070	0.005	0.057	0.0000	-0.13%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.541	0.132	0.027	0.052	0.0000	-0.56%	0.23%	0.01%	0.08%	0.00%
	San Bernardino	-0.034	0.025	0.001	0.008	0.0000	-0.03%	0.04%	0.00%	0.01%	0.00%
	Total	-1.457	0.491	0.121	0.297	0.0001	-0.20%	0.09%	0.00%	0.05%	0.00%
VCAPCD	Ventura	-0.013	0.004	0.001	0.005	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.001	0.000	0.002	0.0000	-0.02%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.045	0.013	0.000	0.014	0.0000	-0.02%	0.03%	0.00%	0.04%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.046	0.014	0.000	0.015	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.640	0.573	0.129	0.367	0.0002	-0.07%	0.06%	0.00%	0.04%	0.00%

2015 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.114	0.062	0.005	0.047	0.0000	-0.02%	0.05%	0.00%	0.04%	0.00%
SCAQMD	Los Angeles	-0.622	0.265	0.079	0.163	0.0001	-0.18%	0.09%	0.01%	0.05%	0.00%
	Orange	-0.163	0.069	0.005	0.057	0.0000	-0.12%	0.07%	0.00%	0.06%	0.00%
	Riverside	-0.502	0.131	0.022	0.046	0.0000	-0.52%	0.23%	0.01%	0.08%	0.00%
	San Bernardino	-0.016	0.024	0.000	0.007	0.0000	-0.01%	0.03%	0.00%	0.01%	0.00%
	Total	-1.303	0.488	0.107	0.272	0.0002	-0.18%	0.10%	0.00%	0.05%	0.00%
VCAPCD	Ventura	-0.012	0.004	0.000	0.005	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.004	0.001	0.000	0.002	0.0000	-0.01%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.013	0.000	0.012	0.0000	-0.01%	0.03%	0.00%	0.04%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.035	0.013	0.000	0.013	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.469	0.570	0.113	0.338	0.0002	-0.06%	0.06%	0.00%	0.03%	0.00%

2016 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.106	0.062	0.005	0.043	0.0000	-0.02%	0.05%	0.00%	0.04%	0.00%
SCAQMD	Los Angeles	-0.497	0.285	0.049	0.116	0.0002	-0.14%	0.10%	0.00%	0.03%	0.00%
	Orange	-0.157	0.068	0.005	0.057	0.0000	-0.11%	0.07%	0.00%	0.05%	0.00%
	Riverside	-0.496	0.131	0.022	0.046	0.0000	-0.52%	0.24%	0.01%	0.08%	0.00%
	San Bernardino	-0.007	0.023	0.000	0.007	0.0000	-0.01%	0.03%	0.00%	0.01%	0.00%
	Total	-1.157	0.507	0.076	0.225	0.0002	-0.16%	0.10%	0.00%	0.04%	0.00%
VCAPCD	Ventura	-0.012	0.004	0.000	0.004	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.001	0.001	0.000	0.001	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.034	0.013	0.000	0.012	0.0000	-0.01%	0.03%	0.00%	0.03%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.035	0.013	0.000	0.013	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.311	0.588	0.082	0.286	0.0002	-0.05%	0.06%	0.00%	0.03%	0.00%

2017 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.086	0.060	0.004	0.035	0.0000	-0.02%	0.05%	0.00%	0.03%	0.00%
SCAQMD	Los Angeles	-0.379	0.315	0.010	0.055	0.0002	-0.11%	0.11%	0.00%	0.02%	0.00%
	Orange	-0.138	0.067	0.005	0.056	0.0000	-0.10%	0.07%	0.00%	0.06%	0.00%
	Riverside	-0.425	0.124	0.019	0.038	0.0000	-0.45%	0.23%	0.01%	0.07%	0.00%
	San Bernardino	-0.007	0.023	0.000	0.007	0.0000	-0.01%	0.04%	0.00%	0.01%	0.00%
	Total	-0.950	0.529	0.033	0.156	0.0003	-0.13%	0.10%	0.00%	0.03%	0.00%
VCAPCD	Ventura	-0.010	0.004	0.000	0.004	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.001	0.001	0.000	0.000	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.027	0.013	0.000	0.011	0.0000	-0.01%	0.03%	0.00%	0.03%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.028	0.013	0.000	0.011	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-1.075	0.608	0.038	0.207	0.0003	-0.04%	0.07%	0.00%	0.02%	0.00%

2018 CNG Engine Emission Inventory, Difference Relative to Historical County Fuel Scenario
Proposed CARB Phase 2 Performance Based Specification Fuel Scenario

Air District	County	Absolute Difference (tons/day)					Relative Difference (% Change in Anthropogenic Emissions)				
		THC	NMHC	CO	NOx	$PM_{2.5}$	THC	NMHC	CO	NOx	$PM_{2.5}$
SDCAPCD	San Diego	-0.019	0.056	0.001	0.010	0.0001	0.00%	0.04%	0.00%	0.01%	0.00%
SCAQMD	Los Angeles	-0.332	0.312	0.009	0.045	0.0002	-0.10%	0.11%	0.00%	0.01%	0.00%
	Orange	-0.137	0.067	0.005	0.055	0.0000	-0.10%	0.07%	0.00%	0.06%	0.00%
	Riverside	-0.397	0.122	0.017	0.035	0.0000	-0.42%	0.22%	0.01%	0.06%	0.00%
	San Bernardino	-0.006	0.023	0.000	0.006	0.0000	0.00%	0.04%	0.00%	0.01%	0.00%
	Total	-0.873	0.524	0.030	0.141	0.0003	-0.12%	0.10%	0.00%	0.03%	0.00%
VCAPCD	Ventura	-0.009	0.004	0.000	0.004	0.0000	-0.01%	0.01%	0.00%	0.01%	0.00%
SBAPCD	Santa Barbara	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
KCAPCD	Kern	-0.001	0.001	0.000	0.000	0.0000	0.00%	0.01%	0.00%	0.00%	0.00%
SJVUAPCD	Kings	-0.001	0.000	0.000	0.001	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Tulare	-0.009	0.012	0.000	0.007	0.0000	0.00%	0.03%	0.00%	0.02%	0.00%
	Fresno	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	-0.010	0.012	0.000	0.008	0.0000	0.00%	0.01%	0.00%	0.01%	0.00%
SLOAPCD	San Luis Obispo	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
ICAPCD	Imperial	0.000	0.000	0.000	0.000	0.0000	0.00%	0.00%	0.00%	0.00%	0.00%
13-County Total		-0.912	0.598	0.032	0.163	0.0003	-0.04%	0.07%	0.00%	0.02%	0.00%