INFORM
Strategies for a better environment

Bus Futures

New Technologies for Cleaner Cities

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Contents

FOREWORD i

1 INTRODUCTION 1

A Shift in Technology 1
Overview and Methodology 2

2 FINDINGS 5

3 CONCLUSIONS 9

4 TRANSPORTATION EMISSIONS, AIR POLLUTION, AND HEALTH 11

Transportation's Role in Air Pollution 11
Vehicle Emissions and Health 13
Particulate Matter 13
Nitrogen Oxides 14
Air Toxics 15
Emissions Standards 17
Emissions Testing 19

5 COMMERCIAL BUS TECHNOLOGIES: CONVENTIONAL NATURAL GAS AND DIESEL BUSES 21

Natural Gas Fuel 22
Commercial Availability of Natural Gas Buses 23
Manufacturers 23
Natural Gas Bus Use by Transit Agencies 25
Transit Bus Costs 28
Procurement Costs 30
Infrastructure Costs 30
Operating and Maintenance Costs 32
Emerging Diesel Pollution Reduction Technologies 34
Low-Sulfur Diesel 35
Diesel Emission Controls 35

6 EMISSIONS COMPARISONS: CONVENTIONAL NATURAL GAS AND DIESEL BUSES 39

The GRI Study 39
CIFER/UWV Bus Tests 41
The California Energy Commission 42
CARB and EPA Engine Certification Data 43
The Coalition for Clean Air 44
Natural Resources Defense Council 45
The Union of Concerned Scientists 46
Engine, Fuel, and Emissions Engineering, Inc. 47
Northeast States for Coordinated Air Use Management 48

7 DEVELOPING BUS TECHNOLOGIES: HYBRID ELECTRIC AND FUEL CELLS 49

Hybrid Electric Technology 50
Fuel Cells 52
Research and Demonstration Initiatives 53
Natural Gas Hybrids 55
Diesel Hybrids 58
Other Hybrid Bus Development Projects 59
Fuel Cell Buses 60

8 EMISSIONS COMPARISONS: NATURAL GAS AND HYBRID ELECTRIC-DIESEL 63

Northeast Advanced Vehicle Consortium 63
New York City Transit 66
Union of Concerned Scientists 67

NOTES 69

BIBLIOGRAPHY 73

Foreword

This new INFORM report brings good news about alternatives to the conventional diesel bus — alternatives that have the potential to meet the travel needs of millions of Americans in and around our urban centers while protecting air quality and human health. *Bus Futures* is the eighth major report published as part of INFORM's ongoing transportation research program, which, since 1986, has sought to clarify for government and business leaders, and for the general public, the steps we can take to move toward environmentally sustainable forms of transportation. It is intended as a guide for public officials, transit agencies, and community leaders involved in decision-making about where they can best invest their resources in new bus procurement, both now and in the immediate future.

Over the past decade, concern has been growing among government, environmental, health, and community leaders about the price we are paying for our reliance on diesel-fueled buses. Emissions from these vehicles are polluting our environment and damaging the health of millions of urban Americans. Diesel exhaust irritates the lungs and is a key aggravating factor in soaring rates of asthma nationwide — especially among children in poor and minority urban neighborhoods. Recently, the effects of the many toxic chemicals contained in diesel exhaust have also come into clearer focus — about half are known or suspected of being carcinogenic. Exhaust from heavy-duty diesel vehicles is considered a probable human carcinogen by the National Institute for Occupational Safety and Health, the World Health Organization, and the International Agency for Research on Cancer.

However, INFORM's research shows that there are many promising alternative bus technologies now under development. *Bus Futures* assesses the commercial availability, costs, and emissions performance of each, from cleaner diesel buses, to conventional compressed natural gas (CNG) buses, to electric-diesel and electric-natural gas hybrids, to hydrogen fuel cell buses. Its conclusion tells the best news of all: One alternative — the conventional natural gas bus — is available here and now. It is today's best choice.

CNG buses are fully commercial *and* they are clean, healthy, and safe. The top five US bus manufacturers accounted for 80 percent of all urban buses sold in 1998. Four of these companies make significant numbers of natural gas buses, and could immediately step up production to meet greater demand. In light of CNG's benefits, transit agencies are well positioned to turn their backs now on conventional diesel buses.

The major obstacle to expanded use of CNG buses is the costs involved in establishing the infrastructure needed for refueling. Investing in this infrastructure, however, can be worthwhile for transit agencies both now and in the longer term. It enables a domestically plentiful fuel to be used today – a fuel that is less susceptible to the price and availability fluctuations of imported fuels. And while communities enjoy the immediate health and environmental advantages of clean CNG bus technology, transit agencies interested in conducting demonstrations of electric hybrids can use natural gas to fuel these buses, avoiding the pollution controls and low-sulfur fuel that hybrids powered by diesel will probably need to meet emissions standards. Nor will these agencies have to worry about toxic emissions, since natural gas is virtually toxic-free. That these benefits are becoming increasingly clear is reflected in the use of natural gas buses by 65 transit agencies throughout the US.

