



A Billion Miles on Alternative Fuels

An Overview of LA Metro's Advanced Technology Programs

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March 11, 2009

Background

- The Los Angeles County Metropolitan Transportation Authority (LA Metro) is the second largest transit operator of CNG transit buses in the world, and has worked closely with bus and engine manufacturers to refine this technology.

Los Angeles serves one of North America's largest and most heavily congested urban areas, with 20 million residents in the region (10 million in LA County) and a service area of approx. 4,000 sq. kilometers.



LA Metro Bus Statistics (FY09 Budget):



- 2,800 buses
- 7.7 million RSH
- 383 million boardings per year
- 97.7 million miles revenue service.
- 97% of bus fleet runs using CNG engines/fuel

Los Angeles 1980-2010 – Los Angeles and Region Confront the Emissions Challenge



- Aggressive Emissions Regulations enacted since 1980:
 - 1993: LA Metro adopts “Alternative Fuel Initiative” (AFI)
 - 2000: EPA “Settlement” with Diesel Engine Manufacturers
 - 2003: AQMD adopts “Fleet Rules”
 - 2006: CARB Adopts Zero Emission Bus (ZEB) Rules (effective 2012)
 - **REGULATORY REQUIREMENTS ARE THE PRIMARY DRIVER OF METRO’S TECHNOLOGY CHOICES**

Early Advanced Technology Program



Due to poor regional air quality, lack of rail system, Metro's bus fleet has been pressed to reduce emissions for many years.

1973: The LA Metro "Steam Bus" Demonstration Project.

Lesson #1 - Not every new idea is a good one.

Lesson #2 – Pick your technology investments carefully.

Advanced Design, High Capacity Bus Programs

1950: High Capacity Bus



1980: High Capacity Bus



2010: High Capacity Bus



Initial Alternative Fuel Programs

- **1989-1998 - Ethanol/Methanol**
 - 333 buses
 - High Cost & Poor Reliability
 - High failure rate of engine and fuel system components
 - \$15 million - incremental cost to operate this fleet annually
 - Diverted resources from other fleet maintenance activities
 - Fleet converted to diesel in 1998-9
- **1995 – Present - CNG**
 - Over 2,500 CNG buses now in operation (97% of bus operation)
 - Cost of operation less than diesel



Los Angeles Metro CNG Fuel Experience



cLEAN Fuel Concepts

Fuel



+

Combustion



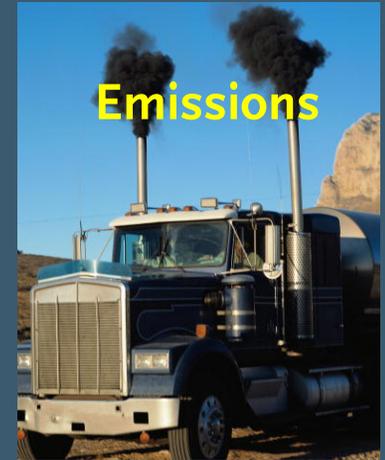
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After-Treatment



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Emissions



- Emissions are a bi-product of fuel composition, combustion, and exhaust after-treatment.
- Emissions are affected by modifications and improvements to each of these three systems. While inter-related, Metro follows technology advancements in each of these areas.

Future Alternative Fuel Technologies

Fuels (base stock for generating energy)

- CNG
- HCNG and Hydrogen
- Electricity (and Energy Storage)
- Other Advanced Blended Gaseous Fuels



Propulsion Systems (conversion of fuel to energy)

- Advanced CNG Engines (Stoichiometric Combustion)
- Alternative ICE (Hydrogen, blended fuels)
- Hybrids (CNG-Hybrid, Gasoline Hybrid)
- Battery Buses (electric motor drive)
- Fuel Cell



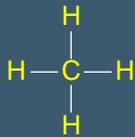
Exhaust (post combustion exhaust after-treatment)

- 3-way catalysts
- Active After Treatment (urea or hydrogen injection into exhaust)

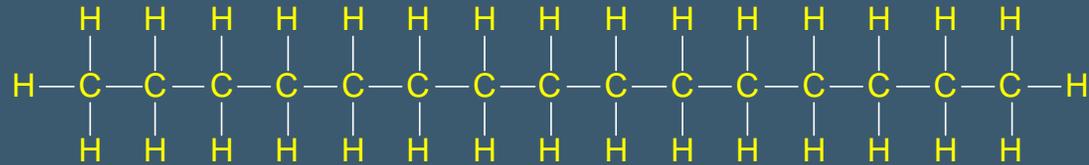


Alternative Fuel Basics

Methane Gas
(CNG) CH_4



Diesel Fuel
 $\text{C}_{15}\text{H}_{32}$



More Carbon = More Energy, More Emissions

“Hydrocarbons”

Hydrogen



Highest Fuel cost, lowest emissions

Methane (CNG): CH_4

Lower Fuel Cost, lower emissions

Gasoline:



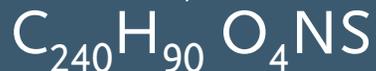
Higher Fuel Cost, higher emissions

Diesel:



