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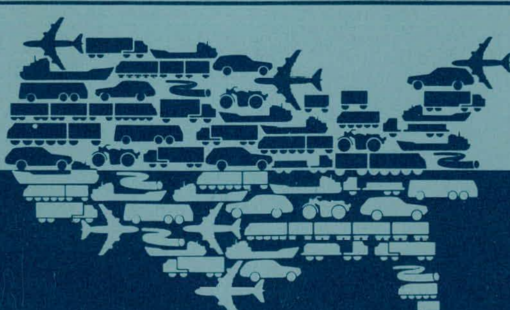
Environmental Development Plan for Transportation Programs

FY80 Update

C. L. Saricks, M. K. Singh, M. J. Bernard III,
and O. M. Bevilacqua



Center for Transportation Research

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ENVIRONMENTAL DEVELOPMENT PLAN FOR TRANSPORTATION PROGRAMS

FY80 Update

by

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Energy and Environmental Systems Division
Center for Transportation Research

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U.S. DEPARTMENT OF ENERGY
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and
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*OMB Associates

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FOREWORD

Environmental Development Plans (EDPs) are prepared by the Department of Energy (DOE) to help fulfill the department's responsibility for developing environmentally acceptable energy technologies. EDPs provide a common basis for planning, managing, and reviewing all environmental aspects of energy programs under DOE's jurisdiction.

EDPs are timed to precede key program decisions as a technology moves from exploratory development to engineering development or technology demonstration. To ensure that environmental, health, and safety (EH&S) considerations are addressed in technology decision making, EDPs (1) identify and evaluate EH&S concerns; (2) define EH&S research and related assessments to examine or resolve concerns; (3) provide coordinated schedules with technology programs for required EH&S research and development, and (4) indicate the timing for Environmental Assessments (EAs), Environmental Impact Statements, Environmental Readiness Documents (ERDs), and Safety Analysis Reports.

The previous EDP for Transportation Programs (DOE/EDP-0037) was published in April 1979. This EDP substantially updates the 1979 document. It draws on analyses contained in EAs, EH&S research, and ERDs for Electric and Hybrid Vehicles (DOE/ERD-0004) and Transportation Programs (DOE/ERD-0027). ERDs are assessments prepared independently by the Office of Environmental Assessments (EV) to provide critical reviews of the environmental readiness of a technology.

This transportation programs EDP is being released under authority of DOE Order 5420.1 dated Aug. 10, 1978. It was prepared jointly by the Office of Transportation Programs (CS) and the Office of Environmental Assessments (EV), with assistance from research and support offices of the Office of Environment.

This EDP is being distributed so that persons with interests and responsibilities in transportation energy conservation will have an opportunity to review it and suggest changes for future updates.

Ruth C. Clusen
DOE Assistant Secretary
for Environment

Thomas E. Stelson
DOE Assistant Secretary for
Conservation and Solar Energy

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PREFACE

The Environmental Development Plan (EDP) is a component of the Department of Energy (DOE) program planning and management system. As the basic environmental planning document for DOE energy systems, it identifies environmental concerns and schedules appropriate research and analyses. The Assistant Secretary for Conservation and Solar Energy (ASCS) and the Assistant Secretary for the Environment (ASEV) are responsible for environmental programs for conservation. The principal responsibilities of each assistant secretary, as they pertain to the activities described in this EDP, are:

- ASCS -- Ensures that program activities are conducted with regard for environmental consequences; prepares environmental assessments and impact statements; conducts appropriate environmental and safety research and development, primarily with regard to safety and control technology.

- ASEV -- Reviews environmental aspects of DOE programs; conducts environmental research and development for environmental protection; provides early identification and consideration of environmental concerns and timely development of plans and funding for their early resolution; prepares Environmental Readiness Documents, and decides whether environmental assessments should result in fingings of no significant impact or environmental impact statements.

Within DOE, technologies are transferred to end-use organizations following successful development and prototype demonstration by front-end organizations, such as the Energy Storage Systems Division of the Office of Advanced Conservation Technologies. The Office of Transportation Programs (OTP) EDP covers environmental concerns associated with transportation system applications and demonstrations, while front-end EDPs address environmental concerns associated with technology research and development.

This EDP was developed by representatives of the ASCS Office of Transportation Programs (Daniel P. Maxfield, project manager) and the ASEV Division of Technology Assessments (David O. Moses, project manager), with assistance from ASEV research and support offices and the Energy and Environmental Systems Division of Argonne National Laboratory.

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1 INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

This is the second annual update of the environmental development plan (EDP) for transportation programs. It has been prepared as a cooperative effort of the Assistant Secretary for Conservation and Solar Energy (ASCS) Office of Transportation Programs (CS/TP) and the Assistant Secretary for Environment (ASEV) Office of Environmental Assessments. Environmental development plans for Department of Energy programs are required by DOE Order 5420.1 (8/10/78).[5] EDPs identify the ecosystem, resource, physical environment, health, safety, socioeconomic, and environmental control concerns associated with DOE programs. The programs include the research, development, demonstration, and assessment (RDD&A) of 14 transportation technologies and several strategy implementation projects. The technologies and strategy areas under development are listed by subprogram in Table 1.1. This EDP update presents a research and assessment plan for resolving any potentially adverse environmental concerns arising from these programs.

The EDP process provides a framework for:

- Incorporating environmental concerns into CS/TP planning and decision processes early to ensure they are assigned the same importance as technological, fiscal, and institutional concerns in decision making.
- Resolving environmental concerns concurrently with energy technology and strategy development.
- Providing a research schedule that mitigates adverse environmental effects through sound technological design or policy analysis.

This EDP also describes the status of each environmental concern and the plan for its resolution. Much of ongoing DOE research and technology development is aimed at resolving concerns identified in this EDP. Each EDP is intended to be so comprehensive that no concerns escape notice. Care is taken to include any CS/TP action that may eventually require an Environmental Impact Statement. Because technology demonstration and commercialization tend to raise more environmental concerns than other portions of the transportation program, most of this EDP addresses these concerns.

1.1.1 Program Overview

Methods for reducing per capita energy consumption in passenger and freight transportation can be divided into five categories, network improvements, operational changes, demand reductions, modal shifts, and improved vehicular energy conversion. The transportation program addresses each of these areas.

A major effort is underway in the last category, improving vehicular energy conversion. Sections 2.1 to 2.4 focus on this program while Sec. 1.2 presents an overview. This technological portion of the transportation program may produce the most adverse environmental effects.

Table 1.1 Transportation Technologies and Strategies by Program and Subprogram

	Technology	Generic Program Area (Heading Code)[a]	Section Reference	TP Branch	Section Reference
1.	Stirling Engine	21601	2.2.1		
2.	Gas Turbine Engine	21501	2.2.2		
3.	Turbocompound Diesel Engine Demonstration	21403	2.2.3		
4.	Gas Turbine in Bus Demonstration	21502	2.2.4		
5.	Continuously Variable Transmission	none	2.2.5	Automotive Technology Development	1.2.1, 2.2
6a.	Transportation Systems Bottoming Cycle: Heavy Duty Diesel Truck Application	21402	2.2.6		
7.	New Hydrocarbons: Low Process Energy Petroleum Fuels	31101	2.2.7		
8.	Alcohol Fuels	32101-02	2.2.8		
9.	Synthetic Fuels	31101-03	2.2.9		
10.	Advanced Fuels: Hydrogen	none	2.2.10		
11.	Evaluation and Demonstration of Electric Vehicles	35100-03	2.3	Electric and Hybrid Vehicle Systems	1.2.2, 2.3
12.	Hybrid Vehicles	21701 21801	2.3		
13.	Advanced Vehicles	none	2.3		
6b.	Transportation Systems Bottoming Cycle: Marine Diesel Application	21405	2.4.1		
14.	Medium Speed Diesel Alternative Fuels	31102	2.4.2		
System Program					
1.	Freight Transport	11103, 21205-07	2.5.1	Transportation Systems Utilization	1.2.3, 1.3 2.4, 2.5, 2.6
2.	Intercity Passenger Transport	13603-04 21105	2.5.2		
3.	Vehicle Performance Improvements	11101-06 23101-05 23201-02	2.6		

[a]Internal CS/TP classification system.

The other three categories, which represent strategy development, also are emphasized in the transportation program. Specific elements are described in Secs. 2.5 and 2.6. Section 1.3 provides an overview.

1.1.2 DOE/NEPA Process

The DOE environmental impact evaluation process derives from broad policies set forth in the National Environmental Policy Act of 1969 (NEPA)[7] and from the more specific guidance provided by the Council on Environmental Quality (CEQ).[3,4] The DOE process, which is described fully in 10 CFR 1021, is designed to incorporate environmental considerations into day-to-day project decisions.

Basic to the process is the development of a number of environmental documents required by NEPA. For CS/TP, the major environmental documents produced in connection with its projects are the EDP, the Environmental Assessment (EA), and the Environmental Impact Statement (EIS) or, conversely, a Finding of No Significant Impact (FoNSI). Figure 1.1 shows the development of these documents from NEPA to the demonstration, commercialization, or implementation of a transportation technology or strategy. Section 4.2 contains a description of these documents.

1.2 TECHNOLOGY DEVELOPMENT PROGRAMS

The major thrust is to develop transportation technologies and operating strategies that will signficantly reduce energy consumption and ultimately eliminate dependence on petroleum-based fuels. This EDP schedules the resolution of primary environmental concerns resulting from technology changes in the transportation system. Section 1.2 summarizes transportation technology development programs and the technologies being considered.

1.2.1 Automotive Technology Development Program

The Automotive Technology Development Program consists of propulsion system technology and alternative fuels RDD&A aimed at improving vehicle energy conversion or efficiency, and reducing the dependence of the total highway transportation system on petroleum fuels. An overview of this subprogram is in Sec. 2.2.

Propulsion system technology development is based on rapid commercialization of cleaner operating and more efficient heat engines. To achieve this goal, alternatives to Otto cycle internal combustion engines (ICE) and improvements to Otto cycle and diesel engine vehicles are being studied.

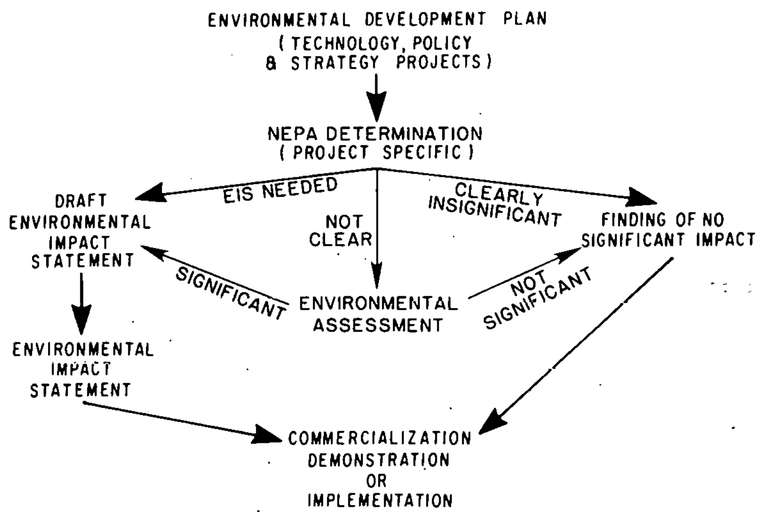


Fig. 1.1 DOE Implementation Process for National Environmental Policy Act (1969)

The heat engine systems research and development program now focuses on two advanced engines, the Stirling and gas turbine. Other engines have been studied in the past, but Stirling and gas turbine engines show the most promise for meeting fuel economy and air quality goals, and achieving early commercialization. Both of these engines have multifuel capability, so the goal of reducing the dependence of transportation on petroleum-derived fuels is being served.

The RDD&A program for these engines meets the requirements of the Automotive Propulsion Research and Development Act of 1978 (P.L. 95-238).[11] This law provides for a multiyear effort to develop advanced automotive propulsion systems. In FY83, the government will decide whether to proceed with development of advanced Stirling and gas turbine engines. The current effort focuses on joint DOE/industry development to ensure that marketability is considered throughout the engine development programs and that the manufacturing skills needed for these engines are transferred to industry. An industry decision on limited production of the gas turbine could occur in FY84 and on full production in FY87. Similar industry decisions on the Stirling engine could be made in FY87 and FY90, respectively.

Vehicle Systems Branch hardware development is concentrated on the turbocompound diesel engine, gas turbine bus, and heavy duty diesel truck bottoming cycle. All have target commercialization dates in the mid to late 1980s and all are joint DOE/industry projects. Demonstrations of two turbocompound diesel trucks occurred in FY79 and FY80. Demonstrations are also underway for five urban and four intercity gas turbine buses. Truck bottoming cycle demonstrations with 5 to 10 trucks are scheduled for FY83 and FY84. Development of a hydromechanical continuously variable transmission (CVT) for ICEs stopped in FY78, but CVT studies continue in the advanced gas turbine program. Controlled speed accessory drive development is now wholly a private industry activity, although demonstration of present technology was underway during FY80 in General Services Administration vehicles.

The objective of the Alternative Fuels Utilization Program (AFUP) is to promote alternative fuels by reducing uncertainties associated with their use in highway vehicles. Alternative fuels can be used as direct substitutes for petroleum fuels or as components of fuel blends. The program covers fuel distribution, use, and vehicle emissions. The program plan employs a system planning and analysis approach for the optimization of the resource-fuel-engine system with respect to energy use. System optimization is necessary for maximizing petroleum displacement. The overall program provides information on infrastructure and vehicle requirements and how these relate to alternative fuel specifications and use.

The AFUP divides fuels into four classes, namely, alcohols, new hydrocarbons, synthetics, and advanced fuels. Alcohol blends now are commercialized for some applications. Neat alcohols and synthetic fuels will become available in the late 1980s or early 1990s. New hydrocarbons (broad cut fuels) are not likely to be available prior to the early 1990s. Advanced fuels, such as hydrogen, are long-term (post-2000) alternatives. Large-scale fleet tests for alcohol/gasoline blends and neat alcohols are expected to be completed by FY83 and FY88, respectively. Fleet tests of synthetic fuels are scheduled to begin in FY83. Fleet tests of new hydrocarbon fuels are planned to begin in FY86. No advanced fuel tests are scheduled at this time.

1.2.2 Electric and Hybrid Vehicle Systems Program

Electric and hybrid vehicle (EHV) development plans are based on the requirements of the Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976 (P.L. 94-413 as amended).[70] The RDD&A of the Electric and Hybrid Vehicle Systems Program is in turn based on using electricity from domestic nonpetroleum energy resources for automobiles and light duty trucks, especially in urban areas. In addition to petroleum fuel savings, reduction of most air pollutants, with corresponding improvement in air quality, may be expected in many urban areas by 2000 by substituting electrics and hybrids for ICE vehicles.

An electric vehicle is any highway vehicle using energy stored in batteries as a primary source of motive power. The vehicle may contain secondary energy storage devices, such as flywheels or hydraulic tanks, that store energy and perform a load-leveling function for the batteries. The thrust of vehicle systems development is to develop and test electric vehicles that employ near-term technologies, which presently include nickel-iron, lead-acid, and zinc-chlorine batteries.

A hybrid vehicle is an electric vehicle with ancillary motive power provided by a heat engine or secondary energy storage system. In hybrid vehicle development, no final design has been selected, but development of vehicle components, such as flywheels, heat engines, batteries, and continuously variable transmissions that could be combined into a hybrid vehicle, is continuing under DOE/industry sponsorship. A major assessment of component combinations is underway. Preliminary hybrid vehicle design work has resulted in selection of a vehicle design for the Near-Term Hybrid Vehicle Program, and a test vehicle is to be completed in FY82.

Timing and organization for the EHV program has changed considerably since the previous EDP. Program details, including a description of the technology, are in Sec. 2.3.

More than 70 EHV demonstration sites have been established, and about 1200 electric vehicles will be participating by the end of 1980, as the Vehicle Evaluation and Improvement program continues to advance the state of the art. Field testing for commercialization will get underway during FY81. Development of an advanced vehicle continues.

1.2.3 Hardware Programs under Transportation Systems Utilization

Hardware development in this program includes two active projects, the Marine Diesel Bottoming Cycle and Medium Speed Diesel Alternative Fuels, both of which are described in Sec. 2.4. In the bottoming cycle for marine diesels, exhaust heat energy is converted into usable work, increasing specific power, thus providing the same total output at a reduced horsepower rating.

Alternative fuels for marine vessels and railroad locomotives may reduce the need to produce energy-intensive specification diesel fuels for these uses. A third project, a bottoming cycle demonstration for pipeline compressor engines, has been studied but is not programmed.

The technology development program for the marine bottoming cycle includes a one-vessel demonstration in FY83-FY84. The bottoming cycle program expects commercialization in the mid-1980s. The alternative fuels project will undergo preliminary laboratory testing, full-scale engine testing, and in-locomotive operational testing through FY82.

1.3 STRATEGY PROGRAM UNDER TRANSPORTATION SYSTEMS UTILIZATION

In addition to the technologies described above, CS/TP is developing strategies which, if implemented, will contribute to the conservation and optimum use of transportation fuels. These strategy projects focus on the identification of deficiencies in the transportation infrastructure, the elimination of institutional and regulatory impediments to transportation energy conservation, and information dissemination to major decision makers and users.

The strategy program areas for which environmental concerns are described in this EDP include projects and studies that may eventually require an EA. Two such program areas, freight and intercity passenger transport, are described in Sec. 2.5. In freight transport, environmental concerns include investigation of mode shifts, intermodal cooperation, and freight consolidation. In intercity passenger transport, the concerns include examination of commercial aviation operations. Implementation dates for strategies resulting from this program are not clearly defined at this time. Other strategy projects described in Secs. 2.5 and 2.6 are not expected to require environmental review.

1.4 PRIMARY ENVIRONMENTAL CONCERNS AND RDD&A REQUIREMENTS

The process for developing primary environmental concerns is described in Appendix B. In brief, concerns that directly impede the technology or strategy development program, but which should be resolved by the structure of the program itself, are first separated from environmental concerns; Appendix A details these environmental concerns. Environmental concerns then are classified as primary or secondary. If the concern is exploratory, i.e., characterized by a lack of understanding of the cause/effect relationship of the concern or the magnitude of impact, it is classified as primary. Where there is some understanding of relationship and magnitude, four criteria are used to determine concern status: (1) emergence of the impact before 1985, (2) length of time required to resolve the issue via environmental research and assessment as informed by technology development and scheduled demonstrations, (3) severity of the impact (dose-response), and (4) size of the human or animal populations at risk. Since the objective of this plan is to insure resolution of important environmental concerns before a technology or strategy is commercialized or implemented, any environmental problem identified with criteria (1) or (2) and (3) or (4) is designated primary.

