1993 WINDSOR WORKSHOP *on* ALTERNATIVE FUELS

.....

Proceedings

October 1993

June 14 - 16, 1993

Holiday Inn
Toronto Downtown - City Hall
Toronto, Canada

Sponsored by:
Energy, Mines & Resources Canada - CANMET
US Department of Energy

Presented by:
ORTECH International

ORTECH
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Proceedings of the

1993 WINDSOR WORKSHOP

on

ALTERNATIVE FUELS

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PREFACE

In the tradition of previous years, EMR's Canada Centre for Mineral and Energy Technology (CANMET), and the U.S. Department of Energy (DOE) teamed up once again to sponsor the Windsor Workshop on Alternative Transportation Fuels. 1993 marked the 10th anniversary of this Workshop which began in 1983 in Windsor, Ontario. We would like to express our appreciation to ORTECH International for a fine job in coordinating this event.

The 1993 workshop attracted 271 participants from 9 countries including, France, Japan, Australia, Hong Kong, Italy, Korea, The United Kingdom, The United States and Canada; continuing to indicate the growing awareness and importance of alternative transportation fuels in the world marketplace.

Following in the footsteps of its predecessors, the 1993 workshop maintained its established approach to encourage an informal exchange of information with a focus on infrastructure barriers, and the readiness of alternative fueled vehicles to enter the marketplace. Participants included engine and vehicle manufacturers, fuel suppliers, public and private research organizations, and academic and regulatory bodies. In keeping with this informal theme, many of the papers presented in these proceedings are not in text format. After each paper a brief summary of the question and answer period is appended, which should serve as a reminder of some of their more salient points.

The development of alternative transportation fuels, and ultimately the quality of the environment, can only be enhanced by the exchange of information on worldwide industrial trends and technical progress. Since inception the Windsor Workshops have proved to be an invaluable forum for this exchange, and we will endeavour to organize such timely and productive workshops in the years to come

Mark your calendars now, the next workshop will once again be held in Toronto, at the Holiday Inn Downtown City Hall, June 13 - 15, 1994. We hope to see you all again in 1994. We would like to extend our warm gratitude to the organizers and participants of the 1993 Windsor Workshop.

Bernie James
Energy, Mines & Resources Canada

John Russell
U.S. Department of Energy

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

JUNE 14-16, 1993

TABLE OF CONTENTS

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

JUNE 14-16, 1993

TABLE OF CONTENTS

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

JUNE 14-16, 1993

TABLE OF CONTENTS

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

JUNE 14-16, 1993

TABLE OF CONTENTS

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

OPENING ADDRESS

Norman Moyer
Assistant Deputy Minister, Corporate Policy and
Communications Sector, Dept. of Energy, Mines & Resources Canada

NOTES FOR AN ADDRESS

DELIVERED ON BEHALF OF
BILL MCKNIGHT
MINISTER OF ENERGY, MINES AND RESOURCES CANADA

BY MR. NORMAN MOYER
ASSISTANT DEPUTY MINISTER
CORPORATE POLICY AND COMMUNICATIONS SECTOR

AT THE
1993 WINDSOR WORKSHOP

TORONTO, ONTARIO
JUNE 14, 1993

Thank you, David for that kind introduction, and good morning, ladies and gentlemen. It's an honour to be here today among the top performers of the North American alternative transportation fuel industry. Mr. McKnight was unable to attend due to a previous commitment, and he sends his regrets.

As most of you are no doubt aware, I am privileged to share the stage this morning with Chuck Imbrecht, who I understand is serving his fifth consecutive term as Chairman of the California Energy Commission. Welcome to Toronto! I know many people gathered here today are looking forward to your keynote address.

I would like to start off today by saying a few words about the Windsor Workshop. As most of you know, this workshop has been a tradition in the transportation industry for a decade now. Over the years it has evolved into the most important forum on alternative fuels in North America. Your discussions have progressed from technical papers and discussions on alternative fuel concepts and theories to Original Equipment Manufactured alternative fuel vehicles using propane, natural gas and methanol. In fact, the world's first hydrogen fuel-cell-powered bus was just unveiled on Tuesday.

Indeed, the Windsor Workshop provides an excellent example of technology transfer in action. I think this is extremely important. Your industry is rapidly developing — it is imperative that the lines of communication remain open as to your successes, your emerging opportunities, and the barriers that stand in the way of your goals.

Therefore, Energy, Mines and Resources, through the Canada Centre for Mineral and Energy Technology — CANMET, to many of you — is proud to be a sponsor of this workshop, particularly on this, its tenth anniversary. CANMET firmly supports your efforts to accelerate the commercialization of your technologies through concerted technology transfer. To recognize the major successes that some of you have achieved in this regard, I will be presenting an award later on behalf of CANMET. The award recognizes industry's efforts in commercializing new technologies in the areas of energy efficiency and alternative energy. I'll tell you more about that in a few minutes.

But first, I'd like to talk about some of the barriers that are inhibiting the commercialization of alternative transportation fuels here in Canada. Some of these are institutional, while others are technical. In any case, substantial effort and resources will be required to overcome these obstacles, which poses a challenge in these times of economic restraint.

The question that remains is this: how can we most effectively address these barriers when government and industry are each under pressure to operate as cost-effectively as possible?

I believe the answer is in the formation and maintenance of strategic alliances — alliances that will not only advance alternative transportation fuels, but will boost the competitive prospects of your entire industry. Of course, we do not need to look very far into the past to see successes in this regard. By working together, government, industry and academia have been able to introduce a new fleet on alternatively fuelled vehicles in this country. Over 140,000 propane vehicles and 35,000 natural gas vehicles are on the road in Canada. Domestic sales of ethanol-blended gasoline exceeded 256 million litres last year. And we're road-testing some of the first methanol, ethanol, hydrogen fuel-cell-powered and electric vehicles in the world.

The credit for these achievements must be shared — by industry, by universities and research organizations, and by government at all levels. Our successes in the alternative transportation fuels industry clearly demonstrate what strong partnerships can achieve in this country. Let me say a few words about that now.

Federal R&D Program

As many of you know, the Government of Canada has supported the alternative transportation fuels industry since 1980. In recent years, responsibility for federal R&D activities in this area has been that of CANMET, the main S&T arm of EMR. CANMET's objectives in the alternative fuels area are three-fold: first, we are dedicated to working with your industry to commercialize technologies with near-term market potential, like propane, natural gas and alcohol fuels. Second, we support the development of longer-term alternatives with significant market prospects, including hydrogen-powered and electric vehicles. And third, we are committed to assisting with the development of an infrastructure that will facilitate the market entry of proven alternative fuels.

Our experience has shown that cost-shared research and development is the best way to meet our technology goals. In keeping with this policy, CANMET is working in cooperation with a wide number of stakeholders from both government and industry.

To promote the commercialization of short-term technologies, we have struck R&D agreements with a number of industrial partners, as well as the Canadian Gas Association, the Propane Association of Canada, and the Canadian Oxygenated Fuels Association. Our goals? Technology improvement and cost reduction. At the same time, we are assisting these groups with the development of technical and safety standards needed to encourage the acceptance in the market place.

To promote the development of longer-term alternatives like hydrogen and electric vehicles, we are supporting R&D by several Canadian universities, research organizations, and groups such as the Electric Vehicle Association of Canada and the Hydrogen Industry Council. Our shared objectives for these technologies include cost-performance improvements that will permit eventual manufacturing. For although hydrogen and electric vehicles are expensive, they are also the most environmentally friendly transportation alternatives available to us. Their future market prospects are therefore enormous.

Finally, CANMET is working closely with your industry, other groups within EMR and concerned federal departments to further develop the regulation and fuel infrastructure that is so critical to the commercial penetration of these fuels. I'm pleased to say that a great deal of progress is being made in this regard. Harmonization of standards for emissions, safety and fuel consumption has been achieved for conventionally fuelled vehicles at the national level. Efforts are underway to achieve the same regulatory milestones for new fuels. I want to acknowledge the importance of the strong industry assistance that delegates in this room and your colleagues provide to us through the technical organizations and committees that you have spent many hours serving.

In terms of the refuelling infrastructure, I believe the Government of Canada has played a useful role in funding the construction of natural gas fuelling stations. To date, we have contributed to the development of more than 140 such stations in cities across the country. We are also working with your industry to expand the methanol refuelling network. We hope these will follow the trend of growth already set by propane fuelling stations.

Government and industry alike should be proud of the teamwork that is fostering the successful development of alternative transportation fuels. It has been a tough climb for the past dozen years or so — but I believe we have recently begun to see evidence of our progress.

Market Place for Alternative Fuels

We need only examine the conditions of the transportation market place to recognize that these fuels do have an important role to play. As a result of the initiation of new environmental policies in countries around the world, enormous new markets have been created for alternative fuels. California, for example, is calling for quotas of zero-emission vehicles by 1998. In the interim, demand is going to increase for cleaner transportation technologies. Infrastructures will continue to develop. And the public confidence in these new technologies will grow.

Here in Canada, we have had great success in the sale of natural gas and propane conversion kits for vehicles. Today, there are over 150,000 converted cars and trucks operating on Canadian roads. The recent announcements of OEM vehicle production by the 'Big Three' has added a new factor in the way we do business. The transition zone to our evolution to alternative fuels has expanded. While this development has the benefit of providing added choice for the consumer, it magnifies the requirement for technology development — toward both competitive conversion technologies and leading-edge Canadian technology for OEMs.

In short, we are entering a new era in the development of alternative transportation fuels — one with significant commercial opportunities for your industry. It is interesting to note that other countries are now recognizing what we have known for some time — that alternatively fuelled vehicles have a major role to play in meeting global environmental objectives. As a result, we are facing increased competition. And we must work harder to maintain our technical edge and take advantage of emerging world markets.

As technology developers in the alternative fuels industry, Canadians are among the best. To exploit the full potential of our technologies, we must maintain these strategic alliances between government, industry and academia. They have been the key to our successes in the past. And they will ensure a prosperous future for our technologies.

However, we should not take our partnerships for granted. We need to consult with each other to review the cooperative structures that are in place right now. And we need to identify the issues that most require our attention. However, to do so, we must ensure that everyone is at the table — from all levels of government, and from all sides of the industry. That's the essence of consultation — information sharing. The Windsor Workshop provides an excellent starting point each year for discussion, and we must carry this momentum throughout the year.

Award Announcement

On that note, I'd like to talk a little more about the announcement I made earlier regarding a new CANMET technology transfer award. CANMET has long recognized the value of technology transfer efforts and the role they have played in expanding the contribution of alternative energy and energy efficiency. To show our appreciation, an award will be presented every year in recognition of outstanding contributions in transferring energy efficiency and alternative energy technologies to the market place. This first award is being given for outstanding achievement in alternative transportation fuels. I think this is a clear demonstration of the importance we assign to developments in this key sector.

To select this year's winner, we asked representatives of your industry to provide us with nominations. It was a very close race. The runners up included Mr. Elson Fernandes of Clemmer Industries for the development of a methanol fuel dispensing system, and Mr. Don Henry of Imperial Oil for work on specially formulated motor oil for gaseous fuelled vehicles. Both of you are to be commended for your achievements.

I am now honoured to announce that this year's award has been won by the Engineering Division of Chrysler Canada for your development of vehicles powered by natural gas, propane and methanol which are being mass-produced. Will Mr. Stuart Perkins and his team of John Mann, Jim Lanigan, Larry Robertson and Shawn Yates please come up here to receive these certificates and a small token of our appreciation?

Congratulations!

Thank you, and all the best for a successful workshop.

SUMMARY OF VERBAL COMMENTS OR QUESTIONS AND SPEAKER RESPONSES

OPENING ADDRESS
N. Moyer, Assistant Deputy Minister, Corporate Policy and Communications, Energy, Mines & Resources Canada

No discussion took place after this presentation. However, an annual award by CANMET was announced for alternative energy technology transfers to the marketplace. The Engineering Division of Chrysler Canada was chosen for the 1993 award from a group of several candidates who had been nominated.

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

KEYNOTE ADDRESS

(unavailable at time of printing)

Charles R. Imbrecht
Chairman, California Energy Commission

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

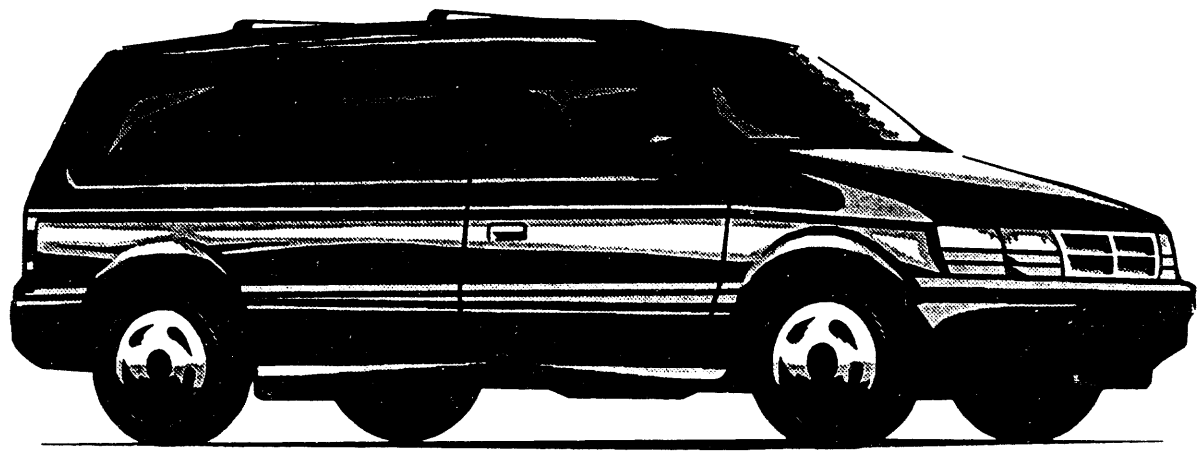
MARKET PLACE IMPLICATIONS IN THE CHANGING WORLD OF MOTOR FUELS POLICY PANEL DISCUSSION

Panel Moderator: Frederick Potter

NEW IDEAS FOR FEDERAL ROLE IN MARKETING AFVs

D. Rodgers
U.S. Department of Energy

New Ideas for Federal Role in Marketing AFVs



TRANSPORTATION TECHNOLOGIES

Office of Transportation Technologies
U.S. Department of Energy

New Ideas

Federal Mandates to Leverage Alternative Fuel Vehicles

- Clean Air Act Amendments of 1990
- Intermodal Surface Transportation Efficiency Act of 1991
- Energy Policy Act of 1992

EPACT Implementation Plan for Alternative Fuels

Strategy

Program Elements

- **Fleet Mandates**
- **Fuel Supply**
- **Consumer Awareness/Education**
- **Incentives/Financial Assistance**
- **Misc. Regulations/Guidelines**
- **Reports/Analysis**

