# Compressed Natural Gas (CNG) Motor Vehicle Fuel Specifications

May 19, 2010

California Environmental Protection Agency

Air Resources Board

# Overview

- Background
- Current Situation
- Studies and Results
- Possible Considerations
- Next Steps

# Background

# Alternative Fuels Regulations

- ARB alternative fuel regulations, 1992
  - Title 13, CCR, §2290 -2293.5
- Includes compressed natural gas (CNG) specifications
  - Title 13, CCR, §2292.5
- Last discussed in 2005

# CNG Specifications

| | | |
|---|---|---|
| Hydrocarbons | Methane (min.) | 88 mol% |
| | Ethane (max.) | 6 mol% |
| | C3+higher (max.) | 3 mol% |
| | C6+higher (max.) | 0.2 mol% |
| Other Specs. | Hydrogen (max.) | 0.1 mol% |
| | Carbon Monoxide (max.) | 0.1 mol% |
| | Oxygen | 1.0 mol% |
| | Inert Gases | 1.5 - 4.5 mol% |
| | Sulfur (max.) | 16 ppmv |
| | Water, Particulates, Odorant | |

# California Public Utilities Commission Pipeline Specifications (Ex. SoCalGas Rule 30)

| | |
|---|---|
| **WI** | 1279 - 1385 |
| **Heating Value** | 990 - 1150 |
| **$CO_2$ (max)** | 3% vol |
| **$H_2S$ (max)** | 4 ppm |
| **$H_2O$ (max)** | 7 lbs/MMSCF |
| **Inerts (max)** | 4% vol |

Source: Rule No. 30 Southern California Gas Company

# Current Situation

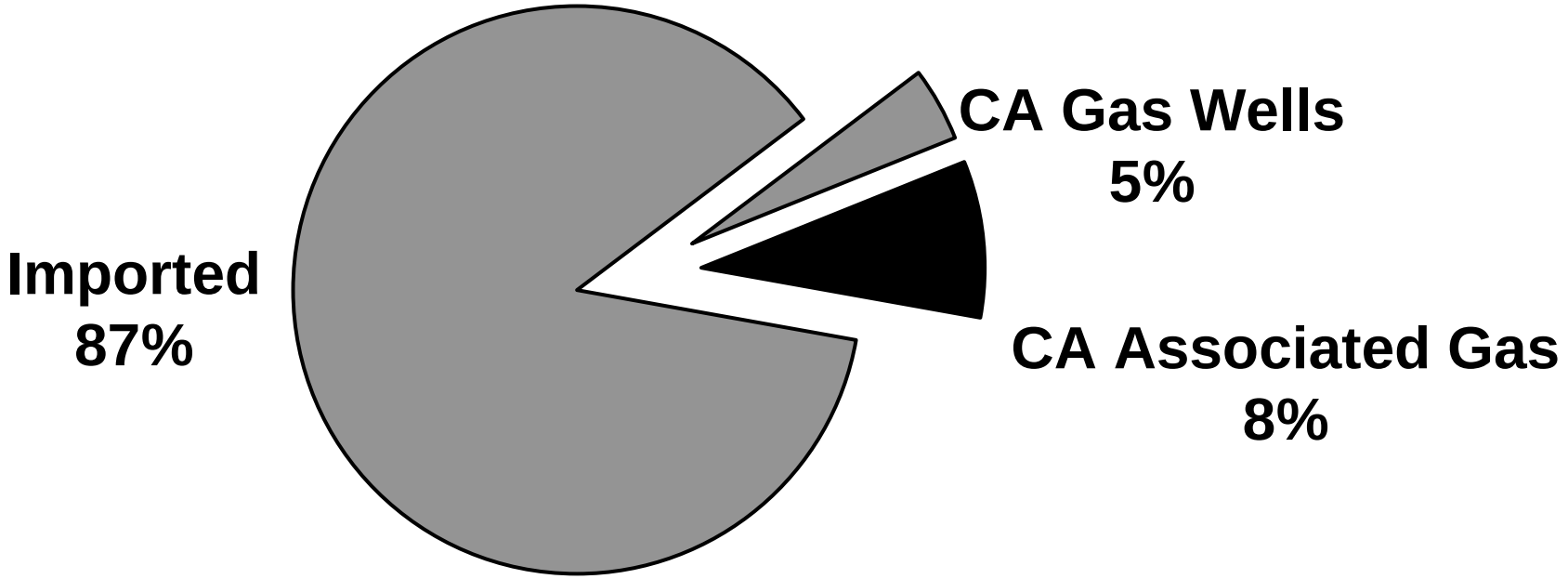
- North American pipelined gas generally meets CARB specifications
  - A portion of potential LNG supplies generally exceeds specifications
- A portion of in-state gas does not meet current CARB specifications

# California Natural Gas Supplies

- **Imported via Interstate Pipeline 87%**
  - Southwest 41%
  - Midwest 24%
  - Canada 22%
- **California Production 13%**
  - Central/Southern CA 8%
  - Northern CA 5%

Source: CEC 2007

# 92% of CA Current Supply Generally Meets CNG MV Specifications




**Note: Does <u>not</u> include potential LNG shipments**

Source: CEC 2006

# Primary Reasons for Off-Specification Natural Gas

- Associated gas
  - Byproduct of oil production
  - Produced from gas fields in Southern and Central CA
- Potential imports of LNG

# Gas Quality Trends

- Imported Pipelined Gas
  - Slight variation of gas quality over time
- Potential LNG Imports
  - May cause decrease in pipeline gas quality
- In-state Production
  - Slight degradation of gas quality over time