For programs under Automotive Technology Development, primary concerns have been identified for light duty heat engines, bottoming cycles, and alternative fuels. For Stirling and gas turbine engines, the possibility of large increases in the production of aluminum and superalloys raises resource and supply questions about metals that would have to be imported, in some cases, from unstable foreign sources. Superalloy production itself can be a source of localized environmental quality problems. In the Stirling engine, containment of hydrogen, if it is used as the working fluid, is a critical issue owing to fire and explosion hazards. The application of organic Rankine bottoming cycle technology to heavy duty truck engines may be a problem because the expected heat recovery working fluid is highly toxic. Exhaust products resulting from cooling exhaust gases, an essential consequence of using waste heat captured by bottoming, could affect the pathology of the exhaust products and thus affect human health. Aldehyde emissions from combustion of alcohol and alcohol blend fuels, and the aromatic content, exhaust and evaporative characteristics of alternative fuels (new hydrocarbons, synthetic fuels, and advanced nonfossil fuels) in general remain primary concerns, as these fuels are specified.

Health and safety concerns are central to programs under Electric and Hybrid Vehicle Systems, with mineral resource and environmental control cost concerns posing possible impairments to the ability of these programs to achieve ultimate goals. Vehicle operation, handling and charging of batteries, and manufacture of batteries and vehicle components all involve possible hazards to vehicle occupants and to workers in production and support industries.

Under Transportation Systems Utilization, primary concerns for hardware programs focus on the bottoming cycle in marine application, also a working fluids issue, and on the alternative fuels selected for demonstration in such medium speed diesel engine off-highway applications as railroad locomotives. Intercity passenger strategies must be examined for safety impact as they are developed, particularly those relating to fuel conservation in aircraft operations in and around air terminals. Finally, the downsizing and increased relative vulnerability of automobiles in crash situations, attributable largely to fuel economy requirements, is a safety concern arising from federal regulations and DOE initiatives and therefore should be addressed by CS/TP vehicle performance programs.

The research and assessment necessary to resolve potential adverse effects of primary concerns are presented in Sec. 3. The type of research required and, as appropriate, the suggested date for deciding whether a standard, guideline, or limit is needed, are listed for each primary concern.

1.5 ENVIRONMENTAL RESEARCH AND ASSESSMENT PLAN

The environmental research and assessment plan is presented in Sec. 4. This plan provides for the primary environmental concerns to be addressed in phase with project milestones. The plan schedules specific environmental research activities and major environmental documents [EA, FoNSI, DEIS, EIS, Safety Analysis and Review (SAR), and Environmental Readiness Document (ERD)] required for each project. It also indicates responsibilities and estimated research costs for each scheduled study.

1.6 PROJECTION OF MARKET PENETRATION AND PETROLEUM ENERGY SAVINGS FOR TRANSPORTATION PROGRAMS

Appendix C presents a market penetration forecast (i.e., magnitude of participation in the national vehicle mix) of the final commercialized product of each technology program, and the resulting cumulative petroleum energy savings by 2000, compared with a baseline case in which the technology does not penetrate the market. The annual increment of vehicle population incorporating each technology is indicated on a graph. Similarly, for each strategy program for which rational impact forecasts could be developed, Appendix C shows attributable cumulative petroleum energy savings projections to 2000. These may be used to compare projected quantified environmental impacts for selected programs to the total expected technology or strategy penetration by the year(s) for which these impact quantifications were developed.

2 TECHNOLOGY DEVELOPMENT ACTIVITIES: PROGRAM ELEMENT DESCRIPTIONS

2.1 INTRODUCTION TO TECHNOLOGY DEVELOPMENT PROGRAM

The technology development program goals of the Office of Transportation Programs (CS/TP) are to provide technologies for passenger and freight transportation. When implemented by industry and accepted by user groups, these technologies are expected to reduce the consumption of petroleum energy for transportation, compared with "business as usual" trends, and ultimately reduce the almost complete dependence of transportation on petroleum fuels. Specifically, CS/TP seeks to improve energy efficiency in transportation to reduce gasoline use 10% from levels currently projected for 1985, and to reduce petroleum energy use in all forms of transportation 25% from consumption levels currently projected for 2000.

These goals are to be accomplished in an operationally safe and environmentally acceptable manner so that public health and environmental quality will be protected without increasing new transportation system life cycle costs and with minimal impact on lifestyles or living patterns. The program has been defined by a thorough study of the maximum pay off to be derived from RDD&A efforts, together with knowledge from complementary efforts by industry and other government agencies. A management level method for assessing the energy efficiency, i.e., fuel saved versus dollars spent, of RDD&A programs is presently under review.

This EDP develops environmental strategies for all environmental concerns with potentially negative impacts associated with hardware and fuels portions of the transportation program. This will resolve environmental concerns concurrent with technology development by assuring that adverse environmental effects are mitigated through sound technological design and, as necessary, the adoption of alternative materials, standards, or procedures.

The purpose of Secs. 2.2 through 2.4 is to describe the technology development program, and each of the 14 technologies currently being studied (see Table 1.1), in sufficient detail to distinguish each technology from other similar ones, thus permitting accurate environmental concern identification and description. Projections of environmental impacts based on completed studies of various technologies are highlighted in Sec. 3 and described in detail in Appendix A. Section 4 programs environmental research and assessment to complement the technology development. At the end of this document is a reference list for the reader needing more information on these technologies, their development, and related environmental concerns.

For easier review and comment, the 14 technologies are grouped under three program headings, Automotive Technology Development, Electric and Hybrid Vehicle Systems, and Transportation Systems Utilization. Estimated cumulative market penetrations and petroleum energy savings attributable to technology and strategy programs through 2000 are presented in Appendix C.

2.2 AUTOMOTIVE TECHNOLOGY DEVELOPMENT

The approach taken by DOE to RDD&A of energy efficient heat engines in the highway system is to concentrate on propulsion systems technology, specifically the development of two new engines, several improvements in powertrain and engine components, and research in alternative fuels. This approach will maximize the effectiveness of DOE participation by (1) encouraging industry to develop energy efficient propulsion systems and (2) providing incentives for alternative fuel development. In addition to achieving these energy goals, DOE expects to improve air quality by optimizing power and speed requirements of existing propulsion systems and by developing two new continuous combustion engines.

The two heat engines under development are the Stirling and the gas turbine. With a broad range of fuel alternatives and improved fuel economy, the Stirling could go into full production in FY93 and the gas turbine in FY91.[9,13]

The hardware items under the Vehicle Systems branch of the heat engine subprogram are a turbocompound diesel engine for trucks, a gas turbine engine for buses, and an organic Rankine bottoming cycle for long-haul diesel trucks. DOE plans for the commercialization of most of these vehicle components during the 1980s.

Within the Automotive Technology Development program is the Alternative Fuels Utilization Branch, which is working on near-term and far-term reduction of highway and nonhighway vehicle dependence on petroleum fuels, and eventual replacement of these fuels. Included are research into and assessments of many types of fuels, such as synthetics, new hydrocarbons, and hydrogen. Plans for emergency fuels and evaluations of new fuel concepts are also being undertaken.

Active involvement of CS/TP in the development, testing, and commercialization of the controlled speed accessory drive for vehicle applications has been concluded. Consequently, research originally required for this program is no longer needed (see element R9.0 in previous EDP). In the future, CS/TP will monitor and consolidate available information on the decisions likely to be taken by industry on further development of this technology.

2.2.1 Stirling Engine

Overview

Research into the Stirling engine as an alternative to the present Otto cycle internal combustion engine is motivated by potential for excellent fuel economy, fuel adaptability, low air pollutant emissions, and low noise levels. A vehicle with this engine would not differ significantly in weight, performance, or appearance from a typical Otto cycle engine vehicle.

The Stirling, an external continuous combustion engine, has a closed cycle. A gas, such as hydrogen or helium, is sealed within the engine. A reciprocating piston arrangment fulfills the requirement of compressing a cold fluid and expanding a hot fluid. The net work output, neglecting other losses, is the difference between the expansion and compression work.[2] The reference Stirling engine, or MOD 1, has four double-acting pistons. Each piston serves as the displacer for one cylinder and as the power piston for the next cylinder, thus specific volume (volume/power) is nearly halved. The four cylinders are arranged in a square so one heater can be used for all cylinders. The MOD 1 has an iron alloy heater head that, unlike the earlier Stirling test engine, contains no cobalt, a relatively hazardous metal for which there are no domestic reserves. Regenerators and coolers are positioned between the bottom side of one piston and the top side of the adjacent piston; permitting storage of some of the heat of compression and its subsequent return to the working fluid during the expansion phase of the cycle. The engine has a U-shaped double crankshaft with combining gear to translate the piston displacement into rotary motion. Fabrication of the first engine is scheduled for completion early in 1981. Eventually eight Stirling engines will be built. Four are to be installed in vehicles.[10,12,13]

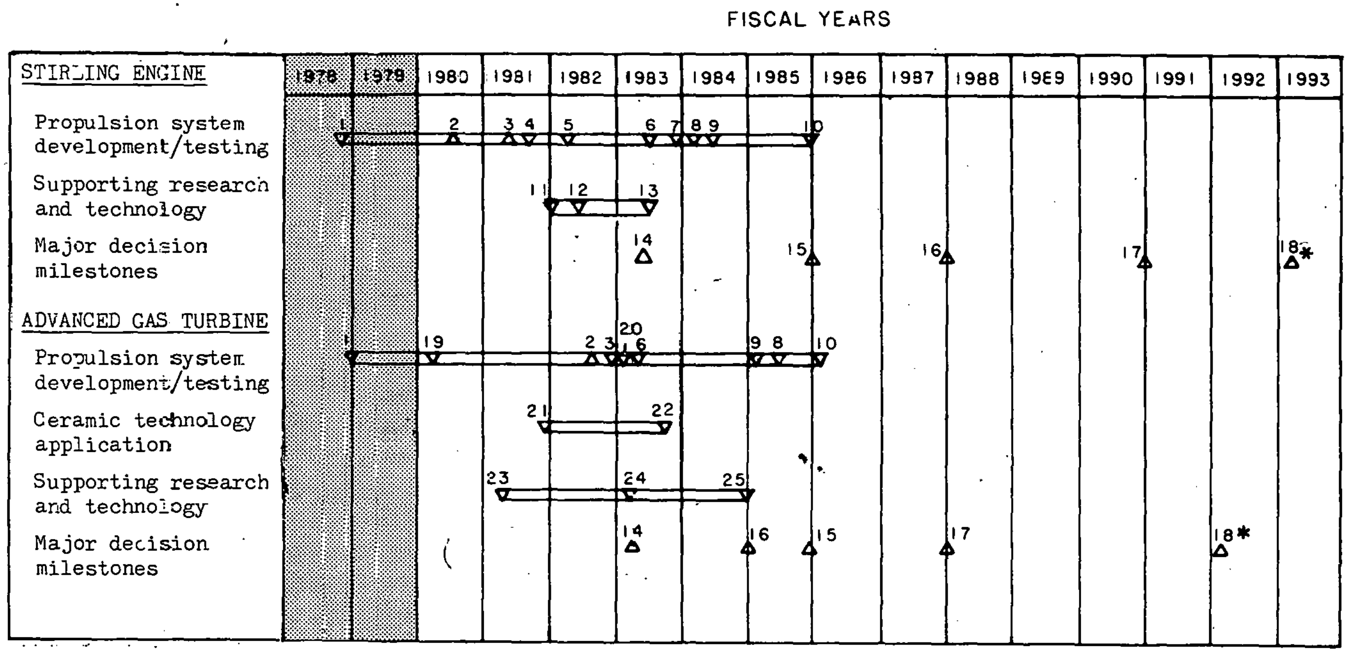
A key problem in developing the Stirling engine for automotive applications relates to the higher operating temperatures and pressures needed to achieve high engine efficiency, and to the need to seal off the working fluid from the crankcase.[2] Engine materials needed for high operating temperatures may not be in adequate or assured supply for full production. This is especially true for aluminum.[18,21] Moreover, the higher operating temperatures that produce greater fuel economy also produce oxides of nitrogen. Careful combustor design is expected to alleviate this problem. In the MOD 1, combustion gas recirculation keeps the combustion temperature down and NO_x emissions under 0.4 gm/mi.[10,13]

The Stirling engine has multifuel capability. Gasoline, kerosine, diesel, methanol, and other alcohol fuels have been demonstrated in the baseline P-40 Stirling engine.[10,14] Further testing is planned for these and other synthetic fuels in rigs and engines to quantify engine performance and emissions.[13,15]

Two recent technological concepts for the Stirling engine may be significant in the development program during and after FY80, affecting concerns described in this EDP. The first concept substitutes helium for hydrogen as the working fluid. Tests have been scheduled to evaluate the feasibility of this substitution. Although it would penalize engine thermodynamic efficiency slightly, helium would reduce safety concerns associated with this technology, if used in a mass-produced engine. The second concept is a downsized version of the engine (25 hp to 50 hp has been suggested) for the post-1990 automobile market, which is likely to include more small, lightweight vehicles. A parametric and feasibility assessment of this small Stirling engine concept is underway.

Program

The RDD&A program for the Stirling engine is summarized in Fig. 2.1. Separate Energy Systems Acquisition Project Plans (ESAPPs) for the management of this program and the gas turbine program (see Sec. 2.2.2) were completed in FY80.[9,13] Objectives of these RDD&A programs are keyed to meeting the



LEGEND

△ Major milestone
▽ Intermediate milestone
* Expected commercialization
1 Fuel economy and emissions assessment begins.
2 System design freeze, MOD I.
3 Initiate final design, MOD II.
4 Initiate licensing strategy.
5 Preliminary marketing and financial analyses.
6 MOD I engine dynamometer tests completed.
7 U.S. engine manufacturer involved.
8 System design freeze, MOD II.
9 EPA vehicle tests completed for MOD I.
10 EPA vehicle tests completed for MOD II.
11 Low-cost alloy development.
12 Seals and controls study
13 Heater-head fabrication technology and costing.
14 Government decision to proceed with devel. of MOD II.
15 Government-funded portion of program ends.
16 Industry decision on limited production.
17 Industry decision on production of up to 20,000 units/yr.
18 Gear up for full production.
19 Reference powertrain, MOD I.
20 Reference powertrain, MOD II.
21 Vehicle demonstration at 2075°F engine temperature.
22 Vehicle demonstration at 2265°F engine temperature.
23 Aerodynamic improvements.
24 Materials study completed.
25 Technology package defined.

Fig. 2.1 Advanced Automotive Heat Engine Research, Development and Demonstration Milestone Schedule requirements of the Automotive Propulsion Research and Development Act of 1978 (P.L. 95-238).[11] This law mandates accelerated development of advanced automotive propulsion systems. Program objectives are: (1) at least a 30% improvement in fuel economy by 1985 over the internal combustion engine but with equivalent performance, (2) emission levels below federal standards, (3) adaptability to a variety of fuels, and (4) potential for cost competitive mass production. NASA Lewis Research Center is responsible for managing the Stirling RDD&A program.

An industry go/no-go decision on commercialization is expected in FY83, at which time DOE will assess its role in completing the Stirling engine project in FY85. An industry decision to begin limited production of the Stirling engine could occur in FY87. A decision to begin full production could occur in FY90 if a "go" decision is made in FY83.

2.2.2 Gas Turbine (Brayton) Engine

Overview

The gas turbine or Brayton cycle engine is an alternative to the Otto cycle internal combustion engine. Its attractiveness lies in its potential for greater fuel efficiency than the conventional internal combustion engine. It is also free of exhaust odor and smoke and has a reputation for dependability as a result of successful use in aircraft. A highway vehicle with a gas turbine engine would require little change from existing mid- and full-size vehicles in overall weight, materials, shape, and auxiliary systems. The gas turbine engine has been under development for 25 years for automotive use, but major engineering problems remain.

The automotive gas turbine is a continuous internal combustion engine that is simple and lightweight. For the open cycle gas turbine, ambient air is compressed by the compressor rotor and partially heated by a heat exchanger or regenerator. Additional heat is provided by burning a mixture of air and fuel in the combustor. Expansion of the hot gas across the turbine rotor causes it to rotate and produce power. The turbine exhaust gas is passed through the heat exchanger or regenerator to transfer heat to the incoming air, thereby reducing fuel consumption. The engine has multifuel capability and low emissions of CO, HC, particulates, and, in general, NO_x.[2]

The two major engineering problems that must be overcome during the next five years are maintaining high component efficiencies as engine component sizes are reduced, and operating the engine at higher temperatures to increase part load fuel economy.[2,9,17] Rupture-resistant ceramics capable of long-term, high-stress performance at high temperatures must be perfected to eliminate the present need for superalloys, for which continuous supplies of constituent metals are not assured.[16,23] Superalloys also may have undesirable environmental effects.[9]

A secondary concern is NO_x emission. Although CO and HC emissions are low for this engine, higher combustion temperatures of advanced engines promote the formation of NO_x. Combustor modifications and a different method of injecting fuel into the combustor have resulted in NO_x emissions at acceptable levels.[9,17] However, whether a low NO_x combustor can be achieved without sacrificing good driveability is still a concern.

Further development of the gas turbine is aimed at greater fuel efficiencies through still higher operating temperatures, i.e., up to nearly 1250°C (2300°F) at the turbine inlet. This requires ceramic combustors and turbine wheels.[15,23]

Table 2.1 summarizes alternative engine designs and possible fuels. Both single- and two-shaft designs have multifuel capability. This flexibility is part of the attractiveness of the gas turbine engine as an alternative to Otto cycle and diesel engines requiring refined petroleum fuels or fuel blends with specific characteristics. Although test gas turbine engines ordinarily use readily available current fuels, such as No. 2 diesel, gasoline, and kerosene, other fuels, such as methanol and hydrogen, are not expected to pose problems.

Program

The RDD&A program for the gas turbine engine is summarized in Fig. 2.1. Three contractors are involved in engine development, each with a different design. An ESAPP for the management of this program designed to meet the requirements of P.L. 95-238 has recently been completed.

Table 2.1 Gas Turbine (Brayton) Engine Vehicle Design Alternatives

Subsystem	Designation	Alternative	Development Contractor
Engine (open cycle)	AGT-100	Two-shaft system	General Motors/Detroit Diesel Allison
	AGT-101	Single-shaft types	Garrett AiResearch/ Ford Motor Co.
	AGT-102		Chrysler/Williams Research Co.
Transmission options		Conventional gearing, continuously variable	
Fuel options		Gasoline, kerosene, off-spec distillates, diesel, methanol, hydrogen, and natural gas	

The government will review continuing its funding of development of the gas turbine in FY83. An industry decision on limited gas turbine production could occur in FY84 and on full production in the early FY87.

2.2.3 Turbocompound Diesel Engine Demonstration

Overview

While contemporary turbocharged aftercooled diesel engines have proved to be fuel efficient, available energy still is rejected as waste heat in the exhaust and cooling systems. In the turbocompound engine, a power turbine driven by exhaust energy is geared to the crankshaft through a torsional isolator and reduction gear train. As a result of continuing improvements, an 18% increase in power and an 8.5% reduction in fuel consumption is forecast for this system in a 373 kW (500 hp) engine. Over-the-road revenue-service tests completed during FY80 indicate a 6% increase in fuel economy for a Class 8 truck with a high horsepower diesel engine.[25]

Program

Cummins Engine Company has been working since 1973 to bring a turbocompound diesel engine to laboratory stage. The Cummins program is designed to demonstrate the viability of the engine for trucks and buses. DOE is involved on a short-term basis to accelerate commercialization of the technology. Road tests of two trucks, one on-road and one off-road, were underway during FY79 and early FY80, following engine preparation and instrumentation. During FY79, an Environmental Assessment was completed for the turbocompound program.[26]

2.2.4 Gas Turbine Bus Demonstration

Overview

As described in Sec. 2.2.2, the primary objective of transportation research and development in gas turbine technology is development of an automobile gas turbine engine. In the Vehicle Systems branch, a complementary program is being carried out for heavy duty gas turbine engines for trucks and buses.