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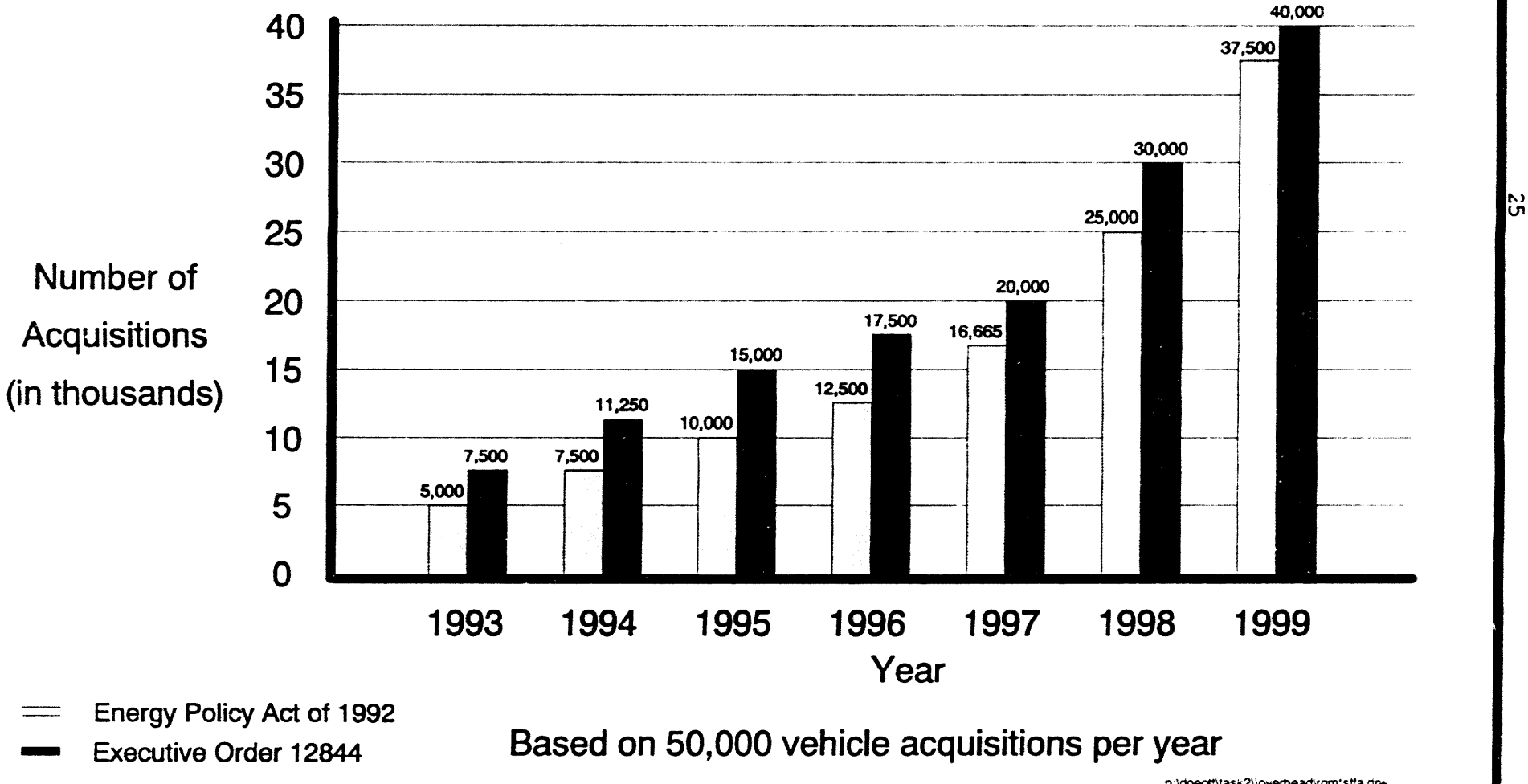
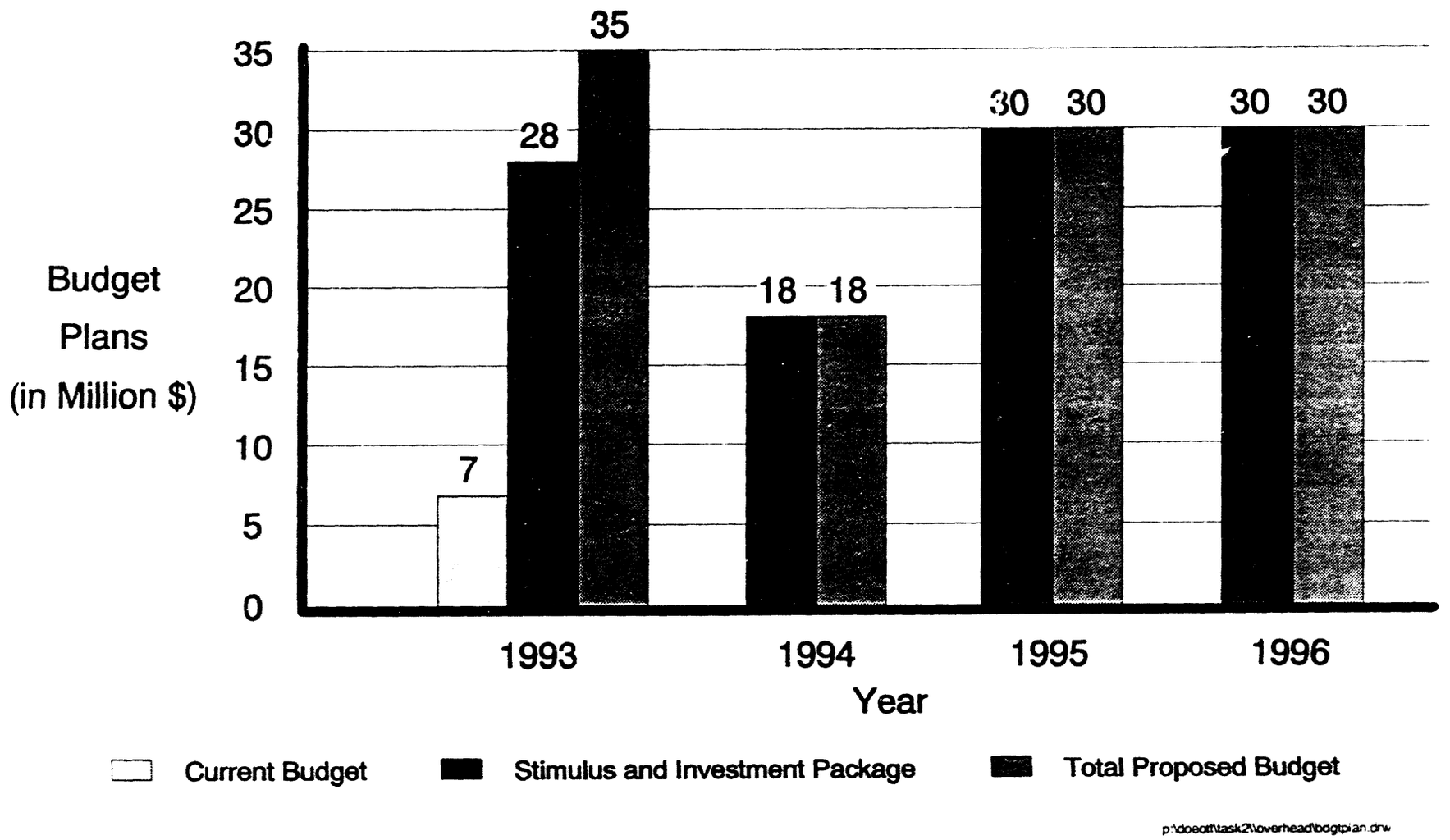
Requirements for Federal Fleet Alternative Fuel Vehicle Acquisition



Budget Plans for Federal Fleet Alternative Fuel Vehicle Acquisition



New Ideas

Three Components of Alternative Fuel Vehicle Marketing

- Concentration
- Concentration
- Concentration

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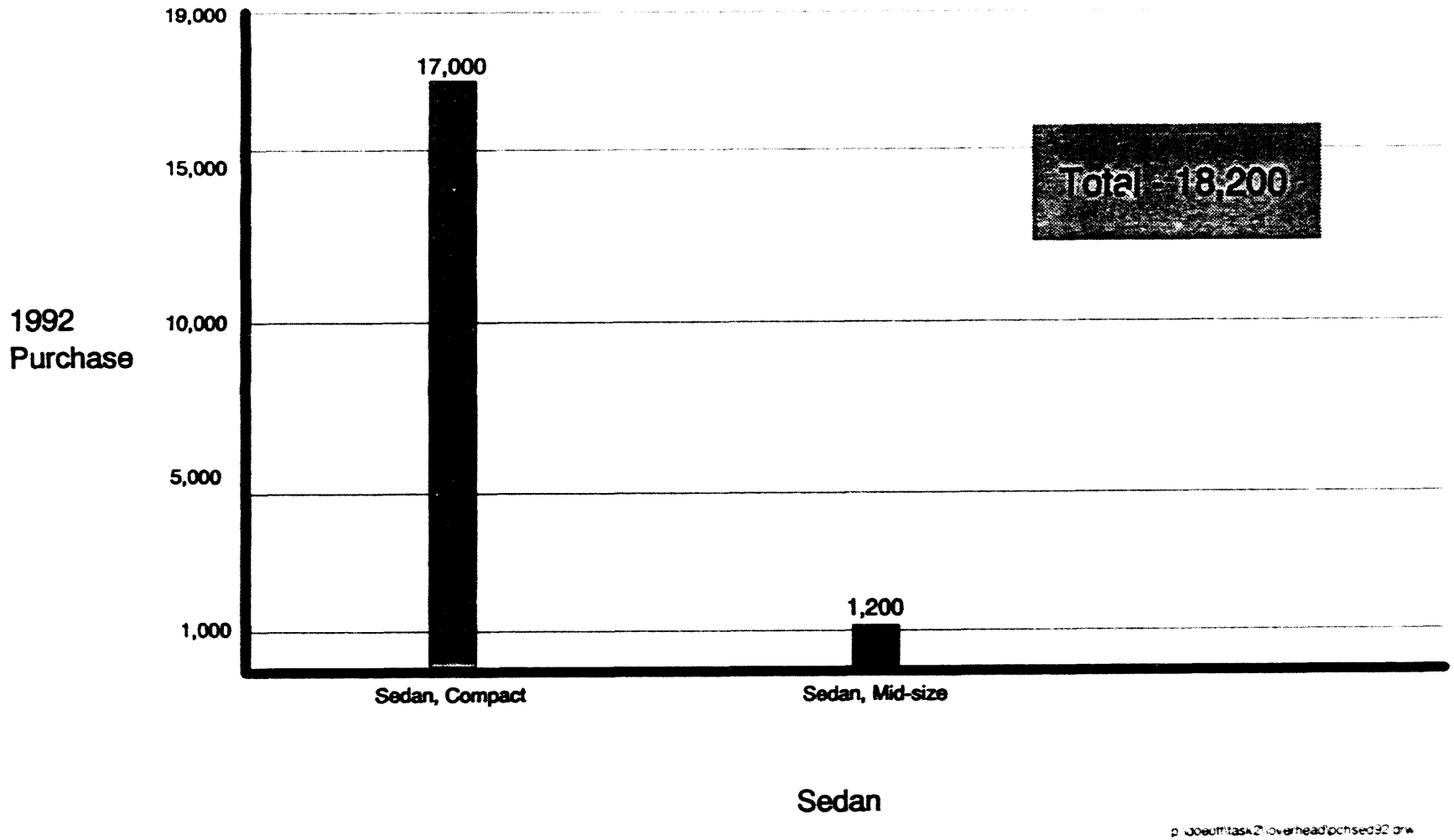
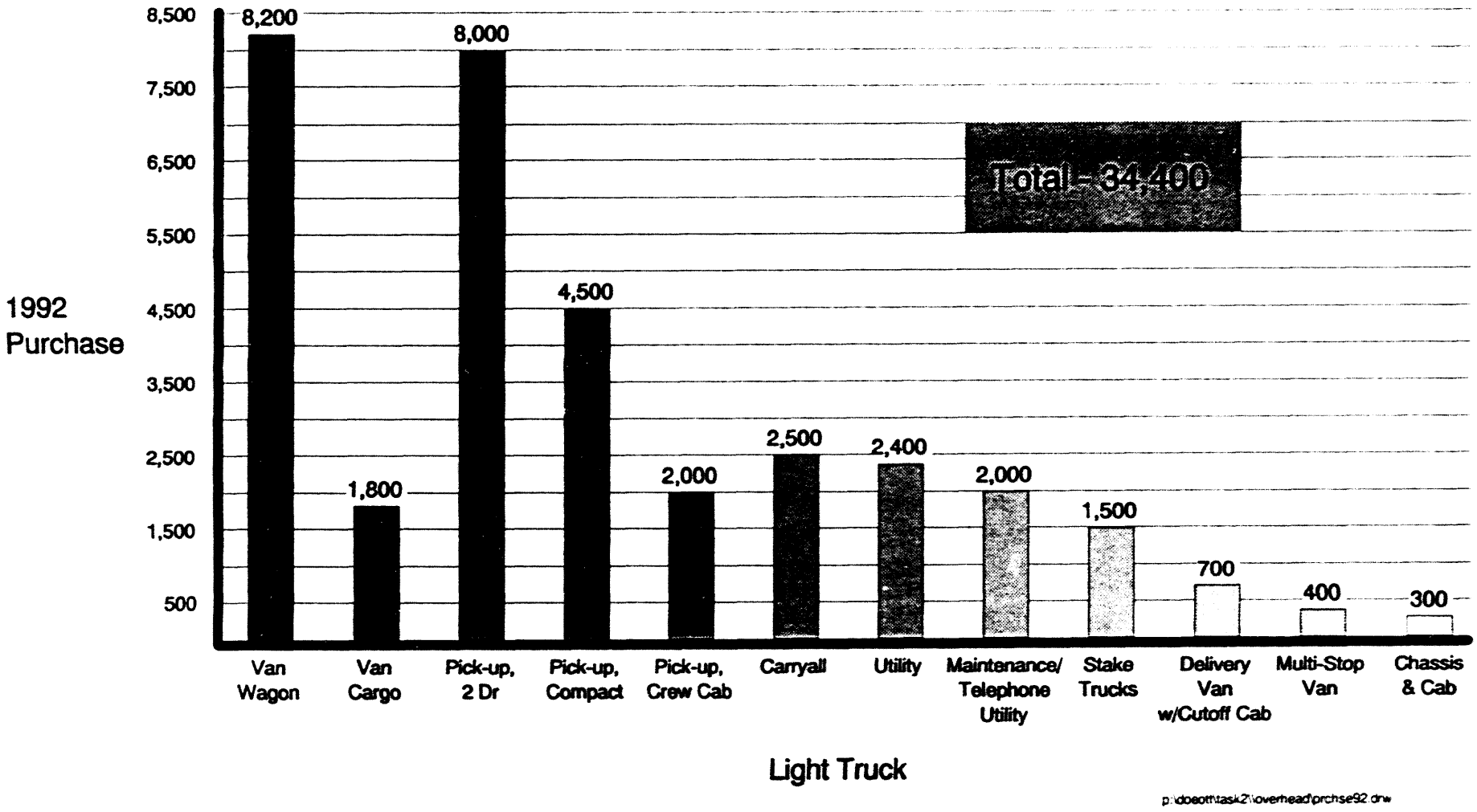
Federal FY 1992 Purchases - Sedans
Overview by Category



Federal FY 1992 Purchases - Light Trucks
Overview by Category



Federal Fleet Alternative Fuel Vehicle Summary
In Operation April 1993

Vehicle Type	Model Year	Fuel	Quantity
Chrysler Van	1991	CNG	2
	1992	CNG	75
Dodge Spirit	1992	M85	2,500
Ford Taurus	1991	M85	40
Ford Econoline Van	1992	M85	20
Chevrolet C-20 Pickup Trucks	1992	CNG	600
GM/Chevy Lumina	1991	M85	25
	1992	E85	24
LLV & Jeep (USPS)	1984 - 1993	CNG	1,075
Total			4,361

Source: GSA-IFMS, USPS, and DOE data

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Federal Fleet Alternative Fuel Vehicle Summary
Estimated FY 1993 Acquisitions
(Includes Postal Service/DOD)

Vehicle Type	Model Year	Fuel	Quantity
Chrysler Van	1993	CNG	100
Dodge Spirit	1993	M85	2,555
Ford Taurus	1993	M85	300
Ford Ecostar Van (USPS)	?	Electric	6
Chevrolet C-20 Pickup Trucks	?	CNG	45
GM/Chevy Lumina	1993 1993	M85 E85	50 50
Conversions (DOE/NREL)	-	CNG LPG	1,800
Conversions (USPS)	-	CNG	1,400
Conversions (ARPA)		CNG	?
Total			6,256

