California Transit Bus Trends

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South Coast Air Quality Management District

Transit Trends
10th National Clean Cities Conference
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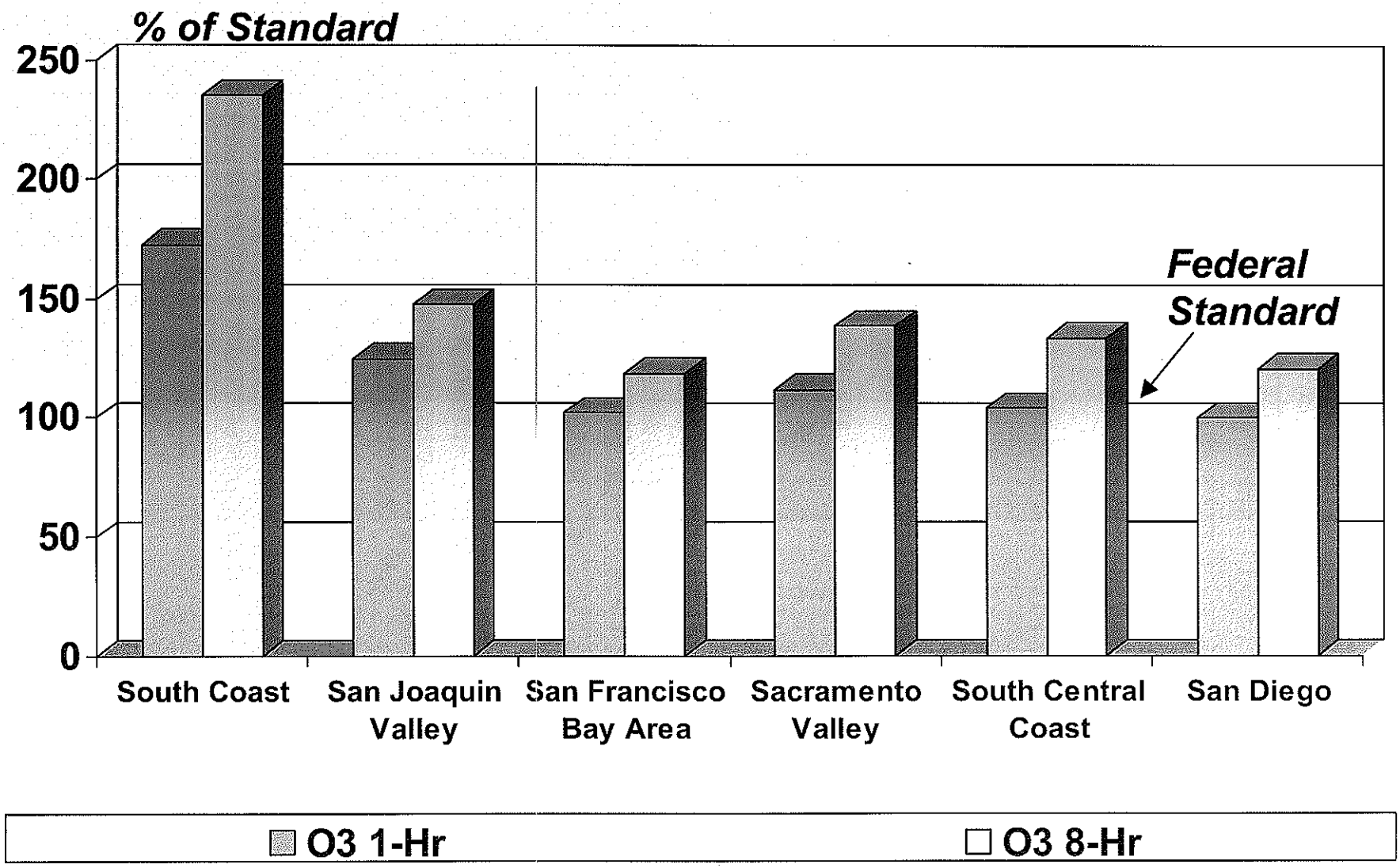
May 4, 2004

