"The Research Behind the Regulations"

presented at the Alcohol Week Conference on

New Fuels for Cleaner Air

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Outline

The Research Behind the Regulations

I. The Potential of Methanol as a Passenger Car Fuel

   A. Methanol's Advantages Compared to Gasoline
   B. Current Technology vs. Advanced Technology Vehicles
   C. Potential Efficiency Improvements
   D. EPA/Industry Cooperative Programs
      1. Toyota
      2. Nissan

   E. EPA In-House Programs
      1. Ricardo HRCC Engine
      2. Cold Start
      3. Catalyst Optimization
      4. Dissociation

II. Methanol as a Clean Bus Fuel

   A. EPA Reassessment of Diesel Bus Emissions
   B. Environmental Impacts of Diesel Particulate
   C. EPA Emission Standards
   D. Recent EPA Methanol Bus Chassis Data
      1. Particulate
      2. Nitrogen Oxides
      3. Formaldehyde

   E. New York City Methanol Bus Program

III. The Effects of Oxygenated Blends on Motor Vehicle Emissions

   A. EPA Approved Blends
      1. Gasohol
      2. Oxinol
      3. DuPont
      4. MTBE

   B. CO Emission Reductions
   C. HC Emissions
      1. Many factors must be considered
      2. No change at equal RVP
      3. Increase at higher RVP

