



# A Billion Miles on Alternative Fuels An LA Metro Overview of Alternative Fuel echnologies

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Los Angeles Metro  
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# 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.



# Metro Statistics

## LA Metro Statistics:

- 2,500 buses
- 250 Rail Vehicles
- 500 million boardings per year
- 105 million revenue service miles.
- 97% bus fleet runs using CNG engines/fuel



# Los Angeles 1980-2010 –Confronting 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)



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# Los Angeles 1975



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# Los Angeles 2008



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# Los Angeles Metro Early Alternative Fuel Vehicles

# 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.

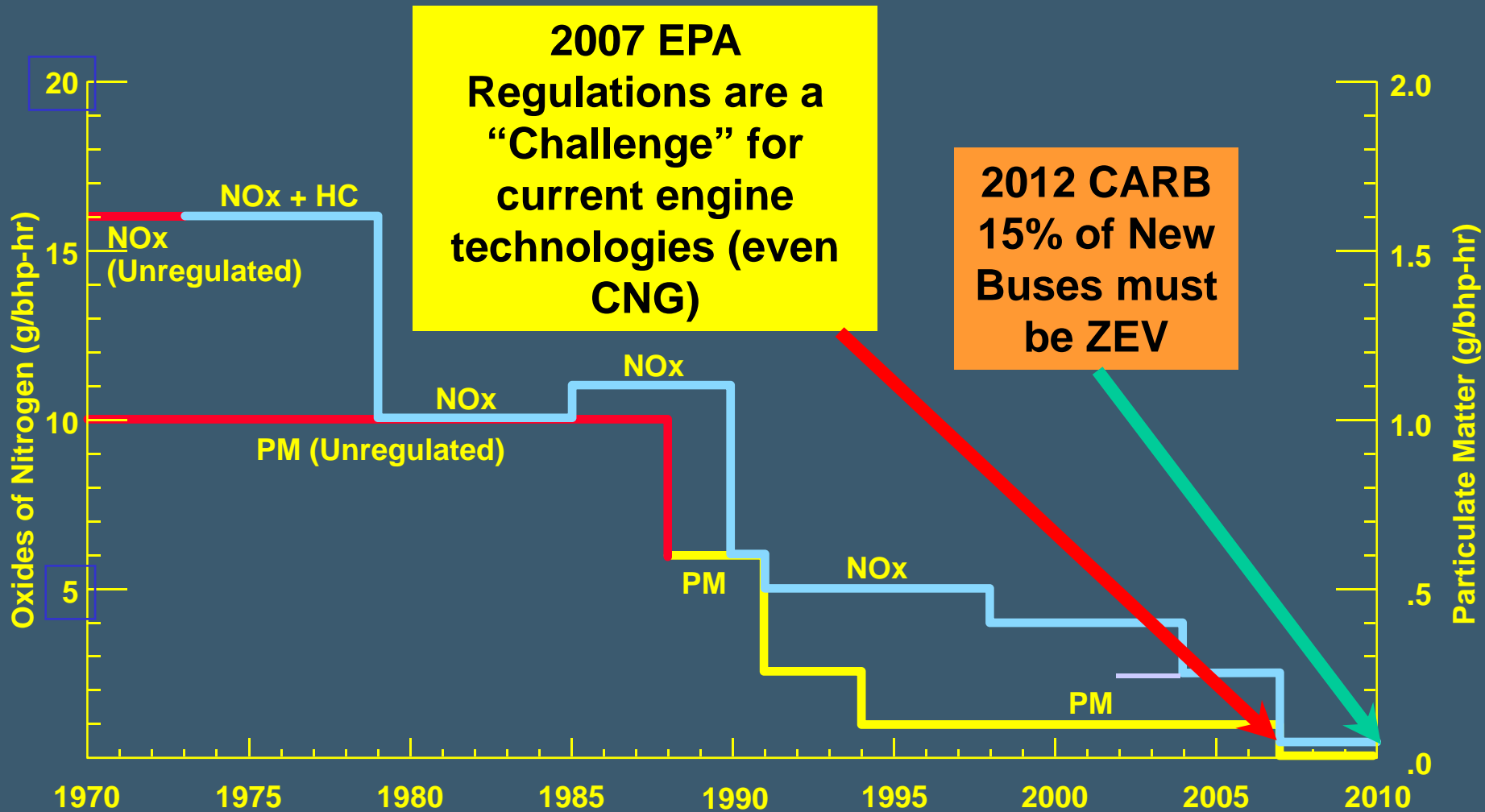