Heavy duty gas turbine engines have been developed by a number of manufacturers. Those developed by the Detroit Diesel Allison Division (DDAD) of General Motors Corporation (GMC) have reached a stage where volume production can be seriously considered. The engines are two-shaft, regenerative gas turbine engines covering a power range of 224 kW to 373 kW (300 hp to 500 hp). They have been manufactured and field tested in trucks, transit coaches, intercity coaches, marine craft, industrial electrical generators, and air compressors.[6,29] As a result of the gas turbine field experience with buses and the demonstrated potential in heavy trucks, DOE has initiated a comprehensive gas turbine-in-bus demonstration program.

Program

The DOE gas turbine-in-bus demonstration program is designed to provide performance and operating data that will accelerate acceptance and commercialization of heavy duty gas turbine engines by the transportation industry. The overall program is divided into two subprograms, one with gas turbine-powered buses in urban environments and the other with gas turbine-powered coaches in intercity operations (see Fig. 2.2). DDAD/GMC 404-4 gas turbine engines will be used in both subprograms.

The urban bus demonstration, which is being conducted in conjunction with the Urban Mass Transportation Administration (UMTA) of DOT, puts five transit coaches in revenue service in each of five cities for one year. The first demonstration program already is underway in Baltimore, Md. Coaches are purchased by the transit operating agencies with UMTA capital grant funds, so the buses can remain in service after the demonstration. The demonstration, which is to proceed in three phases over the next several years, calls for operations under different environmental conditions coinciding with forecast coach and turbine engine developments and production schedules. An evaluation will be completed for each phase. The final evaluation is expected to be completed prior to likely commercialization in 1986.

The intercity bus demonstration represents DOE assistance for further development of a Greyhound program dating from 1970. Since that year, Greyhound has tested DDAD/GMC gas turbine engines in eight intercity coaches. Under the DOE/Greyhound program, new DDAD/GMC 404-4 turbine engines have been installed in four standard intercity motor coaches operating in heavy duty intercity revenue passenger service in the Northeast Corridor. The demonstration is designed to evaluate gas turbine fuel efficiency and reliability. The first phase of the program, which will conclude in FY81, will be followed by additional test runs in selected interurban corridors in FY82 and FY84.

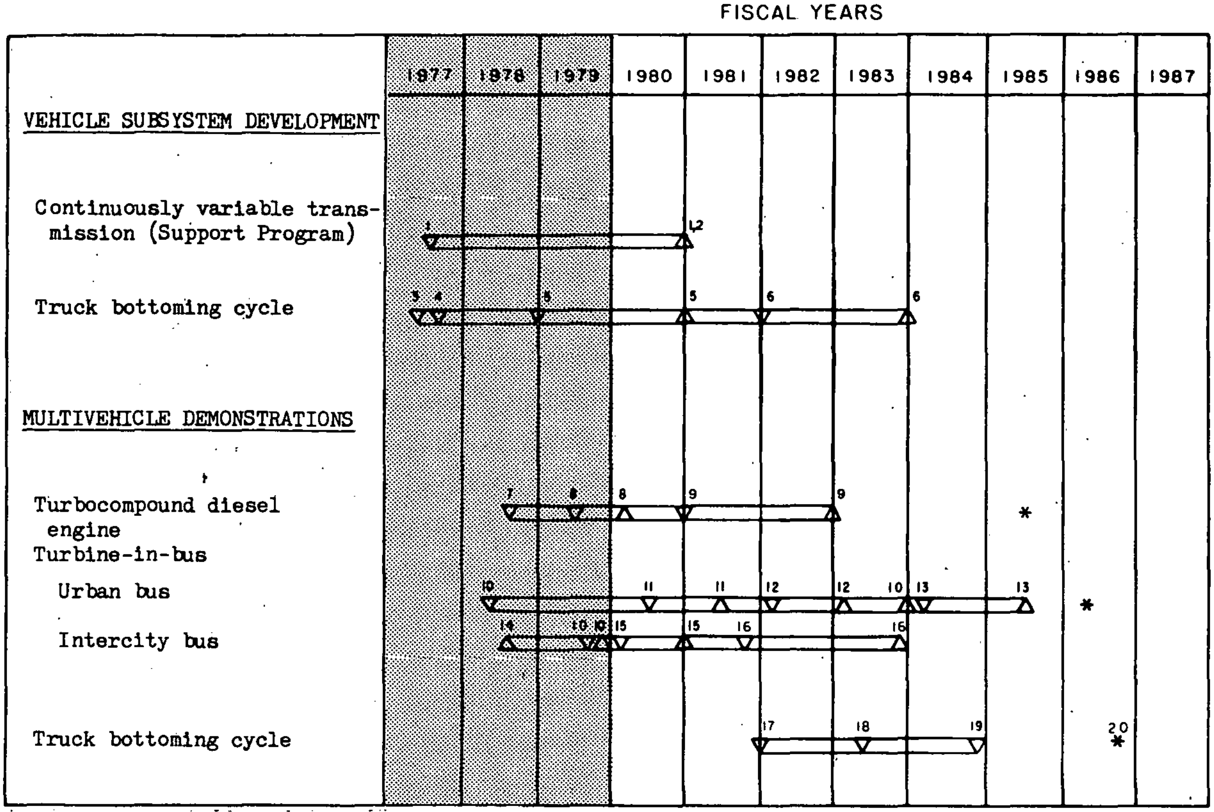
2.2.5 Continuously Variable Transmission

Overview

A continuously variable transmission (CVT) transmits engine power to the rear wheels at independently controlled speed ratios. Currently available transmissions have either a limited number of discrete ratios, or a range of continuously variable ratios, the choice of which cannot be controlled. The CVT presents an opportunity to improve the matching of prime-mover characteristics with drive load, thereby maximizing energy efficiency.

Program

Further development of a hydromechanical CVT for conventional vehicles has been stopped because substantial noise levels were encountered during tests. However, support for CVT development, as applied to gas turbine engines, will continue as part of the advanced gas turbine program. From FY82



LEGEND

△ Major milestone
▽ Intermediate milestone
* Expected commercialization
1 Systems definition and design period.
2 Systems evaluation; possible gas turbine application.
3 Begin component testing; one unit.
4 Begin dynamometer testing; one unit.
5 One-truck road test period.
6 Performance and endurance test period; on dynamometer and in 10 trucks
7 Program to accelerate commercialization initiated.
8 Two-truck road test periods; one conventional, one turbocompound.
9 Improve engine efficiencies.
10 Engine and coach integration period.
11 Five urban bus demonstrations; one test track, four in one city.
12 Eleven urban bus demonstrations; one test track, ten in two cities.
13 Eleven urban bus demonstrations; one test track, ten in two more cities.
14 DOE/Greyhound program initiated.
15 Demonstration of four units in Northeast corridor service.
16 Additional corridor demonstrations.
17 Begin identification of users for 100-unit demonstration.
18 Begin manufacture of 100 units.
19 Decision to commercialize; 100-unit demonstration begins.
20 Achieve production rate of at least 10,000 units/yr.

Fig. 2.2 Vehicle Systems Research, Development, and Demonstration Milestone Schedules to FY87, system evaluation of one or two CVT types for application to the 100 hp single-shaft turbine engine will occur. Commercialization of the single-shaft turbine with CVT may occur in FY90.

2.2.6 Transportation Bottoming Cycle: Heavy Duty Diesel Truck Application

Overview

The major portion of wasted energy in an internal combustion engine is in exhaust gases. Owing to its relatively high cycle efficiency at moderate peak cycle temperatures of about 315°C (600°F), the organic Rankine bottoming cycle offers good potential for converting this wasted energy to usable shaft power. The bottoming cycle is most effective when engine load and speed are nearly constant over a large portion of the operating hours, and when high mileages are accumulated. Therefore, the concept is being developed by CS/TP for demonstrations in long-haul diesel trucks, marine medium speed diesel vessels, and possibly rail diesel or pipeline diesel applications.

Fuel savings and emissions reductions of up to 15% can be expected during a typical duty cycle.[6] Over-the-road tests of a single vehicle resulted in average fuel savings greater than 11%.[31] Design goals are to make system costs recoverable in one year through reduced fuel costs.

Program

Prototype truck bottoming cycle units currently are mounted on a test dynamometer with a Mack diesel engine, and in a Mack diesel truck. Over-the-road tests were made in FY80 and more tests are scheduled for FY81. A 10-vehicle fleet demonstration is planned for FY83 and FY84, to be followed by a 100-vehicle demonstration. The trucking industry is expected to determine the need for production of this system as vehicle tests run to completion.

2.2.7 New Hydrocarbons

Overview

New hydrocarbon fuels are fuels derived from nonpetroleum resources, such as oil shale or coal, that have physical and chemical properties significantly different from existing petroleum fuels. Synthetic crudes derived from oil shale or coal are relatively heavy, with high carbon/hydrocarbon ratios. It will be necessary to pretreat synthetic crudes via hydrotreating to use them in existing refineries to produce synthetic diesel fuel or gasoline.

However, if high carbon synthetic crudes are used to produce fuels requiring less refinery processing, i.e., minimal hydrogenation with a large percentage of the final product captured on a straight run, there is potential for improving the energy balance of these synthetic fuels. In addition to saving energy by not pretreating the crudes, production of a single fuel from the same input means less of the gross energy in the crude is consumed in refining operations. This processing energy saving represents about an 8% increase in the net fuel energy extracted from the crude.[47]

Use of new hydrocarbon fuels, however, will require the modification of existing engines or the development of advanced engines that accept less refined fuels. Continuous combustion engines, such as the gas turbine or Stirling, and some stratified charge engines, may be capable of using low-processed hydrocarbon fuels. The efficiency of such engines with these fuels is yet to be assessed, owing in part to the lack of characterization of a suitable refinery product. At present, there are no nonmilitary engines that accept a nonhydrotreated, nonpetroleum fuel. Consequently, this program is concerned with optimizing fuel/engine systems and determining whether overall energy consumption is actually reduced by such fuels when all factors from resource through end-use are considered. Commercialization of minimally processed synthetic fuels is not likely prior to the early 1990s.

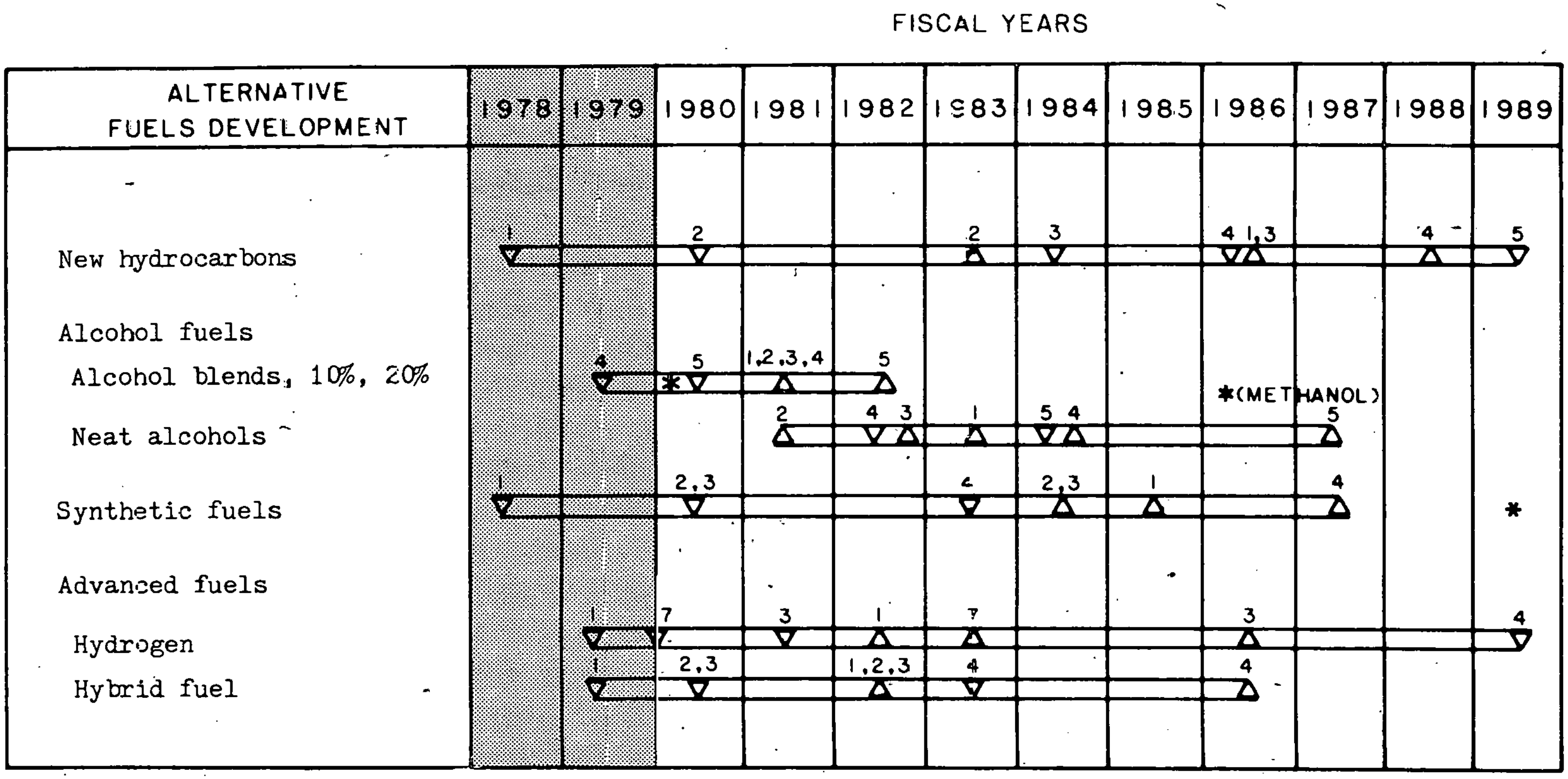
Program

The near-term program objective involves testing and evaluating various new hydrocarbon fuels in continuous combustion and intermittent combustion research engines to determine the feasibility of using minimally processed fuels in these engines. The long-term objective is to optimize the resource/fuel/engine system for efficiency, emissions, performance, and commercialization. Research during FY80 through FY83 will endeavor to define the composition and properties of candidate hydrocarbon fuels. Fuels representing a cross section of early options will be formulated for preliminary laboratory testing. New fuel specifications will be developed. During FY84 to FY86, alternative hydrocarbon fuels will be tested in several engines. Engine performance will be evaluated and fuel/engine systems will be optimized. Engineering fleet tests with fewer than 50 vehicles will be conducted between FY86 and FY89. Fleet reliability tests are planned to begin in FY89. Line 1 in Fig. 2.3 includes these project milestones.

2.2.8 Alcohol Fuels

Overview

The term alcohol refers to all oxygenated hydrocarbons, including ethers; however, emphasis in this program is on ethyl and methyl alcohols and their use as alternative fuels for highway vehicles. Alcohols can be produced from a wide variety of nonpetroleum resources including coal, agricultural crops and residues, wood and forest residues, and municipal solid waste. Alcohols also can be used either in mixtures with gasoline or distillates (alcohol blends), or by themselves as a substitute fuel (neat alcohol). This versatility of resource bases and end-use forms, and the fact that they are immediately available petroleum substitutes, has focused attention on alcohols as alternative fuels.



LEGEND

- △ Major milestone
- ▽ Intermediate milestone
- * Expected commercialization
1. Technology study and evaluation period.
2. Define fuel composition and properties (blend percent, cetane number, etc.); laboratory testing.
3. Engine/fuel evaluation; emission and performance evaluation; engine/fuel optimization.
4. Engineering fleet test decision; small-scale test of engine/fuel/vehicle systems.
5. Reliability fleet test decision; broad-scale evaluation of engine/fuel/vehicle systems
6. Assemble engine design data.
7. On-board hydrogen storage R&D study.

Fig. 2.3 Alternative Fuels Research, Development and Demonstration Milestone Schedule

Alcohol/gasoline blends containing perhaps as much as 20% alcohol can be used in conventional automobiles without extensive engine modifications. However, alcohol/gasoline blends of more than 10% alcohol may require adjusting a gasoline fuel metering system to correct for differences in the stoichiometry and heating value. Because of potential material incompatibility, certain parts in the fuel system may have to be replaced to avoid premature deterioration. Another problem with blends is the separation of the alcohol and gasoline phases in the presence of water. Material incompatibility and phase separation are more of a problem with methanol blends than ethanol blends. There also is a problem with fuel volatility, especially with methanol blends, which may necessitate modifying the formulation. In general, technical problems associated with alcohol/gasoline blends are well understood, and solutions have been identified.

Alcohols also can be blended with diesel fuel. However, because alcohols have poor spontaneous combustion properties (i.e., low cetane numbers) and low miscibility in diesel fuel, it is necessary to modify the diesel engine fuel system to use diesel fuel/alcohol blends. Alcohols can be mixed with diesel fuel by fumigation, injection of diesel/alcohol fuel emulsions, or by injecting the alcohol and diesel fuel separately. The maximum amount of alcohol that can be substituted for diesel fuel appears to vary with engine load.

Using neat alcohols in internal combustion gasoline engines requires extensive fuel system and material modifications. Cold start performance necessitates modifying the fuel composition or the carburetion. Additional engine modifications, such as increasing the compression ratio, would be required to optimize the use of neat alcohols, but are not necessary for acceptable operation.

Neat alcohols, having low cetane numbers, can be used in unmodified diesel engines only with the addition of ignition accelerators, which are expensive and increase NO_x emissions. Neat alcohols are not generally considered good diesel fuel substitutes.

A wide range of annual petroleum energy savings from increased use of alcohol fuels is possible by 1990, depending on the percentage of alcohol used in fuel blends, and the rate and volume of manufacturer and user conversion to alcohol-base products.

Program

The alcohol fuels program has two components. One is concerned with testing and evaluating alcohol/gasoline blends to verify solutions to problems and to demonstrate the practicality and reliability of blends as petroleum extenders. The other component is to identify and evaluate new systems in order to optimize resource-engine-fuel systems based on neat alcohol fuels. The alcohol blend program component responds to the near-term nature of this alternative fuel. The critical information to emerge from these studies is the need for engine or fuel specification modifications. The neat alcohol program component is long-term. Because of overlaps in technology, the alcohol blend and neat alcohol projects are integrated.

