**Heavy Vehicle
Hybrid Propulsion Systems R&D
Program Plan, FY 2000-2005**

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**Office of Heavy Vehicle Technologies
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Energy Efficiency and Renewable Energy
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Program Plan, 2000-2005

Heavy Vehicle Hybrid Propulsion Systems R&D

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1.0 INTRODUCTION

1.1 Background

The Strategic Plan of the Office of Transportation Technologies (OTT) addresses the energy, economic, and environmental challenges in meeting the future demand for transportation goods and services consistent with its vision that “within the first decade of the twenty-first century, the United States will turn the corner in the growth of petroleum use for highway transportation.” In particular, Energy Information Agency data show that since the 1973 oil embargo, most of the increase in U.S. highway fuel consumption has been due to trucks (see Figure 1). In addition, fuel use by all trucks in 1996, for the first time, exceeded that of automobiles.

Figure 1. Increasing Highway Fuel Use Due Mostly to Trucks

Truck fuel use is growing because the demand for freight transportation has increased as the nation's economy and gross domestic product have grown. Over the next 20 years, the largest growth of oil demand is expected in the area of freight (5.2%), compared with personal vehicles (3.3%). The situation is more urgent than commonly perceived as world oil production has peaked and oil availability will steadily decline, exacerbated by increasing growth rates in developing countries.. This situation is shown in Figure 2.

Figure 2. Global Production of Oil

Ref. Scientific American, March 1998

Heavy trucks, such as tractor-trailer combinations, provide inter-city freight delivery. Medium and light trucks deliver goods and commodities within cities. The health and continued growth of the U.S. economy, therefore, is dependent on maintaining the energy security and profitability of the trucking industry, now and into the foreseeable future.

The Office of Heavy Vehicle Technologies (OHVT) was created by the OTT organizational restructuring in March 1996 to focus on the R&D needs of heavy vehicles (trucks and commercial transport vehicles). The heavy vehicle industry (which includes the trucking industry and other truck users, truck manufacturers, engine manufacturers, fuel producers, and component suppliers) as a whole will need to maintain a dominant role in assuring that the U.S. economy remains healthy.

1.2 Situation Analysis

Truck Classes 3 - 6 (10,001 lbs. to 26,000 lbs. gross vehicle weight) represent 38 percent of trucking (by value) involving movement within states, primarily local deliveries of food, consumer staples, and manufactured goods between businesses and consumers. The largest concentration of these are trucks and buses in private fleets. Private fleets include wholesalers or distributors, retailers, and manufacturers.

Due to their operating service, Class 3-6 trucks are prime candidates for compressed natural gas (CNG)-fueled hybrid-electric propulsion systems. These vehicles are used in short-haul applications, which exhibit poor fuel economy and high emissions due to their stop-and-go drive cycle.

1.3 Legislative Drivers

There are Public Laws dating to 1974, when the Energy Research and Development Administration (the predecessor agency to the Department of Energy) was established, that guide, direct, and control research and development activities within the Department. These Acts are listed below.

P.L. 93-275, “Federal Energy Administration Act of 1974.”

P.L. 93-577, “Federal Nonnuclear Energy Research and Development Act of 1974.”

P.L. 94-163, “Energy Policy and Conservation Act (EPCA),” 1975

P.L. 95-91, “Department of Energy Organization Act,” 1977

P.L. 95-238, Title III - “Automotive Propulsion Research and Development Act of 1978.”

P.L. 100-494, “Alternative Motor Fuels Act of 1988.”

P.L. 102-486, “Energy Policy Act of 1992,”

Section 2023, “Alternative Fuel Vehicle Program.”

Section 2027, “Advanced Diesel Emissions Program.”

2.0 Goals and Objectives

2.1 Overview

The mission of the OHVT is to conduct, in collaboration with its heavy vehicle industry partners and their suppliers, a customer-focused national program to research and develop technologies that will enable trucks and other heavy vehicles to be more energy efficient and able to use alternative fuels while simultaneously reducing vehicle emissions.

The Heavy Vehicle Hybrid Propulsion Systems R&D program was initiated by OHVT as a means of accelerating the time-to-market for heavy vehicle hybrid technology. Using the urban service truck and transit bus as platforms, hybrid/electric propulsion systems will be developed as commercially viable replacement (new production and retrofit) to current technology. Competitively selected industry teams will focus on powertrain component cost reduction and technology advances in pre-competitive technologies such as advanced power electronics and high power energy storage.

2.2 Goal Statement

The goal of the Heavy Vehicle Hybrid Propulsion Systems R&D Program is to achieve commercial viability by 2005 of advanced, high efficiency and low emission compressed natural gas (CNG)-fueled hybrid-electric propulsion systems in urban trucks and buses.

2.3 Program Objectives

The technical objectives for the Heavy Hybrid Vehicle program are:

- C to achieve a nominal doubling of the fuel economy. It is recognized that fuel economy is highly dependent on the driving cycle. A measurable improvement of at least 50 percent increased fuel economy is expected as a minimum, independent of driving cycle.
- C to achieve a dramatic reduction in regulated emissions so that future urban trucks and buses will readily comply with the most stringent national and regional emission standards.
- to complete technology development by 2004.
- C to achieve commercial viability by 2005.

3.0 Program Plan

The Heavy Vehicle Hybrid Propulsion Systems R&D Program is a collaborative industry-government program for the development of advanced hybrid-electric propulsion technology for urban cycle trucks and buses. Potential end-user organizations are also involved and specific applications are targeted to enhance potential market success.