   D. Projected Fleetwide Impacts
   E. Volatility Rulemaking

METHANOL'S ADVANTAGES OVER GASOLINE

LOW EMISSION POTENTIAL

HIGH EFFICIENCY POTENTIAL

LEAN BURN CAPACITY

DISSOCIATION POTENTIAL

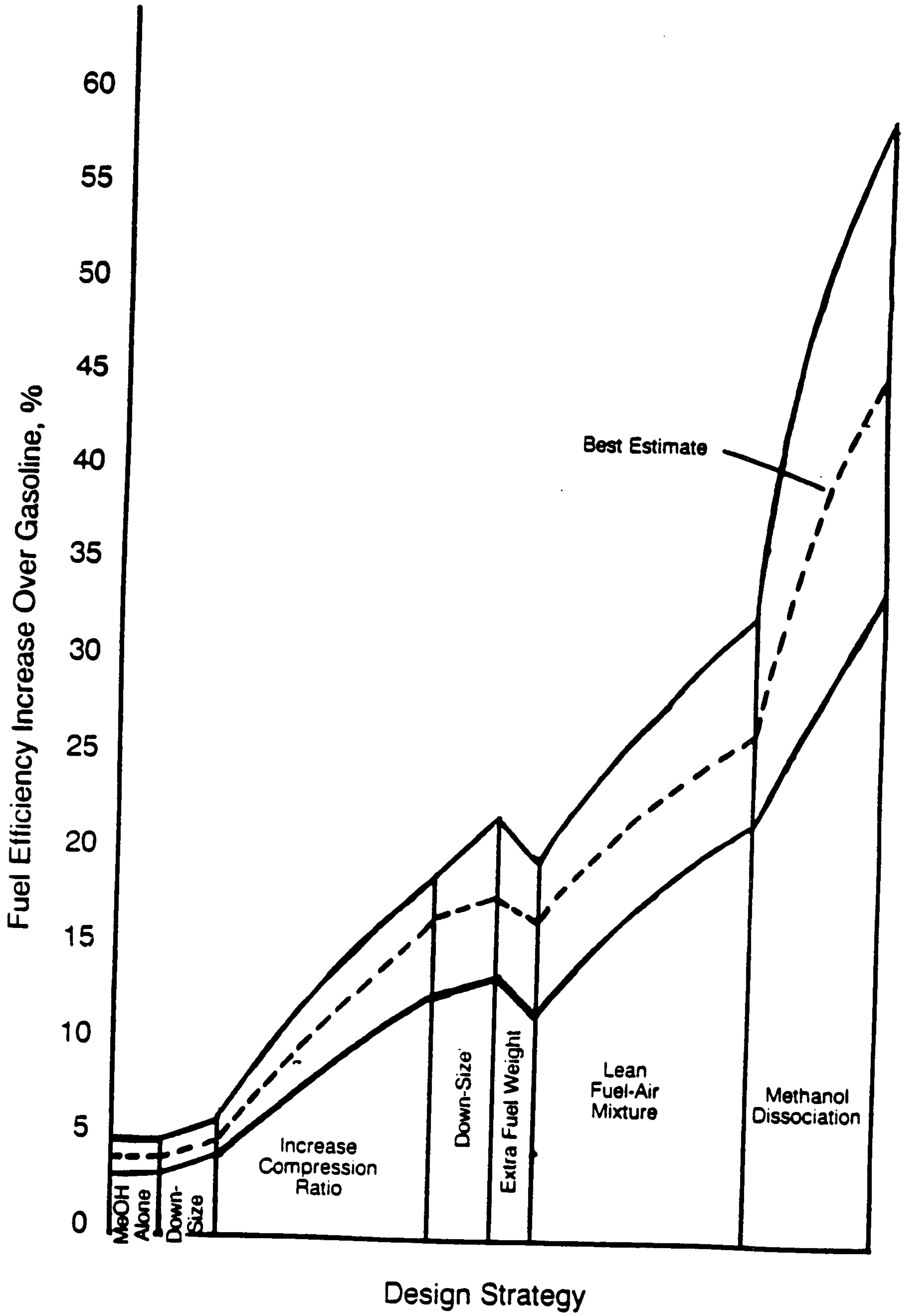
Methanol Vehicle Technologies

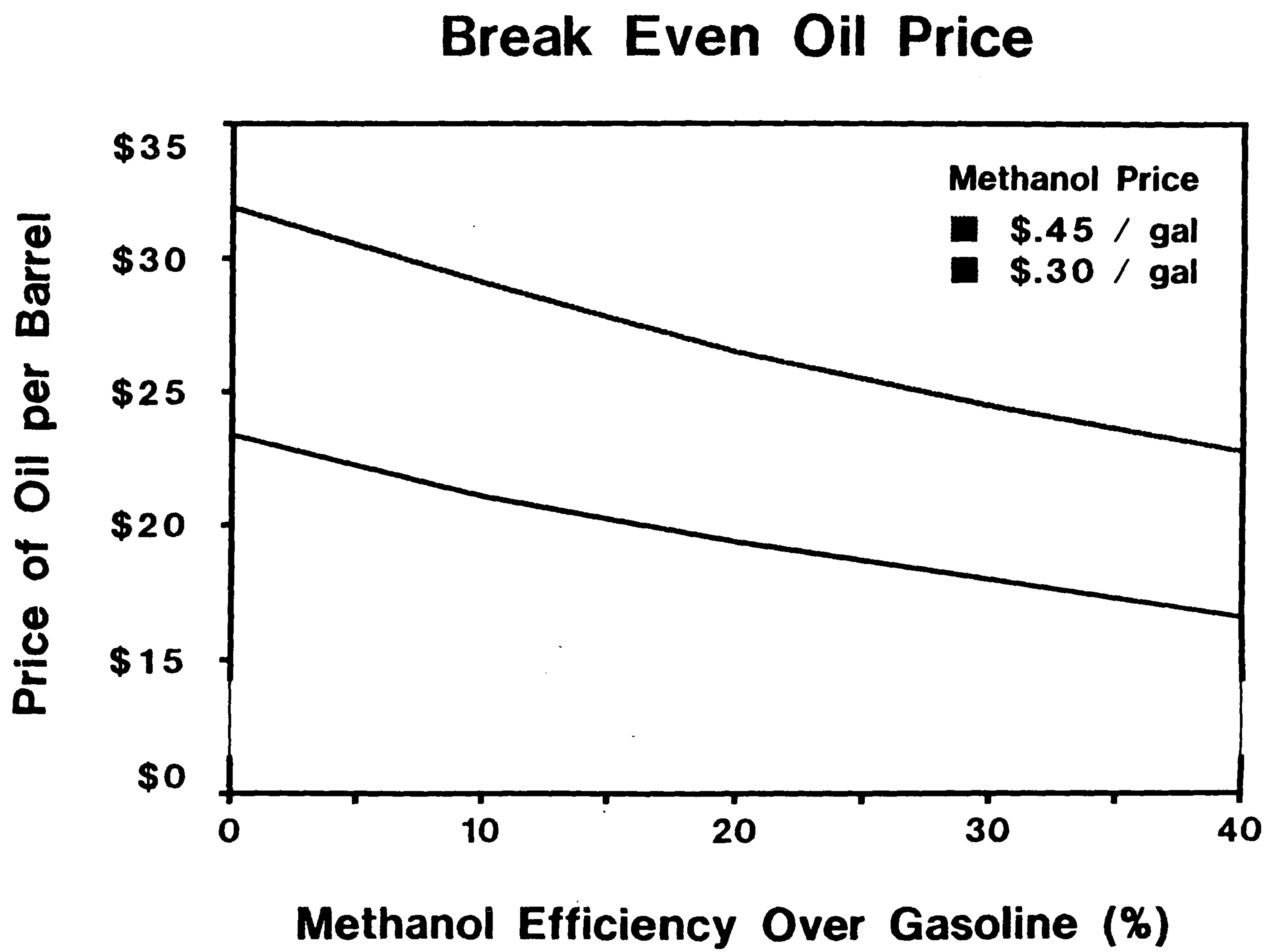
Parameter	Current	Advanced
Compression Ratio	Low (FFV) to High	High
Air-Fuel Ratio	Stoichiometric	Lean
Fuel Injection	Port or Throttle Body	Sequential
Aspiration	Natural	Turbocharger
Fuel	M85	M100 /Dissociation
Catalyst	Stock	Optimized