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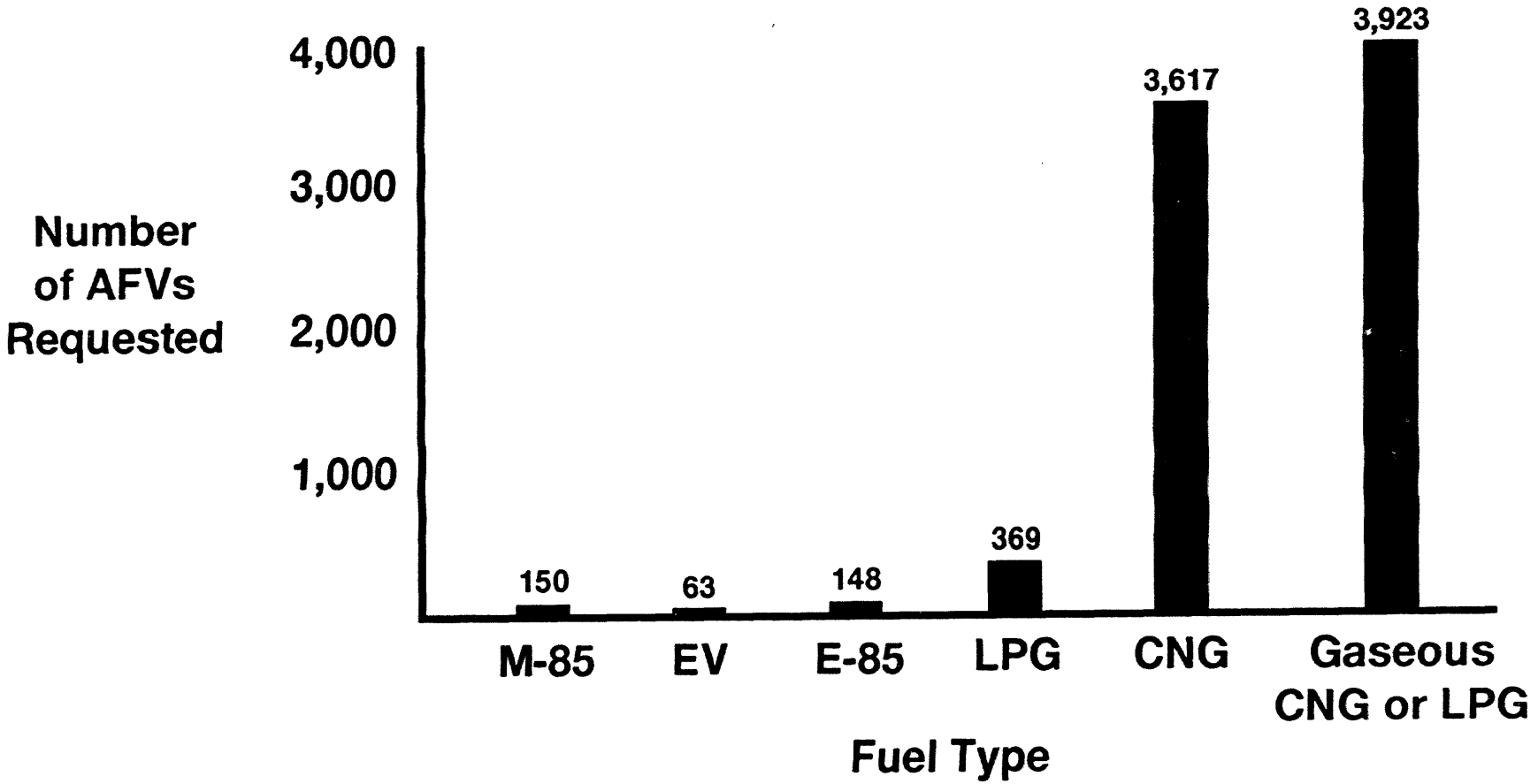
FY93 State Requests for AFVs



SOURCE: DRAFT DOE REPORT

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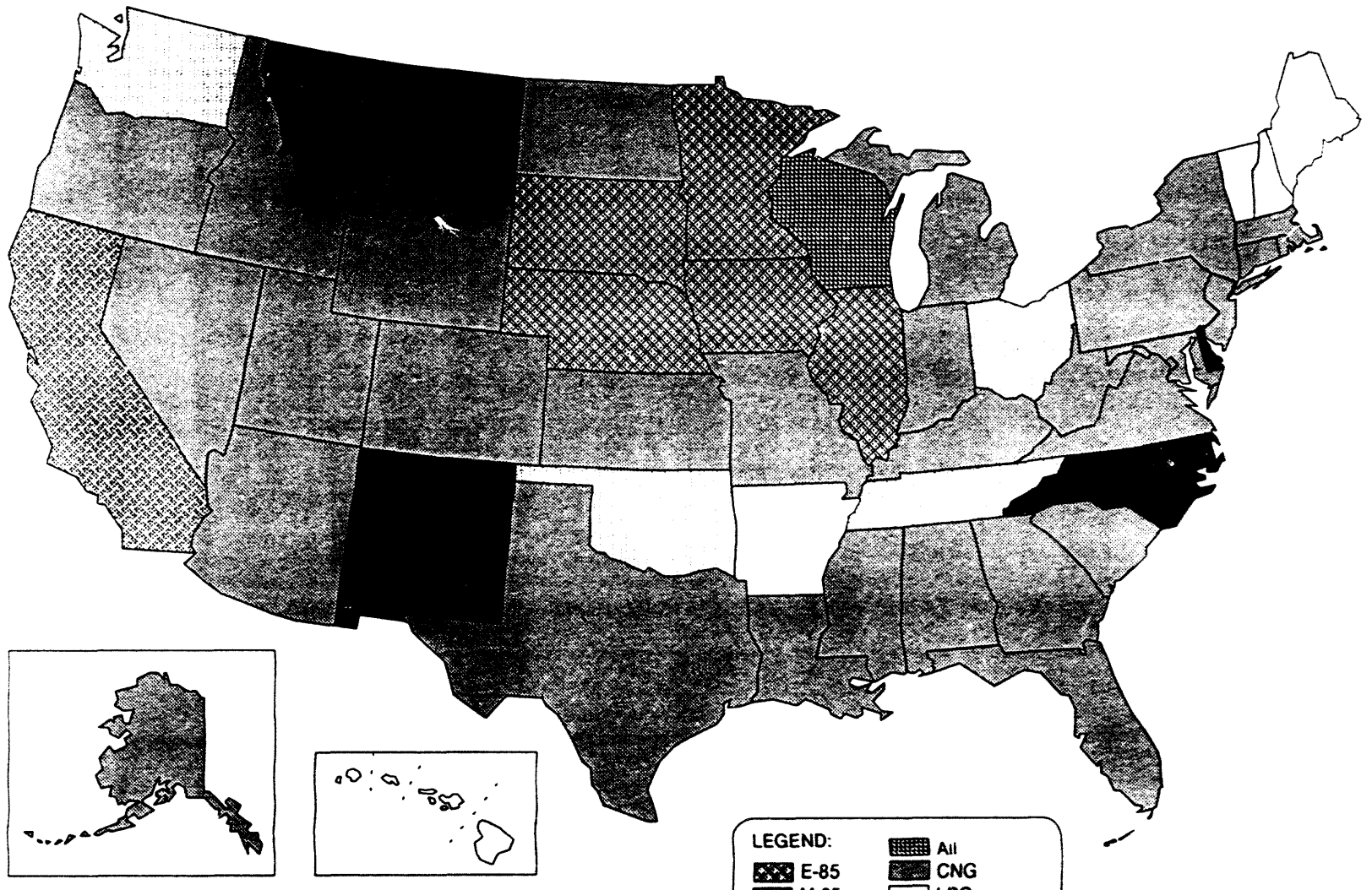
Most Requested Fuel Types



SOURCE: DRAFT DOE REPORT

Top Five Problems/Concerns Expressed by the States

1) Funding the incremental cost of AFVs.

2) Availability of alternative fuels and AFVs.

3) Limited range of dedicated AFVs in large states.

4) Lack of information on alternative fuels and AFVs.

5) Lack of vehicle/facility standardization.

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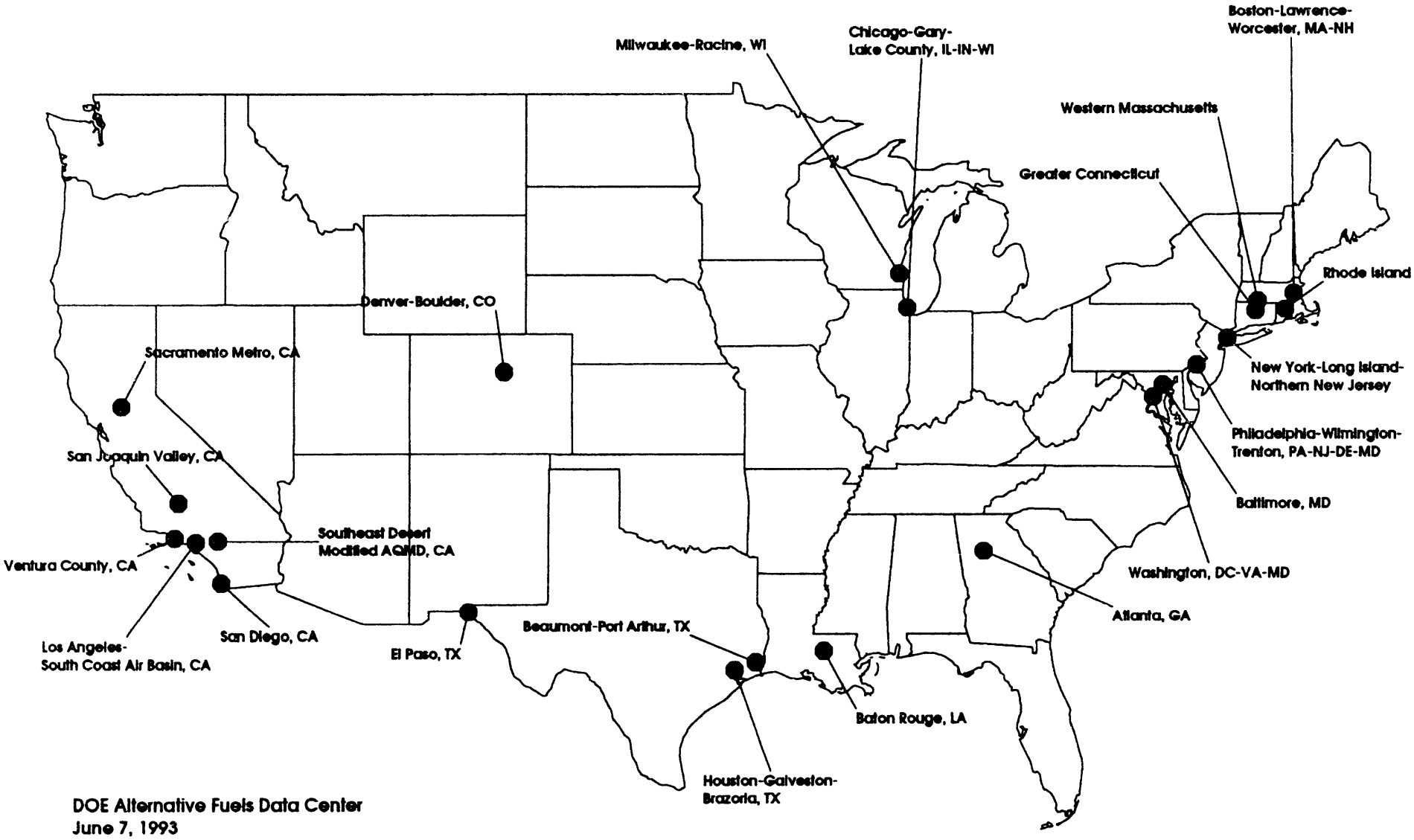
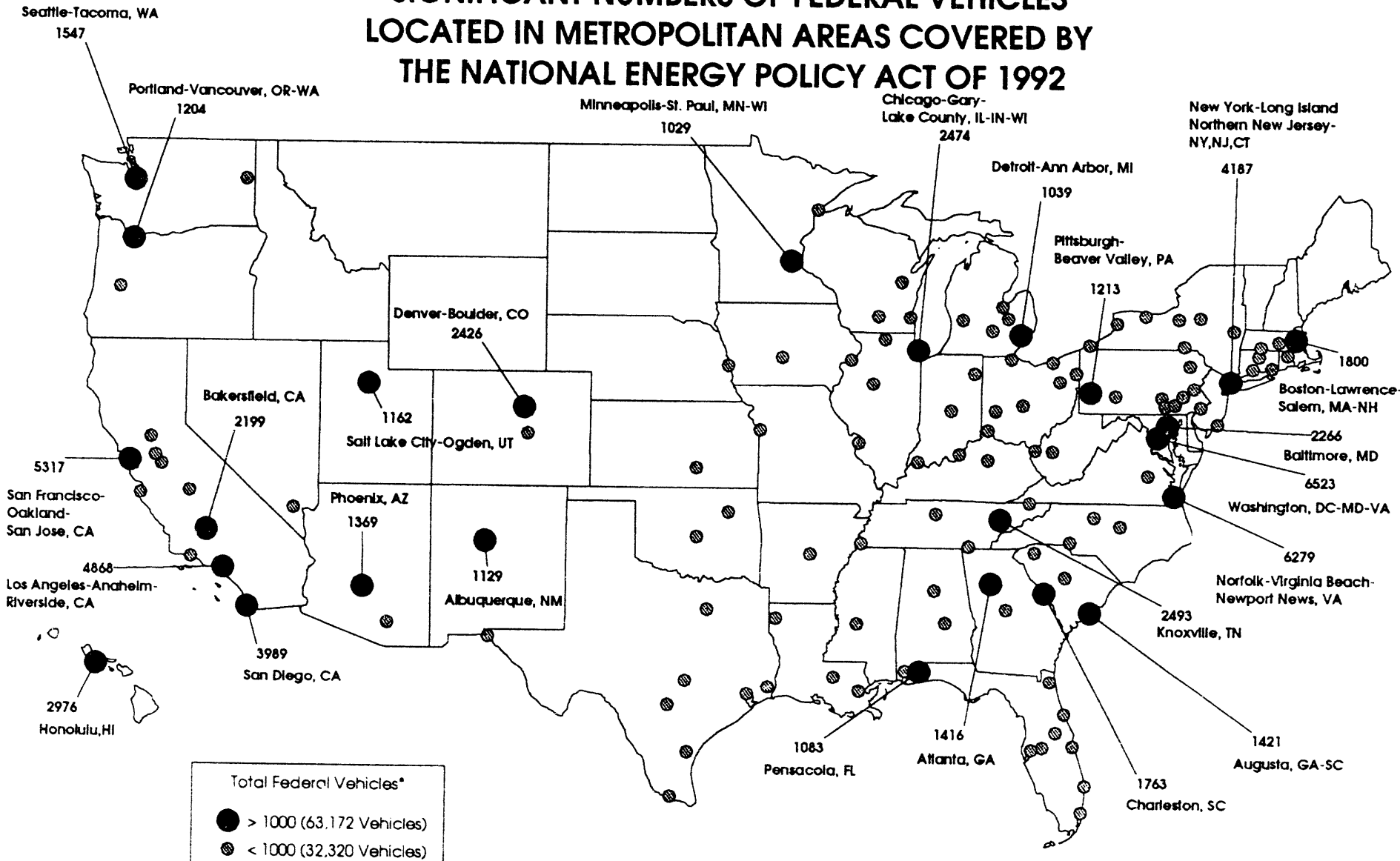
22 Non-Attainment Areas
Covered By The Clean Fuel Fleet Program