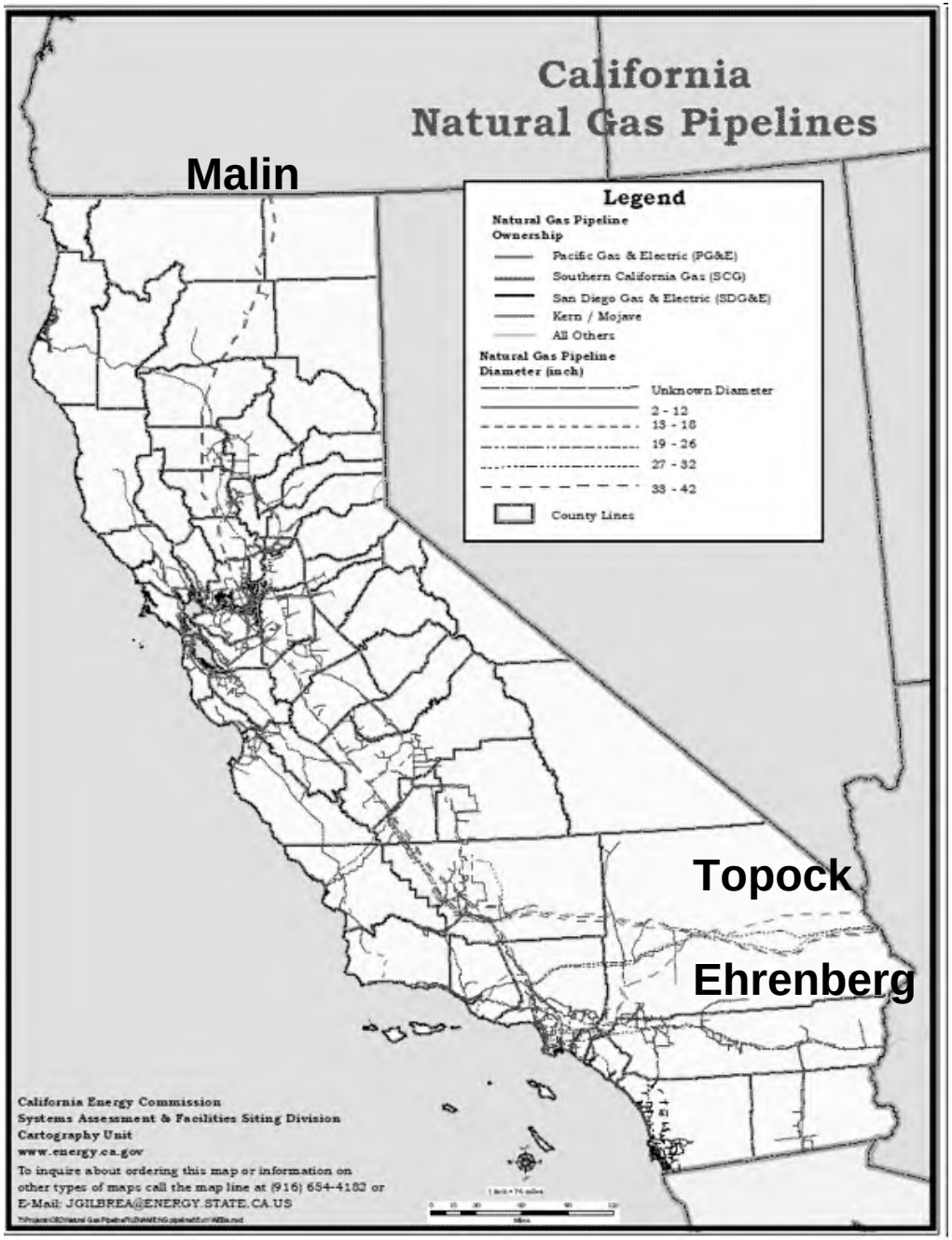
# Imported Pipelined Gas Quality Fuel Composition – Northern CA

| | 1999 | | 2009 | |
|---|---|---|---|---|
| | **Malin** | **Topock** | **Malin** | **Topock** |
| **Methane** | 94.9 | 96.12 | 95.93 | 95.86 |
| **Ethane** | 3.15 | 1.69 | 2.17 | 1.79 |
| **C3+** | 0.20 | 0.27 | 0.33 | 0.57 |
| **C6+** | 0.01 | 0.01 | 0.01 | 0.02 |
| **Inerts** | 1.65 | 1.9 | 1.55 | 1.75 |
| | | | | |
| **MN*** | 98.7 | 101.9 | 95.3 | 95.31 |
| **WI*** | 1340.1 | 1333.4 | 1341.13 | 1335.64 |

* MN and WI are not a part of CARB specifications

Source: PG&E 1997-2000, 2008-2009

# California Natural Gas Pipelines




Source: CEC

# Imported Pipelined Gas Quality Fuel Composition – Central & Southern CA

| | 1999 | | 2009 | |
|---|---|---|---|---|
| | **Ehrenberg** | **Topock** | **Ehrenberg** | **Topock** |
| **Methane** | TBD | TBD | 95.77 | 96.38 |
| **Ethane** | TBD | TBD | 1.96 | 1.55 |
| **C3+** | TBD | TBD | 0.5 | 0.44 |
| **C6+** | TBD | TBD | 0.03 | 0.02 |
| **Inerts** | TBD | TBD | 1.73 | 1.61 |
| | | | | |
| **MN*** | TBD | TBD | 100 | 101 |
| **WI*** | TBD | TBD | 1337.37 | 1335.37 |

* MN and WI are not a part of CARB specifications

Source: SoCalGas 1997-2000, 2008-2009

# Associated Gas Generally Does Not Meet CNG Specifications

- Heavy in non-methane hydrocarbons
- Exceeds ethane and C3+ specifications
- Higher energy content that may cause engine problems

# Associated Gas Production Areas Primarily in Southern & Central CA

- San Joaquin Valley (SJV)
  - Fresno, Kern, Kings, Tulare
- South Central Coast (SCC)
  - Ventura, Santa Barbara, San Luis Obispo
- South Coast Basin
  - Los Angeles, Orange, San Bernardino

Source: Department of Conservation 2001

# Associated Gas Fuel Composition

| | Fresno | Kern | Kings | Santa Barbara | San Luis Obispo | Ventura |
|---|---|---|---|---|---|---|
| **Methane** | 86.19 | 93.83 | 86.19 | 91.28 | 88.42 | 92.48 |
| **Ethane** | 8.35 | 1.84 | 8.35 | 4.08 | 5.41 | 4.22 |
| **C3+** | 2.43 | 2.76 | 2.43 | 2.78 | 4.23 | 1.39 |
| **C6+** | 0.02 | 0.07 | 0.02 | 0.04 | 0.04 | 0.02 |
| **Inerts** | 3.01 | 1.49 | 3.01 | 1.83 | 1.88 | 1.89 |
| | | | | | | |
| **MN*** | 80 | 86.63 | 80 | 85 | 78 | 90 |
| **WI*** | 1352 | 1367 | 1352 | 1366 | 1385 | 1351 |

NOTE: North American Pipeline Gas Composition
Methane %: 95-96, MN: 95-100, WI: 1330-1345

# In-State Production vs. CNG Specs

| | In State | CARB Spec |
|---|---|---|
| **Methane** | 86.19 - 93.83 | 88 – 98.5 |
| **Ethane** | 1.84 - 8.35 | 0 - 6 |
| **C3+** | 1.39 - 4.23 | 0 - 3 |
| **C6+** | .02 - .07 | 0 - 0.02 |
| **Inerts** | 1.49 - 3.01 | 1.5 - 4.5 |
| | | |
| **MN*** | 78 - 90 | 81** - 108 |
| **WI*** | 1351 - 1385 | 1280 - 1385 |