Methanol Vehicle Emissions and Efficiency

Parameter	Current	Advanced
HC Reactivity	20 to 50 % lower	85 to 95% lower
Formaldehyde	4 to 8 times higher	gasoline level
Carbon Monoxide	gasoline level	much lower
Nitrogen Oxides	gasoline level	gasoline level
Energy Efficiency	gasoline level	20 to 40% higher

Methanol Engine Efficiency




Break Even Oil Price
Price of Oil per Barrel
$35
$30
$25
$20
$15
$0
0
10
20
30
40
Methanol Efficiency Over Gasoline (%)
Methanol Price
$.45 / gal
$.30 / gal

Ricardo HRCC Engine

Ricardo modified a VW engine with
High Compression Ratio, Compact Combustion Chamber design

Lean combustion, sequential fuel injection, M100, EGR

Engine installed in an Audi 5000 Diesel provided
5 percent higher fuel economy and
20 percent better performance

Work now underway to optimize for emissions,
especially to meet 1.0 gpm NOx

Direct injection work planned

Toyota Lean Combustion System

Developed circa 1984 to comply with Japanese NOx standards

Components :

- ☐ Lean burn sensor in place of oxygen sensor
- ☐ Swirl control valve upstream from intake valve
- ☐ Sequential port fuel injection with optimized injection timing

EPA interested in system for its potential use with Methanol

At EPA's request, Toyota provided an LCS Methanol vehicle

Toyota Lean Burn Methanol Results

Vehicle performed well on both M85 and M100

Meets current HC and CO standards, and
less than 1.0 gram/mile NOx

Very low aldehyde emissions : less than 10 mg/mile

Evap emissions less than 1 gram/test,
M100 lower than M85

Fuel economy as good or better than
comparable gasoline vehicles

Future Plans for Toyota Lean Burn System

- New leaner M100 calibrations to be evaluated on current vehicle
- Engine out emissions and air/fuel ratio mapping over FTP on current vehicle
- EGR evaluation on current vehicle
- Development of new methanol lean burn engine optimized for emissions and fuel economy
- Delivery of vehicle with new engine in mid-1988