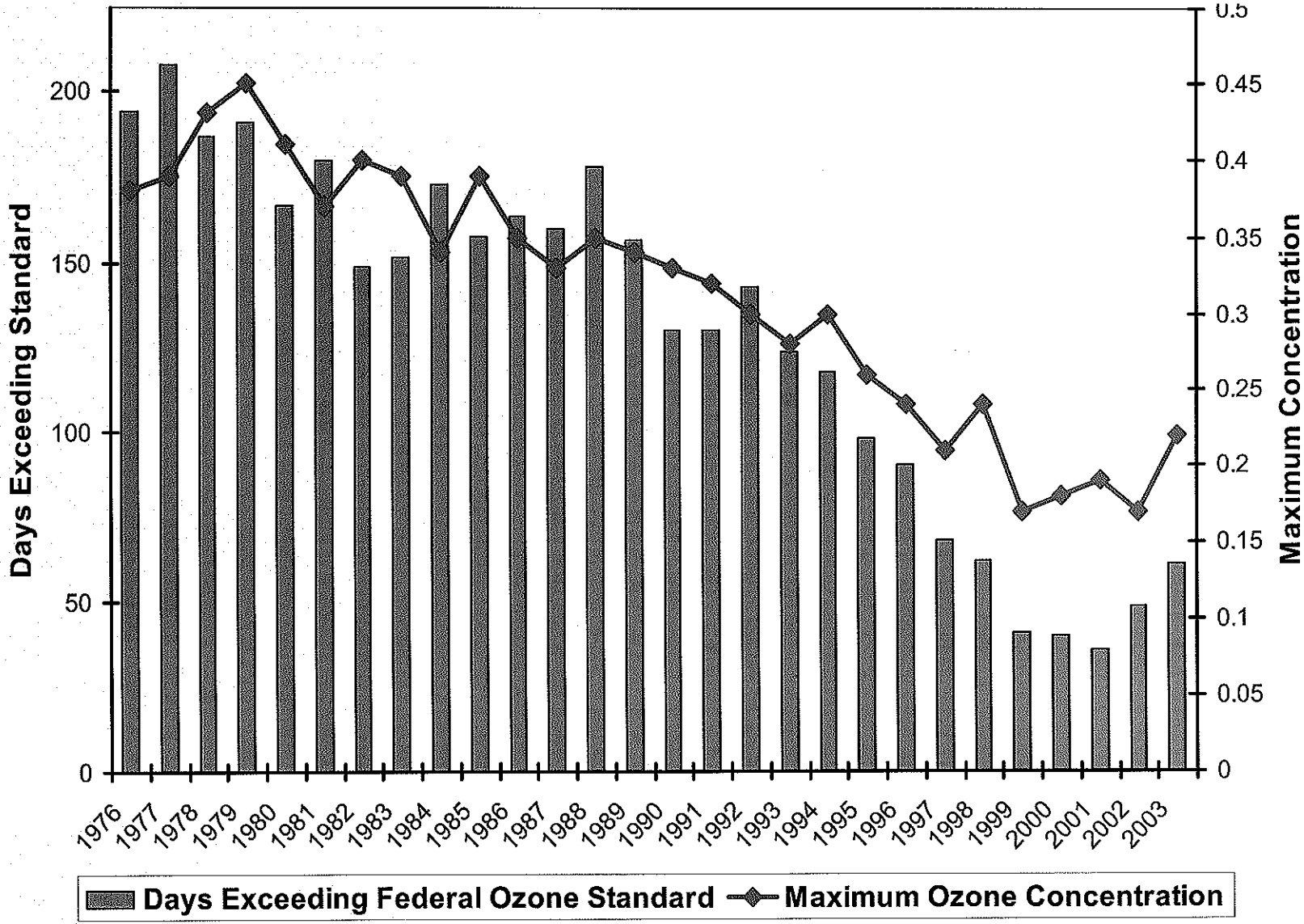
Overview

- Air Quality Concerns
- Incentive Programs
- Regulatory Programs
- Transit Bus Trends
- The Future