For alcohol blends and neat alcohols, basic problems in gasoline engine/vehicle modification have been solved. Work in this area and on further emissions and performance testing will continue into FY81 in conjunction with fleet tests. Work on alcohol composition and alcohol blend formulation and evaluation will continue through FY81. Small-scale engineering fleet tests incorporating engine/vehicle system modifications and alternative blend formulations will be conducted during FY80 and FY81, while large-scale fleet reliability tests will be initiated during FY80 and continued through FY82. Emphasis in fleet tests will be on conventional internal combustion engines with spark ignition.

Engineering fleet tests of neat alcohols are planned to begin in FY82. Large-scale fleet reliability testing of neat alcohols is planned to begin in FY84 and continue through FY87. Fig. 2.3 illustrates program milestones for alcohol/gasoline blends and neat alcohols.

2.2.9 Synthetic Fuels

Overview

Synthetic fuels are synthetic hydrocarbon fuels designed to meet the specifications of conventional petroleum fuels. Synthetic fuels, or synfuels, generally mean synthetic gasoline and distillate fuels derived from oil shale, tar sands, and coal. With increased focus on developing oil shale and coal, synfuels are likely to emerge in the early 1990s. With only a few potentially significant exceptions, the composition and performance of synfuels are not expected to differ importantly from petroleum fuels.

The notable differences between synthetic and petroleum fuels are the different chemical make-ups of the source materials. Shale, tar sands, and particularly coal have very high carbon/hydrocarbon ratios and must be heavily hydrotreated to yield fuels similar to petroleum fuels. The quantities of chemically bound nitrogen and sulfur in coal, tar, and shale products are large, compared to petroleum. In addition, coal-, tar-, and shale-derived fuels contain larger proportions of aromatic and paraffinic compounds than petroleum fuels. Consequently, use of synfuels will tend to increase emissions of polynuclear aromatic (PNA) hydrocarbons, which currently are unregulated. PNAs are a concern because some are known carcinogens. Exposure to PNAs during fuel distribution and handling poses a potential health risk. This problem has been recognized and possible solutions are under development in DOE-sponsored research.

The chemical composition of coal-derived synthetic crudes, high aromaticity, for example, makes them more amenable to the production of gasoline, whereas synthetic crudes from oil shale can be more readily processed to produce distillate fuels.

To date, the scarcity of synthetic gasoline and distillate fuels has hindered the compilation of data on engine operations with these fuels. Most assessments are based on the chemical composition of synthetic fuels.

Program

This program will test and evaluate the use of synthetic gasoline and diesel fuels in current and improved engines. Of particular concern is the carcinogenic nature of these fuels and how this may affect vehicle emissions and fuel handling. Work in this area is now underway. Whether the problem is in fact greater than present hazards has not been established. During FY80 through FY84, project activities will include characterizing and analyzing the composition and properties of synfuels from coal and oil shale. Limited engine testing will be conducted in current and developmental engines. Engine performance, emissions, and other operating parameters will be examined. Limited engineering fleet tests will begin during FY83 to evaluate selected fuel formulations. Developmental and testing milestones are shown on line 4 in Fig. 2.3.

2.2.10 Advanced Fuels

Overview

Advanced fuels are fuels considered to have a low probability for use in the short term, but may have applications as late as 2000. Two advanced fuels currently under consideration are hybrid and hydrogen fuels. Hybrid fuels are defined as multicomponent fuel mixtures containing components derived from different energy sources. Hybrid fuels include slurries, emulsions, and homogeneous solutions.

Using hydrogen in conventional internal combustion engines poses many technical problems. In the main, the problems arise from critical differences in physical and chemical properties between hydrogen and petroleum-derived gasoline. The most critical problems in using hydrogen in an unmodified engine are induction system flashback and other combustion irregularities, high NO_x emissions from rapid high temperature combustion, partial or complete ignition failure, and cylinder blowby.

Storing sufficient hydrogen on board a vehicle for a useful vehicle range is also a major problem. Use of metal hydrides is a potential alternative to large, heavy, cryogenic, or liquid hydrogen, storage systems. However, overall storage system weight is a problem with hydrides. Work is underway to optimize hydride storage system weight, cost, and performance. Other technical problems include the temperature required to drive hydrogen out of a metal hydride, the maximum rate at which hydrogen can be made available from storage, and a means for providing sufficient free hydrogen for a cold start.

Program

This program will evaluate advanced and hybrid fuels suggested for possible use in highway vehicles. The hydrogen fuel program during FY80 will focus on on-board hydrogen storage problems and solutions. A decision on a hydrogen storage method is expected during FY83. Initial hydrogen engine design evaluations will begin in FY81. Further development, testing, and optimization will take place during FY84-FY86. Small-scale engine/vehicle demonstrations are not planned until FY89.

During FY80, hybrid fuel compositions and performance will be analyzed. There will be limited laboratory testing of alternative hybrid formulations in conventional and developmental engines to identify the need for fuel composition changes and engine modifications, including retrofit. These activities will continue through FY82. A small-scale hybrid fuel demonstration is planned to begin during FY83. Advanced fuel program milestones are on lines 5 and 6 in Fig. 2.3.

2.3 ELECTRIC AND HYBRID VEHICLE SYSTEMS

Overview

The goal of the Electric and Hybrid Vehicle Systems program is to assure the availability and market acceptance of vehicles that depend primarily on externally generated electricity for propulsion energy. This goal conforms to the DOE objective of reducing dependence on imported oil while maintaining continued flexibility in transportation.

Definitions used in this plan are consistent with the Electric and Hybrid Vehicle Act (P.L. 94-413 as amended).[70] An electric vehicle receives all its energy in electrical form. This energy is usually stored in rechargeable storage batteries or other portable sources of electric current on the vehicle. The vehicle may include regenerative braking and a load leveling device, such as a flywheel, to increase vehicle range. A hybrid vehicle receives energy from two sources, one of which is electrical. A hybrid may include a heat engine and batteries. The heat engine may just keep the battery charged or may directly supply drive-train power. A hybrid also may have regenerative braking and load leveling devices.

The EHV plan includes the environmental aspects of complete vehicle systems, such as vehicle manufacturing and operation, and the total supporting transportation infrastructure, most of which will need some modification. This infrastructure includes the vehicle delivery system, charging stations, and maintenance facilities.

The major anticipated markets, to which RDD&A efforts are directed, are an electric car for personal transportation and an electric light duty vehicle for commercial use and the plan will be confined to these applications.[81] Table 2.2 presents characteristics of several potential vehicles.[81] Table 2.3 gives the performance standards of current vehicles, as published in the Federal Register. Figure 2.4 gives battery performance status and program goals.

Program

Overall program strategy is a balance between "market pull" or a demand for EHVs, and "technology push," or new products of proven desirability. The

Table 2.2 Characteristics of Several Potential Electric and Hybrid Vehicles (Source: EHV Programmatic EA[68])

Vehicle[a]	Battery[n] Type	Range[b] km(mi)	Year Available[c]	Gross Weight of Equivalent Conventional Vehicle kg (lbs)[k]	Gross Weight of EHV kg (lbs)	Battery Energy Density Wh/kg	Energy Intensity in 2000: EHV kWh/mi[i]	Energy Intensity in 2000: Hybrid gal/mi[j]	Energy Intensity in 2000: Conventional Vehicle gal/mi[k]
EV Truck[d]	Ni/Fe	80(50)	1985	2,722 (6,000)	3,497 (7,709)	66	0.81	-	0.051
EV Truck[d]	Pb/Acid	80(50)	1985	2,722 (6,000)	3,880 (8,554)	49	0.79	-	0.051
EV Truck[d]	Ni/Zn	80(50)	1988	2,722 (6,000)	3,230 (7,120)	93	0.66	-	0.051
EV Truck[d]	Zn/Cl	187(116)	1990	2,722 (6,000)	3,880 (8,554)	98[l]	0.89	-	0.051
EV Truck[d]	Zn/Cl	187(116)	1990	2,722 (6,000)	4,405 (9,712)	80[m]	1.02	-	0.051
EV Truck[d]	Li/S	280(174)	1995	2,722 (6,000)	4,142 (9,131)	128	0.85	-	0.051
HV Truck[d,h]	Ni/Zn	87(54)	1990	2,442 (5,383)	3,680 (8,113)	93	0.74	0.013	0.051
EV Bus[e]	Ni/Zn	187(116)	1990	11,794 (26,000)	16,672 (36,754)	100	3.41	-	0.167
EV Automobile[f]	Pb/Acid	80(50)	1985	966 (2,130)	1,448 (3,191)	44	0.30	-	0.040
HV Automobile[g,h]	Pb/Acid	87(54)	1990	1,565 (3,450)	2,208 (4,867)	44	0.41	0.016	0.048
EV Automobile[g]	Zn/Cl	187(116)	1990	1,247 (2,750)	1,879 (4,143)	89[l]	0.43	-	0.048
EV Automobile[g]	Zn/Cl	187(116)	1990	1,247 (2,750)	2,168 (4,780)	73[m]	0.50	-	0.048
EV Automobile[g]	Li/S	224(140)	2000	1,247 (2,750)	1,650 (3,638)	120	0.43	-	0.048
HV Automobile[g,h]	Ni/Zn	87(54)	1990	1,565 (3,450)	1,772 (3,906)	81	0.33	0.021	0.048

[a]Each electric vehicle at 80% discharge performs the SAE, J227A-d, driving cycle which includes an acceleration to 72 km/h (45 mph) in 28 seconds.

[b]To 80% battery discharge in the year shown in the next column; hybrids could continue on the heat engine.

[c]Based on expected R&D results. Energy density indicated would not be achieved until this year.

[d]Urban pickup truck or van used in commercial applications.

[e]Small urban transit bus.

[f]Two to four passenger simple urban automobile.

[g]Five passenger luxury urban automobile.

[h]Hybrid vehicle with Otto cycle heat engine to extend range and improve performance.

[i]kWh at power plant, for hybrid averaged over all miles, even those run on heat engines.

[j]Used by heat engine but averaged over all miles driven.

[k]Equivalent sized conventional vehicle.

[l]With off-board refrigerator.

[m]With on-board refrigerator.

[n]Al/Air battery is not range limited thus is not characterized in this fashion.

Table 2.3 Summary of EHV Performance Standards and Equipment Requirements[a,b]

Parameter	Personal use[c]	Commercial[c]
Acceleration from 0 to 50 km/hr	Not more than 13.5 sec	Not more than 14 sec
Gradeability at 25 km/hr	10%	10%
Gradeability for 20 sec	20%	20%
Forward speed for 5 min	80 km/hr	75 km/hr
Range:[d]		
Electric	55 km, C cycle	60 km, B cycle
Hybrid	200 km, C cycle	200 km, B cycle
Nonelectrical energy consumption, hybrid vehicles[e]	Not more than 1.3 MJ/km	Not more than 9.8 kJ/km/kilogram of cargo
Recharge time from 80% discharge	Not more than 10 hr	Not more than 10 hr

[a]Source: Federal Register vol. 45, no. 30 (Feb. 12, 1980).

[b]The effective date of these standards is March 13, 1980. Vehicles must also meet federal standards on emissions and safety standards established by the National Highway Traffic Safety Administration. Standard equipment includes recharge control, state-of-charge meter, and odometer. Heaters are optional.

[c]Tested in accordance with SAE Standard J227a.

[d]Cycles are from SAE Standard J227a.

[e]Consumption of nonelectrical energy must be less than 75% of the total energy consumed.

technology push is primarily oriented to passenger car applications, the most demanding part of EHV technology, while vans and commercial applications are left to market pull. The first successful applications of currently available technology are commercial fleets where use is predictable, namely stop-and-go driving over limited distances. Technology developed for passenger cars also will be applicable to less demanding applications.

Market Demonstration. DOE is required by P.L. 94-413 (as amended by P.L. 95-238) to place up to 10,000 EHVs in private, service, and federal, state, and local government fleets within the next six years. The placement program includes keeping and analyzing data on energy, economics, and the use and determination of infrastructure requirements. CS/TP works with potential users to determine the suitability of EHVs for their operations and to enhance user and manufacturer relationships that lead to vehicle improvement. More than 60 demonstration site operators already are participating (Fig. 2.5); more than 70 are expected by the end of FY80, involving about 1200 vehicles.

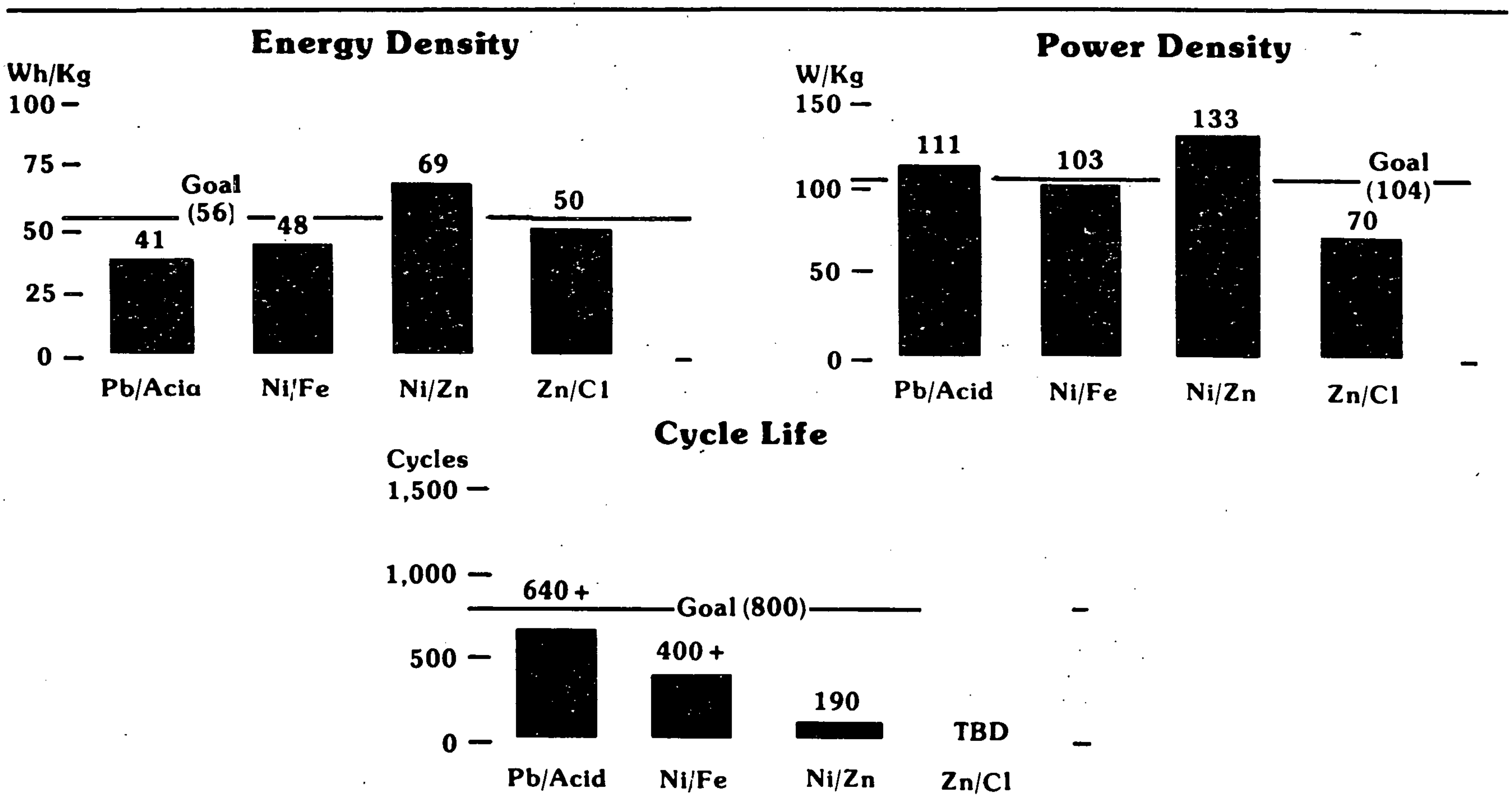


Fig. 2.4 Battery Performance - 1980 Status (Source: U.S. Dept. of Energy)

● **PRIVATE SECTOR - 12 SITE OPERATORS**
AMERICAN TELEPHONE & TELEGRAPH COMPANY — LOS ANGELES, CA
CONSOLIDATED EDISON COMPANY — NEW YORK CITY, NY
LONG ISLAND LIGHTING COMPANY — MINEOLA, NY
WALT DISNEY WORLD COMPANY — LAKE BUENA VISTA, FL
E/HV DISTRIBUTORS, INC — PENNSAUKEN, NJ
ARIZONA PUBLIC SERVICE — PHOENIX, AZ
GENERAL TELEPHONE & ELECTRONICS — TAMPA, FL
LOS ANGELES, CA
HONOLULU, HAWAII
ITT CONTINENTAL BAKING COMPANY — SACRAMENTO, CA
SPOKANE, WA
LINCOLN ELECTRIC SYSTEM — LINCOLN, NE
SOUTHWEST RESEARCH INSTITUTE — SAN ANTONIO, TX
NORTHROP CORPORATION — LOS ANGELES, CA
EHV LEASING — DALLAS, TX

■ **FEDERAL AGENCY - 16 SITE OPERATORS**
DEPARTMENT OF INTERIOR — VARIOUS SITES
DEPARTMENT OF TRANSPORTATION — PUEBLO, CO
GENERAL SERVICES ADMINISTRATION — CAPE KENNEDY, FL
DENVER, CO
DEPARTMENT OF THE ARMY — TEXARKANA, TX
DOE BONNEVILLE POWER ADMINISTRATION — PORTLAND, OR
VANCOUVER, WA
DOE OAK RIDGE NATIONAL LABORATORY — OAK RIDGE, TN
DOE LAWRENCE LIVERMORE LABORATORY — LIVERMORE, CA
DOE BROOKHAVEN NATIONAL LABORATORY — BROOKHAVEN, NY
DOE IDAHO NATIONAL ENGINEERING LABORATORY — IDAHO FALLS, ID
DOE RICHLAND OPERATIONS OFFICE — RICHLAND, WA
DEPARTMENT OF NAVY — CALIFORNIA AND MARYLAND
TENNESSEE VALLEY AUTHORITY — CHATTANOOGA, TN
U S AIR FORCE — KELLY AIR FORCE BASE, SAN ANTONIO, TX
McCLELLAN AIR FORCE BASE, SACRAMENTO, CA
WRIGHT PATTERSON AIR FORCE BASE, DAYTON OH
ENVIRONMENTAL PROTECTION AGENCY — VARIOUS SITES
DEPARTMENT OF TREASURY — DAWSON, GA
BRUNSWICK GA
DOE SOLAR ENERGY RESEARCH INSTITUTE — DENVER CO