* MN and WI are not a part of CARB specifications

** MN 81 is the practical low value, MN 72 is the theoretical low value

# Potential LNG Imports Generally Do Not Meet Specifications

- Potentially exceeds ethane and C3+ specifications
- May not meet inert specifications
- Higher energy content may cause engine problems

# Potential LNG Imports Gas Quality Fuel Composition

| | Tangguh | Malaysia | Sahkalin |
|---|---|---|---|
| **Methane** | 96.3 | 91.23 | 93.765 |
| **Ethane** | 2.6 | 4.3 | 3.45 |
| **C3+** | 0.7 | 4.36 | 2.53 |
| **C6+** | 0 | 0 | 0 |
| **Inerts** | 0.4 | 0.12 | 0.26 |
| | | | |
| **MN*** | 101.4 | 79.0 | 90.2 |
| **WI*** | 1372 | 1422 | 1397 |

* MN and WI are not a part of CARB specifications

Source: 2009 Publicly Available Gas Quality Data

# Imports vs. CNG Specs

| | LNG Imports | CARB Spec |
|---|---|---|
| **Methane** | 84.83 - 96.33 | 88 – 98.5 |
| **Ethane** | 2.6 - 13.39 | 0 - 6 |
| **C3+** | 0.7 - 4.30 | 0 - 3 |
| **C6+** | 0 - 0.04 | 0 - 0.02 |
| **Inerts** | 0 - 0.4 | 1.5 - 4.5 |
| | | |
| **MN*** | 75.09 - 101.4 | 81** - 108 |
| **WI*** | 1372 - 1424.5 | 1280 - 1385 |

* MN and WI are not a part of CARB specifications

** MN 81 is the practical low value, MN 72 is the theoretical low value

# Discussion

# Assessment of the Current CNG Specifications

# Current CNG Specifications

- Supports Low-Emission/Clean Fuels Program and Regulations
- Reflects quality of imported and in-state produced NG at time when specs were established
- Based on available technologies at that time
- Developed in consultation with industry and other interested parties

Assessment

# Disadvantages of the CNG Specifications

- Some in-state and LNG supplies do not comply
- Current engine technologies have evolved
- Limits availability of on-spec CNG fuel in some areas in CA
- Restricts expansion of the NGV market
- No trading within HC specs

# CNG Studies and Results

# CNG Studies and Test Programs

I. SoCalGas and SDG&E Heavy-Duty CNG Vehicle Report, 2008

II. SwRI Heavy-Duty Natural Gas Engine Study, 2009

III. Sierra Research Statistical Analysis of SwRI HD Natural Gas Engine Study, 2009

IV. SwRI Light-Duty Natural Gas Vehicle Study, 2010

V. Sierra Research Statistical Analysis of SwRI LD Natural Gas Vehicle Study, 2010

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# CNG Studies and Test Programs

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# I. Heavy-Duty CNG Vehicle Report (SoCalGas & SDG&E)

Comprehensive survey, inventory and assessment of all HD CNG engines in operation in 13 counties at end of 2008

## Objective

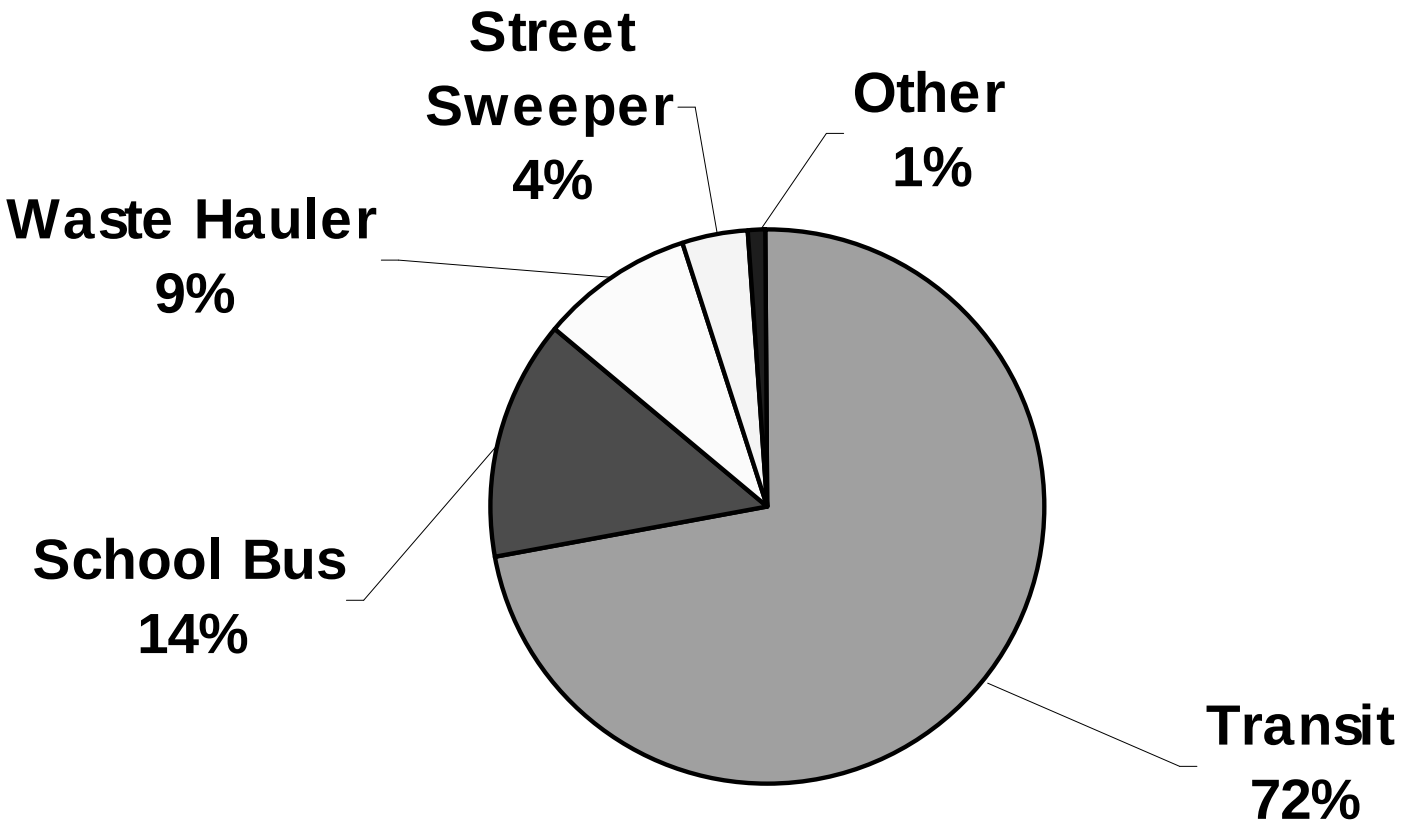
- Compile inventory of all HD CNG engines in 2008 and estimate changes over time