Ozone Air Quality in California



Southern California Air Quality Trends



Constraints in Achieving Standards

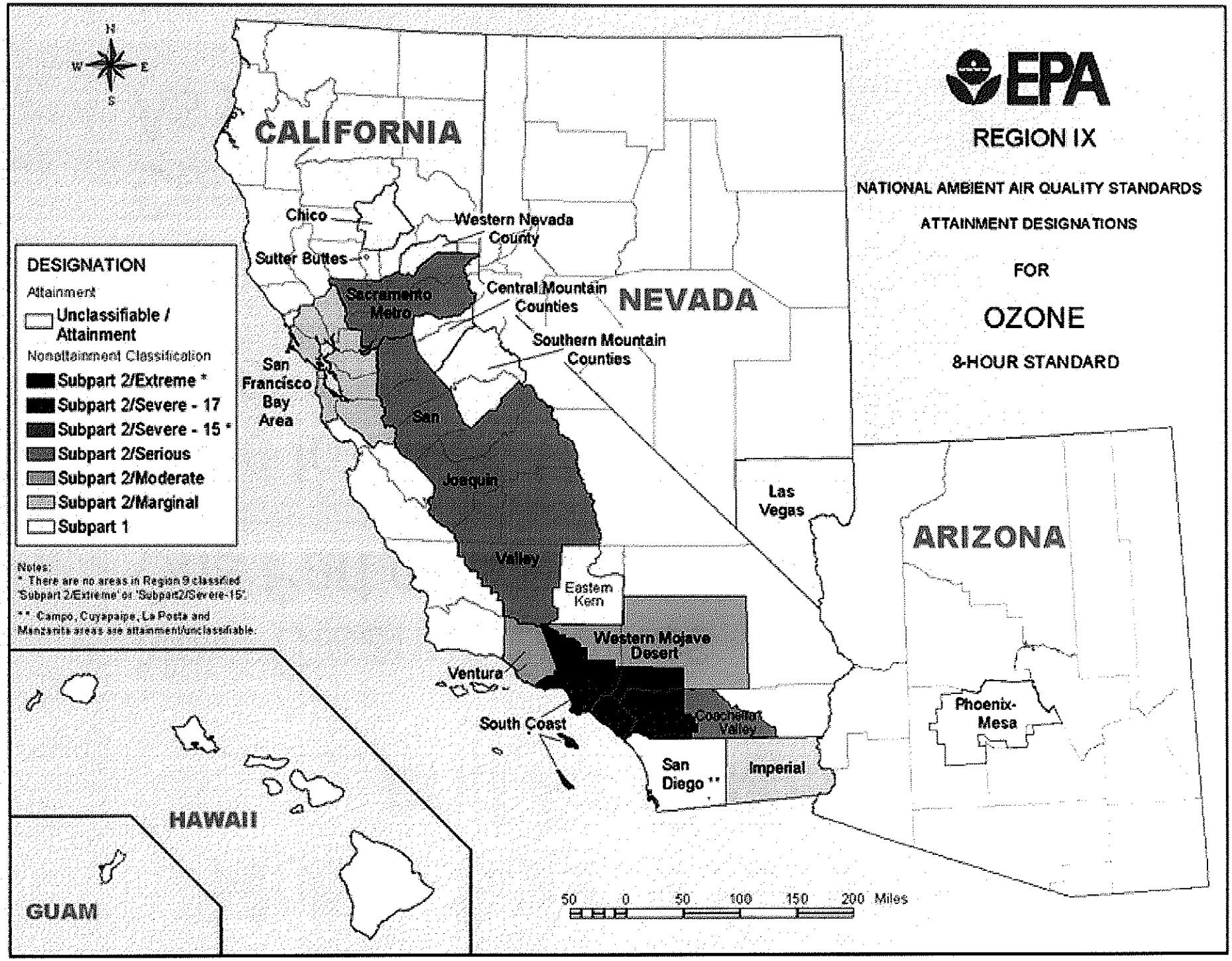
South Coast Air Basin

- Increasing Population, Vehicles, VMT
  - ↑15% in Population (17 mil. in 2010)
  - ↑34% in Number of Vehicles (11 mil. in 2010)
  - ↑31% in VMT (387 mil. in 2010)

- Expanding Economy
  - Consumer Products
  - Ports / Airports / Trains
  - Industrial Sources

Challenges to Attainment / Reducing Air Toxics Levels

- Slow Turnover of Existing Gasoline Vehicles
- Long Life of Existing Diesel Engines
- Funding to Implement New Technologies
- Development of Future Control Measures to Meet New Federal/State Clean Air Goals
- International/National versus Local needs


N
W
E
S
CALIFORNIA
NEVADA
ARIZONA
HAWAII
GUAM
EPA
REGION IX
NATIONAL AMBIENT AIR QUALITY STANDARDS
ATTAINMENT DESIGNATIONS
FOR
OZONE
8-HOUR STANDARD
DESIGNATION
Attainment
Unclassifiable / Attainment
Nonattainment Classification
Subpart 2/Extreme *
Subpart 2/Severe - 17
Subpart 2/Severe - 15 *
Subpart 2/Serious
Subpart 2/Moderate
Subpart 2/Marginal
Subpart 1
Notes:
* There are no areas in Region 9 classified 'Subpart 2/Extreme' or 'Subpart2/Severe-15'.
** Campo, Cuyapaipe, La Posta and Manzanita areas are attainment/unclassifiable.
Chico
Western Nevada County
Sutter Buttes
Sacramento Metro
Central Mountain Counties
Southern Mountain Counties
San Francisco Bay Area
San Joaquin Valley
Las Vegas
Eastern Kern
Western Mojave Desert
Ventura
South Coast
Coachella Valley
San Diego **
Imperial
Phoenix-Mesa
50 0 50 100 150 200 Miles

Mobile Source Emissions and Air Quality

- New Cleaner Engines – One Part of Solution
- Need to Clean Up Existing Engines - Second Part of Solution
- Public Policy – Deploy the Cleanest Commercially Available Technologies As Early As Possible

Approaches to Reducing Transit Bus Emissions

- Economic Incentive Programs
- Regulatory Actions

Economic Incentive Programs

- FTA Funding – 80 to 90% of Cost
- Mobile Source Credits – South Coast
- State/Local Heavy-Duty Vehicle Programs (1998-2003)
  - Carl Moyer (1,186 Buses; $13.7 M)
  - MSRC (1,396 Buses; $37.6 M)

Regulatory Programs

Adopted 2000

- California Transit Bus Rule

- South Coast Transit Bus Fleet Rule

Regulatory Programs

- California Transit Bus Rule
  - Transit Properties to Choose Path: Alternative Fuel or Diesel
  - Diesel Requirements More Stringent In Order to Achieve Similar Reductions as Alternative Fuel Technologies
  - Eventual Introduction of Zero-Emission Buses