★ **STATE AND LOCAL GOVERNMENT - 24 SITE OPERATORS**
STATE OF NEW YORK — ALBANY NY
ALLEGHENY COUNTY — PITTSBURG PA
UNIVERSITY OF HAWAII — HONOLULU, HI
AUSTIN, TX
PHILADELPHIA, PA
UNIVERSITY OF TENNESSEE, KNOXVILLE, TN
FT COLLINS, CO
KANSAS CITY, MO
DENVER OBSERVATORY — DENVER CO
GREENVILLE, SC
TUCSON, AZ
COLUMBUS, OH
HEMPSTEAD TOWNSHIP NY
ONONDAGA COUNTY NY
OAKLAND COUNTY PONTIAC, MI
EDMOND, OK
SAN JOSE, CA
PORTLAND, OR
CYPRESS, CA
PORTLAND, ME
CLARK COUNTY, NV
FLORISSANT, MO
LYNWOOD, CA
ROCKLAND COUNTY, NY

▲ **UNIVERSITIES - 12 SITE OPERATORS**
PURDUE UNIVERSITY — WEST LAFAYETTE, IN
TEXAS A & M — COLLEGE STATION, TX
NORTHERN ARIZONA UNIVERSITY — FLAGSTAFF AR
UNIVERSITY OF ALABAMA — HUNTSVILLE, AL
UNIVERSITY OF MARYLAND — COLLEGE PARK, MD
CALIFORNIA POLYTECHNIC UNIVERSITY — SAN LUIS OBISPO, CA
CLARKSON COLLEGE OF TECHNOLOGY — POTSDAM, NY
GREENVILLE TECHNICAL COLLEGE — GREENVILLE, SC
STATE UNIVERSITY OF NEW YORK — STONYBROOK, NY
STEVENS INSTITUTE OF TECHNOLOGY — HOBOKEN, NJ
UNIVERSITY OF MISSOURI — COLUMBIA, MO
WEST VIRGINIA UNIVERSITY — MORGANTOWN, WV

TOTAL - 64 DEMONSTRATION SITE OPERATORS
MAY 1980

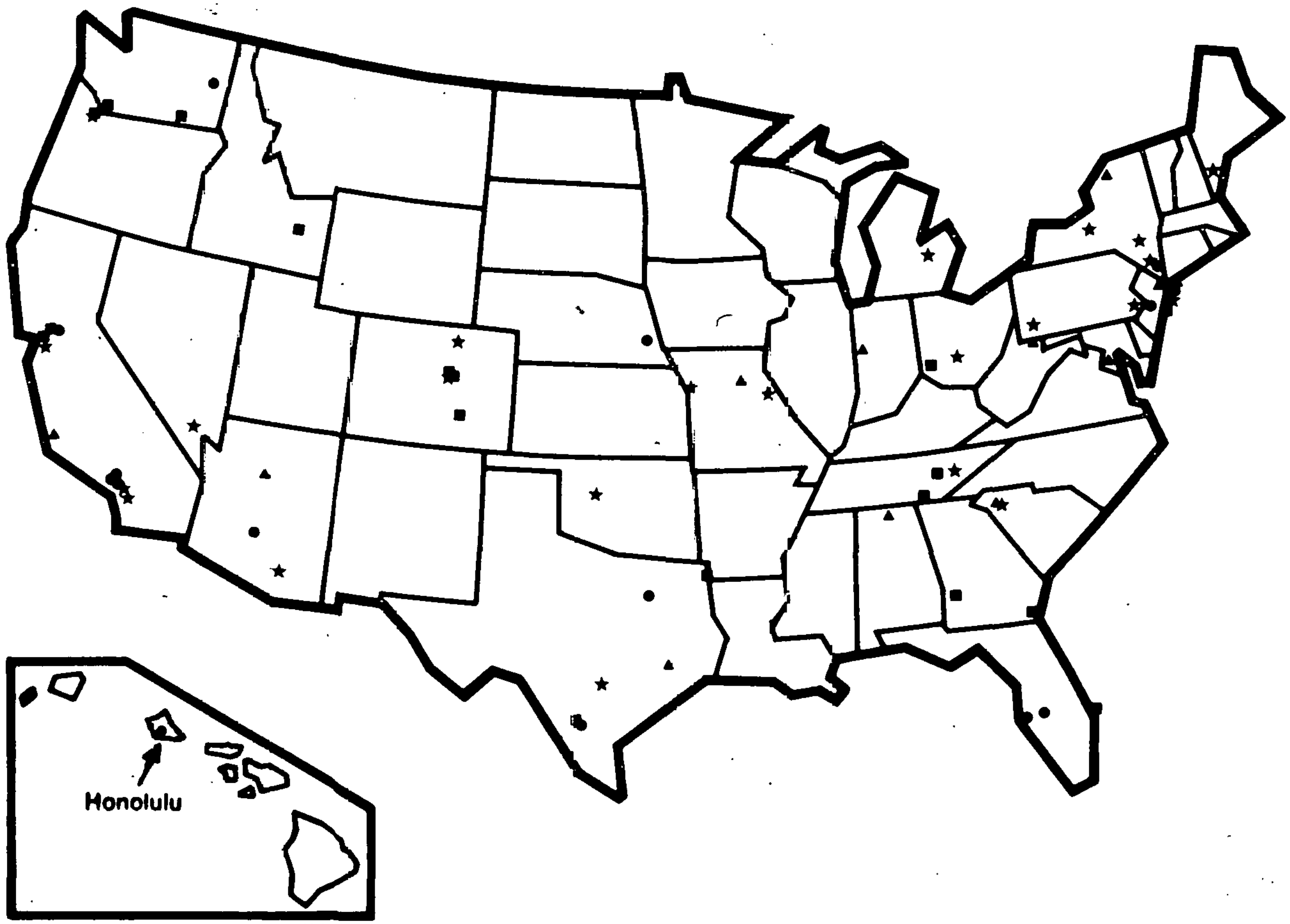


Fig. 2.5 Demonstration Sites in the EHV Program (Source: U.S. Dept. of Energy)

Small business has a primary vehicle supply role, although one large auto manufacturer has supplied vehicles to one site operator and other large business firms are serving as component suppliers. The small firms are capable of expanding to 10,000- to 20,000-unit production levels to satisfy special uses. Loan guarantees are being offered to expand production. No hybrid vehicles yet are in the demonstration.

The Electric Power Research Institute (EPRI) and U.S. Postal Service are also sponsoring the testing and use of electric vehicles. The EPRI-sponsored vehicles are being operated and tested by the Tennessee Valley Authority. In addition, sales are being made directly to organizations and persons outside these programs.

A requisite to the successful introduction and effective use of EVs is a strong existing support infrastructure of (1) electric power generation, transmission, and distribution (in place); (2) residential and commercial battery charging and transfer facilities (need improvement); (3) trained maintenance personnel and maintenance facilities; (4) vehicle dealer networks (in place and adaptable to EHVs); (5) replacement parts (a problem manufacturers must address); (6) vehicle maintenance and repair documentation, and (7) vehicle financing and insurance. Establishing and monitoring the infrastructure is a specific objective of the demonstration.

Vehicle Evaluation and Improvement. The EHV effort includes (1) evaluating the state of the art to determine needs and identify improvement; (2) setting minimum performance standards for participation in the demonstration; (3) testing and evaluating of available vehicles, including verification and safety testing to determine that vehicles offered for demonstration meet performance standards; (4) product improvement engineering, and (5) providing engineering support for vehicles in the market demonstration. Most of the testing will occur in FY81.

The state of the art of EHVs is advancing rapidly. Data on an experimental vehicle, the ETV-1, recently delivered to DOE, indicates that using presently available technology about 100% improvement in range, 50% reduction in acceleration times, and 40% improvement in top speed may be achieved, compared to vehicles tested in 1976. However, such vehicles are not commercially available.

All commercially available EVs employ lead-acid batteries and direct current (d.c.) motors in series or separately excited, and with or without regenerative braking. Motor speed control is generally achieved by thyristor chopper in the armature circuit rather than by the older techniques of variable resistance and battery switching, although some vehicles with separately excited motors employ transistor field chopping with a transmission to get the necessary vehicle speed ranges. Many vehicles have direct drives and no transmission, although some have automatic or manual shift transmissions. Existing technology EVs can have great acceleration and very high top speeds but at the expense of range, cost, and efficiency. A trade-off usually results in modest acceleration and just adequate top speeds.

Electric Vehicle Commercialization. The EVC project has been estabished to concentrate government actions on directly inducing development and large-scale commercial production of electric cars and related components and subsystems, including batteries, by the mid-1980s. These two project goals are the primary and secondary elements of the project.

Tentative objectives for the primary element, which will be updated as technology or market changes dictate, are to accomplish the following by the end of FY86:

- Develop an electric passenger car with tentative range of 100 miles on a stop-and-go urban driving cycle, and all other attributes needed to assure broad market acceptance.
- Initiate limited production of these electric cars.
- Establish the production capacity needed to produce these electric cars at a minimum rate of 100,000/yr.

The primary element will be implemented by providing a practical level of suitable support to a selected manufacturer(s). This element departs from traditional government roles relative to the automobile industry. Rather than promulgating related federal regulations or attempting indirectly to stimulate commercial production through the technology push of research and development or the market pull of market demonstration, the intent of this project element is to directly induce commercial production through a cost and risk sharing business relationship with a major automobile manufacturer, who will determine the designs of vehicles to be produced.

The secondary element of the EVC Project will provide for research and development and commercial production of EV components and subsystems, including batteries. DOE has been sponsoring research, development, test, and evaluation efforts related to EV components and subsystems since 1976. A rapidly expanding technology base has been established. This momentum will be maintained, supplemented by concerted efforts to induce commercial production of promising components, subsystems, and batteries through innovative government/industry business relationships. Components and subsystems include motors, controllers, transmissions, propulsion subsystems, charger/charge indicators, and environmental controls. Battery development and commercialization include lead-acid, nickel-zinc, nickel-iron, and zinc-chlorine technologies.

In addition to direct involvement in the two major elements, DOE will provide technical and commercialization assistance of a nonfinancial nature to the vehicle, subsystem, component, and battery manufacturers. This support will consist of commercialization studies, field test vehicle development, field testing, brokering of coordination with the utility industry, market development assistance, and activities to supplement the incentives efforts underway in the DOE Market Demonstration project.

Hybrid Vehicle Commercialization. A hybrid vehicle is a vehicle that depends only partially on externally generated electricity for propulsion energy. The remaining propulsion energy may be supplied by gasoline, diesel fuel, or some other fuel such as alcohol. The program is following a path similar to that of the EV commercialization effort, displaced by about two years.

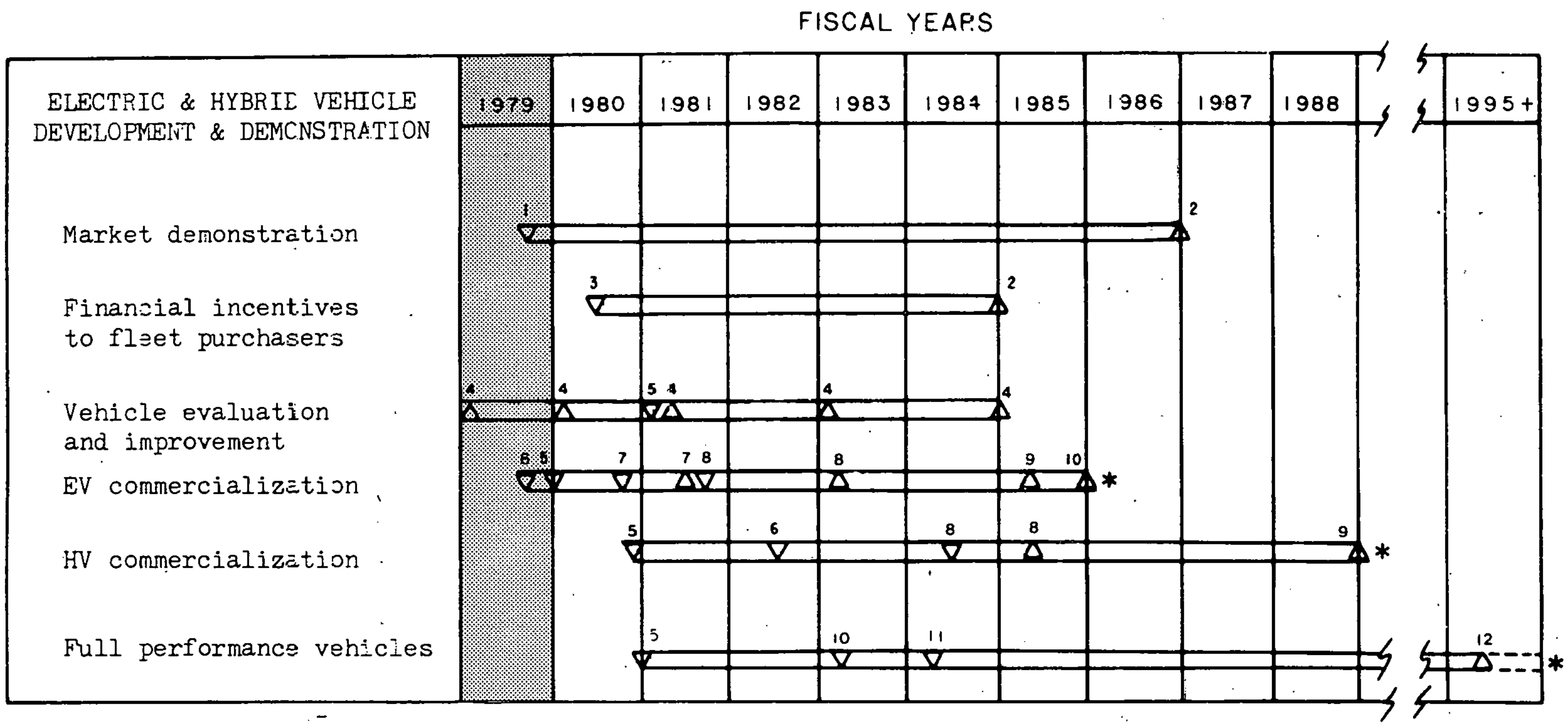
A five- to six-passenger hybrid vehicle suitable for all-purpose family travel can offer savings of 40% to 70% of the petroleum fuel used by internal combustion engine vehicles for the same mission at life cycle costs equivalent to comparable ICE vehicles, using gasoline and diesel fuel prices of $1.50 to $2.00/gal in 1978 dollars. Although hybrid vehicles in normal use offer less savings per vehicle mile than electric vehicles, their potentially greater market and use offer the possibility of greater petroleum savings than anticipated from early EVs.

Development of a near-term hybrid vehicle is in the final design stage. It couples the ETV-1 EV technology of separately excited d.c. motor, transistor field control, and regenerative braking with a fuel-injected 80 peak hp gasoline engine. Also, the EHV near-term system has an improved lead-acid battery, battery switching, and an automatic transmission. The battery alone will provide a 30 to 35 mile range from wall-plug electricity but either system or both will power the vehicle. Test vehicles will be delivered in 1982. It appears likely that hybrid vehicles could be commercialized in the late 1980s. Hybrids with heat engines could use alcohol or synfuels.

Advanced Vehicle Development. A number of advanced technologies in various stages of development with DOE support have the potential to enhance the capabilities or costs of electric or hybrid vehicles. Some of the technologies with such potential are primary metal-air batteries (aluminum-air appears to be the prime candidate), fuel cells, high temperature batteries (lithium-metal sulfide appears to be the prime candidate), inductive coupling to electrified roadways, and flywheels. Other optional approaches to extending vehicle range are rapid battery recharge and rapid battery exchange. Dual-fueled hybrids also have this potential. Several studies are exploring the full potentials of these technologies.

The objective of the DOE EHV program is to demonstrate a full-performance EV or nonpetroleum HV in the early 1990s. At this time it appears that such a vehicle could be commercialized in the late 1990s.

Figure 2.6 shows the EHV program milestone chart. The program has been substantially reorganized since the previous EDP. Of the four development areas described above (points b, c, d, and e), only the EV commercialization program plan has been produced. The most significant change is the inclusion of the zinc-chlorine battery for vehicle testing between late FY80 and early FY83, with possible presentation of this system to the general public by early FY81.



LEGEND

- △ Major milestone
- ▽ Intermediate milestone
- * Expected commercialization

1 First vehicles delivered to demonstration site operators.
2 Program expires.
3 First loan guarantee.
4 Publication of SOA report.
5 Project plan completed.
6 Integrated test vehicle unveiled (ETV-1, HTV-1)
7 Engineering test and decision period for near-term batteries (Ni/Fe, Pb/acid, Zn/Cl).
8 Field test and decision period, involving about 10 vehicles.
9 Mass production begins.
10 Commercialization technology definition complete.
11 In-vehicle testing of advanced batteries (Li/sulfide, Al/air, Na/S); decision to proceed.
12 Mass production in late 1990s.

Fig. 2.6 Electric and Hybrid Vehicle System Research, Development, and Demonstration Milestone Schedules

2.4 TRANSPORTATION SYSTEMS UTILIZATION: HARDWARE PROJECTS

Two active hardware projects are included in this subprogram, the Marine Diesel Bottoming Cycle and the Medium Speed Diesel Alternative Fuels program. A demonstration of a pipeline bottoming cycle is under study but not currently programmed.

The program status for development of modified marine steam turbine engines capable of using a coal-oil slurry as fuel has changed since the previous EDP. The Maritime Administration (DOC-MarAd) has assumed responsibility for design and laboratory testing of modified engines and is presently moving toward a demonstration. DOC-MarAd consequently has assumed responsibility for research elements R24.0 through R26.0 in the previous EDP. CS/TP will monitor MarAd's progress.

Concurrent with specific hardware projects are subprogram appraisals that could result in other hardware development. These appraisals include:

- Rail Transport Systems Project. This project will examine various prime movers applicable to rail propulsion, assess increasing rail electrification, and evaluate new concepts. A study of alternative locomotive technologies will be completed by early FY81.
- Engine, Vehicle, and Component Evaluation Project. This project will establish a formal method for the appraisal of appropriate ideas. An example is the laboratory testing of the automotive microcarburetor. (This project has recently been transferred from the Vehicle Performance branch of Transportation Systems Utilization to the Vehicle Systems branch of Automotive Technology Development.)
- Alternative Transportation Modes Project. This project will assess the potential of telecommunications as substitute for travel.

Some of these projects include strategy aspects that are described in Secs. 2.5 and 2.6.

2.4.1 Transportation Bottoming Cycle: Marine Diesel Application

Overview

This technology involves the recovery of waste heat through the use of an organic Rankine bottoming cycle, as applied to medium speed marine diesel engines. Marine diesel bottoming cycles work on the principles described in Sec. 2.2.6 for heavy duty diesel truck bottoming cycles.

Energy savings of 10% to 15% have been determined to be feasible for this bottoming cycle application. Furthermore, a recent market study shows a favorable potential for this technology with an investment recovery period of five years or less in some cases.[91]

Program

The program is designed to test the energy savings, reliability, and economic feasibility of marine diesel bottoming cycles, and to stimulate their commercialization. State of the art hardware will be used to save technology development costs.

Hardware will be secured beginning in FY81 for a one-vessel one-year demonstration commencing in mid-1983, as shown in Fig. 2.7. Each step towards demonstration has a go/no-go decision point.