## Assumptions

- Test engines classified as MD or HD CNG engines used not including LD OEM
- "Legacy fleet" vehicles defined as engines that cannot operate on sub-MN 80 fuel

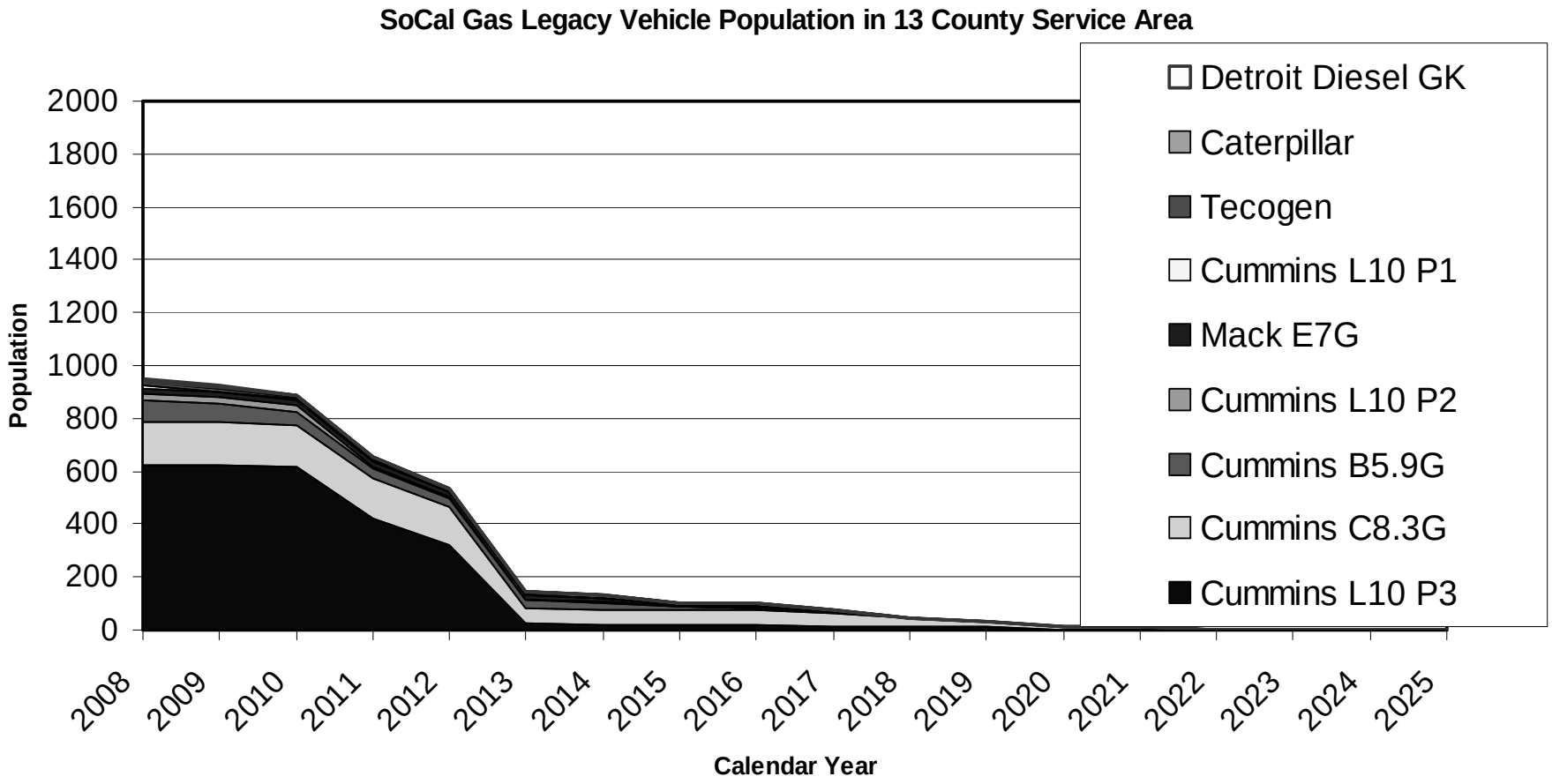
# I. HD CNG Vehicle Report - Results

## 2008 Heavy-Duty CNG Engine Fleet Types



# I. HD CNG Vehicle Report - Results

## "Legacy Fleet" CNG Engines in Operation Through 2025



# I. ARB Staff's Observations

- Information based on 2008 survey
  - Scope specific to SoCalGas and SDG&E service territories (13 counties)
  - Engine expected life based on operator feedback
  - Does not include LD OEM vehicles
- "Legacy fleet" vehicle definition - vehicle engine cannot run on MN < 80
  - Based on manufacturer specs

# CNG Studies and Test Programs

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# II. Heavy-Duty Engine Study (Southwest Research Institute - SwRI)

**Objective**

Test five HD natural gas engines for emissions and engine performance impacts using fuels of varying MN and WI

**Test Engines**

1. 2007 Cummins ISL G
2. 2006 Cummins C Gas Plus
3. 2005 John Deere 6081H
4. 1999 Detroit Diesel Series S50G TK
5. 1998 Cummins C Gas

# II. SwRI Heavy-Duty Engine Study

## Test Fuels

- MN of the NG blends ranged from MN 75 to MN 100. Both high and low WI blends were tested at each MN.

TABLE 2. TARGET CNG COMPOSITIONS SUPPLIED BY SCG

| *Methane Number* | | *75* | | *78* [1] | | *80* | | *89* | *100* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Wobbe Level* | | Low | High | Low | High | Low | High | - | Low | Mid | High |
| *Wobbe Index* | | 1363 | 1385 | 1353 | 1385 | 1347 | 1385 | 1333 | 1302 | 1337 | 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 | 4.0 | 2.7 | 4.0 | 2.2 | 4.0 | 1.9 | 3.5 | 4.0 | 2.1 | 0.0 |

[1] Methane number 78 fuel was tested with the 1998 model year Cummins C Gas engine only.