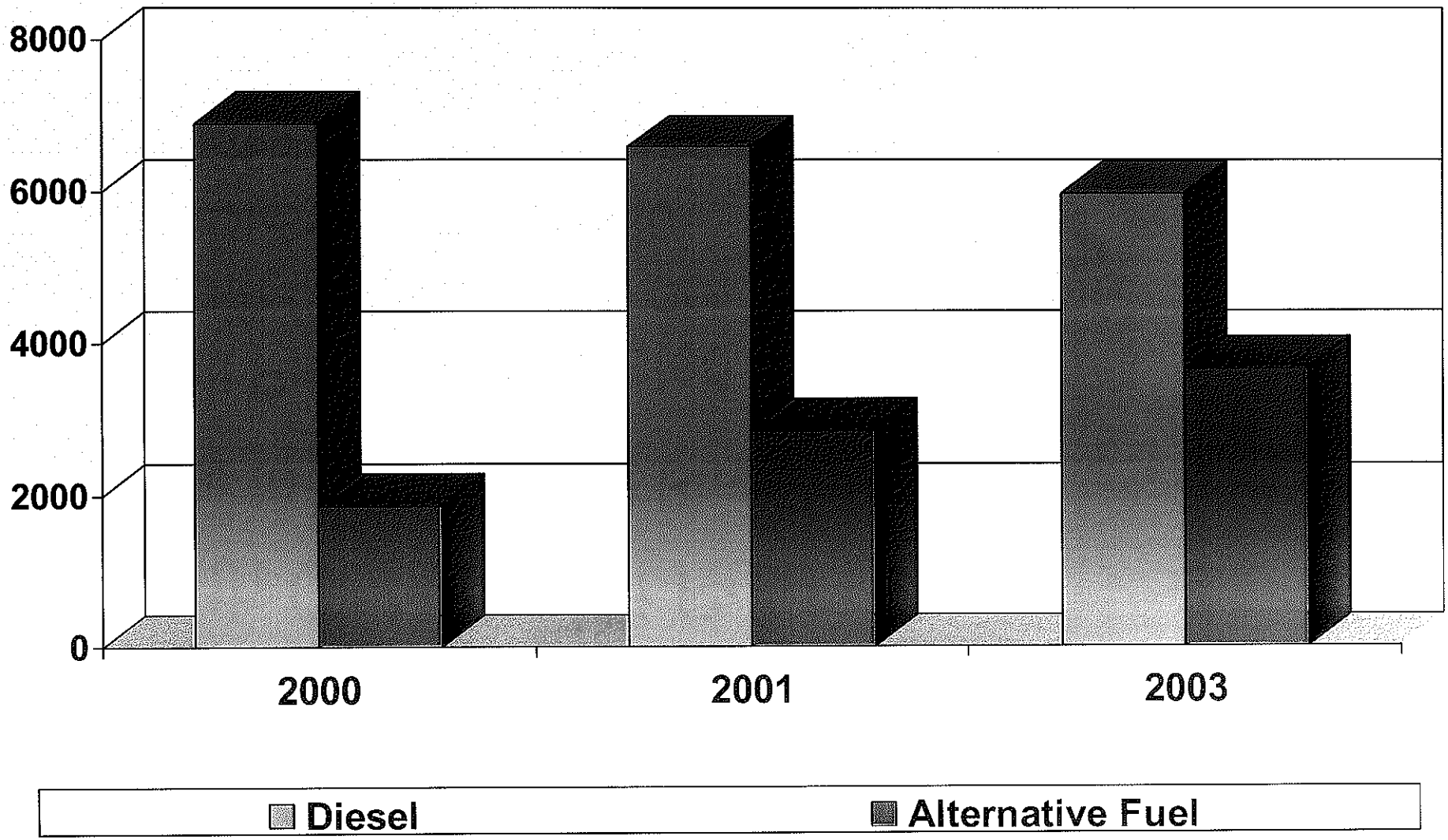
Regulatory Programs
(continued)

- South Coast Fleet Rule
  - Similar to State Transit Bus Rule
  - Transit Properties Located in South Coast with 15 or More Buses Required to Purchase Alternative Fuel Buses
  - Large Transit Properties Chose Alternative Fuel Path
  - Smaller Transits Purchasing Alternative Fuel or Gasoline Hybrids