2.4.2 Medium Speed Diesel Nonhighway Alternative Fuels Program

Overview

Alternative fuels for medium speed railroad locomotives and inter-coastal and inland marine vessels include various off-specification diesel fuels, synthetic fuels, and nondiesel fuels, such as alcohol. Properties of these fuels have been described in Secs. 2.2.8 and 2.2.9. Their proven value in rail and marine applications would provide alternatives to No. 2 diesel fuel in emergencies. Furthermore, proof that rail and marine medium speed diesels can operate on a wide range of alternative fuels would mean that future energy sources, such as coal, oil shale, and tar sands, could be refined to final products that optimize yield and minimize refining costs rather than to energy intensive equivalents of diesel fuels.

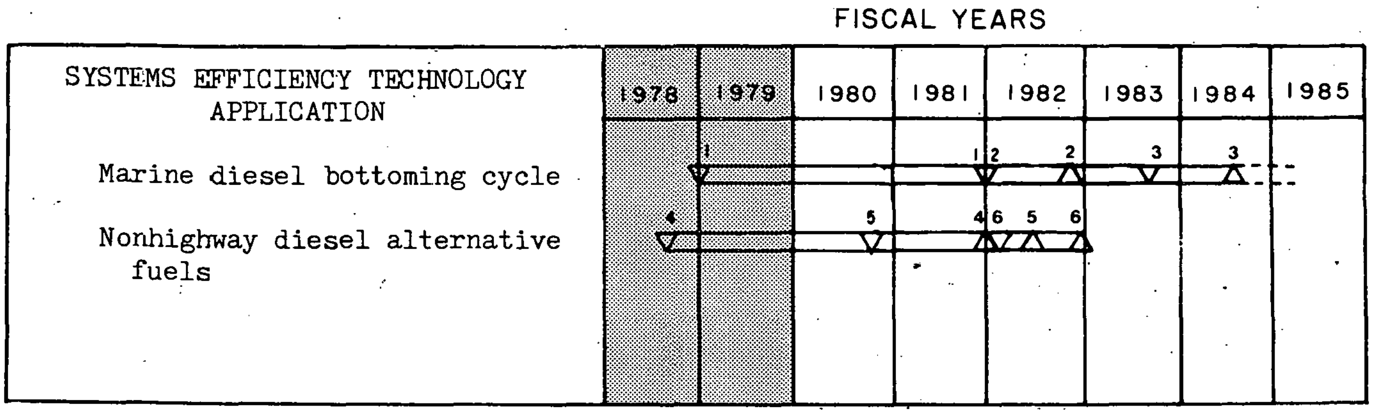
Program

The primary objective of this program is to demonstrate that current medium speed diesel engines can operate on certain alternative fuels and to define engine performance characteristics during such operations. The initial demonstration will be a joint DOE-Federal Railroad Administration-Association of American Railroads (DOT-FRA-AAR) rail application. Through FY80, diesel fuel properties are being varied. A number of blends are being tested for effect on the performance of a laboratory two-cylinder diesel. Thermal efficiency, power output, exhaust emissions, engine wear rates, and other parameters are being measured. Non-diesel fuels, primarily simulated coal-derived liquids and methanol, also are being tested. For these latter fuels, the test engine is being modified with an additional small diesel fuel pump and injector for ignition purposes.

By FY81 a joint DOE-FRA-AAR program will be initiated to follow up previous work and develop a test program for a multicylinder engine using alternative fuels. During FY82 that program will include laboratory testing and the controlled operation of a locomotive. Each program step has a go/no-go decision point on continuing engine development and testing.

2.5 STRATEGY PROGRAM: SYSTEMS EFFICIENCY

In addition to the above technologies, CS/TP is developing strategy projects that will, if implemented, contribute to the conservation and



LEGEND

△ Major milestones
▽ Intermediate milestones
1 Preliminary design and economic feasibility study period.
2 Hardware technology defined; unit developed.
3 One-vessel demonstration and decision period.
4 Prelininary laboratory test period.
5 Full-scale engine test period.
6 Controlled operational test and decision period (one rail locomotive).

Fig. 2.7 Systems Efficiency Research, Development and Demonstration Milestone Schedules optimum utilization of transportation fuels.[93] These projects focus on identifying deficiencies in the transportation infrastructure, eliminating institutional and regulatory impediments to transportation energy conservation, and communicating energy conservation information to major decision makers and energy users. In particular, these projects are intended to produce (1) more efficient use of existing transportation systems by encouraging improved vehicle and network operation and use patterns, (2) increased load factors through vanpooling and carpooling, and (3) shifts to more efficient modes of transportation.

Two strategy program areas under management of the Systems Efficiency Branch of Transportation Systems Utilization will eventually require an environmental or safety review or both. These programs, freight and intercity passenger transport, are described below. Other Systems Efficiency strategies include (1) assistance to state and local governments in the preparation of plans to comply with the Emergency Energy Conservation Act and other fuel conservation measures, (2) the Marine Outreach program for marine operators, (3) the federal Ad Hoc Ridesharing program, and (4) the Remote Telecommunications Feasibility program, which investigates and promotes substitution of telecommunications for transportation. These programs will apparently have no negative environmental effects; thus no research is scheduled for them in this EDP. Other programs, including a local telecommunications substitution strategy and a bikeways outreach effort, are in development and will be evaluated for environmental significance in future EDP updates.

2.5.1 Freight Transport

The freight transportation system can be more energy efficient and within the freight program are a number of activities geared to making improvements.

One activity is the Voluntary Truck and Bus Fuel Economy program, a joint industry/government (DOE/DOT/EPA) effort to reduce fuel use by commercial truck and bus operators, in which major emphasis presently is on trucks. DOE has focused on disseminating information, making fuel economy presentations to the industry, participating in industry trade shows, and developing marketing and educational programs to accelerate industry acceptance and use of fuel-efficient principles and techniques.

Another DOE activity is investigation of modal shifts in freight transportation. CS/TP is participating with the DOT Federal Railroad Administration in studying the economic practicality and relative energy efficiency of moving trailers on railroad flatcars (TOFC). Modeling techniques have been developed to describe freight shipper behavior and to test various modal shift strategies for energy and economic impacts. Subsequently, demonstration programs designed to test the modeled strategies will be conducted.

Other activities within the freight program include (1) monitoring and intervening in transportation regulatory agency actions; (2) participating in joint agency conferences; (3) continuing liaison with modal industries and trade associations in assessing conservation strategy options; (4) encouraging voluntary energy conservation in the ocean trades; (5) initiating staff efforts to foster energy conservation through improved operating procedures among surface freight transportation modes, intermodal cooperation, and freight consolidation, and (6) developing legislative proposals for regulatory problems that cannot be resolved by regulatory agencies. Demonstration projects in the freight program are being considered. Projects relating to transportation of energy materials have been transferred to the DOE Assistant Secretary for Resource Applications. CS/TP therefore is no longer responsible for research elements R28.0 through R30.0 in the previous EDP.

2.5.2 Intercity Passenger Transport

Intercity passenger transportation is unique in that all common carriers are regulated economically and operationally by federal agencies, although there is a trend toward less economic regulation of the aviation industry. The absence of a free market has resulted in energy inefficient operations, especially among air carriers, already the most energy inefficient of the intercity passenger modes. Activity in intercity passenger transportation focuses on three distinct areas, achieving modal shifts, improving the operating efficiency of current vehicles, and altering or eliminating regulatory barriers to energy-efficient operations.

Activity in modal shifts will be to support selected congressional legislation increasing subsidies to the rail and bus industries and eliminate subsidies to commercial aviation. Efforts to improve operating efficiencies will focus on air travel where improvements in the air traffic control systems and changes in operating procedures can produce significant energy savings. More than 50 changes in commercial and general aviation operating procedures are being evaluated, some of which may lead to demonstrations. Changes being studied include maintenance procedures, aircraft ground handling for taxiing and gate procedures, and in-flight control procedures, such as minimizing holding patterns. Regulatory activity will consist of intervening in major regulatory proceedings that clearly affect energy efficiency or fuel consumption, as well as evaluating regulatory reform legislation. Several DOT Federal Aviation Administration (FAA) regulations are currently under review.

2.6 STRATEGY PROGRAM: VEHICLE PERFORMANCE

Vehicle Performance programs under Transportation Systems Utilization are to increase public awareness of the means by which individual motorists may achieve fuel-efficient personal transportation through vehicle selection and good driving practices. The two principal activities are the DOE Driver Awareness program and extensive distribution of the EPA new car Gas Mileage Guide.

The Driver Awareness program employs existing educational and informational media to disseminate information on fuel-efficient practices to energy policy administrators, fleet personnel, individual drivers, and commercial vehicle operators at federal, state, and local government levels. Among the program offerings are an instructional training course, regional seminars and workshops, moderator packages, and public education materials. An important part of this program is the Voluntary Truck and Bus Outreach, designed to encourage private motor freight truck and bus operators to promote fuel-efficient practices among drivers and maintenance persons. A special target of the outreach program is fleet purchasing, which accounts for up to 25% of new car sales.

The EPA Gas Mileage Guide is published and distributed by DOE through a CS/TP Vehicle Performance program. The guide is distributed to the widest possible audience, including car dealers, public libraries, state and local vehicle agencies, and consumer groups, to increase awareness of the guide and to influence consumers to buy fuel-efficient cars. Several vehicle performance strategies currently under review may eventually evolve into programs. These include (1) outreach programs to promote improved private vehicle maintenance, such as tune-ups, (2) investigation of other nonhardware ways of achieving fuel efficiency under 1985 and subsequent Corporate Average Fuel Economy (CAFE) standards for automobiles and light trucks, and (3) identification of performance improvement factors, including aerodynamics, tires, and lubricants. None of the present or projected programs will require environmental review; however, downsizing of vehicles resulting in part from CAFE requirements, which is a performance parameter, raises safety issues requiring further study.

3 PRIMARY ENVIRONMENTAL CONCERNS AND RDD&A REQUIREMENTS

3.1 INTRODUCTION

This section describes the primary environmental concerns for each project in the transportation program and the environmental research and assessment requirements for resolving these concerns. The full concern list for each project is in Appendix A. The process by which these concerns are classified and designated as primary or secondary is described in Appendix B. Only adverse environmental impacts brought about by changes in the transportation system are considered. Positive impacts such as reduced dependence on petroleum fuel, conservation of energy, improved air quality, reduced vehicle noise levels, and reduced user cost are noted in Sec. 2.

The research and assessment requirements are determined by starting with the primary concerns, assessing the state of research and understanding of each primary concern, and then determining what further environmental research and assessment studies are needed to identify hardware designs, control techniques, or alternatives required to resolve each concern. This process is also described in Appendix B.

3.2 AUTOMOTIVE TECHNOLOGY DEVELOPMENT: PRIMARY CONCERNS AND RESEARCH REQUIREMENTS

Before discussing the specific primary concerns of the Automotive Technology Development program, a general concern should be noted. While some CS/TP research is being conducted in passenger and freight modal shifts, as described in Secs. 2.5 and 2.6, CS/TP generally appears to be constrained by such goals as maintaining mobility from searching for combinations of strategies that would produce the maximum reduction in dependence on petroleum fuels for the transportation system. Such combinations would include strategic, economic, operating, and technological options.

For example, the advanced automotive heat engines under development in CS/TP contribute to the continued existence of the automobile as it is today, a personal vehicle that requires its own right-of-way and that is large and powerful on a per-passenger basis, compared to other surface transportation modes.

Furthermore, the automobile generally will continue to cause more pollution, more passenger and pedestrian injuries and fatalities, and to require more land, natural resources, and fuel than options requiring less propulsion energy to move individuals, even under current technology. Similarly, funding improvements in heavy duty trucks under Vehicle Systems branch programs increases the competitive position of this mode, compared to other modes. If truck use increases as a result of CS/TP technologies, total specific energy consumption in freight movement could actually increase. Also, mixing increasing numbers of trucks with increasingly smaller cars could occur, thus increasing public safety problems.

DOE assists DOT and other agencies in performing research and assessments needed to arrive at combinations of strategies that minimize negative energy and environmental impacts. This issue is not developed further in the Automotive Technology Development program discussion of this EDP because it is precluded by Congressional mandate from being addressed within the context of the technology development program.

The environmental concerns for the Automotive Technology Development program are compiled and cross referenced in Appendix A, Tables A.1 to A.3. This discussion summarizes those table entries.

Several primary concerns are indicated for the two advanced heat engines even though their production goals are a decade away. Primary ecosystem and water quality concerns arise from potentially major increases in U.S. production and use of toxic superalloy metals, such as compounds of nickel and yttrium, which are projected to be necessary in the gas turbine engine. These concerns would be reduced if a ceramic-based engine were developed for commercialization. The significantly increased use of aluminum in the Stirling engine raises concerns of resource availability and, consequently, balance of trade economics, although downsizing the engine could mitigate this concern (see Table A.1, Appendix A).

Safety concerns are also included among primary concerns for advanced heat engines. Vehicle crashes involving these engines are not fully predictable. In the Stirling, hydrogen may pose new public and occupational safety hazards if not replaced by a relatively inert working fluid, such as helium. In the gas turbine, the ability of the engine housing to contain high speed turbine wheels in collisions is yet to be determined by vehicle crash tests.

For the truck bottoming cycle, emission characteristics should be similar to those of standard heavy duty diesel engines, unless exhaust cooling is shown by testing to alter them. This would be a primary concern. In addition, the present working fluid of the bottoming cycle is toxic. Because actual information concerning the effects of this toxicity on truck maintenance personnel, truck drivers, the public, and the ecosystem has not been generated in practice or by demonstration, several primary concerns arise. Two toxicity/toxicology studies of the working fluid for this bottoming cycle currently are being sponsored by the EV Office of Health and Environmental Research. Future issues relative to the handling, transport, and long-term environmental impacts of bottoming cycle fluids should be studied in all the potential technology applications under various DOE offices (see Table A.2, Appendix A).

The environmental concerns associated with the introduction of alternative fuels for the transportation system are related to the chemical composition of the fuels, vehicle exhaust, and evaporative emissions. Potential public and occupational health effects from direct exposure to fuels derived from coal, tar sands, or oil shale, and indirect health effects occurring from changes in the composition of vehicle emissions may be serious. The key concerns are aldehyde emissions from neat alcohols, increased evaporative HC emissions from alcohol/gasoline blends, aromatic compounds in new hydrocarbon and synthetic fuels, and the combustion products of these alternative fuels.

Several other concerns have been identified for this subprogram, but are designated secondary by virtue of the probability and time frame for emergence/resolution, or the limited risk associated with the concern. These secondary concerns are described in Appendix A, Table A.3. Research programs for these concerns will be identified in subsequent EDPs as necessary.

Since the previous EDP, considerable research has been conducted in alternative fuels, which has increased understanding of environmental concerns associated with these fuels. A detailed description of the impact of alternative fuels use projected in Appendix C is presented in Table A.3.

Table 3.1 presents the primary concerns identified for all Automotive Technology Development programs and the level of understanding of the impact of each concern. These correspond to the levels designated in Appendix B, Table B.2.

Table 3.1 relates the primary concerns with the research requirements for concern resolution. The type of research and assessment required for specific and aggregate concerns is listed. Also included in the table are possible standards, guidelines or limits that may be needed, and the date when they should be established. The table also lists responsibilities for specific research items, and cross references the specific environmental research activities described and scheduled in Sec. 4. This pattern is repeated in subsequent tables covering the other transportation programs.

Table 3.5 identifies those concerns the status of which has been changed from primary to secondary or secondary to primary for this update. The basis for each status change is provided, supported by quantitative information where available. Nine additional concerns for Automotive Technology Development programs have been identified. They are included in Tables A.1 through A.3. These new concerns, which are designated either primary or secondary, are summarized in Table 3.6.

3.3 ELECTRIC AND HYBRID VEHICLE SYSTEMS: PRIMARY CONCERNS AND RESEARCH REQUIREMENTS

Major assessments conducted since the previous EDP have contributed to better definition and understanding of the environmental concerns associated with EHVs. This is mainly the result of the comprehensive research required to produce the EHV programmatic EA.[68] Table 3.2 shows the population of electric and hybrid vehicles projected in each future market penetration analyzed by that EA, compared to the DOE goal. Tables A.4 to A.7 in Appendix A detail the relevant concerns arising from these assessments and assign quantitative values to the most significant impacts.

Health problems, usually from emissions into air or water, and safety issues are still of major concern in EHV systems. New emission control standards would mitigate a large number of these potential problems if they were established and enforced. The generation of SO_x from power plant coal combustion is pollution for which political pressures may force a less stringent emission or air quality standard than needed for reasonable protection of public health and the ecosystem. Beyond 2000, during high EHV market

Table 3.1 Automotive Technology Development Concern/Research Relationship Map

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	<u>Ecosystem</u>						
A1-2.0 A1-25.0	Heat Engines	Could cause significantly increased production of superalloys for large-scale introduction of improved heat engines.	II Superalloys are generally toxic to humans, to fish and have some effect on plant growth. Current control mechanisms generally expected to be insufficient.	Nickel on Toxic Pollutant List. Pollution controls due 1983.	Study of toxicity and health effects (ongoing FY80), environmental controls, & annual production rate.	TP/ASEV/ ASFE	R1.0 R2.0 R4.0
A2-23.0	Truck Bottoming Cycle	Release of the probable working fluid, trifluoroethanol (TFE), during shipping, vehicle accidents, disposal/recycling may lead to localized adverse impacts.	II Toxic but research has been limited to laboratory animals. On-road risk not determined. Cleanup procedures for localized spills have been identified.	Containment goals due 1982.	Environmental control for demonstration.	TP/ASEV	R10.0
				Shipping guidelines, system design goals to minimize spillage impacts, effluent and waste disposal goals due 1983.	Transport, fate and effects study.	ASEV	R10.0
					Environmental control study.	ASEV	R10.0
	<u>Resource</u>						
A1-3.0	Stirling Engine	Materials, especially metals, could pose major constraint. However, current reference engine has significantly decreased reliance on imported metals. Downsizing of engine would decrease reliance on aluminum.	II Quantities, source and availability not well defined, but better understood than at time of previous EDP.	---	Critical materials study set for completion early FY81.	TP	R1.0

Note: Level of Understanding:

0 = Concern identified but no understanding of impacts or severity.

I = Initial understanding but not relevant to transportation system or environmental systems.

II = Qualitative understanding of impacts on environmental systems but not transportation system components.

III = Full understanding of the effects on all systems/subsystems.

IV = Sufficient design, control technique, modification or alternative available.