Joint Nissan /EPA Program

Baseline Sentra delivered in July 1987

- Part-throttle lean combustion, sequential fuel injection, turbocharger
- Meets current emission standards
- 106 hp vs 70 hp for gas Sentra
- 42 mpg vs 36 to 41 mpg for gas Sentra

Three engines will be delivered in fall 1987

Upgraded Sentra scheduled for delivery in summer 1988

- Maintain high performance of baseline vehicle
- Low ozone potential - 5 mgpm formaldehyde emissions
- Gasoline equivalent fuel economy of 45 to 50 mpg

In-House Concepts

Cold Start

- Atomizer Nozzle
- Ignition System Design
- Resistance Heating/ Partial Oxidation

Dissociation

- Southwest Research Institute Contract
- Industry Interaction

Catalyst

- Washcoat Formulations
- Preheater

EPA Reassessment of Transit Bus Emissions

More Sophisticated Analysis

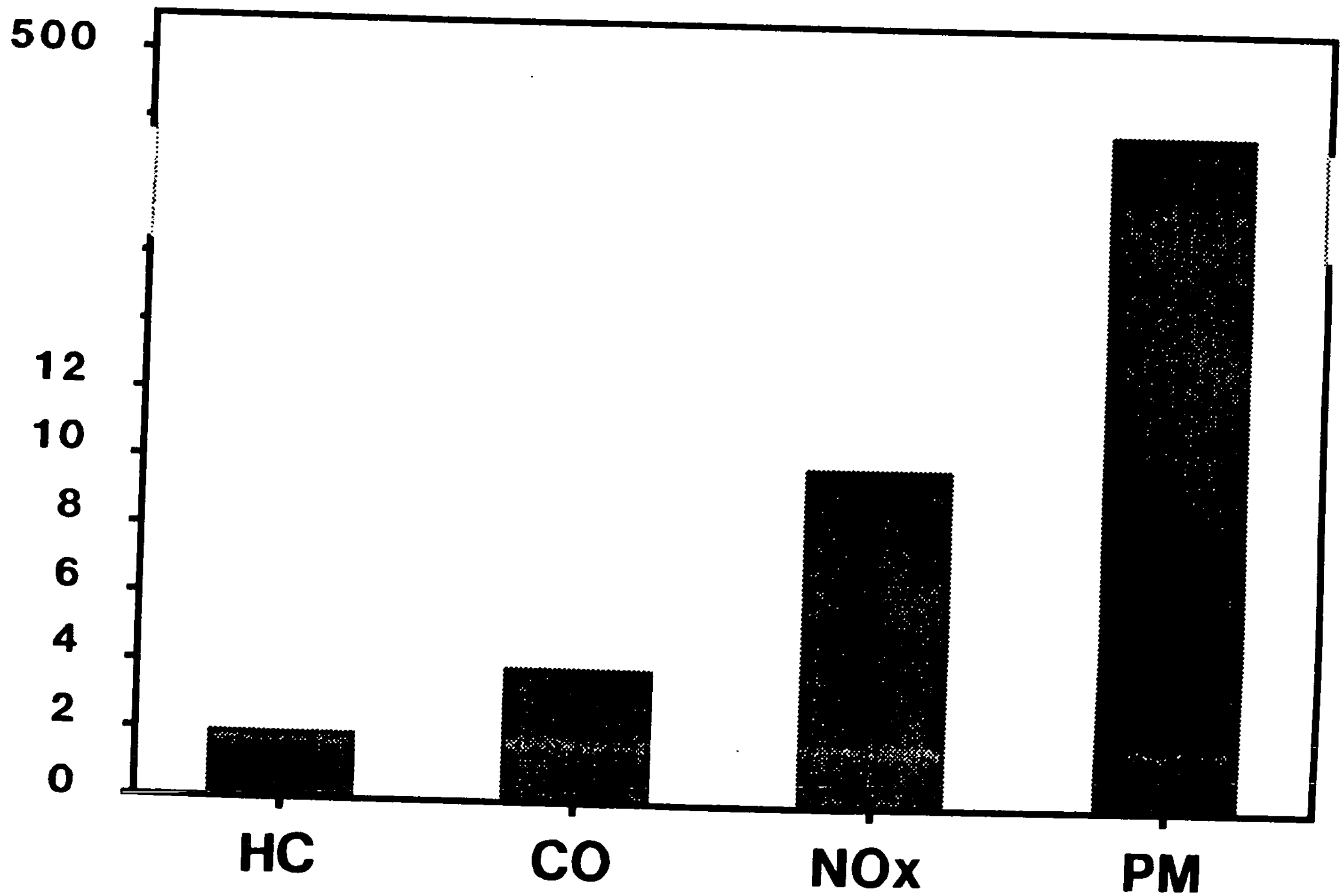
* Larger and more accurate emission data base
* Very high public exposure