DOE Alternative Fuels Data Center
June 7, 1993

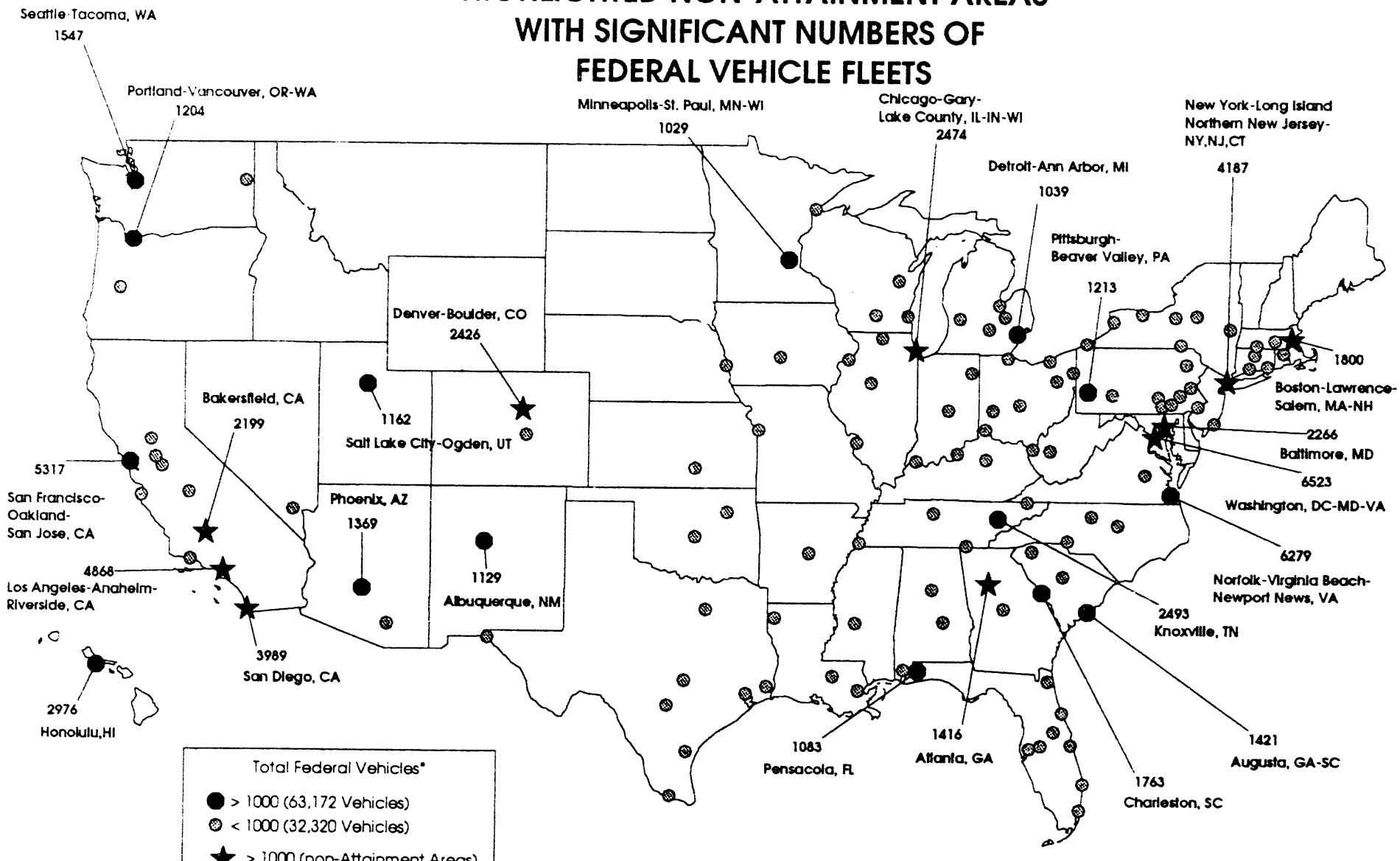
SIGNIFICANT NUMBERS OF FEDERAL VEHICLES LOCATED IN METROPOLITAN AREAS COVERED BY THE NATIONAL ENERGY POLICY ACT OF 1992



*Does not include Post Office and DOD civilian, Air Force and Marine Corps vehicles

DOE Alternative Fuels Data Center
June 7, 1993

HIGHLIGHTED NON-ATTAINMENT AREAS WITH SIGNIFICANT NUMBERS OF FEDERAL VEHICLE FLEETS



*Does not include Post Office and
DOD civilian, Air Force and Marine Corps vehicles

DOE Alternative Fuels Data Center
June 7, 1993

Clean Cities

Clean Cities Program

P120-G1084701

Clean Cities

Purpose

- Concentrate alternative fuel types
- Create "grass roots" market demand
- Promote coordination of city, state, federal, industry

P120-G1084703

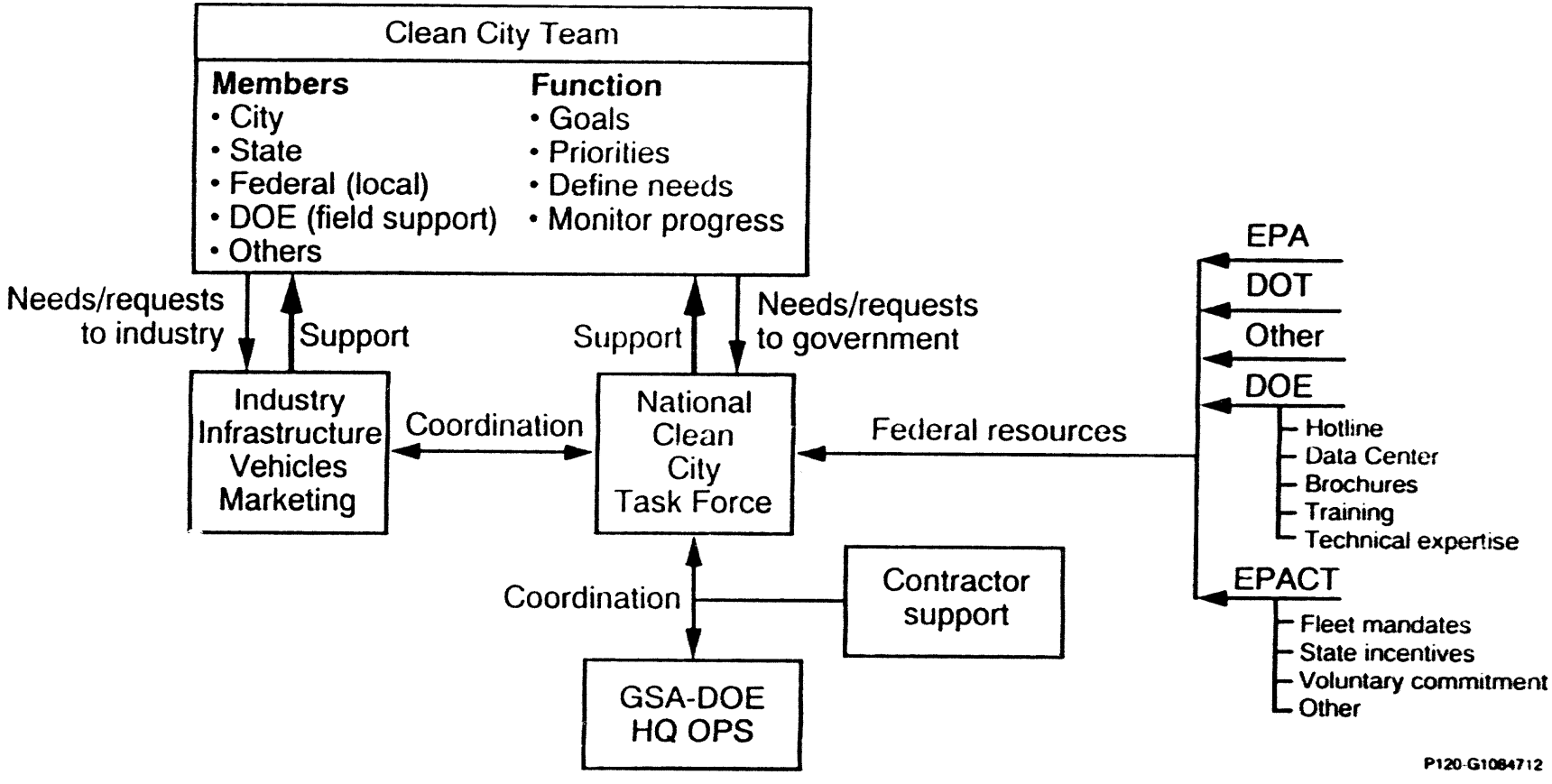
Clean Cities

How Does It Work?

- City makes choice and commitment
- State honors commitment
- Federal agencies (local) honor commitment
- Federal agencies (Headquarters) provide support activities
- Industry meets commercial needs
- Public joins in

Clean Cities

Clean Cities Organization



Clean Cities

Unique Focus

- Grass roots leadership
- "A person" (city) becomes responsible for success
- Partnerships with clear goals and leadership

SUMMARY OF VERBAL COMMENTS OR QUESTIONS AND SPEAKER RESPONSES

POLICY PANEL DISCUSSION: MARKET PLACE IMPLICATIONS IN THE CHANGING WORLD OF MOTOR FUELS
D. Rogers, U.S. Department of Energy

Q. Frederick Potter, IRI: Would you comment on the President's Task Force for fleet conversion?

A. Executive Order 12844 calls for federal fleets to accelerate their acquisition of alternative fuel vehicles beyond the plan in the Energy Policy Act of 1992. It established a task force to help the implementation of the executive order. The appointed chairman is Garry Mauro of the Texas General Land Office, and Dr. Susan Tierney of the Department of Energy is the vice chair. The task force goal is to produce recommendations by August 1, 1993 on how the federal government can maximize development of alternative fuels. The first meeting was in Austin, Texas on June 7, 1993 with members from automobile manufacturers, fuel suppliers, fleet operators, and state and local governments.

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

MARKET PLACE IMPLICATIONS IN THE CHANGING WORLD OF MOTOR FUELS POLICY PANEL DISCUSSION

Panel Moderator: Frederick Potter

POLICY ISSUES FOR ALTERNATIVE FUELS IN CANADA

A.C. Taylor
Energy, Mines & Resources Canada

(Other presentations made during this Panel Discussion are unavailable)

POLICY ISSUES FOR ALTERNATIVE FUELS IN CANADA

A.C. TAYLOR

ENERGY, MINES AND RESOURCES CANADA

NOTES FOR PRESENTATION

WINDSOR WORKSHOP
14 JUNE 1993

WHERE IS CANADA IN ALTERNATIVE FUELS ?

Are we still "ahead of the U.S." in Alternative Fuels ?

. . . . . probably not

This is good news - we need the help

bad news - maybe our approach needs a fresh look

EMR is working with others to

clarify our goals in alternative fuels

examine our policy and activities

NEED FOR A REVIEW

There are several reasons for a review

- technology has changed
- fuel and vehicle markets and regulations are changing
- increased U.S. activity presents opportunities for Canada
- several provincial governments are reviewing policy and activities
- a number of federal ATF programs expire in 1994
- the ATF industry and vehicle manufacturers are seeking clarification of government's commitment to alternative fuels.

SCOPE OF OUR REVIEW

1. Clarifying our Goals

We're learning more about the benefits

- environment
- user costs
- industry opportunities
- fuel markets
- energy security

But the real question is what are we trying to achieve

- different goals bring different roles

eg. how important is
- new technology
- export markets
- factory-produced vehicles
- government fleet use ?

SCOPE OF OUR REVIEW (continued)

2. Examining policies and activities

   Financial support

      fuel taxation
      support to associations
      grants for conversions
      vehicle taxation incentives

   Information

      information to users
      marketing and promotion
      standards
      feasibility studies

   Technology

      longer term research
      technology transfer
      export markets

SCOPE OF OUR REVIEW (continued)

3. Consultation

- some aren't shy
- discussion paper
- informal channels
- formal processes
- plenty of controversy !

HOW HAVE WE BEEN APPROACHING ALTERNATIVE FUELS ?

1. Assist with the development of technology

   - federal R&D
   - contributions to industry
   - demonstration projects

2. Remove market barriers

   - regulatory
   - infrastructure
   - conversion costs
   - fuel supply costs
   - lack of information

3. Let the market develop

WHAT HAS BEEN ACHIEVED WITH THIS ?

British Columbia

NGV

- showcase for NGV development
- fleet and private (light duty vehicles)
- public fueling network
- demonstration of transit buses
- ferries

Propane

- strong fleet auto propane market
- extensive fueling infrastructure

Methanol

- two stations operating
- interest in light duty vehicle demonstration in 1993/94

Hydrogen

- Ballard fuel cell bus

Alberta, Saskatchewan, Manitoba

Propane

- strong auto propane market
  very favourable propane prices
- extensive fueling infrastructure

NGV

- little NGV use except Alberta
- some success in fleet use in Alberta
- transit bus demo planned for
  Edmonton and Calgary
- development of composite on-board
  NGV cylinder in Alberta

Methanol

- one station operating in Calgary
- interest in light duty vehicle
  demonstration in 1993/94
- transit buses in Medicine Hat

Ethanol

- production and marketing (as a blend)
  in Saskatchewan and Manitoba

Ontario

Propane

- strong auto propane market
- extensive fueling infrastructure
- factory production of vans and/or pickups is a possibility

NGV

- good light duty market, esp. in S.W.
- over 50 public stations, private as well
- 1000 VRAs, with production in Toronto
- production of NGV vans in Windsor
- over 50 transit buses in operation
- bus production with export potential
- production of steel cylinders

Methanol

- one station in Toronto, another soon
- several makes of vehicles produced
- vehicle demo through car rentals
- interest in light duty vehicle demonstration in 1993/94
- transit bus demo in Windsor

Ontario (continued)

Ethanol

- one plant with production increasing
- considerable interest in other plants
- successful marketing of blends

Electric Vehicles

- development work and production of a test quantity of vans in Windsor
- battery development in Toronto

Quebec

Propane

- some propane vehicle activity
- reasonable fueling infrastructure

NGV

- was an original leader in public fueling
- reasonably loyal vehicle market
- focus has moved from public to private fueling in recent years

Atlantic Canada

Propane

- very limited use of propane vehicles owing to high fuel cost
- market demonstration underway in Newfoundland, to address barriers
- potential in Maritimes under study

Summary for Canada

- considerable interest in ATF
- considerable R&D activity
- opportunities for ATF use and ATF equipment
- different patterns by region
- growth is slow - it's a hard sell
- success stems from cheap fuel, and in some cases, strong gov't support

SHOULD GOVERNMENT DO MORE TO HELP ?