Table 3.1 (Cont'd)

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	<u>Physical Environment</u>						
A1-7.0 A1-31.0	Heat Engines	Potential localized water quality problems with superalloys.	II As above, under ecosystem concerns.		(See under A1-2.0, A1-25.0)		
A2-26.0 A2-28.0	Truck Bottoming Cycle	Impact of TFE manufacture on air and water quality.	II Manufacturing waste results undefined. Limited data available from 20 years of TFE manufacture. See Ref. 28.	(See under A2-23.0)	Environmental control study.	ASEV/TP	R10.0
A2-27.0		Cooled exhaust gases have undefined pollution characteristics.	II Reactivity of primary tailpipe emissions is affected by change in exhaust temperature.		Emission tests by development contractor.	TP	R3.0
A3-3.0 A3-12.0 A3-27.0 A3-34.0	Alternative Fuels	Impact of evaporative and exhaust emissions on air quality from any combination of alternative fuels and heat engines.	I or II depending on pollutant.	Decision on new exhaust and evaporative emissions goals for use of alcohol blend as transport fuel, due 1983; decisions on other alternatives have longer time-frame.	Fuel composition analysis and engine emission tests. Complete reports for alcohol application to diesel, FY80.	TP	R14.0
					Effects, environmental control study, possibly transport and fate studies, depending on R&D results.	ASEV	R14.0
	<u>Health</u>						
A2-33.0	Truck Bottoming Cycle	Impact of TFE on production and maintenance labor.	II TFE is very toxic; impacts have been identified and safe handling procedures and antidotes recommended.	Handling/distribution control procedures for trucking industry due 1983; already in place for manufacture.	Same as under ecosystem.	ASEV	R10.0
A2-33.5		Effect on public health of emissions changes.	II See physical environmental concern above.				

Table 3.1 (Cont'd)

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	Health (Cont'd)						
A3-16.0 A3-17.0	Neat Alcohol Fuels	Aldehydes exhaust emissions. Interaction effects with other compounds, chemicals and drugs.	II Aldehydes are highly toxic. Accumulation kinetics and dose-effect relationships unknown. Understanding synergistic effects difficult.	EPA decision on need for emission standards for formaldehyde and unburned methanol and controls on distribution of methanol needed by 1987.	Engine emission tests.	TP	R14.0
					Fate and effects study. Effects study of methanol inhalation, toxicity scheduled FY81; study of short term toxicity of alcohol blend emissions in laboratory animals scheduled FY81.	ASEV	R14.0
A3-5.0 A3-37.0	New Hydrocarbon, Synthetic Fuels	Aromatic content of fuel, and exhaust and evaporative emissions.	II Aromatics are known carcinogens.	Emission goals and handling/distribution control procedures due 1987.	Effects study to be defined when fuels are specified.	ASEV/ASFE	R14.0
	Safety						
A1-14.0	Stirling Engine	Explosion and fire of hydrogen as a working fluid.	III Production, distribution and utilization hazards of hydrogen known. 18%-59% in air is explosive.	Safety goals due 1985.	Control technology: determine design for MOD II engine. May be obviated by helium.	TP/ASEV	R5.0
A1-36.0	Gas Turbine Engine	Rotational energy in turbine wheels.	II Effect in crash situations.	Containment goals due 1984.	Effect and design studies.	TP/DOT	R6.0
A2-35.0 A2-36.0	Truck Bottoming Cycle	Driver and public safety due to hot TFE in accident situation; potential of fire.	II TFE is quite toxic and somewhat flammable; alternative fluid is less toxic but very flammable. "Safe" fluid may reduce cycle efficiency. Spill cleanup method set.	System rupture goals due 1982.	Same as under ecosystem.	TP/AC/ASEV	R10.0
	Socioeconomic						
A1-17.0	Heat Engines	Materials use may alter balance of trade.	II See resource concern above.				

Table 3.2 Electric and Hybrid Vehicles on the Road by Scenario and Type in 1985, 1990, and 2000, in Thousands

	Light Truck[a]			Local Bus[b]			Automobile			Total		
Scenario	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
LOW[c]												
Electrics	34	131	2000	0	10	60	20	70	940	54	211	3000
MEDIUM												
Electrics	55	245	4750	0	40	190	40	125	3060	95	410	8000
DOE GOAL												
Electrics	Not Distributed Among Vehicle Types									42	398	8600
Hybrids										0	275	7800
Advanced[d]										0	0	3000
Total										42	673	19400
HIGH												
Electrics	116	471	8850	2	72	121	50	297	8480	168	840	15900
Hybrids	0	62	4470	0	0	0	0	29	2080	0	115	8100
Total	116	533	13300	2	72	121	50	326	10600	168	955	24000

[a]Under 10,000 lbs GVW.

[b]Transit and school.

[c]LOW and MEDIUM have only electrics.

[d]Full performance vehicles.

penetrations (see Table 3.2), localized effects from electric vehicle production, such as metal mining and processing and battery manufacturing, and from coal combustion to generate electricity for battery charging, may be significant if adequate standards are not imposed or enforced in advance.

In the near term, prior to commercialization of the zinc-chlorine battery, except for arsine and stibine generation during and right after lead-acid battery charging, EHV environmental concerns will be low level for two reasons:

1. The number of vehicles on the road will be small.
2. P.L. 94-413 requires updating standards governing vehicle performance and public and occupational health and safety as knowledge improves during the market demonstration.

Concerning stibine, Ref. 84 establishes procedures for safe battery charging and testing. More definitive data on which to base future standards is now being collected.

In the mid-term, 1985-1990, when vehicles are in more widespread postdemonstration use, thus under less control, and the zinc-chlorine battery may have been commercialized, health and safety problems may become more important relative to the user, maintenance mechanic, and factory worker producing vehicles or vehicle subsystems. These concerns arise from caustic or toxic battery materials, especially in crashes, and uncertain failure modes of various components.

When EHVs replace some conventional vehicles, and if and when nickel-based batteries come into large-scale use, balance of trade impacts may be significant.

Table 3.3 presents the primary concerns of the Electric and Hybrid Vehicle Systems program and describes the level of understanding of the impact of each concern. Changes in concern status are indicated in Table 3.5. New and deleted concerns are described in Table 3.6.

3.4 TRANSPORTATION SYSTEMS UTILIZATION

3.4.1 Systems Efficiency Hardware Programs: Primary Concerns

Table A.8 of Appendix A describes concerns for transportation systems technologies being developed under Systems Efficiency branch programs of Transportation Systems Utilization.

The tetrafluoroethanol (TFE) working fluid in the marine bottoming cycle is expected to be highly toxic. Health and safety primary concerns are identified,[27] along with concerns pertaining to the ecosystem and physical environment. Toxicity/toxicology studies are underway (see Sec. 3.2.1). Because the exhaust gas cooling rate changes the characteristics of the propulsion system emissions, an assessment of these emissions is necessary.

Table 3.3 Electric and Hybrid Vehicle Systems Concern/Research Relationship Map

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	Resource						
A4-30.0	Ni Batteries	Some sources of imported nickel, cobalt are unstable; zinc capacity limited.	III Depending on price scenarios balance of trade impacts could be negative.		Worldwide demand and cost analysis.	TP/AC	R17.0
A4-60.0	Zn-Cl Battery	Battery zinc demand could be 41% of U.S. total zince demand by 2000.	III New recycling technologies required.		Analysis of industrial capacity.	TP/AC	R17.0
	Physical Environment						
A7-4.0 A7-5.0	EHV System	Air and water emissions from all phases of vehicle materials extraction to vehicle production.	II or III Depending on pollutant.	Pb/Acid battery manufacturing standards proposed by EPA. Ni battery standards should be set by 1982. Mining standards must be reviewed.	More research needed to set standards. Commercialization may be affected by stringent existing standards. Monitor.	EPA/ASEV/AC/TP	R18.0 R19.0 R20.0
	Health						
A4- 6.0 A4-10.0 A4-10.5 A4-12.0	Lead-Acid Battery	Use of lead, lead oxide, antimony in battery raises health concerns. Environmental effects of this battery must be known before extensive commitment.	III EPA has studied lead extensively. Extensive experience has been gained in industrial handling of lead and other battery materials. Existing controls may be satisfactory.	Proposed New Source Performance standards for Pb/acid battery manufacture issued 1/80; guidelines for battery materials in manufacture, recycle, disposal overdue.	Study of alternative procedures and materials, health effects studies (underway during 1980). Control technology to be studied.	ASEV/AC/TP	R20.0
			II Stibine harmless at low levels; must assure procedures to maintain low levels.	Standards and procedures for battery charging, testing, and regenerative braking, Jan. 1981.	Complete data collection.	ASEV/AC/TP	R21.0

Note: Level of Understanding:

0 = Concern identified but no understanding of impacts or severity.

I = Initial understanding but not relevant to transportation system or environmental systems.

II = Qualitative understanding of impacts on environmental systems but not transportation system components.

III = Full understanding of the effects on all systems/subsystems.

IV = Sufficient design, control technique, modification, or alternative available.

Table 3.3 (Cont'd)

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	Health (Cont'd)						
A4-35.0	Batteries, General (Ni/Fe, Ni/Zn, Li/S)	Use of nickel, lithium, mercury, sodium hydroxide and other additives in electrodes.	II Nickel carbonyl and other forms of nickel are known carcinogens in humans and for experimental animals. Existing industrial controls may be satisfactory.	Emission goals on manufacture, recycle, and disposal operations due 1980. Production of nickel-containing battery regulated by OSHA.	Effects and control technology studies.	ASEV/EPA	R20.0
			II Mercury a known health problem.	Workplace exposure limits exist.	Dose-response, control studies.	ASEV/OSHA	R20.0
A4-97.1	Motors	Copper aerosol.	I New concern.	Need unknown.	Effects characterization. Control technology study.	TP/ASEV	R20.0
A4-106.0	Flywheel	Manufacturing hazards of composite materials.	I Some relevant plastics industry experience in aerospace components.	Standards for workplace.	Hazard identification. Control technology study.	ASEV/AC/ OSHA	R19.0
A4-116.0	Body/Chassis	Manufacture or repair of fiberglass or fiber-reinforced plastics.	II Hazards from abrasive fine particulate matter, epoxies, resins, and evaporative hydrocarbons not clearly determined.	Standards for workplace.	Effects study. Control technology study.	ASEV/OSHA	R19.0
A5-1.0	Electric Vehicle	Operation may expose occupants to toxic materials.	II Low concentrations of toxics may exist.	Standards for design, operation and replacement.	Effects study. Control technology study.	ASEV/TP/ AC	R18.0 R20.0 R21.0
	Safety						
A4-13.0 A4-16.0 A4-24.0 A4-25.0 A4-37.0 A4-38.0 A4-45.0 A4-46.0 A4-56.0	Batteries	Electrolyte spillage, fire, electric shock potential.	II Hazards are recognized but possible solutions are not defined or being studied.	Electrolyte containment standards; flammable material overheat and short circuit protection standards; design standards to reduce conductive surface exposure. First DOE handling guidelines promulgated, 1978. Monitor to determine future needs.	Study of alternatives including laboratory tests of concepts. Characterize gases, aerosols and quantities produced. Effects research. Control technology study.	AC/ ASEV/TP	R22.0

Table 3.3 (Cont'd)

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	<u>Safety</u> (Cont'd)						
A4-14.0 A4-23.0 A4-36.0 A4-67.0		For aqueous batteries, explosion potential of hydrogen and other gas formed during charging.	II If maintenance-free, sealed batteries can be used, problem solved.	Venting standards. DOE performance standard is less than 4% hydrogen during operation.	Venting designs.	AC/ ASEV	R22.0
A4-69.0	Zinc - Chlorine Battery	Chlorine gas control is critical for this battery system.	II Extent of chlorine gas seepage from battery unknown. Potential concentrations of chlorine in worst case accident unknown. Effects of various concentrations known.	Venting standards for batteries in parked vehicle; accident survival standards for battery due 1982.	Study of concentrations in the air due to slurry spillage for various situations. Study of containment requirements. Failure modes unknown.	AC/ASEV/ TP	R22.0
A4-78.0	Sodium-Sulfur Battery	Na electrode explosive in contact with H_2O..	II Hazards are recognized but possible solutions are not defined or being studied.	Containment goals due 1982. Standards for battery, due 1982.	Research design. Study of containment requirements.	AC/ASEV	R22.0
A4-91.0	Chargers	Shock hazard control.	II Hazards to operators, maintenance personnel.	Design standards to minimize shock potential. First version promulgated by DOE.	Study of alternative design options. Characterize gases produced, health effects.	TP/ASEV	R22.0
A4-94.0		Toxic gas release from fire, overheating during failure or accident.	0 On-board charger presents greatest problem. Rate of release unknown. Efforts to identify alternative materials unknown.	Material standards for charger. Design standards to minimize overheating were due 1979.	Laboratory study of gases produced.	TP/ASEV	R22.0
A4-107.0 A4-109.0 A4-110.0	Flywheel	Large amounts of rotational kinetic energy stored must be controlled during failure. Gyroscopic torque effects during adverse road conditions.	II Nonshattering materials available, energy release rates unknown. II Torque effects unknown.	Standards, controls and inspections for manufacture, repair and operation due 1982.	Alternative designs for containment shell, warning devices, vehicle testing on slippery roads.	TP	R22.0

Table 3.3 (Cont'd)

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	Safety (Cont'd)						
A4-106.0 A4-108.0		Fire hazards	II Fire hazards present with composites and with bearing lubrication	Standards for repair and operation due 1982.	Measurement, effects, control technologies studies.	TP/ASEV	R22.0
A4-106.0 A4-109.0		Possible fiber/epoxy emissions of toxic gases during overheating due to malfunction.	II Hazard recognized, extent of impact unknown.	Goals to assure safe concentrations in vehicle due 1982.	Measurement, effects, control technologies studies.	AC/TP/ ASEV	R22.0
A4-107.0		Possible eye injury from vacuum pump oil film coating cornea.	II Seal effectiveness unknown, thus potential of eye damage unclear.	Goals for seals due 1982.	Vacuum equipment design. Effects, control technology studies.	AC/T P ASEV	R22.0
A4-117.0 A5-3.0	Electric Vehicle	Impact protection.	II Many existing EHV designs do not meet all FMVSS. DOE demonstration vehicles must meet FMVSS.	Front, rear, side and rollover standards. DOE performance standards state that FMVSS apply. Also	Laboratory and field test of alternative design concepts.	TP/DOT	R22.0
				DOE requires additional measures to protect for shock, battery materials spillage.	Laboratory and field test of alternative high strength, low weight materials.	TP/DOT	R22.0
A5-2.0		Routine operation and failure procedures.	II Must be compatible with existing traffic patterns.	Vehicle handling standards and routing failure standards. DOE performance standards state FMVSS apply. Also, acceleration, gradeability, forward speed capability, other standards issued.	Systematic identification of handling requirements and potential failures. Demonstration data analysis. Control technology studies.	TP/DOT/ ASEV	R22.0
A6-4.0 A6-5.0	Hybrid Vehicle	Potential for explosion and fire from certain combinations of two energy systems. All "failure-trees" for combinations of energy systems not complete.	II	Goals for isolation of energy sources due 1982.	Characterization and measurement studies of hybrid failure modes. Control technology studies.	TP/ASEV	R22.0

Table 3.3 (Cont'd)

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	Socioeconomic						
A4-98.0 A7-15.0	Electric Motor	Fire control.	III New material will result in new types of fire; shocks to fire fighters.	Guidelines for current levels of effectiveness were due 1979.	Fire fighting modifications, control technology studies.	TP/ASEV	R22.0
A7-14.0	EHV System	Vehicle costs relative to alternatives.	II Life cycle costs and market penetration studies not encouraging.		Methods to reduce capital and operating costs.	TP	R23.0
A7-14.4		Ni and Co in Ni electrode batteries imported. Availability of the metals and impact on U.S. balance of trade and vehicle price in question in high market penetration scenarios.	II Uncertain world metals markets could preclude large-scale commercialization of Ni batteries.		Projections and analysis of world demand and supply.	TP/AC	R17.0

Environmental concerns associated with the medium speed diesel engine alternative fuels program are covered under the Automotive Technology Development alternative fuels program in Sec. 3.2.2.

Table 3.4 lists the primary concerns identified above for the Systems Efficiency technology subprogram and describes the level of understanding of of each concern. One deleted concern is described in Table 3.6.

3.4.2 Strategy Program: Primary Concerns

Table A.9 in Appendix A describes concerns for the Strategy Programs under Transportation Systems Utilization.

The intercity passenger project has a number of concerns, one of which is primary at this time. Safety problems arising from expected changes in operating techniques of intercity passenger modes require study. These changes may involve replacing energy-intensive airline practices and modifying fuel-inefficient DOT/Federal Aviation Administration requirements. No primary issues have been identified at this time for the freight project.

The safety of downsized automobiles in collision with heavier vehicles is a concern that has arisen in connection with vehicle performance parameters, although the concern is not yet directly linked with a specific strategy program. As autos become lighter in response to CAFE standards, they provide less protection to occupants in collisions with heavy trucks and heavier electric and hybrid vehicles. The probability of automobile occupants surviving such collisions may eventually be so low that dedicated roadways may be the only solution. Identified intercity passenger and vehicle performance primary concerns are summarized at the end of Table 3.4.

Table 3.4 Transportation Systems Utilization Concern/Research Relationship Map

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	<u>Ecosystem</u>						
A8-1.0	Marine Bottoming Cycle	Working fluid impact resulting from spill during shipping.	II Several working fluids are proposed, most are very toxic, impacts unknown. Fluorinols, the most likely candidates, are highly toxic, but low in flammability. Handling and spill cleanup procedures have been identified.	Fluid-release containment goals due 1982.	Environmental control for demonstration.	TP/ASEV	R10.0
				Shipping guidelines due 1982.	Transport, fate and effects study.	ASEV/AC ASEV/TP	R10.0 R10.0
	<u>Physical Environment</u>						
A8-4.0	Marine Bottoming Cycle	The rate of cooling of exhaust gases changes emission characteristics. May be similar to cooled diesel exhaust of turbocompounded engines.	I Results unknown.	Emission guidelines for normal operation due 1982 and 1983.	Demonstration data assessment should indicate controls needed.	TP	R12.0
A8-5.0		Air quality impacts from working fluid spills.	II Working fluid not finalized, effects unknown. except in qualitative comparison among candidates.	See ecosystem above.			R10.0
A8-6.0		Manufacturing waste.	II By-products of manufacture unknown. Limited data available from 20 years of fluorinol manufacture. See Ref. 28.	Effluent and waste disposal goals due 1982 and 1983.	See ecosystem above.	ASEV	R10.0

Note: Level of Understanding:

0 = Concern identified but no understanding of impacts or severity.

I = Initial understanding but not relevant to transportation system or environmental systems.

II = Qualitative understanding of impacts on environmental systems but not transportation system components.

III = Full understanding of the effects on all systems/subsystems.

IV = Sufficient design, control technique, modification or alternative available.