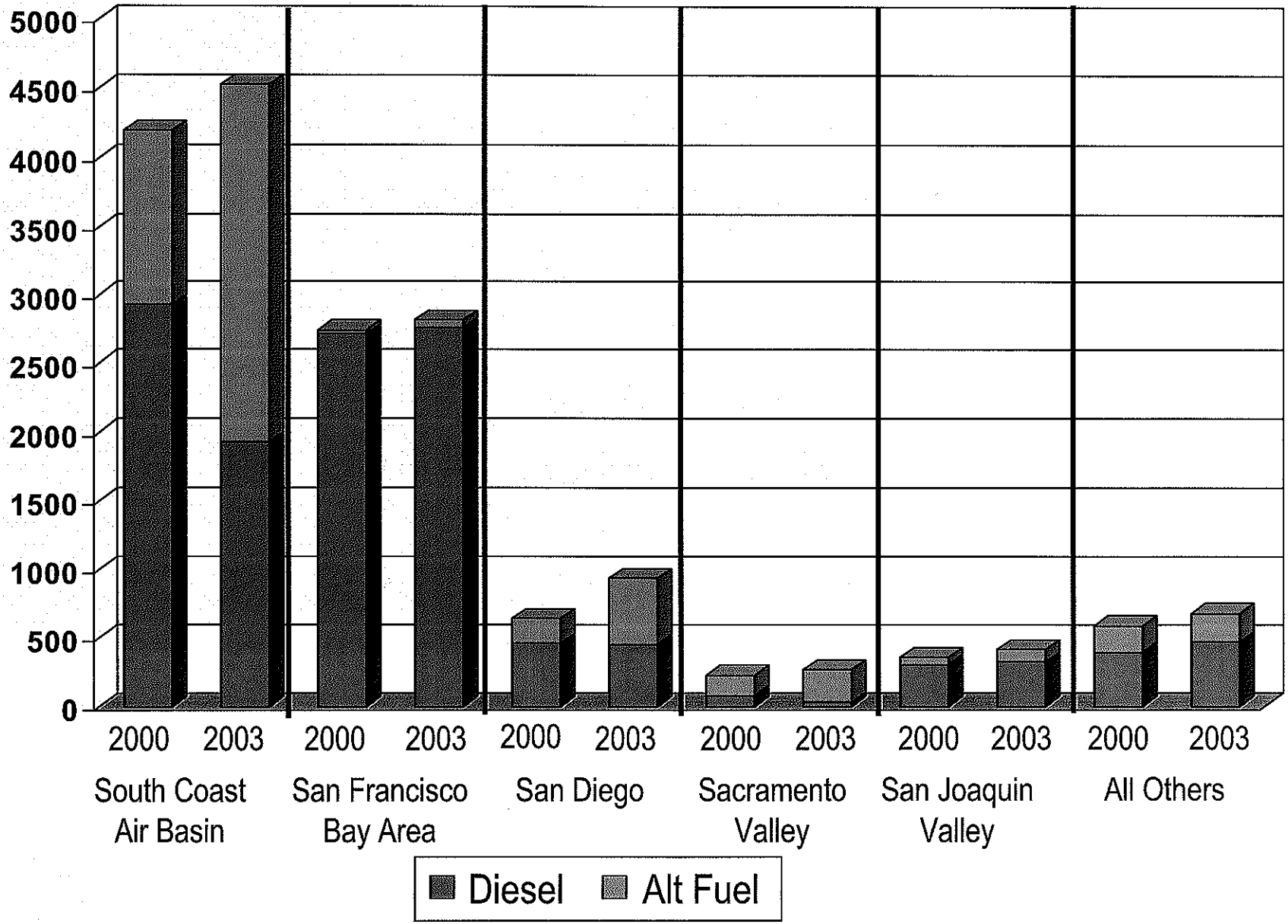




California Transit Bus Trends



Bus Trends by Region



Successes/Challenges

- Mixed Findings on Operational/Maintenance Costs versus Diesel
- Technology Issues Related Primarily to Vehicle Integration (Engine, Fuel System, Body Design)
- Need to Balance New Technology Deployment with Operational Needs
- Need for Full Commitment to Alternative Fuel Technology to be Successful

Why Choose Alternative Fuel Path?

- Alternative-Fueled Buses – Inherently Cleaner than Conventional Fueled Vehicles
- Alternative Fuel Technologies Continue to Improve Relative to Performance/Costs/ Environmental Benefits
- Reduces Foreign Dependency on Petroleum-Based Fuels