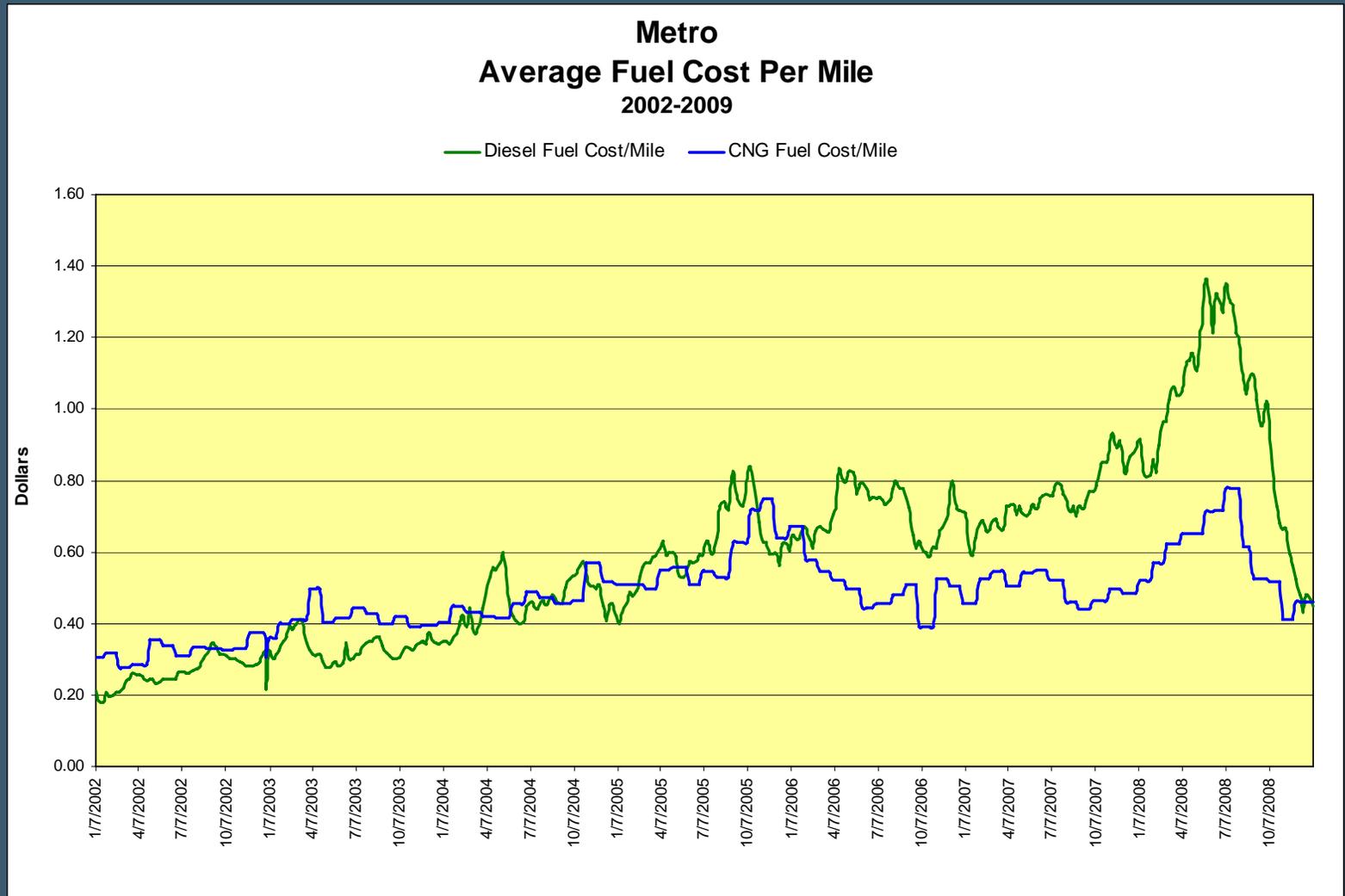
Higher Fuel Cost, higher emissions

Coal:



Lowest fuel cost, extremely high emissions

Comparison of CNG and Diesel Fuel Prices 2002-2009



The NABI BRT



Advanced BRT Vehicle Concept



Some of the Original "Advanced Concept Vehicles" considered for LA



"No more shoeboxes!"

- In 2003, Metro initiated a procurement for an articulated vehicle with a unique, attractive, streamlined appearance.
- 3-door, level boarding
- CNG (ULEV) and Low noise (<78db)
- GPS tracking & Passenger Counters
- Enhanced Passenger Features

Metro's CNG Bus Fleet

- Metro uses purpose-built transit vehicles using specially designed natural gas engines and 15,000-28,000 standard cubic feet of fuel storage.
 - 400 mile range
 - Fuel storage built above/below passenger compartment.
 - Gas stored at high pressure (3,600psi) in composite fuel storage cylinders.
 - Buses are capable of “Fast fueling” in 5-8 minutes
 - Operationally identical (*at least from the Operator's perspective*) to diesel buses.
 - CNG is cleanest fuel option available in this size vehicle.



**Vehicle Appearance is
an increasingly
important
consideration**

Nabi 45' Compo Bus

- Current Order 260 Buses
- Delivery underway
- Lightweight Composite Construction
- Cummins ISL-G engine – anticipate quiet operation
- 46 Passengers
- Very durable, no corrosion, anticipated long life



A high-angle, nighttime photograph of Los Angeles, California. The city is densely packed with lights, and the downtown skyline is visible in the distance. A major highway in the foreground shows long-exposure light trails from cars, creating a sense of motion. The overall scene is a vibrant, illuminated urban landscape.

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