# Initial Alternative Fuel Programs

- 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



# Emission Regulation History

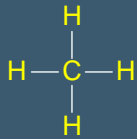


# Los Angeles Metro CNG Fuel Experience

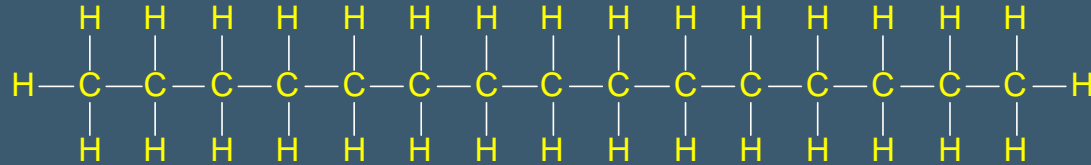


# Alternative Fuel Basics

Methane Gas  
(CNG)  $\text{CH}_4$



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



**More Carbon = More Energy, More Emissions**

## “Hydrocarbons”

Hydrogen



Highest Fuel cost, lowest emissions

**Methane (CNG):**



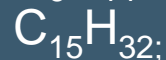
**Lower Fuel Cost, lower emissions**

Gasoline:



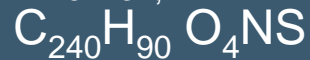
Higher Fuel Cost, higher emissions

Diesel:



Higher Fuel Cost, higher emissions

Coal:



Lowest fuel cost, extremely high emissions

# Alternative Fuel Emission Concepts



Fuel



Combustion



After-Treatment



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.