Current Certification Data for Heavy-Duty Diesel Engines

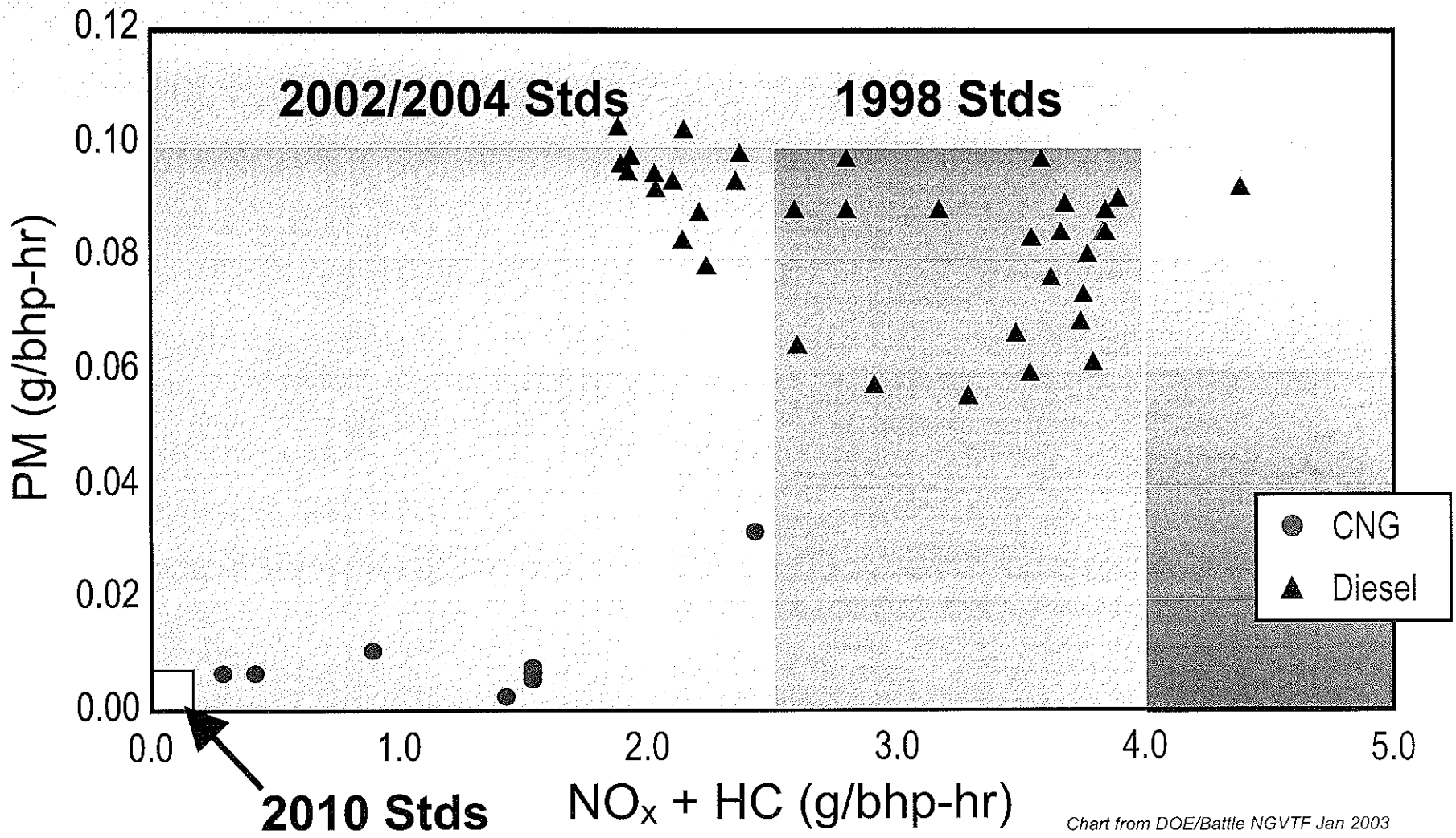
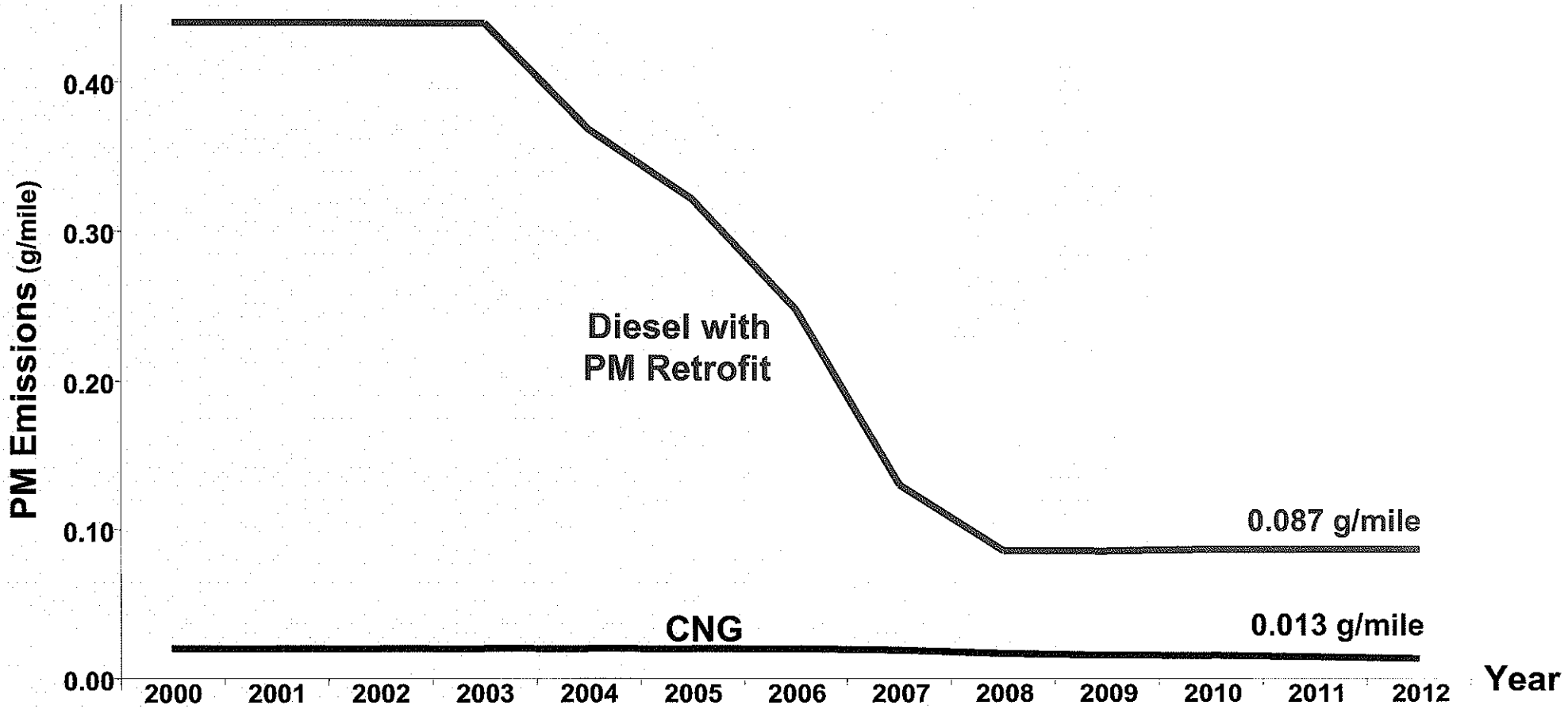


Chart from DOE/Battle NGVTF Jan 2003

Estimated In-Use PM Emissions - Bus Fleet Average



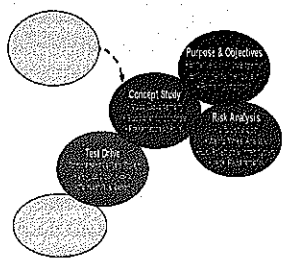
Source: California Air Resources Board (2000)