3.1 Technology Background

Technologies developed in the Heavy Vehicle Hybrid Propulsion Systems R&D Program apply principally to Class 3-6 trucks and buses. This truck and bus market has not advanced on a technology basis as has the automobile over the past 10-15 year period. Automotive fuel economy regulations (CAFE) and emission regulations have forced sweeping changes in automotive design over the past 10 years. Since efficiency and vehicle emissions are interrelated, a vehicle systems design approach was adopted to solve both requirements for the automobile. This approach did not benefit buses and trucks because unlike automobiles, buses and trucks had only to comply with engine-based (not vehicle based) EPA emission standards, and there is no complementary fuel economy requirement. Thus, the component approach for emission testing of buses and trucks coupled with the absence of fuel economy requirements has resulted in a different, less technology oriented trend for heavy-duty vehicles compared to automobiles over this time period. As an example, over the past 20 years, transit buses, while meeting EPA emission standards, have increased in weight, decreased in passenger capacity, and generally are considered to have lesser durability, reliability, and quality than earlier models, while barely maintaining fuel efficiency.

A vehicle systems efficiency approach utilizing advanced hybrid-electric propulsion technology will strengthen the heavy-duty vehicle industry such that a more reliable, lower maintenance, more efficient, higher quality product will result.

3.2 Technical Program

Heavy Hybrid Vehicle Development -- The principal program thrust is system level integration, vehicle testing, and manufacturing development by competitively selected industry teams which include a hybrid propulsion system developer and a vehicle manufacturer. Research and development activities are conducted in three phases:

- C Phase I -- Technology Selection and System Design Definition
- C Phase II -- Systems Integration and Establishment of Manufacturing Techniques
- C Phase III -- Build Manufacturing Prototypes and Vehicle Performance Testing

Phase I -- Technology Selection and System Design Definition. Competitively selected and funded industry teams will perform the analysis that will guide powertrain component, subsystem, and system

selection and identify the proposed technical and management approaches for goal achievement. Possible parallel technical pathways to goal achievement will be identified.

Phase II -- Systems Integration and Establishment of Manufacturing Techniques. The integration of hybrid propulsion systems into prototype vehicle architectures will be targeted at meeting the efficiency and emissions performance goals that are consistent with the typical needs of the urban truck and bus industry. Typical powertrain characteristics such as power, torque, speed, cost, durability, reliability, maintainability, installation envelope, and power density that are consistent with truck and bus owner/operator requirements will be targeted.

State-of-the-art computer models will be used to perform bench-scale powertrain and pre-prototype vehicle simulations to define the technical pathways to efficiency and emissions goals. The specific technical path and priority R&D opportunities will be largely defined by the industry participants.

Phase III -- Build Manufacturing Prototypes and Vehicle Performance Testing. This activity will provide the development for manufacture and the testing of hybrid propulsion systems in prototype vehicle architectures that are targeted at meeting the efficiency, emissions, and commercialization goal of the urban truck and bus industry. Typical powertrain characteristics such as power, torque, speed, cost, durability, reliability, maintainability, installation envelope, and power density shall be consistent with truck and bus owner/operator purchasing expectations.

3.3 Schedule and Milestones

The schedule and milestones for the OHVT Heavy Vehicle Hybrid Propulsion Systems R&D Program are shown in Figure 3.

Figure 3. Program Milestones

Following negotiation of three industry Cooperative Agreements in the August to October, 2000 time period, a workshop will be held with industry to review advanced technologies which may in the future have a positive impact on the development of heavy hybrid propulsion systems. The start of Phase I begins in the December, 2000 - January, 2001 time period. The three cost-shared DOE program phases will be completed in FY 2004, following which industry manufacturing and testing will continue.

3.4 Resource Requirements

Preliminary program resource requirements through FY 2004, in thousands of dollars, are shown in the following table.

	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Heavy Hybrid Vehicle Development	4,000	4,000	8,000	10,000	14,000

DOE Heavy Hybrid Program Preliminary Schedule

*To be provided by other funding.

4.0 Implementation Plan

4.1 Industry-Government Coordination for Development

The program is being implemented as a cooperative industry-government program with industry and end user firms utilizing cooperative agreements as the contract approach to goal achievement. The program will leverage technologies resulting from other programs such as the Light-Duty Clean Diesel program and the light-duty PNGV hybrid-electric program..

4.2 Outreach

Multiple outreach activities sponsored by industry and government will provide valuable information about the importance of the program and its accomplishments to the public. The objective is to ensure wide industry and public acceptance of the program and its anticipated benefits at the earliest possible time.

5.0 Management Plan

The Assistant Secretary for Energy Efficiency and Renewable Energy (EE) maintains overall responsibility for all program management and policy. The Assistant Secretary exercises control of the OHVT Heavy Vehicle Hybrid Propulsion Systems R&D Program activities through the Deputy Assistant Secretary for Transportation Technologies and the Director of the Office of Heavy Vehicle Technologies.

5.1 Assigned Responsibilities

Lead Management responsibility for all OHVT Heavy Vehicle Hybrid Propulsion Systems R&D activities resides with DOE Headquarters. These responsibilities are shared between the Director of the Office of Heavy Vehicle Technologies and the Team Leaders for the Office of Heavy Vehicle Technologies.

Organizational Structure