# II. SwRI HD Study – NOx Results

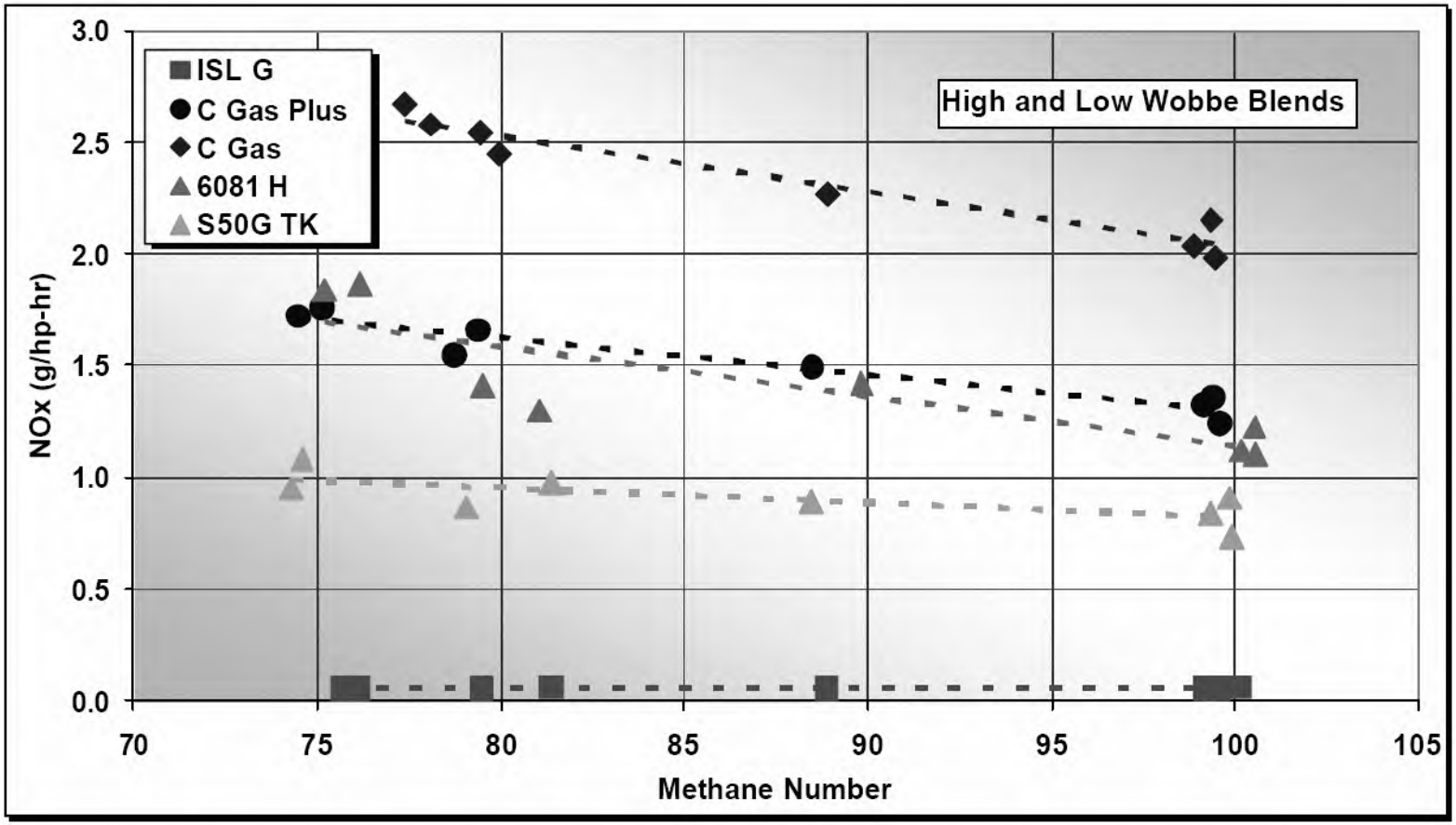


FIGURE 94. HOT-START AVERAGE BRAKE-SPECIFIC $NO_X$ RESULTS VERSUS TEST FUEL METHANE NUMBER FOR ALL TEST ENGINES AND FUELS