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# CNG Comparison Data

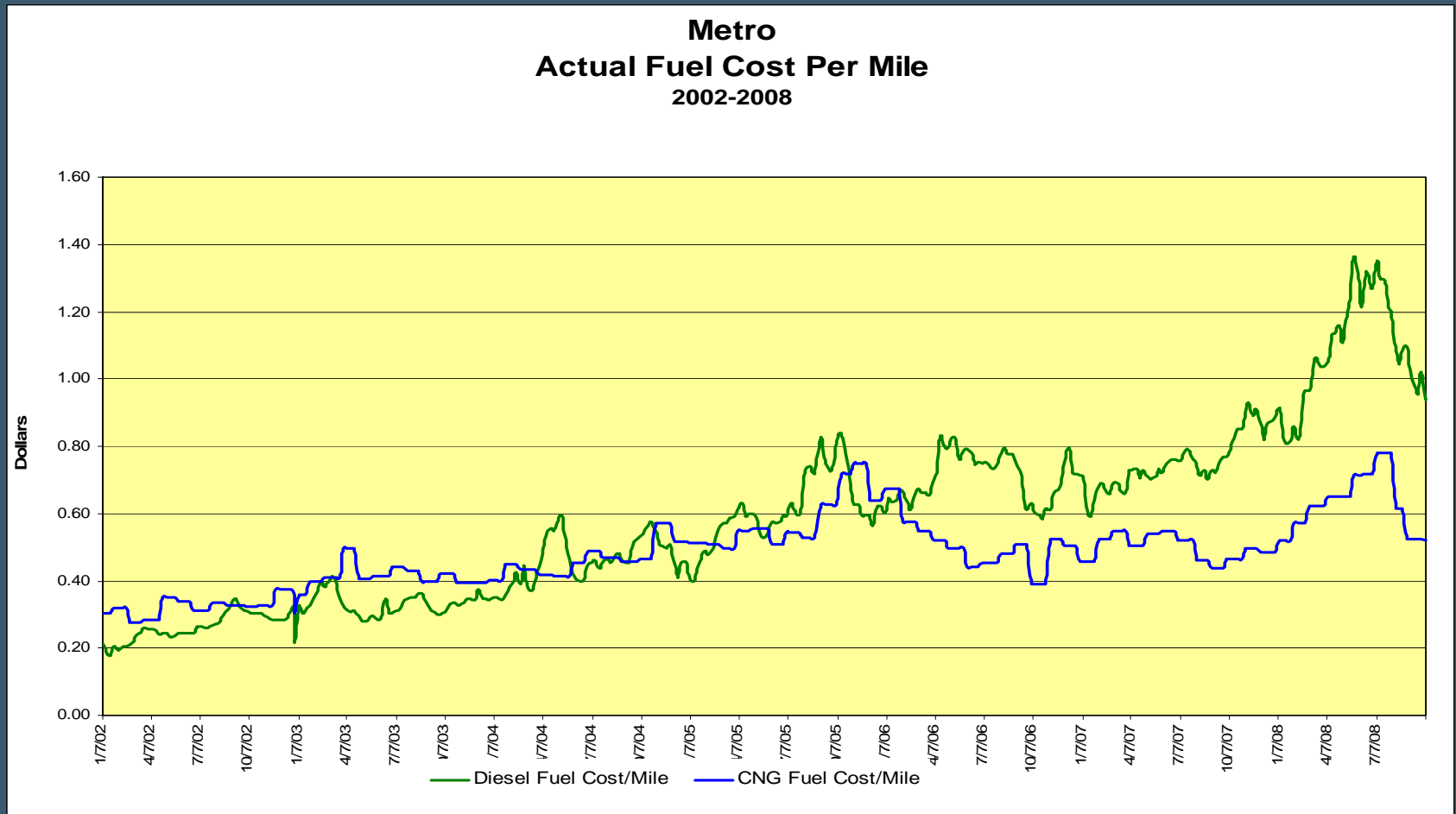
- Metro's experience is that vehicle maintenance costs are 10-15% higher for CNG vehicles (fuel system, filters, spark plugs)
- Reliability (up time) is comparable (new CNG vs. old diesel) –long term durability of alt fuel engines has been mixed
- Past experience is that CNG fueled buses will cost \$50,000 more to purchase than diesel
- Metro subcontracts CNG fueling system operation. Costs are included in fuel cost comparison information. This CNG fueling public private partnership and costs \$0.20 - \$0.30/therm (these costs are reflective in our fuel price comparison).
- In addition to direct fuel cost savings, through next year Metro is receiving a CNG fuel tax credit (saves about \$20 million annually)
- Metro's maintenance facility upgrades cost \$0.7 - \$1.1 million

NOTE: Limited recent comparative experience (last major diesel vehicle purchase was 1991)