Looking ahead, moving to natural gas buses now can facilitate the transition to the hydrogen fuel cell buses of the future. Depots and refueling systems adapted for natural gas today will easily be able to handle hydrogen – another gaseous fuel – tomorrow. And transit agencies with a CNG infrastructure already in place will be able to fuel their fuel cell buses themselves, with hydrogen obtained from natural gas, its most efficient source.

In the next decade, more than $10 billion in public funds will be spent to purchase more than 75,000 new buses. But the decisions that transit agencies and local communities make now are not just a matter of technology and economics. They are a matter of our priorities. How important is it to safeguard human health and especially the health of our children, who are the ones most vulnerable to environmental contaminants? How important is it to address the undue impacts of pollution on poor and minority urban communities? What example do we want to set for millions of travelers from abroad, whose own priorities may be influenced by the choices they see being made in the cities they visit here? For those to whom these are important concerns, *Bus Futures* points the way to a future of dependable transportation, cleaner air, and better health for communities throughout the United States.

Joanna D. Underwood
President
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1 INTRODUCTION

Across the country, transit authorities are looking with fresh eyes at the fuels and bus technologies they will choose to meet the needs of riders in the decades ahead. Both passengers and the residents of communities in which transit buses operate are demanding cleaner vehicles, for the benefit of both air quality and the health of themselves and their children.

Community demands for cleaner buses have grown in response to increasing information about the health and environmental hazards of diesel exhaust from trucks and buses. In particular, the link between rising rates of asthma in urban centers and emissions of particulate matter and nitrogen oxides from diesel-burning vehicles has provoked widespread concern. In 1997, there were over 30,000 hospitalizations for asthma in New York City alone, where hospitalization rates for the disease increased 22 percent between 1988 and 1997. The largest increase, of more than 60 percent, was seen in children from low-income communities.[1] Diesel exhaust also contains toxic air contaminants that are carcinogenic or suspected of being carcinogenic.

Until very recently, there was only one bus choice — the conventional diesel bus.* Increasingly, however, competition from cleaner fuel options and more efficient engines is growing. For some transit agencies and their governing boards, the conventional diesel bus is becoming a thing of the past.

A Shift in Technology

The new fuel and engine options now emerging are clearly part of a major shift in the transportation sector. The zero-sum game of trying to wring yet more pollution reductions from vehicle emissions already subject to rigorous environmental controls has led to a decade-long search for alternative environmental protection strategies. Foremost among these is the use of natural gas, which can be used today in conventional vehicles powered by slightly modified internal combustion engines. Hence, while many transit agencies see hydrogen as the ultimate pollution-free fuel option and low-sulfur diesel as a way to reduce emissions from conventional diesel buses in the short term, an immediate shift can be made right now, from conventional diesel to cleaner compressed natural gas.

* A conventional vehicle is one in which an internal combustion engine provides power directly to the wheels.

In the next few decades, there will clearly be a significant transition in engine technology for transit buses and other vehicles...a shift from the internal combustion engine to more efficient alternatives such as hybrid electric and, ultimately, fuel cells. New electric propulsion technologies with profound environmental advantages are already beginning to enter the marketplace. Electric vehicle drivetrains use energy much more efficiently than conventional mechanical drivetrains, thereby reducing energy use and the potential to pollute. The electricity to run an electric drivetrain can be generated by a wide variety of fuels, including fossil and alternative fuels, or by an on-board generator. This range of innovative options for electrical generation, combined with the energy efficiency and fuel flexibility of these engine technologies, creates enormous opportunities for dramatically reducing urban air pollution. Both hybrid electric and fuel cells are currently being demonstrated by a number of transit agencies across the United States.

To ensure that the buses of the future perform as expected, training is especially critical. These technologies involve components with which transit agencies have little or no experience thus far – such as advanced high-voltage battery packs and gaseous hydrogen. Transit personnel will need to be trained in the proper use and maintenance of these vehicles, and new infrastructure may also have to be built.

Overview and Methodology

With fuels and technologies changing so quickly, it is often not clear to transit agencies exactly what is available today and what they can plan for the foreseeable future. The choice of technologies most often cited includes conventional diesel buses, conventional diesel buses equipped with control technologies and using low-sulfur diesel, conventional natural gas buses, hybrid electric buses, and fuel cell buses.

To assist transit agencies and policy makers in making their bus purchase decisions, this report provides an overview of bus technologies, their emissions performance, and their commercial availability. It focuses specifically on today's two mainstream technologies – natural gas and diesel buses; fuel cell buses are also briefly discussed because of the great interest that has been taken in this option by both transit agencies and the general public. The report includes a discussion of the health effects of air pollution, as well as information on the costs of different vehicles and their associated infrastructure. Finally, it addresses the operational and maintenance experience of transit agencies around the country, which varies widely depending on local conditions and needs.

Research for this report involved an extensive review of reports, conference presentations, newsletters, and other publications on vehicle technologies and alternative fuels from transit agencies, federal and state agencies, government research institutes, industry associations, and nonprofit organizations. In addition, numerous interviews were conducted with transit agency personnel and industry experts.