# II. SwRI HD Study – NMHC Results

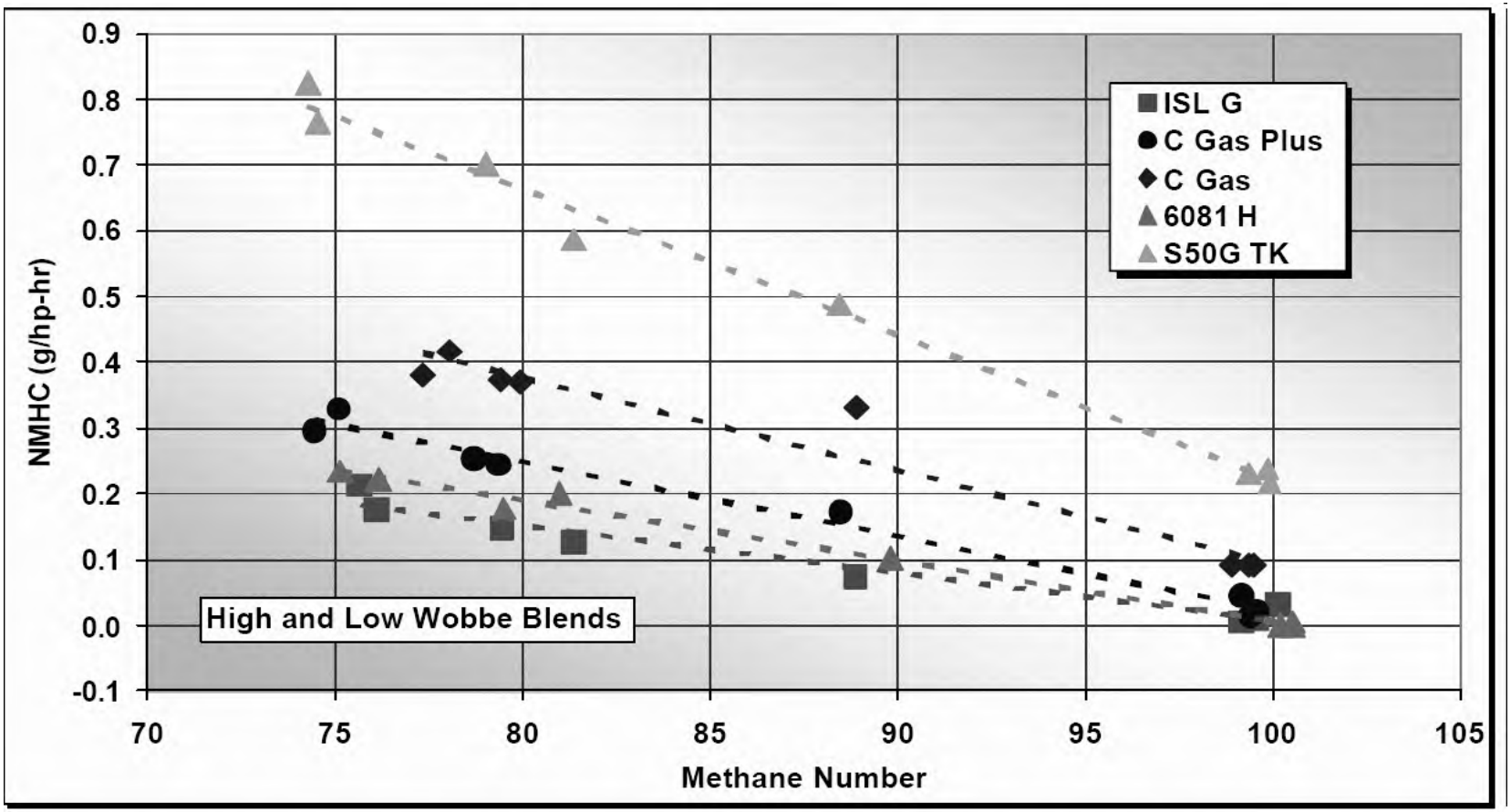


FIGURE 95. HOT-START AVERAGE BRAKE-SPECIFIC NMHC RESULTS VERSUS TEST FUEL METHANE NUMBER FOR ALL TEST ENGINES AND FUELS

# II. SwRI HD Study – Results

- NOx and NMHC increased as MN decreased for older engines
- PM showed no significant trends for all engines
- CO increased as MN decreased for some engines
- Fuel consumption increased with lower WI fuels
- Slight changes in engine performance
- No engine knock or auto ignition

# II. SwRI HD Study – Results (cont.)

- Changes in MN resulted in significant emission variation for some pollutants
- WI had a slight effect on some regulated emissions

# II. ARB Staff's Observations

- Tested fuels ranged in MN
  - MN tested:  MN 75, 78, 80, 89, 100
  - High and Low WI tested at each MN
- Test engines serviced and repaired before emissions testing

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# III. Statistical Analysis of SwRI HD Engine Study

## (Sierra Research Inc)

**Objectives**

- Identify statistically significant relationships between MN, WI, engine emissions

**Assumptions**

- CNG fuel used at the lowest MN and highest WI under the:
  - Current prescriptive CARB CNG regulations (MN 72.4, WI 1385)
  - Performance-based CNG regulation proposed by SoCalGas and SDG&E (MN 75, WI 1385)

# III. HD Statistical Analysis – Results

| Maximum Theoretical Change in 2008 NOx and NMHC Emissions (TPD) | | | | | | |
|---|---|---|---|---|---|---|
| | | NOx Change | | | NMHC Change | |
| County | Total NOx Inventory | Existing Reg[a] | Proposed Reg[b] | Total NMHC Inventory | 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** |

# III. HD Statistical Analysis – Results

| Maximum Theoretical Change in 2018 NOx and NMHC Emissions (TPD) | | | | | | |
|---|---|---|---|---|---|---|
| | | NOx Change | | | NMHC Change | |
| County | Total NOx Inventory | Existing Reg[a] | Proposed Reg[b] | Total NMHC Inventory | Existing Reg[a] | Proposed Reg[b] |
| San Diego | 113 | 0.011 | 0.01 | 133 | 0.063 | 0.056 |
| Los Angeles | 330 | 0.05 | 0.045 | 277 | 0.35 | 0.312 |
| Orange | 95 | 0.06 | 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 | 0 | 31 | 0 | 0 |
| Kern | 48 | 0 | 0 | 12 | 0.001 | 0 |
| Kings | 18 | 0.001 | 0.001 | 17 | 0 | 0.001 |
| Tulare | 31 | 0.008 | 0.007 | 42 | 0.013 | 0.012 |
| Fresno | 72 | 0 | 0 | 75 | 0 | 0 |
| San Luis Obispo | 15 | 0 | 0 | 21 | 0.001 | 0 |
| Imperial | 29 | 0 | 0 | 29 | 0 | 0 |
| **13-County Total** | **933** | **0.179** | **0.163** | **901** | **0.671** | **0.597** |

# III. Statistical Analysis of SwRI HD Engine Study – Results

**Results**

- Slight increase of NMHC and NOx from present
- Maximum theoretical increase of NMHC and NOx under current CARB specs is larger than increase under performance-based reg (MN 75/80 and WI 1385)
- The magnitude of impacts decline over time

**Conclusion**

- Performance regulation based on MN 75/80 and WI 1385 does not have potential to increase emissions above levels that could already occur under existing CARB specs

# III. ARB Staff's Observations

- Potential impacts based on theoretical limit
  - Lowest MN and highest WI under current CNG specs (MN 72.4, WI 1385)
- MN and WI were not evaluated as independent variables

# CNG Studies and Test Programs

I. SoCalGas and SDG&E Heavy-Duty CNG Vehicle Report, 2008

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VI. CE-CERT HD & LD Natural Gas Engine and Vehicle Study, 2010

# IV. Light-Duty Vehicle Study (SwRI)

## Objective

- Determine the emissions and fuel economy (FE) for six CNG fuel blends on a test vehicle over the FTP-75 and UC driving cycles

# IV. SwRI LD Vehicle Study

## Test Vehicle

- 2003 Honda Civic GX

## Test Fuels

- Six test fuels blends of varying MN (68-89) and WI (1333-1390) were produced by SwRI as specified by SoCalGas
- Fuel blends represent worst-case NG scenarios under theoretical standards as well as typical fuel compositions found in the region

# IV. SwRI LD Vehicle Study - Results

- Average FTP-75 NOx emissions were 50% of the certification standard
- CO emissions were about 10% of the certification standard
- NMHC results were well below the NMOG standard

# IV. ARB Staff's Observations

- LD vehicle technologies can operate on various fuel blends with minimal impacts
  - Consistent with expectations

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# V. Statistical Analysis of SwRI LD Vehicle Study

## (Sierra Research Inc)

**Objective**

- Analyze the data obtained from the LD Vehicle Test Program

# V. LD Statistical Analysis - Results

| Summary of Findings on Emissions and Fuel Economy Changes Due to CNG Fuel Formulation | | |
|---|---|---|
| | **FTP Composite** | **UC Drive Cycle** |
| **THC** | Emissions Decreased | No Fuel Effect |
| **NMHC** | Emissions Increased<br>Max Effect + 0.002 g/mi (MN 68 fuel) | Emissions Increased<br>Max Effect + 0.002 g/mi (MN 68 fuel) |
| **CO** | Emissions Increased<br>Max Effect + 0.043 g/mi<br>(MN 80 High WI) | No Fuel Effect |
| **NOx** | Emissions Decreased | No Fuel Effect |
| **CO2** | Emissions Increased<br>up to 4.0 g/mi | No Fuel Effect |
| **FE** | No Fuel Effect | FE increased up to 0.7 mpg<br>(MN 80 High WI) |