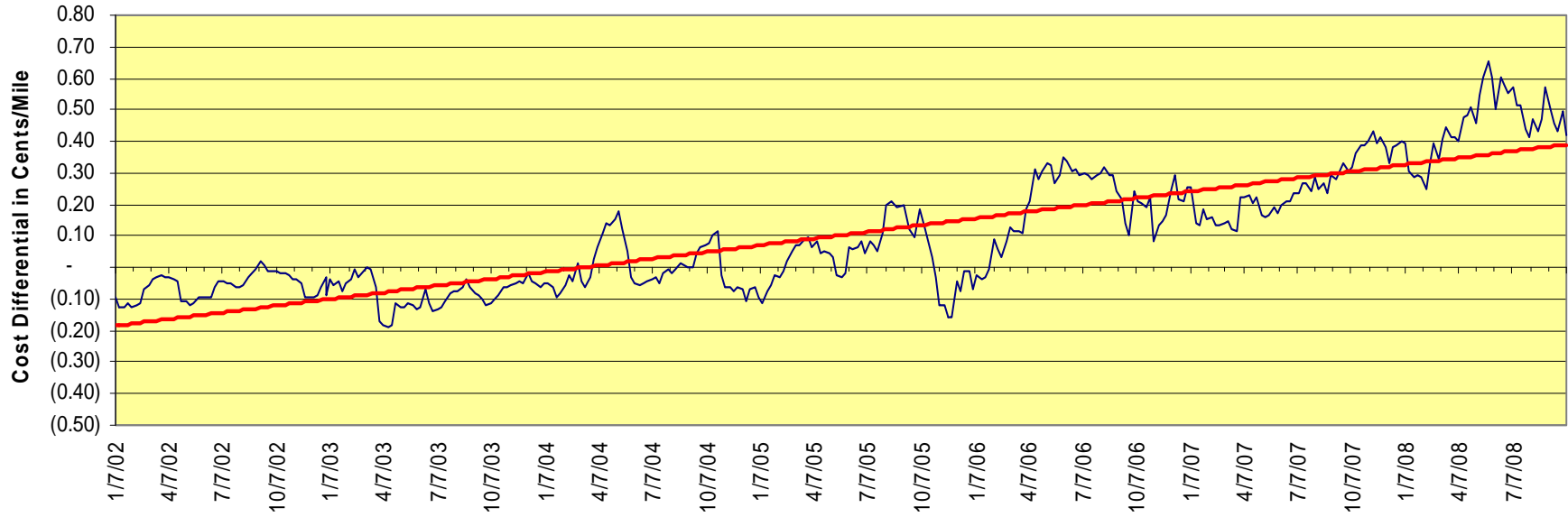
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# Comparison of CNG and Diesel Fuel Prices 2002-2008



# Relative Price Differential – CNG and Diesel

### Actual Cost Savings per Mile CNG vs. Diesel \*



\* CNG costs include compression, facility costs.  
Does not include current fuel tax rebate.





# NGV Tax Credit Rebate (Jan 2007 – Aug 2008)

In 2007, Metro started receiving a temporary \$0.50/gge CNG fuel tax credit. This rebate is ongoing, and is currently slated to expire in 2009.

|  |             |
|--|-------------|
| • Total CNG Bill (Jan 2007-Aug 2008):  | \$82.5m     |
| • Total CNG Tax Credit Rebate*:        | \$35.7m     |
| • Net CNG Fuel Cost:                   | \$46.8m     |
| • Total Hub Miles:                     | 166,282,984 |
| • Average CNG Fuel Cost per Mile**     | \$0.48      |
| • Average Diesel Fuel Cost per Mile*** | \$0.87      |

\* \$0.50/gge CNG fuel tax credit runs until Dec 2009

\*\* Includes est. \$0.15/mile for CNG facility maintenance and amortization.

\*\*\* Based on 3.3mpg during Jan 2007-Aug 2008.

# 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)



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# Other Notes – Future Technologies

- METRO will continue evaluation of Fuel Cells and Other Advanced Fuel Technologies, and will also consider new technologies for greenhouse gas reduction
- Metro is currently exploring options for meeting CARB ZEB Regulations in 2012. Potential technologies include fuel cell, battery and/or advanced energy storage systems and drivetrains
- Paradigm shift – End of “One-size-fits-all” vehicle solutions.
  - Segregation of vehicle types; some technology choices will dictate dedication of specialized equipment/infrastructure to specific lines/routes. (e.g. electric catenaries; specialized fueling; optimized hybrid vehicles).
  - Consideration of vehicle design and ROW throughout planning, construction and operation process



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# Summary



- Metro continues to evaluate a number of advanced fuels and technologies through ATVC Partnership
- We are looking to partner with other regional agencies to further improve air quality and enhance regional mobility
- Metro expects to continue developing and refining plans for our post-2010 bus fleet
  - Choose the best technologies for 2010 and beyond
  - Incorporate CO2 emission reduction strategies
  - Look beyond capital and operating costs (emissions, reliability)



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