The Future

- Natural Gas Engine Manufacturers to Produce 0.2 gm/bhp-hr Engines by 2007
- Diesel Engines at 1.2 gm/bhp-hr in 2007
- Current Gasoline Hybrid Buses at 0.6 gm/bhp-hr
- Commercial Zero-Emission Buses
  - Electric – Available Today
  - Fuel Cell – Future Date Uncertain

Concept Study

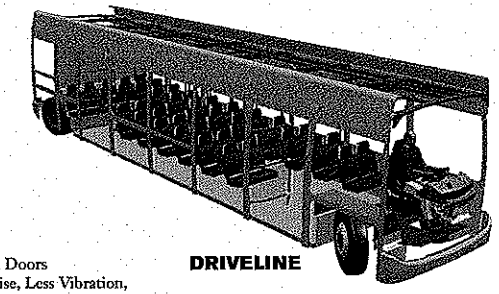
The objective of this project is to build up knowledge, within Scania as well as on Lund Institute of Technology, around fuel cell- and hybrid electric driveline technologies, and to educate appropriate resources for future activities involving those technologies. The availability of such resources will play an important role when our organisation will have to initiate the integration of these new technologies, especially as the concentration have been extremely focussed on diesel engine- and mechanical driveline development and optimisation in the past.



After the finalisation of the EU programme the concept bus is to go though an extensive range of driving tests to verify the potential of the build in technology in decrease of energy usage, noise and vibrations. Data will be digitised, in compatible format, and verified, for use in full vehicle simulation tools. New improven duty cycles will be developed. New models for fuel cell systems and driveline sub systems will be developed. The improved full vehicle simulation tool together with up to date component data will be used for an extensive concept study. Component data will be arranged in database for easy access. Risk study is to involve life cycle cost, well to wheel analysis, fuel/fuel infrastructure and legal requirements.

Vision

The future will demand more integrated urban passenger transport systems, which will be able to lift the image of this transport mean to a level which will be attractive to a wider range of the population as is today. Metros, light rail and other highly integrated urban transport systems have proven how to make public transport systems popular, though at an extremely high investment level! Future bus designs taking advance of the flexibility of new modern electric driveline technologies in combination with advanced traffic control- and information systems, might well be the perfect solution for future transport systems in medium size cities. Integrated with the already existing rail- and metro systems these new vehicles will be very attractive in larger cities as well. No-matter the fact that most money is spend on investments for railroad transport systems, buses move far more people!



FUNCTIONALITY

Customer:
- Increased Capacity
- Better Passenger Exchange
- Flexible Layout
- Reduced Emissions
- Easy change of driveline
- Improved Swept Area

Passenger:
- Low Flat Floor
- No Wheel Housings
- All Seats Pointing Forwards
- Low Entrance Height for All Doors
- Improved Comfort, Low Noise, Less Vibration, Steeples Drive, Controlled Limited Acceleration

Scania:
- Use of Standard Truck Components
- Increased Degree of Pre-assembly
- Simple Geometry
- Less Capital Bindings in Production
- Increased Product Flexibility

DRIVELINE

Base For Future Drivelines:
- Diesel Electric Drive, Euro III & IV
- Other fuels
- Hybrid Drive with Regenerative Braking
- Fuel Cell Technology

Improved Manoeuvrability by 4WS

Scania Hybrid Fuel Cell Concept Bus

Scania introduces a hybrid fuel cell concept bus to meet future environmental compatibility requirements for buses in inner-city operations. This concept bus is powered by a fully hybrid electrical propulsion system, including a fuel cell system supplying the necessary energy. It regenerates braking energy, is fuelled by gaseous hydrogen and drives emission free!