# V. Statistical Analysis of LD Vehicle Study – Results

## Findings

- Analysis found some instances of statistically significant relationships between MN, WI, and vehicle emissions
  - MN generally had a greater impact on emissions than WI

## Conclusion

- The variations in NG quality had little impact on emissions from the vehicle studied

# V. ARB Staff's Observations

- Test fuels ranged in MN
  - MN tested:  MN 68, 75, 80, 89
  - High and Low WI tested at each MN

# CNG Studies and Test Programs

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# VI. CE-CERT HD and LD Natural Gas Engine and Vehicle Study (CEC, CE-CERT)

## Objective

- Address impacts of using broader range of NG compositions, such as those expected with greater introduction of LNG

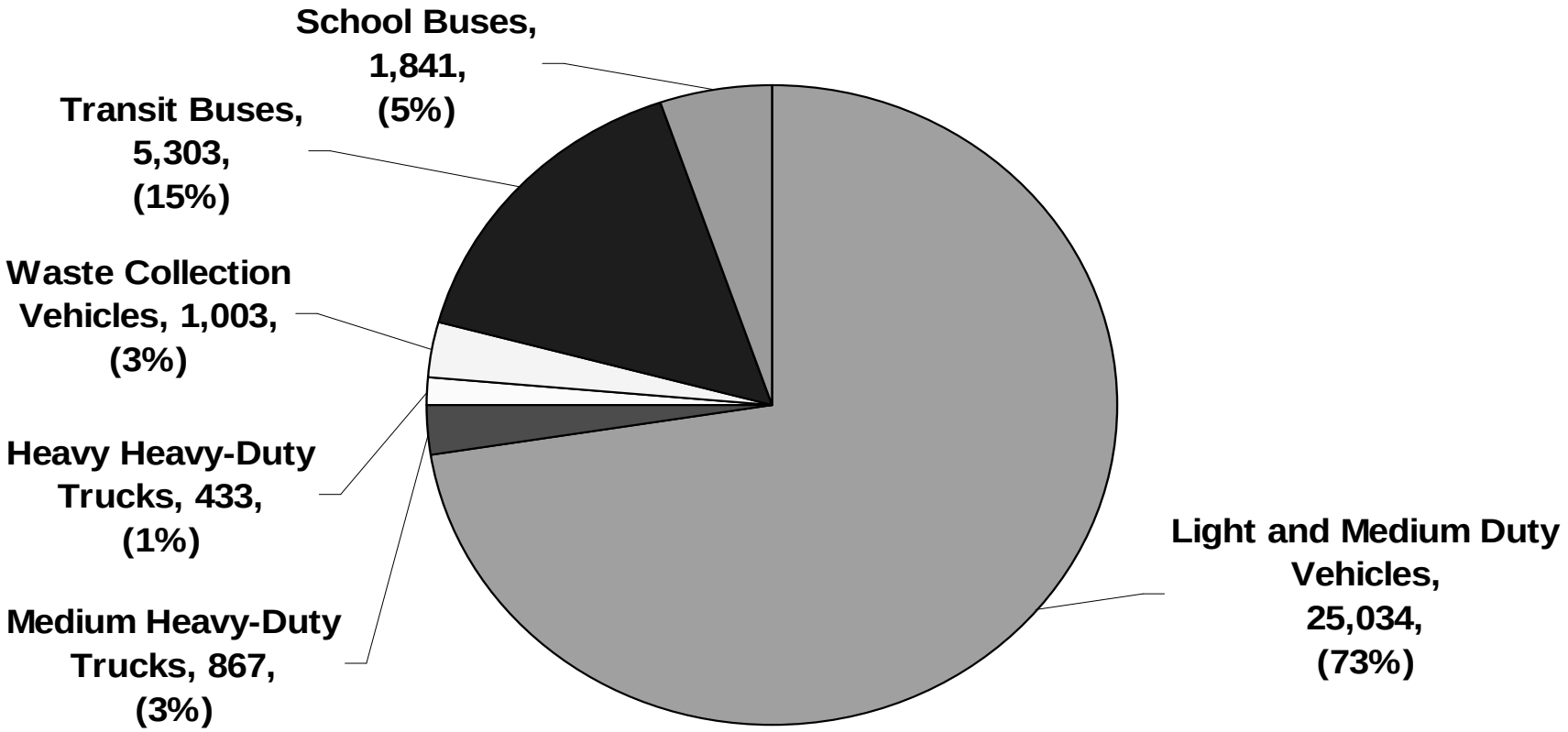
# VI. CE-CERT HD and LD

- Overall Test Program:
  - **Light-Duty Testing**
    - CNG Vehicle Testing – 2 test vehicles, 4 test fuels
  - **Heavy-Duty Testing**
    - CNG Vehicle Testing – 3 test vehicles, 5 test fuels
    - LNG Engine Testing – 1 test engine, 3 test fuels
- Status - Testing to be completed
  - Discuss at next CNG public meeting