.... some observations

1. Might not be much more activity without gov't action
   - demand for factory vehicles
   - will OEM production continue in Canada?
   - infrastructure growth
   - trade opportunities

2. What could governments do?
   - push on fleets, consumers (demos?)
   - buy vehicles for own fleets
   - fueling infrastructure
   - technology

WHAT ARE OUR OPTIONS FOR FURTHER ACTION ?

broad regulation of fleets or fueling not likely

more aggressive subsidies unlikely
- fuels
- fueling infrastructure
- developing technologies
- vehicles and conversions

could increase information programs

be a broker in the market place
(strategic alliances)

convert government fleets

longer term R&D commitments

project-oriented activity

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

MARKET PLACE IMPLICATIONS IN THE CHANGING WORLD OF MOTOR FUELS POLICY PANEL DISCUSSION

Panel Moderator: Frederick Potter

INTERMINISTERIAL COMMITTEE ON CLEAN TRANSPORTATION FUELS

M.D. Harmelink
Ministry of Transportation of Ontario

INTERMINISTERIAL COMMITTEE ON CLEAN TRANSPORTATION FUELS

Co-chaired by
M.D. Harmelink, MTO / B. Beale MOEE

Presented to the
1993 Windsor Workshop
On Alternative Fuels

M.D. Harmelink
Director

ONTARIO

Ministry of Transportation

Transportation Technology and Energy Branch

June 14, 1993

Mission

- Develop government policy options and strategy options to guide the development and use of clean fuels for transportation
- Coordinate clean fuels activities among provincial ministries

TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

Objectives

- Assess the potential of clean fuels and develop associated policy options and measures to address:
  - Air quality
  - Health and safety
  - Energy security
  - Transportation efficiency/effectiveness
  - Ontario industry opportunities
- Determine role of and potential for reformulated gasoline/diesel fuel, commercial alternative fuels and advanced technologies

TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

Clean Fuels

- Modified existing fuels
  - Reformulated gasoline and diesel
- Commercial ATF's
  - Natural gas
  - Propane
  - Methanol
  - Ethanol
- Energy technologies
  - Electricity
  - Hydrogen

TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

WORK GROUPS

• WG-1 Vehicle Emissions	MTO/MOEE
• WG-2 Air Quality Analysis	MOEE
• WG-3 Health and Safety	MOL/MCCR
• WG-4 Technology Review	MTO
• WG-5 Industry Analysis	MOEE/MEDT
• WG-6 Market Analysis	MOEE

TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

WG-1 Vehicle Emissions

- Initial emission inventories for gasoline
- 5%, 10% , and 16% penetration by each clean fuel by 2010 in combination with gasoline
- 5% ,10% and 16% penetration by a generic clean fuel in combination with reformulated gasoline in the year 2010

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WG-2 Air Quality Analysis

- Run ADOM model to establish baseline air quality estimates
- Run ADOM model for 16% penetration by a generic clean fuel in combination with reformulated gasoline in the year 2010
- Work with canyon models to predict local impacts of clean fuels and reformulated gasoline

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WG-3 Health and Safety

- Review of toxicity characteristics of conventional gasoline and clean fuels
- Toxicity on workers and public to be assessed
- Concerned with aldehydes, benzene and other toxics

TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

WG-4 Vehicle Technology Review

- Assess impacts of new car emission standards on benefits of clean fuels
- Assess possible impact of new fuel economy standards
- Review potential of new and emerging technology with respect to emissions and fuel economy

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WG-5 Industry Analysis

- Assess impacts of gasoline reformulation on petroleum refiners
- Assess impacts of clean fuels on refineries
- Assess industrial opportunities associated with clean fuels

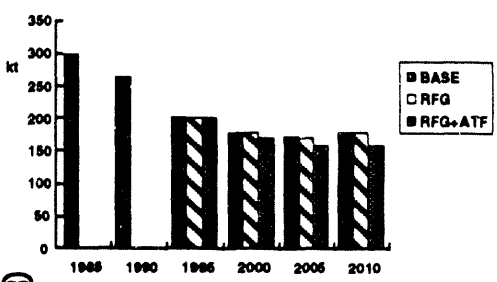
TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

WG-6 Market Analysis

- Review potential for clean fuels in a number of transportation sectors
- Assess the need for market incentives
- Assess government role in promotion of clean fuels

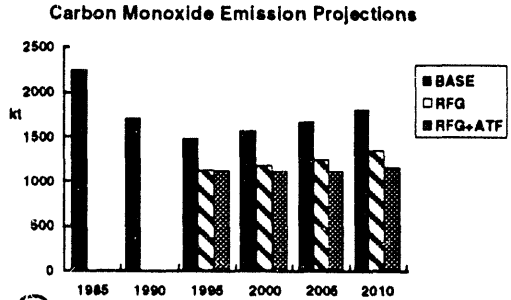
TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

Projected NOx Emissions



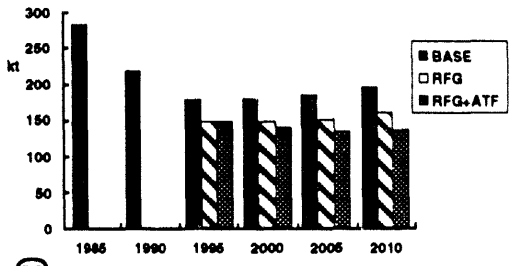
TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

Carbon Monoxide Emission Projections



TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

Projected Hydrocarbon Emissions



TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

Preliminary findings

- Emissions from on-road vehicles will begin to increase after 1995
- Clean fuels can significantly reduce vehicle emissions in Ontario

TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

Issues

- What are the most appropriate means for reducing emissions from on-road vehicles?
- What are the roles of reformulated gasoline and diesel fuel?
- What is the role of commercial alternative fuels?
- What is the appropriate reformulated gasoline recipe for Ontario?

TRANSPORTATION TECHNOLOGY & ENERGY BRANCH

SUMMARY OF VERBAL COMMENTS OR QUESTIONS AND SPEAKER RESPONSES

POLICY PANEL DISCUSSION: MARKET PLACE IMPLICATIONS IN THE CHANGING WORLD OF MOTOR FUELS
M. Harmelink, Ministry of Transportation of Ontario

Q. What reformulated gasoline quality is expected in Ontario?

A. The essential factors will include reduced sulfur content, Reid vapor pressure of 9.5 psi in summer, and oxygenates to provide 2.1 weight percent oxygen.

SUMMARY OF VERBAL COMMENTS OR QUESTIONS AND SPEAKER RESPONSES

POLICY PANEL DISCUSSION:
MARKET PLACE IMPLICATIONS IN THE CHANGING WORLD OF MOTOR FUELS
B. McNutt, U.S. Department of Energy

(Presentation unavailable at time of printing)

Q. Frederick Potter, IRI: Can you comment on trading credits for alternative fuel vehicles that may go below the allowable emission levels?

A I believe that emission results from future vehicles in service may exceed expectations, but the economic benefits for that performance is difficult to assess.

A David Rogers, U.S. Department of Energy: To add to Barry McNutt's reply, there is a concept called ILEV or inherently low emission vehicle. It would meet LEV exhaust emission standards and would have essentially zero evaporative emissions. Vehicles using compressed natural gas or M100 methanol conceivably could meet these standards, and would be eligible for credits under the clean fuel fleet program.

SESSION 1: AVAILABILITY OF ALTERNATIVE FUELED ENGINES AND VEHICLES

Chair: Ron Bright, Ford Motor Company

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

CATERPILLAR'S VIEW OF ALTERNATIVE FUELED MOBILE ENGINES

J.M. Headean
Caterpillar Inc.

Agenda

- Introduction
- Heavy Duty Markets
- Technology Options
  - Fuel Type
  - Engine Technology
- Caterpillar's Technology Selections
- G3306 Mobile Engine
  - Specifications
  - Hardware/Features
  - Performance
  - Product Status
- Summary

Heavy Duty Markets

- Transit Bus
- Refuse Haulers
- Pickup & Delivery
- Line Haul

Technology Options

- Fuel Type
  - CNG
  - LNG
  - HD5
  - Others

Technology Options

- Engine Technology
  - Stoichiometric w/ 3-Way Catalyst
  - Lean Burn w/ Oxidizing Catalyst
  - Dual Fuel (Diesel Pilot)
  - Direct Gas Injection

Caterpillar's Technology Selections

- Factors
  - Current Markets Primarily Intracity
  - Start/Stop Application
  - CNG/LNG/HD5 Regional Opportunity
- Product
  - G3306 Stoichiometric w/ 3-Way Catalyst
    - Lowest Emissions
    - Responsive
    - Fuel Adaptable

G3306 Mobile Engine Specifications

In-line 6, Spark Ignited, 4-Cycle, Turbocharged, Aftercooled

Displacement	638 in^3 (10.5 liter)
Compression Ratio	10.5:1 CNG/LNG
	8.0:1 HD5
Power Rating @ 2100 rpm	250 hp CNG/LNG
	235 hp HD5
Peak Torque @ 1200 rpm	850 lb-ft CNG/LNG
	820 lb-ft HD5

G3306 Mobile New Content

- Center Mount Exhaust Manifold
- Mobile Camshaft
- Altronic DISN Ignition
- Woodward Min/Max Governor
- Deltec A/F Control
- Interface Electronics
- 3-Way Catalyst
- Mobile Gas Regulators
- ATAAC Connections

G3306 Mobile Special Features

- CNG/LNG/LPG Capability
- Low LNG Pressure Capability
  - 25 to 50 psi Operation
- Fuel Tolerance
  - Closed Loop A/F Control
  - Compensates for Seasonal Fuel Changes
  - Compensates for Geographical Fuel Differences
  - Reduces Possibility of Overfueling/Overpowering

G3306 Mobile Engine Emissions
First Transient Cycle Test

	1994 CARB	EPA Cycle	Steady State
NOx	5.0	2.5	0.4
NMHC	1.2	-	-
THC	-	6.7	0.1
CO	15.5	3.5	0.03
PM	0.1	0.02	-

All Units g/bhp-hr

G3306 Mobile Performance Improvements

- Schwitzer S2 Turbocharger
- Woodward Digital Min/Max Governor
- Optimized A/F Response
- Improved Gas Regulator Response
- Added Pre-Catalyst

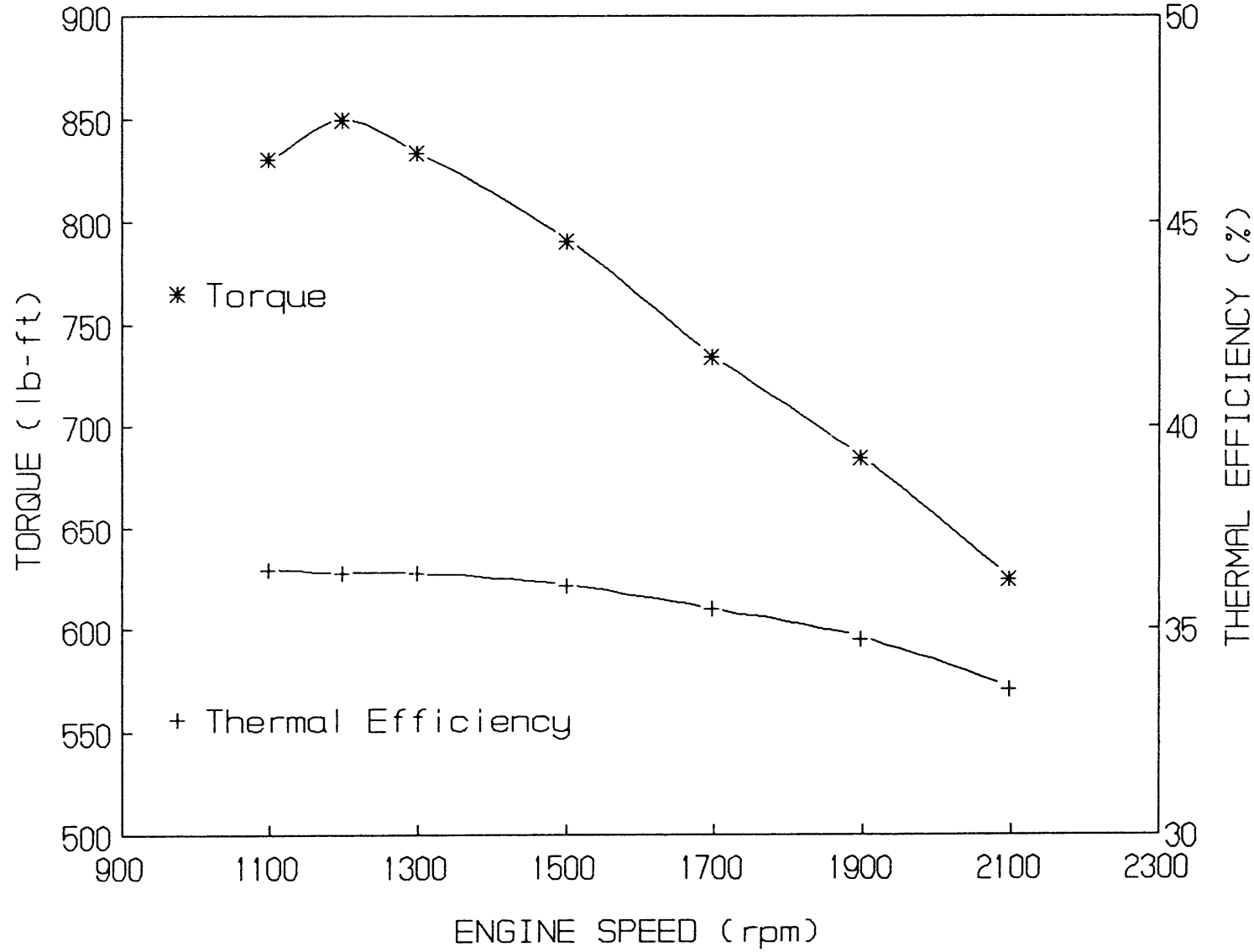
G3306 Mobile Engine Emissions
1993 CARB Certification Test

	1994 CARB	EPA Cycle
NOx	5.0	0.51
NMHC	1.2	0.19
THC	-	-
CO	15.5	4.63
PM	0.1	0.02

All Units g/bhp-hr

G3306 MOBILE ENGINE PERFORMANCE

TORQUE & THERMAL EFFICIENCY



G3306 Mobile Product Status

- 3 Units in Service
  - 2 HD5
  - 1 LNG
- 10 Pilot Units Built for 1993 Delivery
- CARB Certification Testing Complete November 1993
- Planned Production February 1994

Summary

- Heavy Duty Markets Evolving
- CNG/LNG/HD5 Capability Desirable
- Stoichiometric w/ 3-Way Catalyst
  - Robust Technology for Current Markets and Fuels
- G3306 Mobile Engine Developed
  - CARB Certification Underway
  - Optimized Emissions
  - Good Driveability
  - Fuel Flexible
  - Fuel Variation Tolerant
  - Proven Technology

SUMMARY OF VERBAL COMMENTS OR QUESTIONS AND SPEAKER RESPONSES

CATERPILLAR'S VIEW OF ALTERNATIVE FUELED MOBILE ENGINES
J.M. Headean, Caterpillar Inc.

Q. Mostafa Kamel, Cummins Engine Co.: Why was stoichiometric operation chosen for the engine design?

A. We felt that the stoichiometric design offered more flexibility for the stop-and-cooperation and was more suitable for low NOx emissions in inner city use. We also have lean burn engines being developed for long haul applications where higher NO_x emissions are allowed and fuel economy is more important.

Q. James Grieve, Consultant: How does the durability compare for similar engines operated on diesel fuel, propane, and natural gas?

A. These engines are derived from our diesel engines and use the same components. Since the cylinder pressures are lower for propane and natural gas, the engines are not stressed as much and durability is excellent.

Q. Matthew Bol, Sypher:Mueller International: Can you tell us the cost of these engine compared to diesel?

A. I am mainly concerned with engineering and am not prepared to talk about cost.

Q. Anonymous : Can you give the fuel flow rate for these engines?

A. Fuel flow is about 7,500 BTU per horsepower-hour at rated speed and about 6,900 BTU per horsepower-hour at peak torque.

Q. Ron Bright, Ford Motor Co. of Canada: How would you rate customer interest in this engine?

A. Currently there is more demand than supply, both for the product and for information from potential users.

Q. Anonymous; What can you tell us about the catalyst formulation?

A. One of our few proprietary items is catalyst technology. We are developing the stoichiometric three-way catalyst with the supplier, and technology is still evolving.