Greater Concern About Diesel Particulate and NOx pollution

Equity

* Relative to treatment of other vehicle classes
* Credibility for future air quality strategies

Ratio of Transit Bus to Gasoline Car Emissions
(1980 vehicles in use)



Environmental Impacts of Diesel Particulate

Total Suspended Particulate is an EPA Criteria Pollutant

* Very high levels correlated with mortality rates
* Lower levels aggravate respiratory diseases

Diesel Particulate is a Special Health Concern

* Very small size
* Known to contain mutagenic and carcinogenic compounds

Diesel Particulate is Also a Welfare Concern

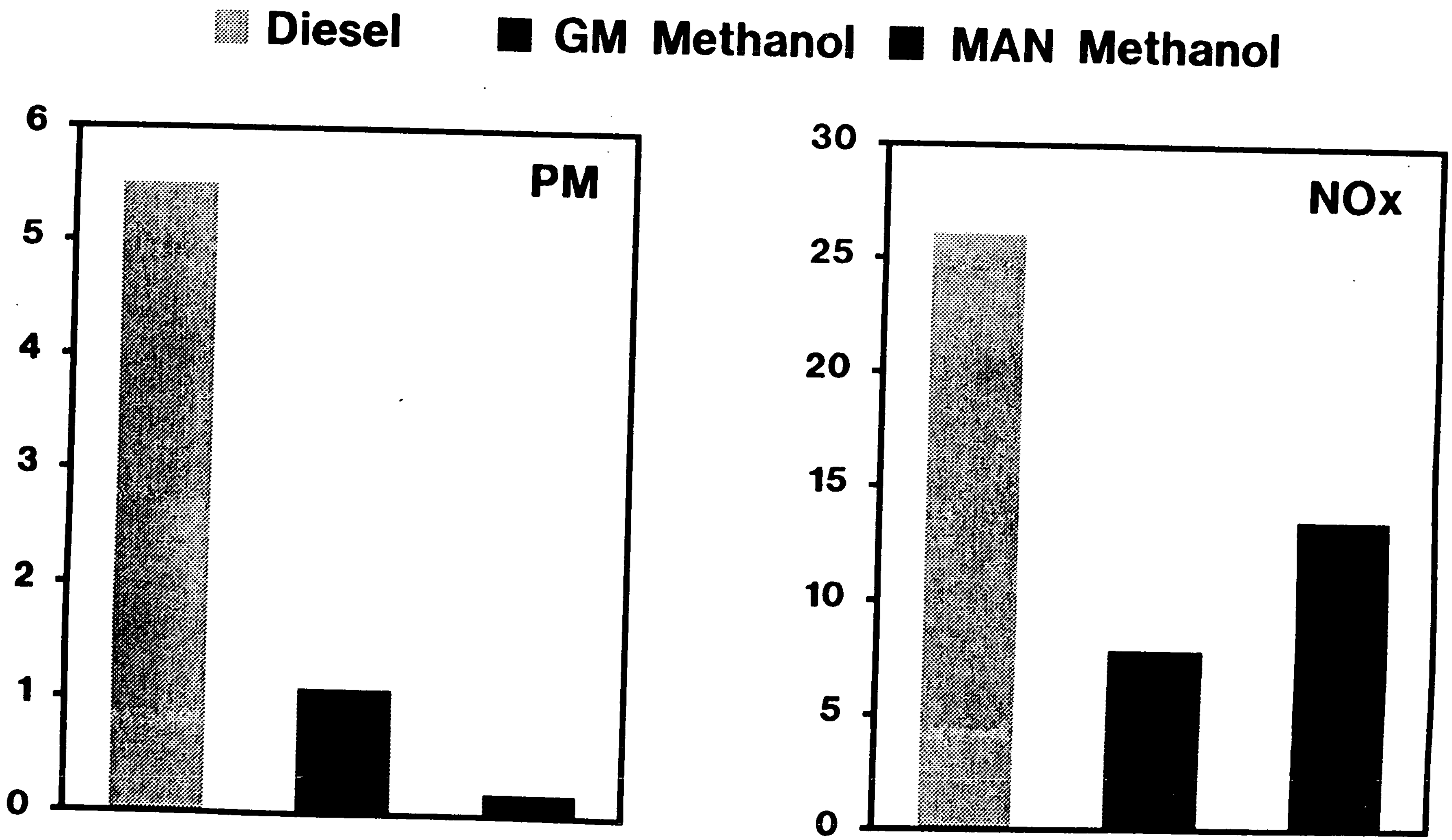
* Very detrimental to visibility
* Soiling and/or corrosion
* Odor