# III. ARB Staff's Observations

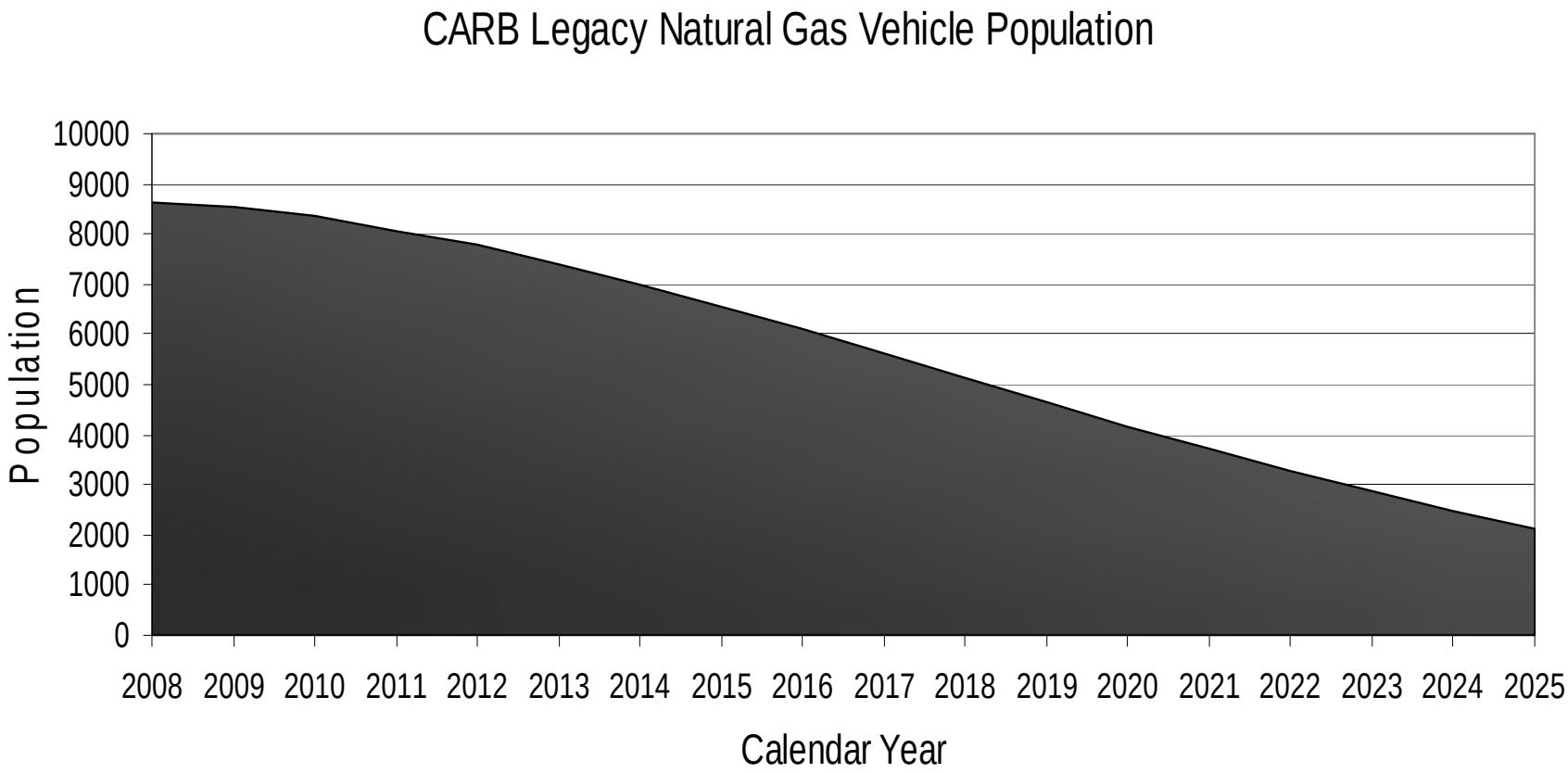
- Test fuels based on range of MN, WI and various fuel compositions
  - MN 83 – 96
  - WI 1330-1436
  - High/Low Ethane
- Engines and vehicles tested as-is

# 2008 CA Natural Gas Vehicle Population




Source: 2008 DMV

# Legacy CNG Engines in Operation



# Discussion

# Consider Changes to the CNG Fuel Regulation?

# Disadvantages of the CNG Specifications

- Relatively inflexible
  - Does not allow trading within HC specs
- Some in-state and LNG supplies do not comply
- Current engine technologies have evolved and can use a broader range of NG compositions
- Limits availability of on-spec CNG fuel in some areas in CA
- Restricts expansion of the NGV market

# Possible Approaches

- Adopt alternative performance based standards?
  - Potential performance metrics:  MN and WI
- Others?

# Potential Advantages of Performance Approach

- Increases flexibility
  - Allows trading within HC spec
- Increase of compliant fuels without loss of benefits

# Potential Metrics for Performance Approach

- Methane Number (MN)
- Wobbe Index (WI)

# Methane Number (MN)

- Similar to Octane Number
- Experimentally derived relationship between fuel composition and engine performance (knock)
- Established index to prevent engine knock
- Some engine manufacturers require minimum MN

# Methane Number (MN)

- Equation:
  - MN = 1.624 * MON – 119.1
  - MON = (20.17 * $H/C^3$ – 173.55 * $H/C^2$ + 508.4 * H/C – 406.14)
  - H/C = (mol % Hydrogen / mol % Carbon)

Source: SwRI 1992

# Wobbe Index

- Measure of fuel interchangeability with respect to energy content and metered air/fuel ratio

$$\text{Wobbe Index} = \frac{\text{Higher Heating Value}}{\sqrt{\text{relative density}}}$$

- Changes in Wobbe Index affect the engine's metered air/fuel ratio and power output

# CNG Specifications

| | | |
|---|---|---|
| Hydrocarbons | Methane (min.) | 88 mol% |
| | Ethane (max.) | 6 mol% |
| | C3+higher (max.) | 3 mol% |
| | C6+higher (max.) | 0.2 mol% |
| Other Specs. | Hydrogen (max.) | 0.1 mol% |
| | Carbon Monoxide (max.) | 0.1 mol% |
| | Oxygen | 1.0 mol% |
| | Inert Gases | 1.5 - 4.5 mol% |
| | Sulfur (max.) | 16 ppmv |
| | Water, Particulates, Odorant | |

# CNG Specifications with possible MN and WI

| | High CH4 High Inerts | High CH4 Low Inerts | Max C2 and Min Inerts (C3 only) | Max C2 and Min Inerts (C3 Equal) | Max C2, C3, & C6 Min Inerts |
|---|---|---|---|---|---|
| **Methane** | 95.5 | 98.5 | 89.5 | 89.5 | 89.3 |
| **Ethane** | 0 | 0 | 6 | 6 | 6 |
| **C3+** | 0 | 0 | 3 | 3 | 3 |
| **C6+** | 0 | 0 | 0 | 0 | 0.2 |
| **Inerts** | 4.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| | | | | | |
| **MN*** | 108 | 108 | 82.36 | 77.86 | 72.83 |
| **WI*** | 1278.8 | 1333.5 | 1380.4 | 1391.5 | 1409 |

* MN and WI are not a part of CARB specifications

Note: CPUC pipeline specifications allow WI 1385 in the pipeline

# What is the Best Approach?

- Should an alternative performance standard be adopted?
  - Appropriate to use Methane Number (MN)?
  - Appropriate to use Wobbe Index (WI)?
  - Appropriate to use both MN and WI?
- Tiered Approach
  - Time frame for implementation?
- Any other approaches?

# Discussion

# Next Steps

# Next Steps

- Evaluate comments
- Develop proposals based on comments
- Evaluate proposals
  - Pros/Cons
  - Impacts
- Discuss at next public meeting

# Schedule

- Public Meeting — May 19, 2010
- Comments due by — June 3, 2010
- Additional Meetings — July – Aug 2010
- Board Hearing — Fall 2010

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# Thank You