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

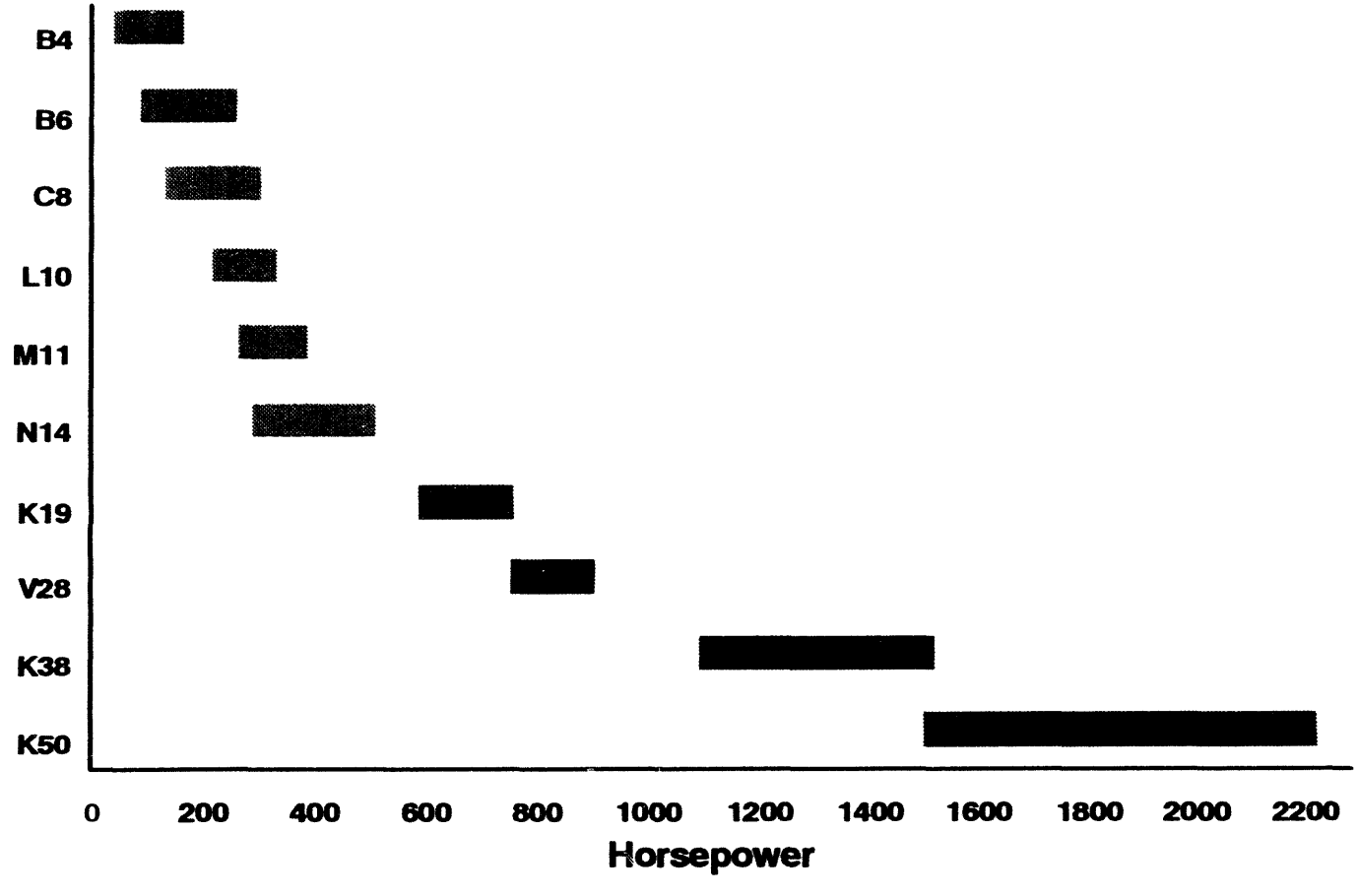
CUMMINS NATURAL GAS ENGINE PROGRAMS L10 G ENGINE UPDATE

V.K. Duggal
Cummins Engine Co. Inc.

Outline

- Cummins Product Line
- Natural Gas Engine Programs
- Technology and Product Evolution
- L10G Status
  - CARB Certification
  - Field Experiences
  - LNG Application
  - Current and Upcoming Developments
- Summary

Cummins Current Product Line



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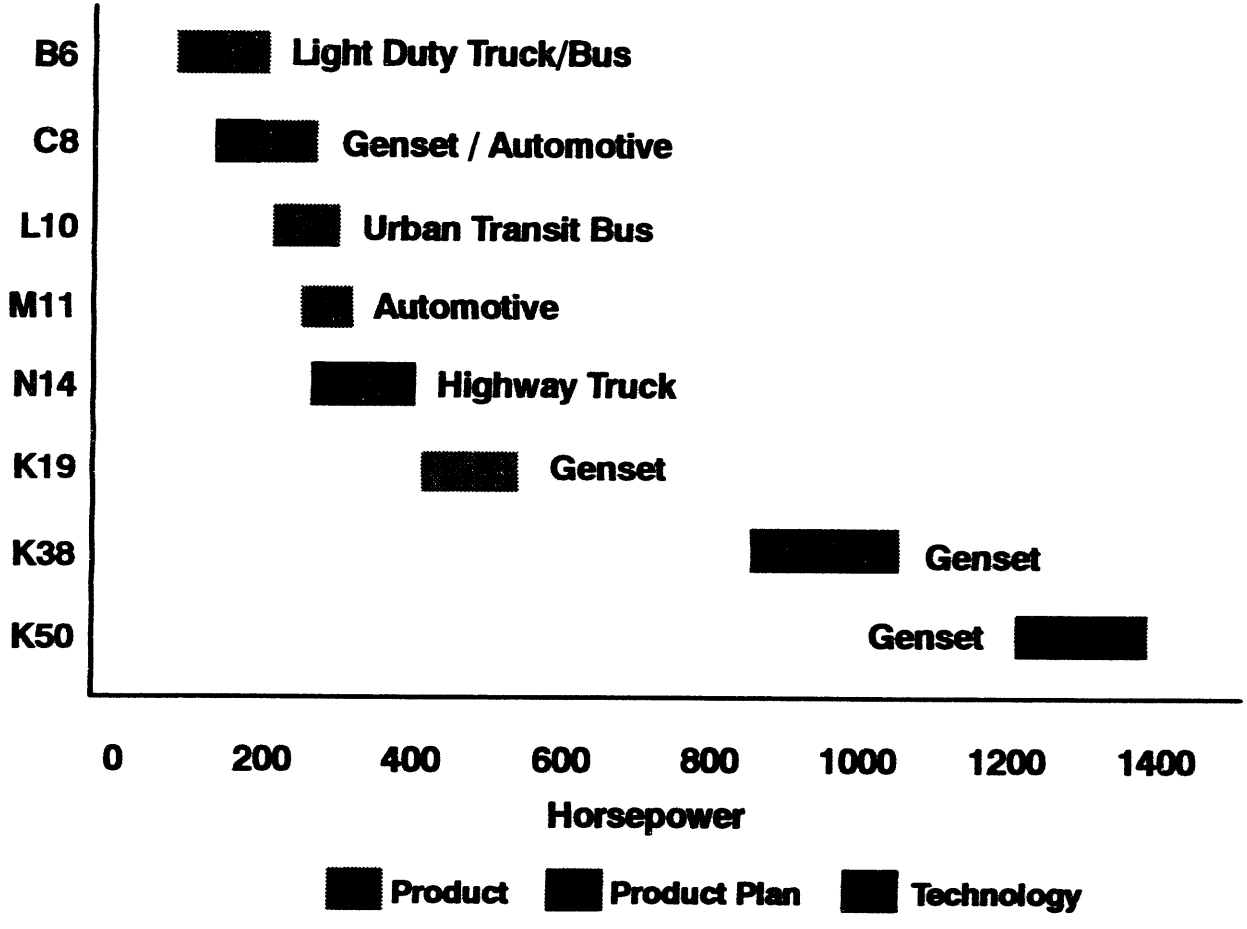
Cummins SI Gas Engines
Product and Technology Programs



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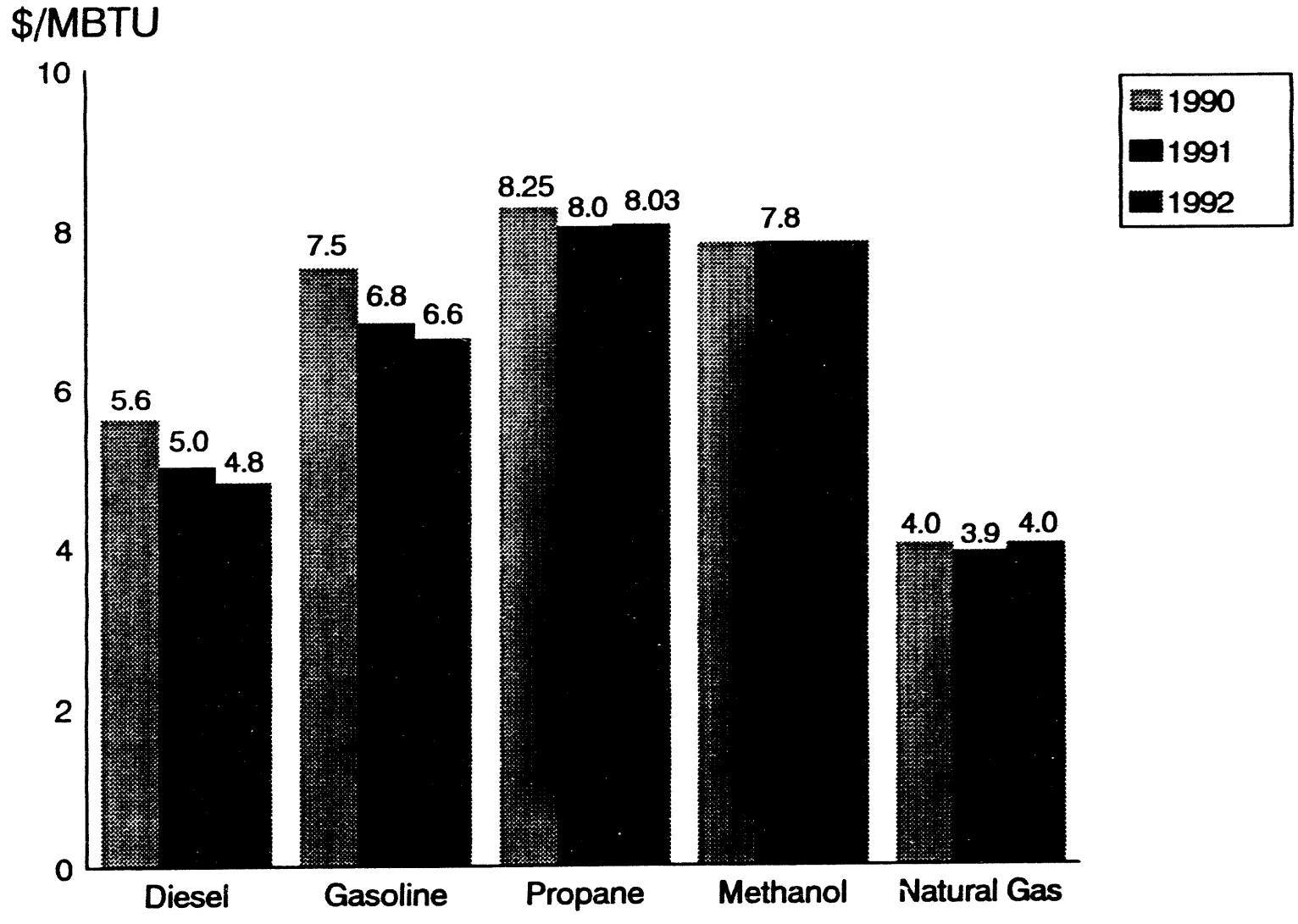
Average Refiners Prices (Without Taxes)



Monthly Energy Review - DOE

93214-4

Technology and Product Evolution

- Current product
  - S.I. natural gas
  - Take advantage of high octane properties, broader combustion limits
  - Implemented lean combustion concept
  - Mechanical systems with limited electronic controls
  - Adapt available subsystems
    - ▸Inherent limitations
  - Optimum NOx particulates trade-off
  - Less cost sensitivity

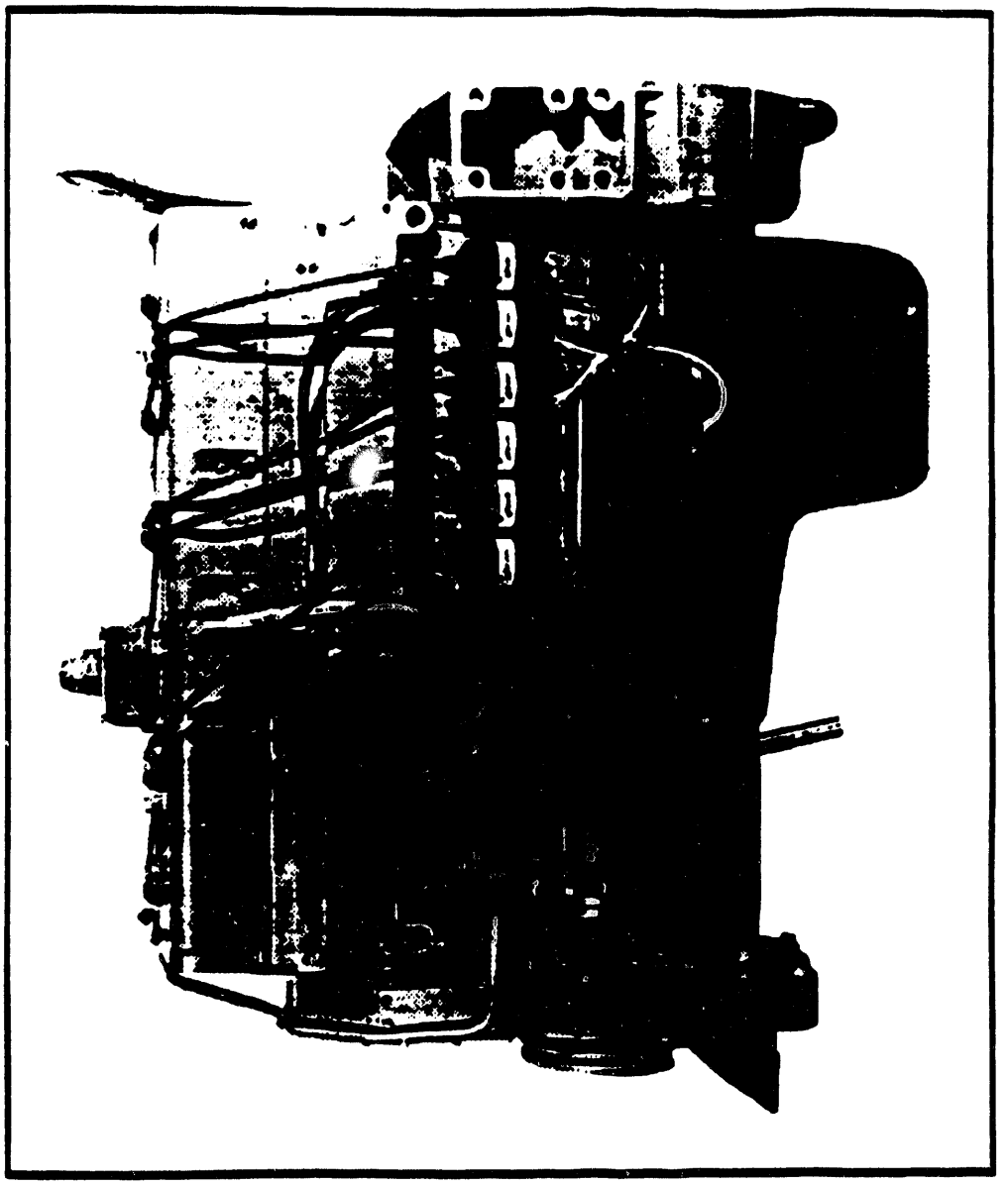
Technology and Product Evolution (Cont'd)

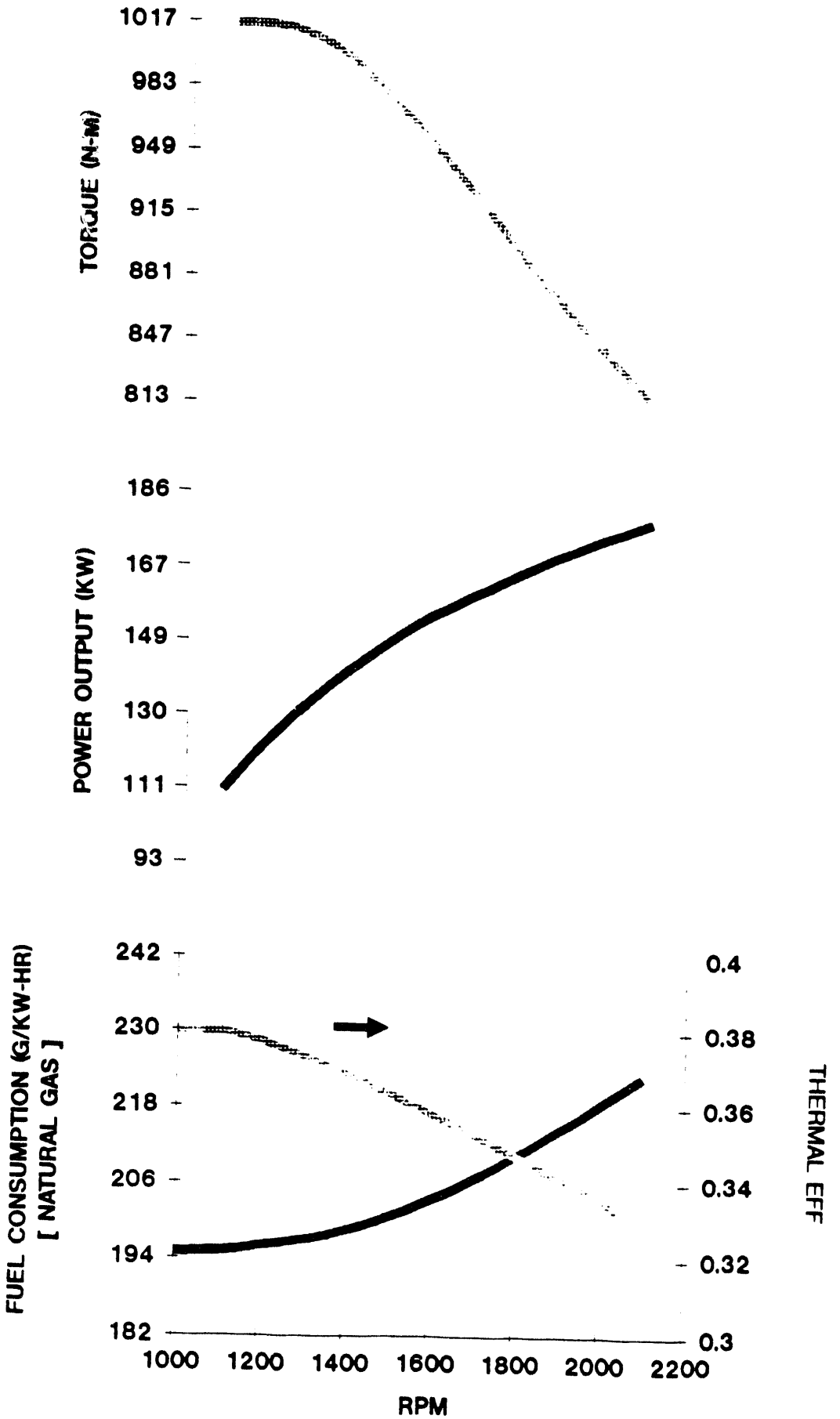
- Next generation product
  - Concept solidified (use across engine families)
  - Integral electronic controls
  - Rationalize subsystem function
  - Design/procure to meet spec
  - Commonalty of subsystems/parts
  - ULEV emission target
  - Cost effective

Current Engine Spec.