Bus and Truck Emission Standards

(g/ hp-hr over EPA test procedure)

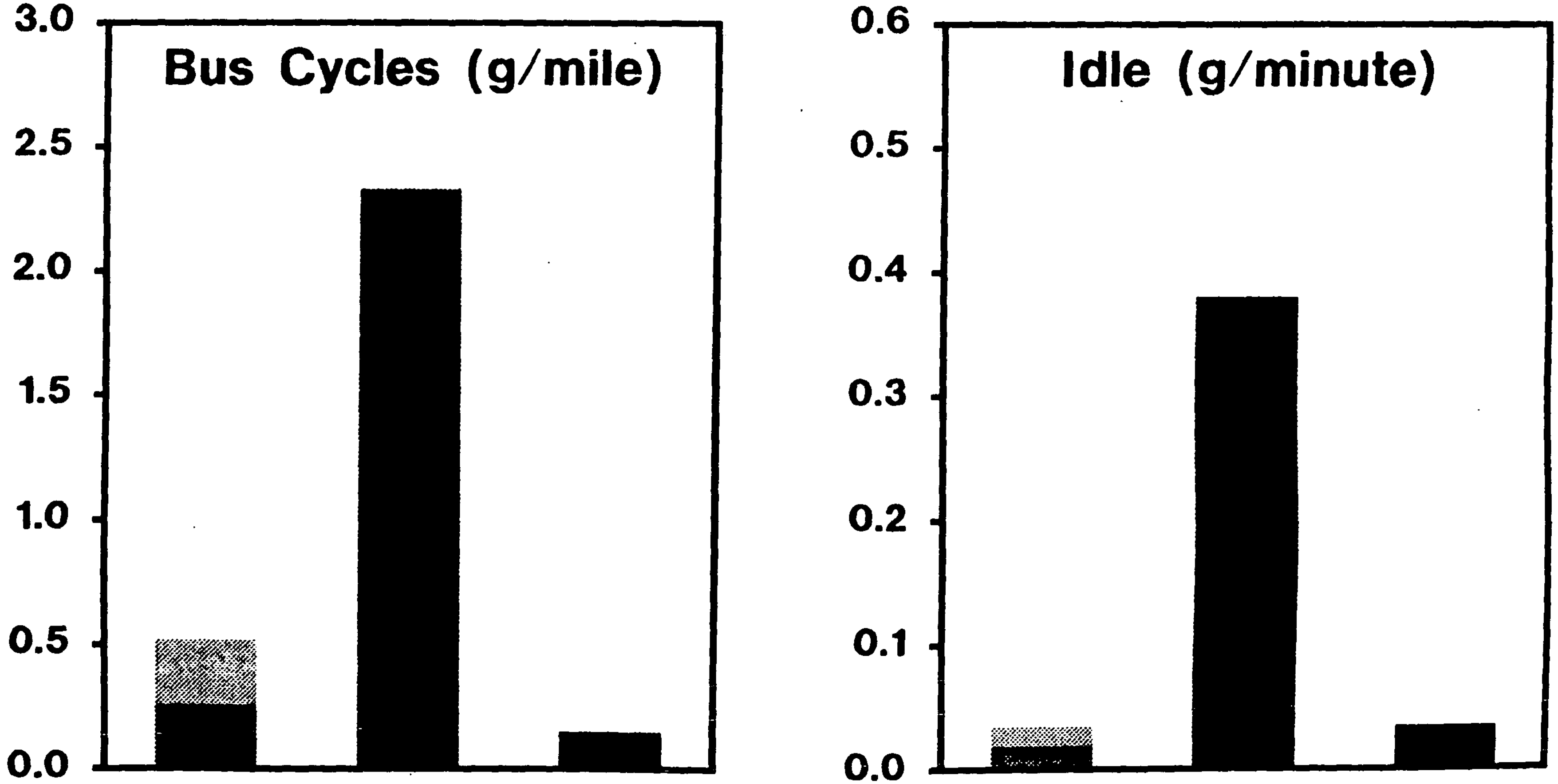
	NOx	PM
Current Engines	5 to 9	0.4 to 0.8
1988 - 1989	10.7	0.60
1990	6.0	0.60
1991 - 1993	5.0	0.25 / 0.10
1994 and later	5.0	0.10