SCANIA

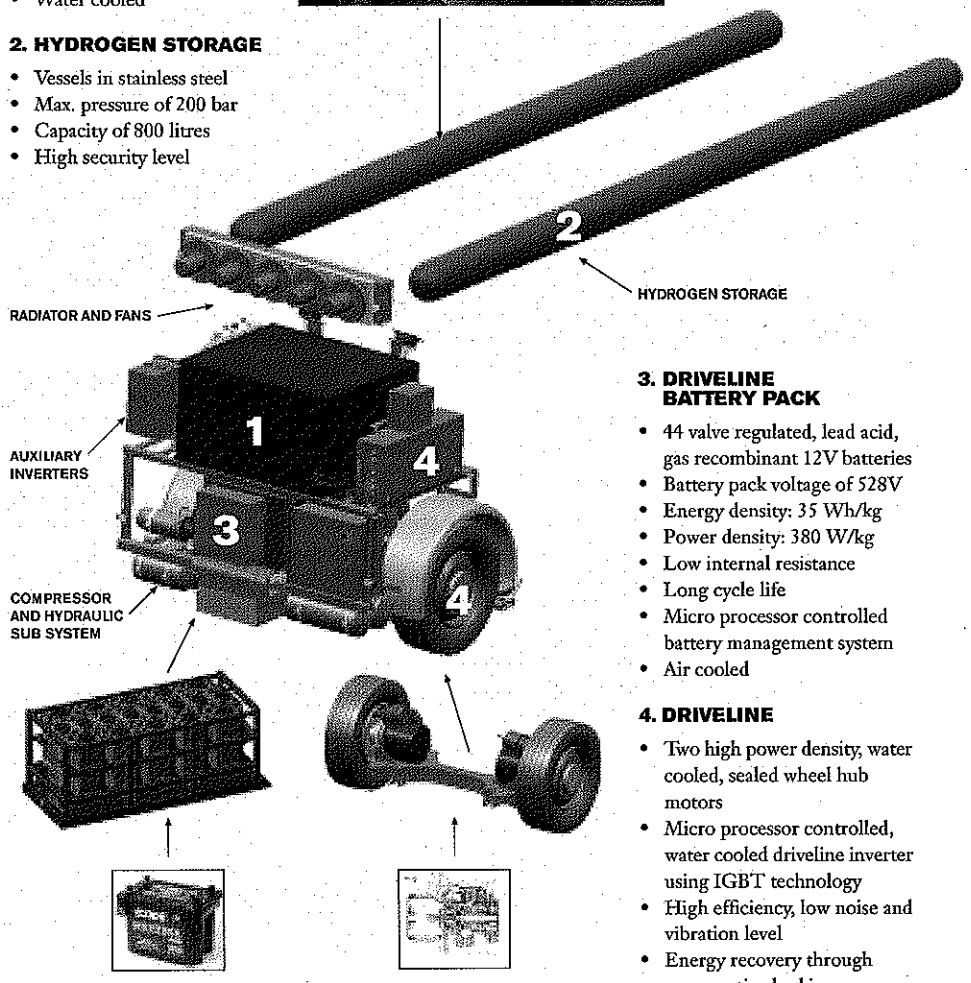
Propulsion System

1. PEM FUEL CELL SYSTEM

- Two stacks of 110 cells
- Power output: 0-50 kW
- Opcon screw compressor, silenced and filtered
- DC/DC converter
- System efficiency 52-57%
- Water cooled

2. HYDROGEN STORAGE

- Vessels in stainless steel
- Max. pressure of 200 bar
- Capacity of 800 litres
- High security level



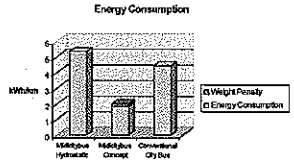
3. DRIVELINE BATTERY PACK

- 44 valve regulated, lead acid, gas recombinant 12V batteries
- Battery pack voltage of 528V
- Energy density: 35 Wh/kg
- Power density: 380 W/kg
- Low internal resistance
- Long cycle life
- Micro processor controlled battery management system
- Air cooled

4. DRIVELINE

- Two high power density, water cooled, sealed wheel hub motors
- Micro processor controlled, water cooled driveline inverter using IGBT technology
- High efficiency, low noise and vibration level
- Energy recovery through regenerative braking

Environmental Impact



The hybrid fuel cell bus is fuelled with pure hydrogen, exhausts only water and is therefore driving EMISSION FREE!

The energy consumption of the prototype has been reduced by 60% compared with the same bus type with a diesel engine and hydrostatic transmission. This enormous decrease in fuel consumption have been obtained via the combination of a high efficiency propulsion system, utilising regenerative braking and the high efficiency of the fuel cell system.

A high focus on all noise sources has resulted in a vehicle where the bypass noise level is as low as 70 dB. Following the environmental impact of noise from the bus is less than that for a VW Golf size passenger car. This ultra low noise level have only been possible to obtain through the design of a bus where all components and sub systems have been specified and designed for low noise.

Bus Features

TRUE LOW FLOOR, EASY ENTRY AND EXIT

With the wheels located outside of the passenger compartment, a clear flat floor with seats and doors suspended from roof is realised. The floor height is 230 mm from the ground and can be lowered or raised an additional 65 mm.

HIGH COMFORT

Internal noise level is ultra low, as noise from the propulsion system is barely recognised in the passenger cabin. Wind, wheel rolling resistance and bumps on the road are responsible for the major part of the noise inside the passenger cabin. This together with electronically controlled acceleration and true steeples drive results in a whole new level of comfort for a city bus.

The driver information have been improved by a touch screen with propulsion system information for energy flow, energy usage, diagnostics, fuel level etc.

MODULAR DESIGN

Propulsion system and auxiliary systems are mounted on one complete frame, which is attached to the bus body via a few bolts and following is easy to remove.

CAPACITY

Passengers:

Seated:	15	(dep. on layout)
Wheel chairs:	1	(dep. on layout)
Standing:	37	

PERFORMANCE

Top speed:	80	km/h
Acceleration (0-30 km/h):	7	sec. (Acceleration electronically controlled)
Range:	250	km

Participants in the Fuel Cell Concept Bus Programme co-funded by funds from EU's Non-nuclear energy (JOULE) programme

AIR LIQUIDE
Project leader. Fuel cell system design and supply. H2 storage and system design and supply

NUVERA FUEL CELLS
Fuel cell design and supply

SAR
Bus supervisor controller design and DC/DC converter specification and supply

SCANIA
Bus design and supply
Hybrid drivetrain specification and supply
Batteries specification and supply

Fuel cell teste

Air-compressor design and supply

ZF DRIVE
Driveline supply and support to Scania