Power	**240 HP**
Torque	**850 FT-LBS**
Transmission	**Automatic**
Engine Cooling	**Water-cooled (city bus specific)**
F/A/Mixing	**Mechanical**
Engine Control	**Limited, non-integral**

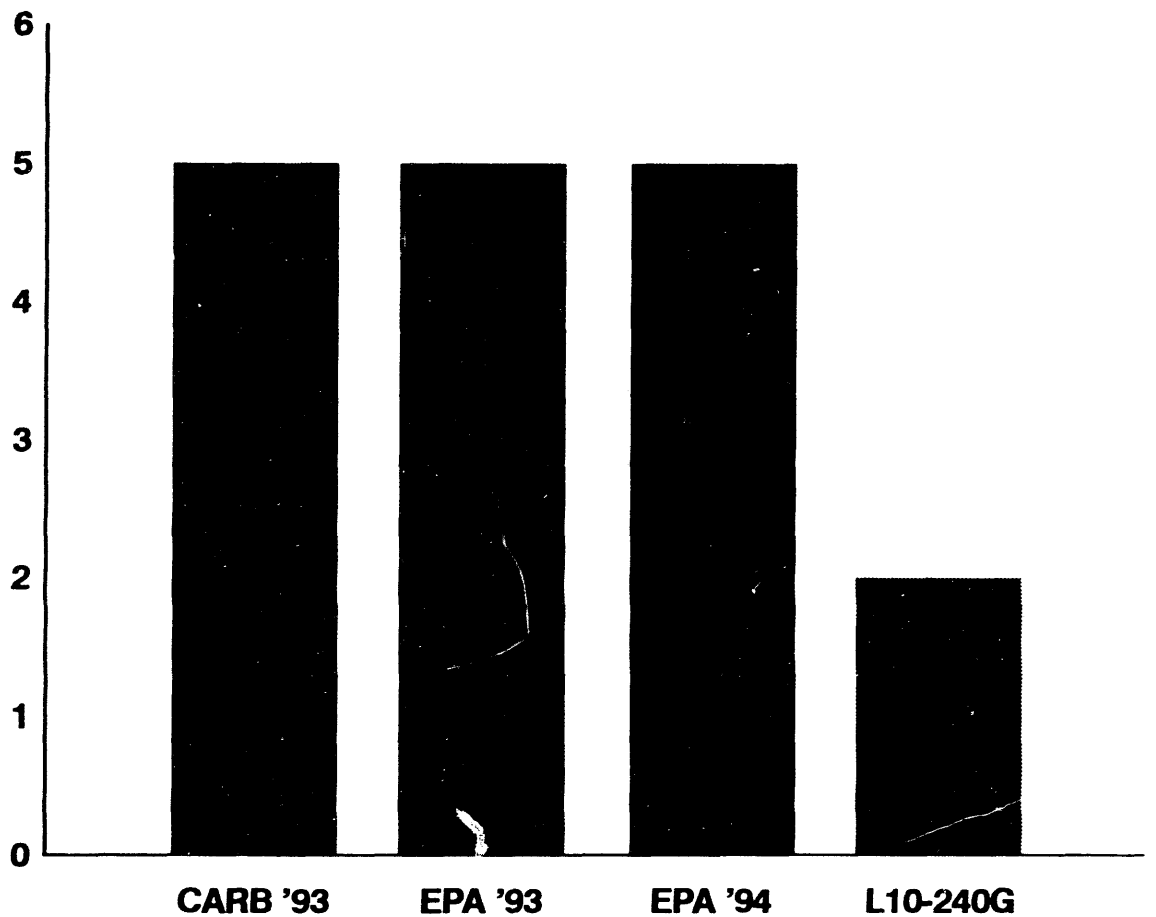
L10-240G




1017
983
949
915
881
847
813
TORQUE (N-M)
186
167
149
130
111
93
POWER OUTPUT (KW)
242
230
218
206
194
182
FUEL CONSUMPTION (G/KW-HR)
[NATURAL GAS]
0.4
0.38
0.36
0.34
0.32
0.3
THERMAL EFF
1000
1200
1400
1600
1800
2000
2200
RPM

548d22

L10-240G NOx Emissions vs. CARB/EPA Standards



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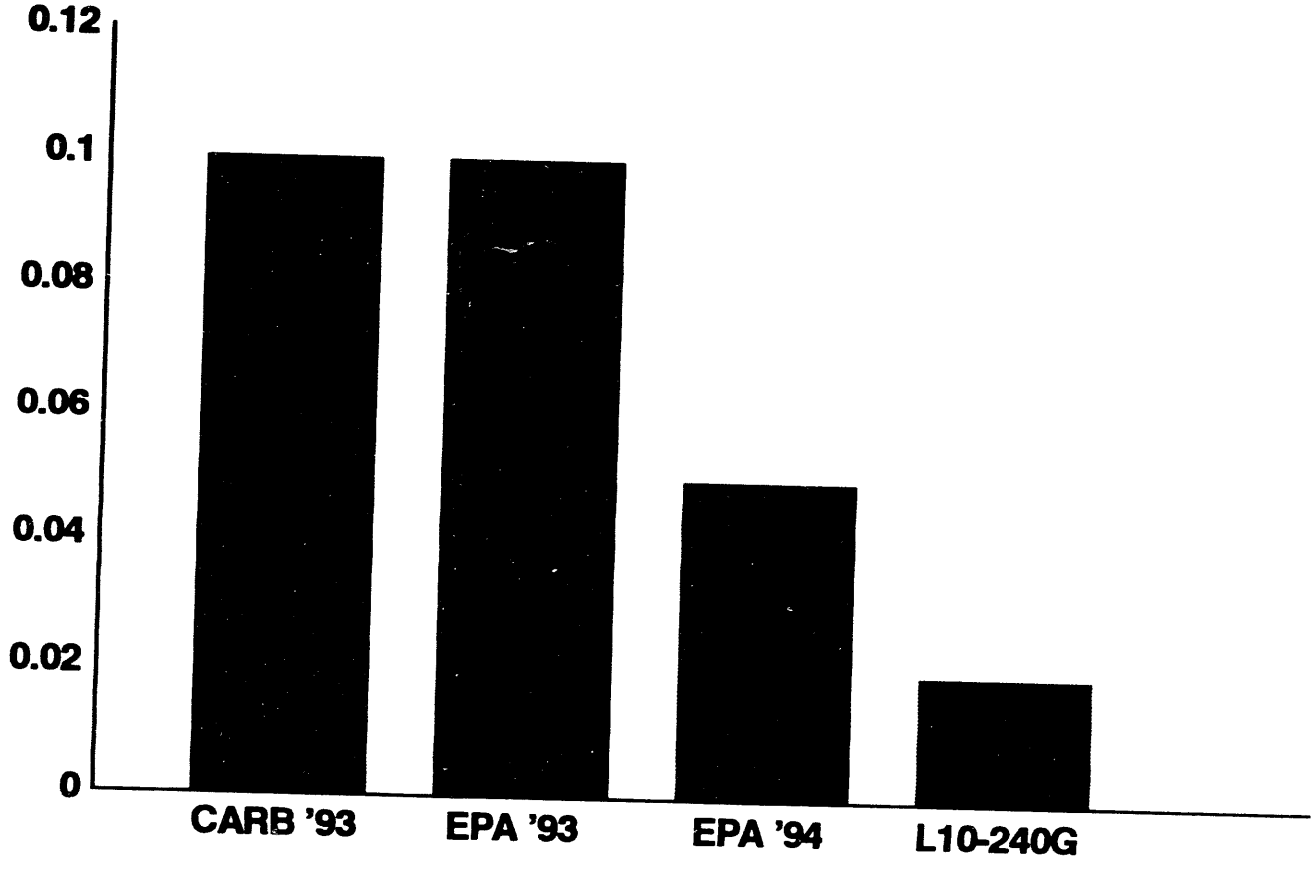
L10-240G Particulate Emissions vs. CARB/EPA Standards



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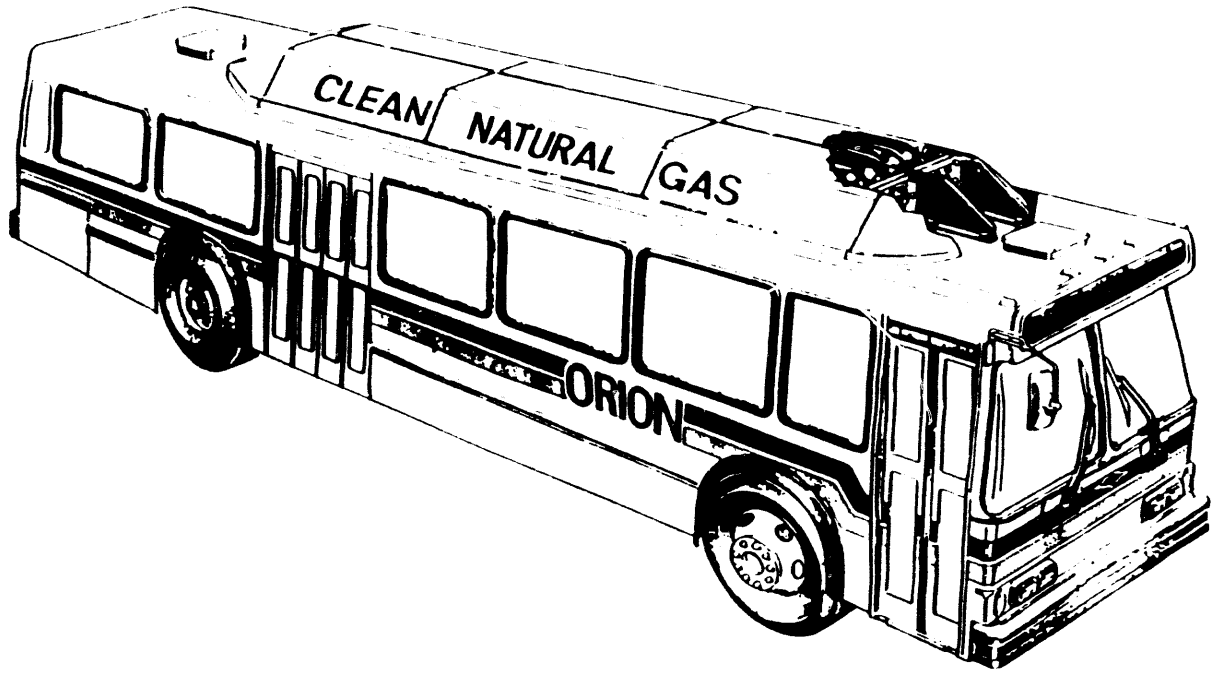
CNG L10 Engine Emissions Cert. Data

(g/bhp-hr)

	1993 CARB Diesel NG Standards	CNG L10 Design Goals	Sacramento Requirement	CARB Certification
NOx	5.0	4.5	2.5	2.0
PM	0.1	0.06	.06	0.02
HC	1.3	0.9	.9	-
NMHC	1.2	-	<1.2	0.6
CO	15.5	4.0		0.4

* Includes DF to 290,000 miles

93283s07

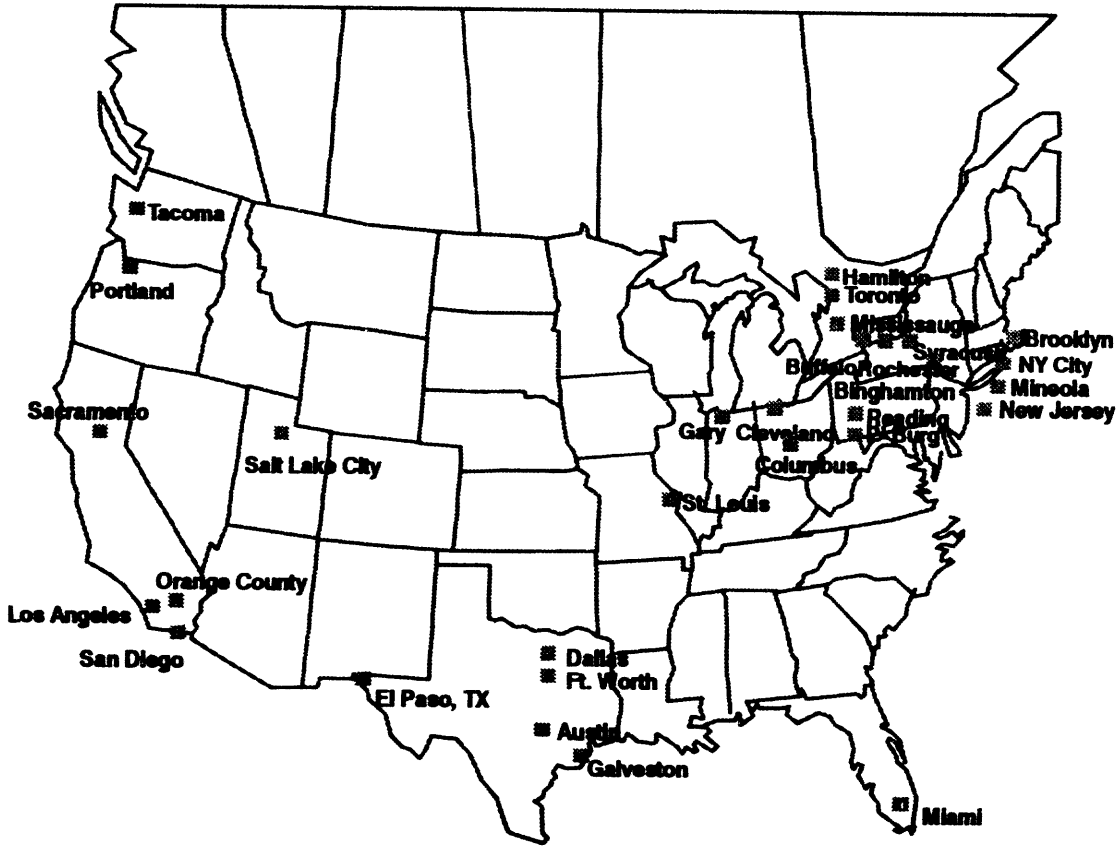


Alu Suisse Cylinders

Construction:	**Al liner hoop wound with fibre tape**
Size:	**20 ft x 13 in**
Water capacity:	**395 litres**
Weight:	**638 lbs**
Gas Volume:	**3450 SCF**
Gas Weight:	**150 lbs**
Range:	**400 miles (4 tanks)**