Diesel vs Methanol Bus Emissions (GPM)



Diesel vs Methanol Bus HCHO Emissions

Diesel GM Methanol MAN Methanol



New York City Demonstration

Settlement of EPA enforcement action

EPA, GM, NRDC, CAS, Celanese, New York City and UMTA

Total GM commitment of $6.7 million

Goal to show commercial viability by 1991

- Phase 1 -- engine R and D
- Phase 2 -- 6 buses in December 1987 at no cost
- Phase 3 -- sale of 26 buses in 1989-90 at diesel price

Oxygenated Blends Approved by EPA

Name	Additive	Oxygen Content
Gasohol	10% Ethanol	3.7%
Oxinol	4.75% Methanol 4.75% TBA	3.5%
DuPont	5% Methanol 2.5% Ethanol	3.7%
MTBE	11% MTBE	2.0%

Effect of Blends on CO Emissions

Technology	3.7% Oxygen	2.0% Oxygen
Non-Catalyst	-18%	-10%
Open Loop	-30%	-17%
Closed Loop	-10%	-5%

Factors Affecting HC Emissions Analysis

Evaporative and Exhaust

- Vehicle Technology
- Low Reactivity of Methanol
- Change in Fuel Volatility

Evaporative Only

- Change in Distillation Curve
- Change in Molecular Weight
- Commingling

Effect of Blends on Exhaust HC

Technology	3.7% Oxygen = RVP	3.7% Oxygen +1 RVP	2.0% Oxygen
Non-Catalyst	-9%	-5%	-5%
Open Loop	-9%	-5%	-5%
Closed Loop	-4%	-1%	-2%

Effect of Blends on Evap HC Emissions

(percent, range from no commingling to maximum commingling)

	Carbureted	Fuel Injected
Ethanol		
= RVP	+7 to +12	-6 to +2
+1 RVP	+61 to +69	+71 to +84
Methanol		
= RVP	-7 to +5	-17 to +5
+1 RVP	+35 to +66	+50 to +77
MTBE	+15	+1

Projected Fleetwide Impacts of Blends in 1990
(percent)

Blend	Hydrocarbons		CO
	= RVP	+1 RVP	
Gasohol	-2 to +5	+15 to +35	-22
Oxinol/DuPont	-5 to +5	+ 9 to +30	-22
MTBE	-1	NA	-12

Options for Blends in Volatility Rulemaking

- Control to same RVP as gasoline
- Temporary 1 PSI RVP allowance (tax exemption)
- Permanent 1 PSI RVP allowance