548d20a

Cummins L10 Natural Gas Engine Locations



Salt Lake City, UT
Toronto, Ont
Los Angeles, CA
Ft. Worth, TX
Dallas, TX
Cleveland, OH
Columbus, OH
Mississauga, Ont
New York City, NY
Pittsburgh, PA
San Diego, CA
Hamilton, Ont
Miami, FL
Newark, NJ
St. Louis, MO
Tacoma, WA
Orange County, CA
Galveston, TX
Reading, PA

Binghamton, NY
Buffalo, NY
Syracuse, NY
Rochester, NY
Mineola, NY
Brooklyn, NY
Portland, OR
Gary, IN
Sacramento, CA
Austin, TX
El Paso, TX

93283s09

Chassis Dyno Results - Sacramento CNGL10 Bus

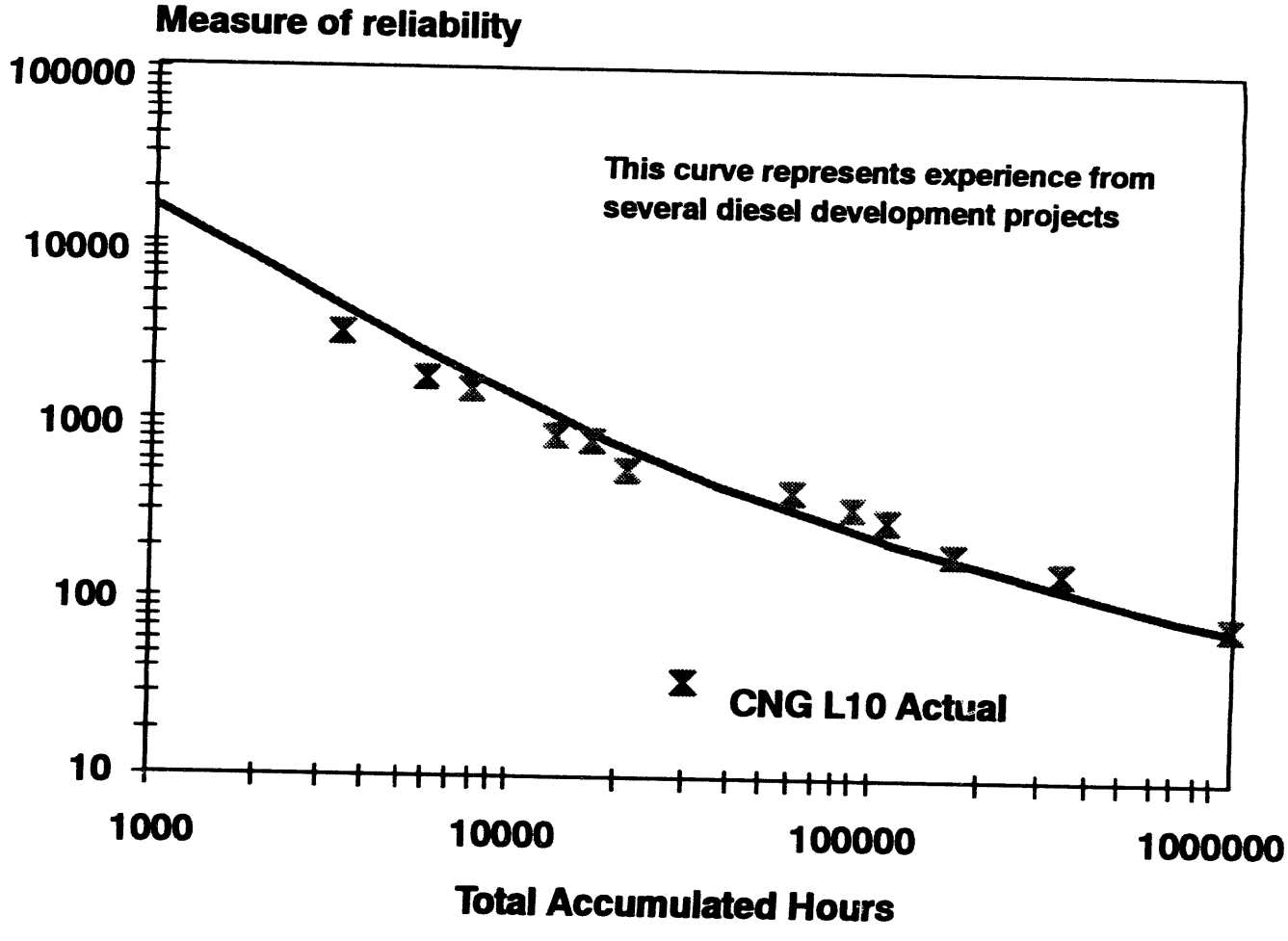
Hot CBD Test Cycle (g/mile)*

NOx	6.5
PART	.025
CO	.035
NMHC	**
CO_2	2430

* Tests at SCRTD

** Not measured

Cummins Reliability Experience



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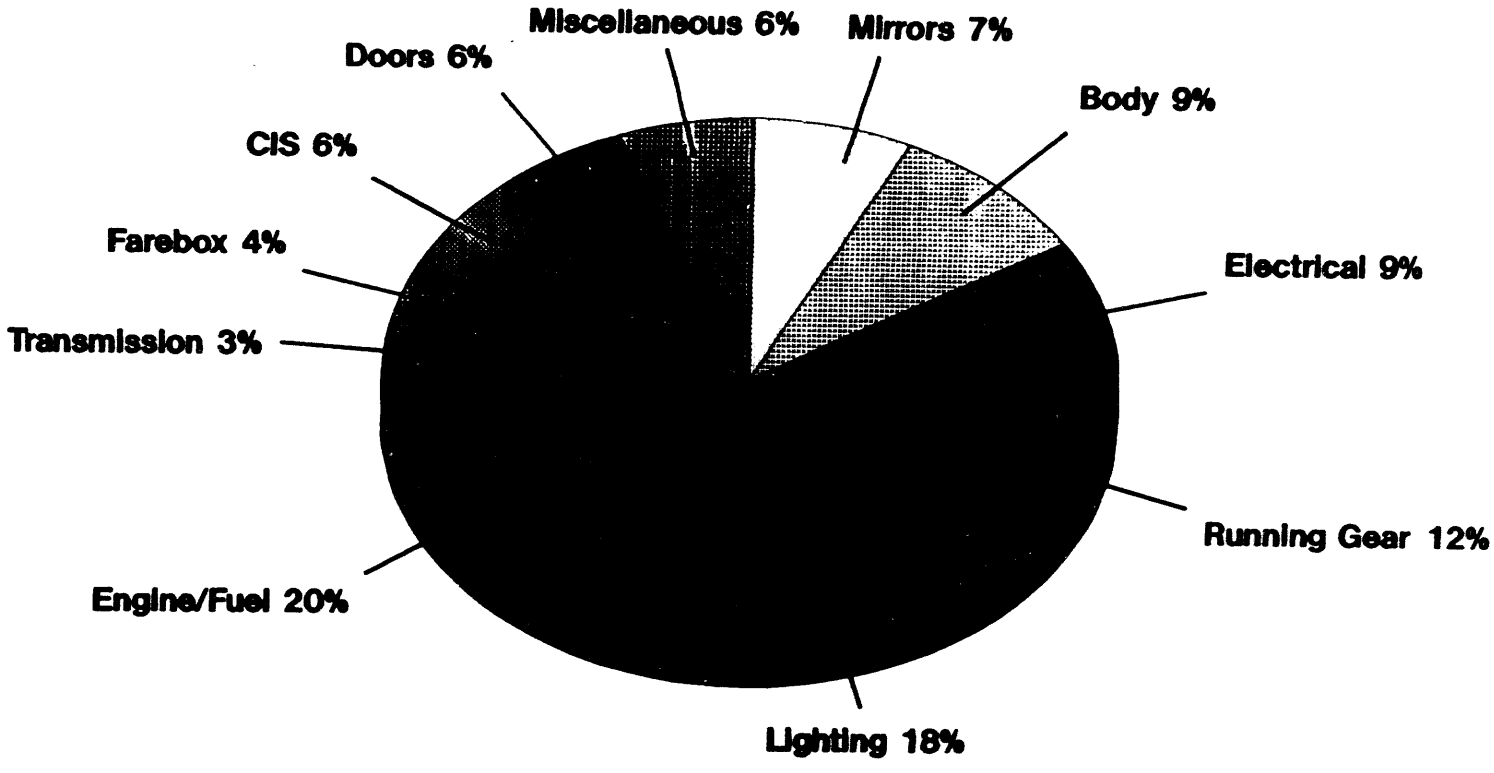
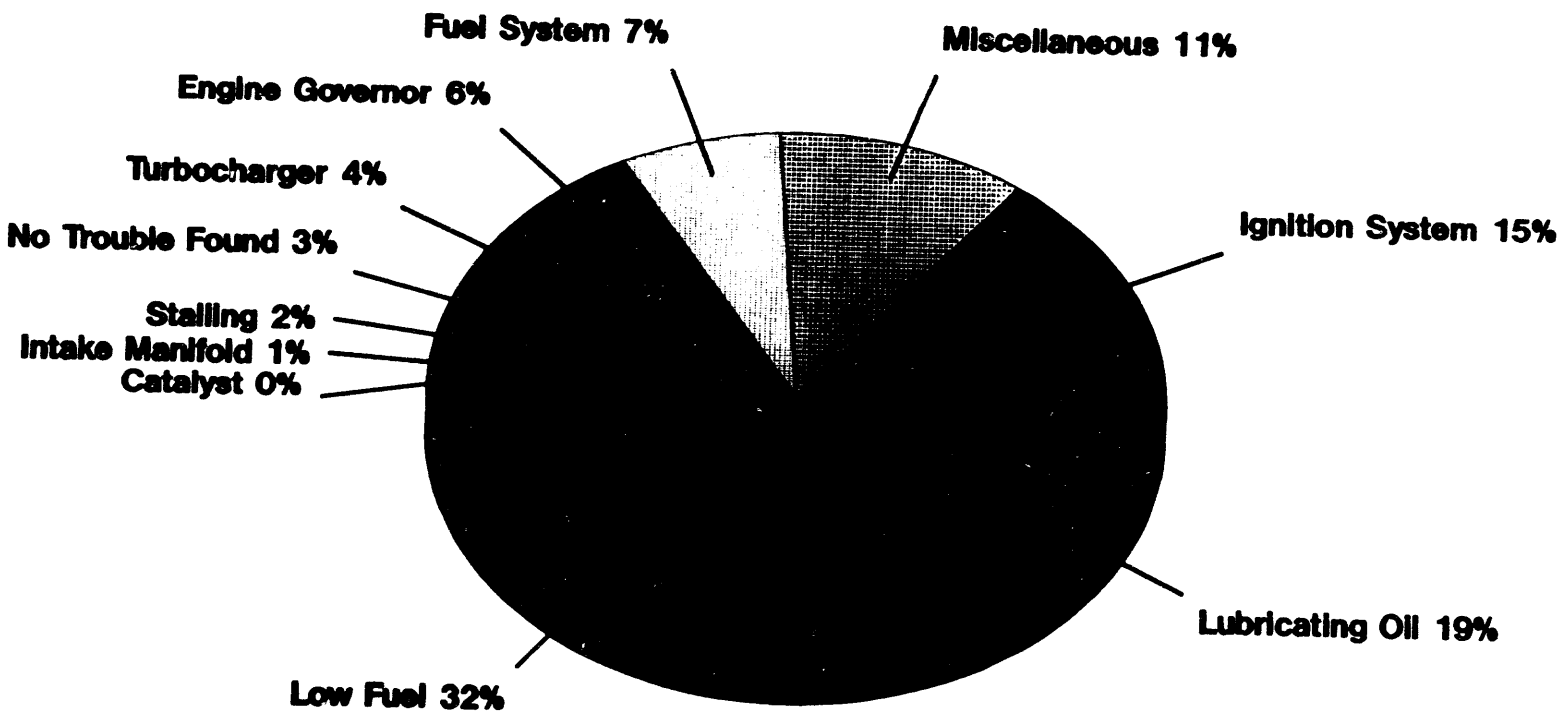
All Repairs & Inspections*



*TTC CNG Bus Operation - MTO Data

Fuel & Engine-Related Work*

(20% of all Repairs/Inspections)



*TTC CNG Bus Operation - MTO Data

9253710

L10G Urban Engine Field Experience

- Field engines in urban bus refuse and urban truck

- A total 350 engines have been built including 100 CARB certified config.
  - Approximately 300 engines in revenue service
  - Over 10,000,000 revenue miles
  - Repeat orders

L10G Urban Engine Field Experience (Cont.d)

- L10 G engine reliability approaching L10 diesel bus engine
- Durability goals B10 - 250K miles; B50-350K miles
- Fuel economy ~ 2.5 - 3.8 MPG equivalent diesel
- Oil consumption ~ 350-600 MPQ equal or better than diesel

LNG Application

- Opportunity for fuel quality control
- Fuel storage medium needs to be transparent to the engine operation
- Standardize components, test schedule, manufacturing costs
- Envision low pressure delivery system

LNG Application (Cont'd.)

- A/F ratio and fuel rate must be managed to maintain engine operation within the design spec. Necessary for emissions, performance and durability

- Systems evaluation planned/on-going in laboratory and in field
  - Gillig buses in Portland, OR
  - Overnite truck in Roanoke, VA

- Develop general application specifications for the OEM's

Current Development Issues

- Sub-system issues
  - Ignition system performance including plug life
  - Fuel delivery system sensitivity
  - Governor control stability
  - Wastegate accumulator drain service requirement
  - Turbocharger wastegate control
  - Catalyst thermal fatigue
  - OEM/engine wiring interface

Developments Perspective

- Current Product Enhancements
  - Digital governing
    - ▸Electronic wastegate control
    - ▸Engine protection
    - ▸Direct electronic link to transmission
    - ▸Fault code logging
  - Shorter plug wire length
  - 260 HP rating

- Future Product
  - Rated at 300 HP and 900 lb-ft peak torque
  - ULEV emissions
  - Full authority electronic control
  - LNG/CNG compatible
  - All automotive markets

93283s15

Summary

- Focused NG product development across engine product lines
- Implemented new technologies and concepts
- Current product L10 G CARB certified close to 1998 ULEV standards. Low NOx emissions on CBD cycle
- Next generation of products planned for mid 90's

Acknowledgements

We acknowledge the following organizations for their support and funding:

Gas Research Institute

Canadian Gas Association

Ontario Ministry of Transportation

Ontario Ministry of Energy

548d35

SUMMARY OF VERBAL COMMENTS OR QUESTIONS AND SPEAKER RESPONSES

CUMMINS NATURAL GAS ENGINE PROGRAMS - L10 G ENGINE UPDATE
V.K. Duggal, Cummins Engine Co. Inc.

Q. Robert Alvey, Brooklyn Union Natural Gas: What type of governor is being used on the current L10 engines?

A. Most of the engines are using the analog version. There are about six digital governors operating in buses in Ontario to gain experience with this newer type.

Q. Morrie Kirshenblatt, Environment Canada: Can you elaborate on the catalyst thermal fatigue that was mentioned?

A. Using an oxidation catalyst, unburned natural gas in the exhaust occasionally causes excessive thermal load. This can occur when the vehicle is coasting downhill. We are working on ways to handle the problem.

Q. Anonymous: Question inaudible.

A. A typical bus engine averages 25 to 30 thousand miles per year, and average speed is 10 to 12 miles per hour.

Q. Anonymous: What was the NOx deterioration factor?

A. We found no deterioration in NOx emissions. Based on emissions tests at intervals of 250 hours operation up to 1000 hours, the NOx data actually showed a negative slope.