Table 3.4 (Cont'd)

Appendix A Primary Concern	System & Technology	Summary of Primary Concern	Level of Understanding (see note)	Possible Standard, Guideline or Limit: Date by which Resolution is Needed	Environmental Research Required	Responsibility	Chapter 4 Research Item
	Medium Speed Diesel Alternative Fuels	See Table 3.1, Alternative Fuels.					
	<u>Health and Safety</u>						
A8-9.0 A8-10.0 A8-11.0 A8-12.0	Marine Bottoming Cycle	Occupational and public hazards associated with working fluid; controls must be established.	II Working fluid not finalized; effects unknown. Controls for fluorinol handling and exposure have been identified.	Goals for fluid containment in system due 1982 and 1983.	See ecosystem design studies.		
	Medium Speed Diesel Alternative Fuels	See Table 3.1, Neat Alcohols, New Hydrocarbons, Synthetic Fuels					
			Strategy Concerns				
A9-17.0	Intercity Passenger	Crash-avoidance capability.	I Specific operating procedures not known. Safety impacts may arise from changes in procedures.	Existing FAA safety standards for airplanes.	Full understanding of effects of specific techniques.	TP/DOT	R27.0
A9-19.0	Vehicle Performance	Occupant Protection	II Shear and stress properties of fiber-reinforced plastics known, but systematic crash tests involving FRP-body vehicles with heavier metal-body vehicles have not been conducted.	FMVSS only current guideline.	Crash tests with mannequins.	DOT	

Table 3.5 Summary of Changes in Concern Status

I. Status Change: PRIMARY → SECONDARY

AUTOMOTIVE TECHNOLOGY DEVELOPMENT

Concern:	A2-6.0 (Turbocompound Diesel Engine)
Basis for Change:	No indication that the turbocompound diesel engine emits pollutants at greater intensity than a conventional diesel of similar displacement under similar operating conditions. Diesel emissions are now under study to identify carcinogenic properties, which would be a primary concern for light duty diesel powered vehicles but not specifically for turbocompound engines.[26]
Concern:	A3-9.0 (Neat Alcohol)
Basis for Change:	In general, terrestrial effects associated with the use of neat alcohols are expected to be less severe than for gasoline. Effects are limited and tend to be reversible; recolonization of disrupted habitats is rapid.[36,41,51]
Concern:	A3-10.0 (Neat Alcohol)
Basis for Change:	Aquatic effects of alcohol spills are minimal compared to gasoline. Spills do not require mechanical removal. Effects are considered to be generally reversible; recolonization of disrupted habitats is rapid.[36]
Concern:	A3-11.0 (Neat Alcohol)
Basis for Change:	Changes in regulated pollutants are sufficiently well understood. While unburned alcohol emissions may increase, their photochemical reactivity is significantly less than gasoline hydrocarbons, implying a potential net positive air quality effect. (Aldehyde emissions are treated as a separate concern.)[34,37,46]
Concern:	A3-14.0 (Neat Alcohol)
Basis for Change:	Alcohols are generally less toxic than gasoline. However, there is a need to establish procedures to minimize exposure of persons to alcohol fuels and vapors during distribution and use. Risk is not significant.[46]
Concern:	A3-19.0 (Neat Alcohol)
Basis for Change:	Possibility of direct contact during the distribution and use of methanol fuels can be minimized with conventional controls. If exposure occurs, research indicates the likelihood of receiving a toxic concentration through dermal absorption is remote, except under extreme conditions.[51]
Concern:	A3-20.0 (Neat Alcohol)
Basis for Change:	Broader alcohol flammability limits do not pose a significant environmental concern. Flammability is mitigated by fuel additives that are likely to be used in neat alcohol fuels, and by a higher flash point, compared to gasoline.[56]

Table 3.5 (Cont'd)

Concern:	A3-26.0 (Alcohol Blends)
Basis for Change:	Effects of using alcohol blends are generally well understood. Increased emissions generally are small in absolute terms. Existing emission standards can be used to control increses in regulated emissions. Current generation vehicle emission systems minimize the impact of alcohol blends on unregulated emissions, such as aldehydes and unburned alcohol, as well as regulated emissions.[42]
	ELECTRIC AND HYBRID VEHICLE SYSTEMS
Concern:	A4-113.0 (EHV Body/Chassis)
Basis for Change:	Overall concern for air quality of full vehicle manufacture is A7-4.0. There is no information to show that EHV body/ chassis will vary significantly from conventional vehicles with respect to manufacturing emissions. OSHA and EPA standards should apply.[68]
Concern:	A7-12.0 (EHV System)
Basis for Change:	DOE program developing vehicles compatible with missions of vehicles for which they would substitute. Therefore, urban structure/lifestyle impact will be minimal.[68]

II. Status Change: SECONDARY ⟶ PRIMARY

	AUTOMOTIVE TECHNOLOGY DEVELOPMENT
Concern:	A3-34.0 (Synthetic Fuels)
Basis for Change:	Increase in emission of aromatic compounds into atmosphere is a major concern. Need to establish aromatic emission standards requires early resolution. Increased aromatics emission involves public health and fuel processing and refining.[47,58]
Concern:	A3-37.0 (Synthetic Fuels)
Basis for Change:	Exposure to synthetic crudes and refined synthetic fuels during storage and distribution poses a potentially significant occupational and public health hazard owing to a relatively high aromatics content. Direct contact with these liquids has been shown to increase the likelihood of skin cancer. Early resolution of this concern is fundamental to the commercialization of synthetic fuels.[43,55,59]
Concern:	A4-26.0 and A4-39.0 (Ni-electrode Batteries)
Basis for Change:	Balance of trade effects would be significant under certain price structures owing to imports of nickel and cobalt.[68]

Table 3.5 (Cont'd)

Concern:	A4-30.0 and A4-60.0 (Zn-electrode Batteries)
Basis for Change:	Costs of increased zinc smelting requirements and zinc recycling would be high and could cause capacity problems in relatively near term.[68]
	ELECTRIC AND HYBRID VEHICLE SYSTEMS
Concern:	A4-6.0 (Pb/Acid Battery)
Basis for Change:	EPA proposed performance standards for battery manufacture published; impact on cost uncertain, but possibly significant, and relatively near-term.[61,68]
Concern:	A4-18.0 and A4-30.0 (Ni-electrode Batteries)
Basis for Change:	Growing uncertainty on stability of nickel and cobalt sources.[68]
Concern:	A7-5.0 (EHV Systems)
Basis for Change:	Increased coal power plant SO_x owing to EHV operation cannot be ignored. Final source performance standards may not be adequate.[68,76]

Table 3.6 Summary of New and Deleted Concerns

AUTOMOTIVE TECHNOLOGY DEVELOPMENT

I. Deleted Concerns

Concerns: A1-1.0, A1-5.0, A1-10.0, A1-11.5
Reason: No compounds of nickel used in reference Stirling engine regenerator seals.[10,12,13]

Concern: A1-6.0
Reason: MOD I engine use of combustion gas recirculation system has eliminated concern over excessive NO_x emission levels.[12,13]

II. New Concerns

Concern: A2-5.1 (Turbocompound Diesel Engine)
Status: Secondary
Brief: Identified in programmatic EA; backpressure employed as a hydrocarbon emission control technique, in addition to permitting turbocharger compressor to be downsized, may have secondary effect on particulate emissions in operation.[26]

Concern: A3-9.1 (Neat Alcohols)
Status: Secondary
Brief: Introduction of ethanol or methanol into waste water and drinking water systems should be subject to effective control and dissipation if source is identified and neutralized.[41,46]

Concern: A3-12.1 (Neat Alcohols)
Status: Secondary
Brief: Ability of carbon canisters to control evaporative emissions from neat alcohols remains in question. Redesign may be necessary.[46,50]

Concern: A3-12.2 (Neat Alcohols)
Status: Secondary
Brief: Evaporative losses during storage and distribution of neat alcohols not clearly defined.[35,38]

Concern: A3-19.1 (Neat Alcohols)
Status: Secondary
Brief: Assessment of body accumulation kinetics for and effect of long-term, low-level exposure to methanol and formaldehyde must be undertaken to determine the severity of health hazard.[57]

Concern: A3-28.0 (Alcohol Blends)
Status: Secondary
Brief: Disposal by burial of alcohol-blend storage-tank water-bottoms, should recycling prove infeasible, will require special attention to avoid groundwater contamination.[57]

Table 3.6 (Cont'd)

Concern:	A3-31.1 (Alcohol Blends)
Status:	Secondary
Brief:	Flammability limits and flash point changes for alcohol blends pose problems similar to those for neat alcohols, although the actual hazard compared to gasoline component of the blend is small.[56]
Concern:	A3-38.0 (Synthetic Fuels)
Status:	Secondary
Brief:	Evaluation of laws and regulations pertaining to distribution and use of synthetic fuels, such as routing and tariff requirements and limits on transportation applications, should be scheduled.[42]
Concern:	A3-38.1 (Synthetic Fuels)
Status:	Secondary
Brief:	Assessment of synthetic fuels distribution infrastructure requirements is advisable, as it is for alcohol blends. Capital requirements are unknown.[42]

ELECTRIC AND HYBRID VEHICLE SYSTEMS

I Deleted Concerns (excludes concerns combined with other concerns)

Concern:	A4-8.0 (Lead-Acid Battery)
Reason:	Lead recycling from scrap now in process.[18,68]
Concern:	A4-68.0 (Zn/Cl Battery)
Reason:	No evidence that shock is a hazard with this battery system. Battery recently demonstrated has no exposed terminals, thus no shock hazard.[74]
Concern:	A4-87.0 (Li-Metal Sulfide Battery)
Reason:	Since lithium currently has few domestic uses, effects on world markets of domestic battery use insignificant.[68]
Concern:	A7-3.0
Reason:	EHV programmatic EA indicates the amount of land required for vehicle system support infrastructure should not be excessive.[68]
Concern:	A7-8.0 and A7-9.0 (EHV System)
Reason:	EHV programmatic EA shows no evidence that aesthetic degradation will be a problem.[68]

II New Concerns and Status

Concern:	A4-16.5 and A4-87.5 (Pb and Li Electrode Batteries)
Status:	Secondary
Brief:	Advance planning required for adequate housing and municipal services in "boom" towns with extensive manufacturing of lead-acid and lithium-metal sulfide batteries after 1986.[68]

Table 3.6 (Cont'd)

Concern: A4-81.1 (Li-Metal Sulfide Battery)
Status: Secondary
Brief: Possible lack of electric power for U.S. aluminum production after 1990.[68]

Concern: A4-83.5 (Li-Metal Sulfide Battery)
Status: Secondary
Brief: Solid waste from battery materials production includes large burdens of pegmatite wastes and mill tailings; more than 200 acres of disposal landfill could be needed annually by 2000.[68]

Concern: A4-97.1 (Motors)
Status: Primary
Brief: Copper aerosol is a new health concern. Little is known. Magnitude of problem unknown.

Concern: A4-97.5 (Motors)
Status: Secondary
Brief: Ozone generation by direct current motors should be analyzed. Little known but problem expected to be minimal.[68]

Concern: A7-10.1 (EHV System)
Status: Secondary
Brief: Ecosystem effects, which will be local, should not develop until after 1990 and should be evaluated on a specific site basis.

Concern: A7-5.5 (EHV System)
Status: Secondary
Brief: High incremental pollutant loadings will be localized in mining and manufacturing areas after 1990.[68]

Concern: A7-6.1 (EHV System)
Status: Secondary
Brief: Solid waste generation could be significant in lithium mining areas after 1990.[68]

Concern: A7-14.2 (EHV System)
Status: Secondary
Brief: Battery industry could require up to 40,000 additional workers in 2000, compared to a no-EHVs economy.[68]

Concern: A7-14.4 (EHV System)
Status: Primary
Brief: U.S. balance of trade would be affected negatively by Ni and Co requirements under plausible price structures when EHV market penetration is high.[68]

Concern: A7-14.6 (EHV System)
Status: Secondary
Brief: Negative effects on local governments in "boom" town areas could be significant after 1990.[68]

Table 3.6 (Cont'd)

Concern: A7-14.8 (EHV System)
Status: Secondary
Brief: DOE encouragement of small manufacturers in early EHV commercialization years could engender unemployment if these manufacturers are priced out of the market by mass producers later.[68]

Concern: A7-18.0
Status: Secondary
Brief: Need for new electric utility generating capacity specifically attributable to EHVs expected to be insignificant before 2000.[68]

Concern: A7-19.0
Status: Primary
Brief: Near-term gearing up and transition problems in the battery, zinc, nickel, cobalt, lead, and motor vehicle industries will result from rapid EV commercialization.[68]

TRANSPORTATION SYSTEMS UTILIZATION

I. Deleted Concern

Concern: A8-2.0
Reason: Production bottoming cycle unit will be stainless steel unless completely unanticipated development problems arise prior to 1983.[91] (Deletion of this concern deletes research element R11.0 carried in previous EDP.)

II. New Concern

Concern: A9-19.0 (Vehicle Performance)
Status: Primary
Brief: Weight differential between downsized conventional automobiles and specialty vehicles (heavy trucks, electrics and hybrids) on the road will continue to increase.

4 ENVIRONMENTAL RESEARCH AND ASSESSMENT PLAN

4.1 INTRODUCTION

This section is the heart of the EDP, the environmental research and assessment plan that complements the CS/TP program presented in Sec. 2. The plan allows the primary environmental concerns summarized in the previous section to be addressed along with project milestones in a timely and coordinated fashion. Activities relating to secondary concerns, such as monitoring the development of a technology to assure environmental standards are met or performing longer range socioeconomic impact analyses necessary to support the National Environmental Policy Act (NEPA) processes described in Sec. 4.2, also are included in the plan. The plan therefore schedules specific environmental research activities and the major environmental documents required for each transportation project.

CS/TP has the ultimate responsibility for ensuring that the environmental requirements are fulfilled in time frames consistent with project demonstration, implementation, and commercialization dates. Much of the environmental research will be conducted by DOE organizations, or other federal agencies such as OSHA, EPA, DOL, and DOT, in conjunction with DOE.

Some environmental research, especially for determining effects of chronic exposure to toxic substances, requires several years to complete. For instance, setting exposure limits for toxic substances can take nearly as much time as a technology RDD&A cycle. The timing for all requirements, as well as their annual updating, is critical to the success of the strategy and technology development program.

This section describes strategies for carrying out the environmental research and assessment plan by identifying the responsibility and time frame for each study and the dates reports and related decisions are due. Many of the requirements were scheduled in the FY79 EDP; some have just been initiated.

4.2 MAJOR ENVIRONMENTAL DOCUMENTS

The National Environmental Policy Act of 1969 requires the preparation of Environmental Impact Statements (EIS) for major federal actions that significantly affect the environment. As an environmental planning document, the EDP must establish a schedule for responding to NEPA guidance. The NEPA process for a DOE action consists of the following steps:

1. Determination by the Assistant Secretary for the Environment (ASEV) of the significance of environmental or health impacts of the proposed program action, based on available knowledge, which leads to one of the following:

   a. Proceeding directly to proposed action, if environmental or health impacts are clearly insignificant; or

b. Preparation of an Environmental Assessment (EA) if these impacts are not clear and cannot be mitigated or of a Draft Environmental Impact Statement (DEIS) if significant impacts have already been identified; or

c. Preparation of a DEIS if the EA cannot result in a Finding of No Significant Impact (FoNSI), or significant environmental and health impacts already are known by the program without the need for preparing an EA.

2. Preparation of a final EIS, where required, following public comment and revisions to the DEIS;

3. Preparation of a Record of Decision, based on the final EIS; and

4. Proceed to proposed action.

The NEPA process assures that all environmental impacts (ecosystem, resource, physical environment, health, safety, and socioeconomic) resulting directly or indirectly from the action will be mitigated by appropriate technological measures, standards, or guidelines. It is thus dependent on the research schedule to precede it. The NEPA process must also identify, and often advance, the state of knowledge necessary to characterize the impacts.

The Electric and Hybrid Vehicle Systems program is an excellent example of NEPA processes. Three EAs have been prepared. One for the Electric and Hybrid Vehicle Demonstration Project is now final. A finding of No Significant Impact was reached by ASEV on this EA. A second EA, covering expected impacts of including EHVs in the computation of petroleum-equivalent fuel economy values for the Corporate Average Fuel Economy (CAFE) standards, was completed in May, 1980. Again a FoNSI was recommended. The third EA on the EHV program, which is scheduled to be completed by late FY80, addresses the full range of environmental impacts of EHV commercialization through 2000. An EIS decision will follow.

ASEV has an internal but complementary process to NEPA. The major document is the Environmental Readiness Document (ERD), which is prepared at key decision points in the development of a technology. It provides an assessment of the environmental status of a technology, is dependent on preceding research, and provides further definition of concerns and research needs. ERDs are not limited to major actions, do not require public review and comment, and are only for technology projects. Where the EIS process must consider alternative actions, the ERD assesses the status of environmental research and presents the environmental readiness specific to continuing development of a single technology. While ASEV and CS/TP share responsibility for the EDP and EIS process, ASEV alone prepares ERDs. ERDs and NEPA documents are scheduled in this section of the EDP. An example of a recently completed ERD is the one prepared for ORCS working fluids.[27]

DOE Order No. 5481.1 established the Safety Analysis and Review (SAR) system which requires incorporating a review process into DOE programs so that potential operating hazards are systematically identified, potential effects are analyzed, and reasonable measures are taken to eliminate, control, or mitigate hazards. A SAR document may categorize identified hazards as low, medium, or high, in ascending order of severity of on-site and off-site effects on persons and the environment. The SAR may be linked to EAs, EISs, or ERDs in that it evaluates programmatic designs against performance assumptions, thus providing the first level of assurance that environmental performance will be as intended. SAR may precede the NEPA process if subelements of a developing technology are identified early as potentially hazardous. A distinction is made between a Preliminary SAR (PSAR) and a Final SAR (FSAR). For complex major projects, for projects where all mitigation strategies have not been finalized, or for projects where insufficient data exists to do risk analysis, a PSAR is written. An FSAR, which satisfies all the points raised in the PSAR, is prepared before demonstration or commercialization. In many cases an FSAR can be written directly. SARs have been scheduled for a number of transporation program elements. The distinction between a PSAR and an FSAR has been made only for the zinc-chlorine battery SAR. Similar distinctions will be made on other programs as additional information is obtained.

4.3 SPECIFIC PROJECT ENVIRONMENTAL RESEARCH AND ASSESSMENT PLANS

This section contains a series of figures showing the environmental research and assessment plan for each transportation project. Each figure shows (1) the major decision points for the project, (2) the schedule for required major environmental documents, (3) the individual environmental research necessary to support decisions at major project milestones, and (4) the writing of the major environmental documents. The responsibility for each research activity is noted. For EAs scheduled beyond FY83, NEPA will review the environmental issues at the time to confirm that EAs still are needed.

An assessment program will be undertaken by the Emission Control Technology Division of ASEV to determine environmental controls and safety equipment required for advanced engine designs and use of alternate fuels. Results will contribute to (1) ERD review, (2) review of project environmental plans, (3) EIS review, (4) evaluation of emission regulations proposed by EPA, and (5) dissemination of requested information on controls and safety equipment.

General state of the art assessments are proposed for FY81. These reviews will determine the need for further control studies and will determine what assessments, definitions of degree, and characterizations would be needed in such control evaluations. Studies would then be scheduled beyond FY81. The initial one-year effort is expected to cost $100,000, with up to $300,000 to be committed as needed for future research.

The text describes required research activities, indicates the dates various reports are due, and assigns responsibilities. Descriptive titles are set off by quotation marks.

4.3.1 Stirling and Gas Turbine Engines Plan

The environmental research schedule for heat engines is shown in Fig. 4.1. By Jan. 1, 1981, "Heat Engine Vehicle Material Requirements" (R1.0), including superalloys, should be established by CS/TP so the study,

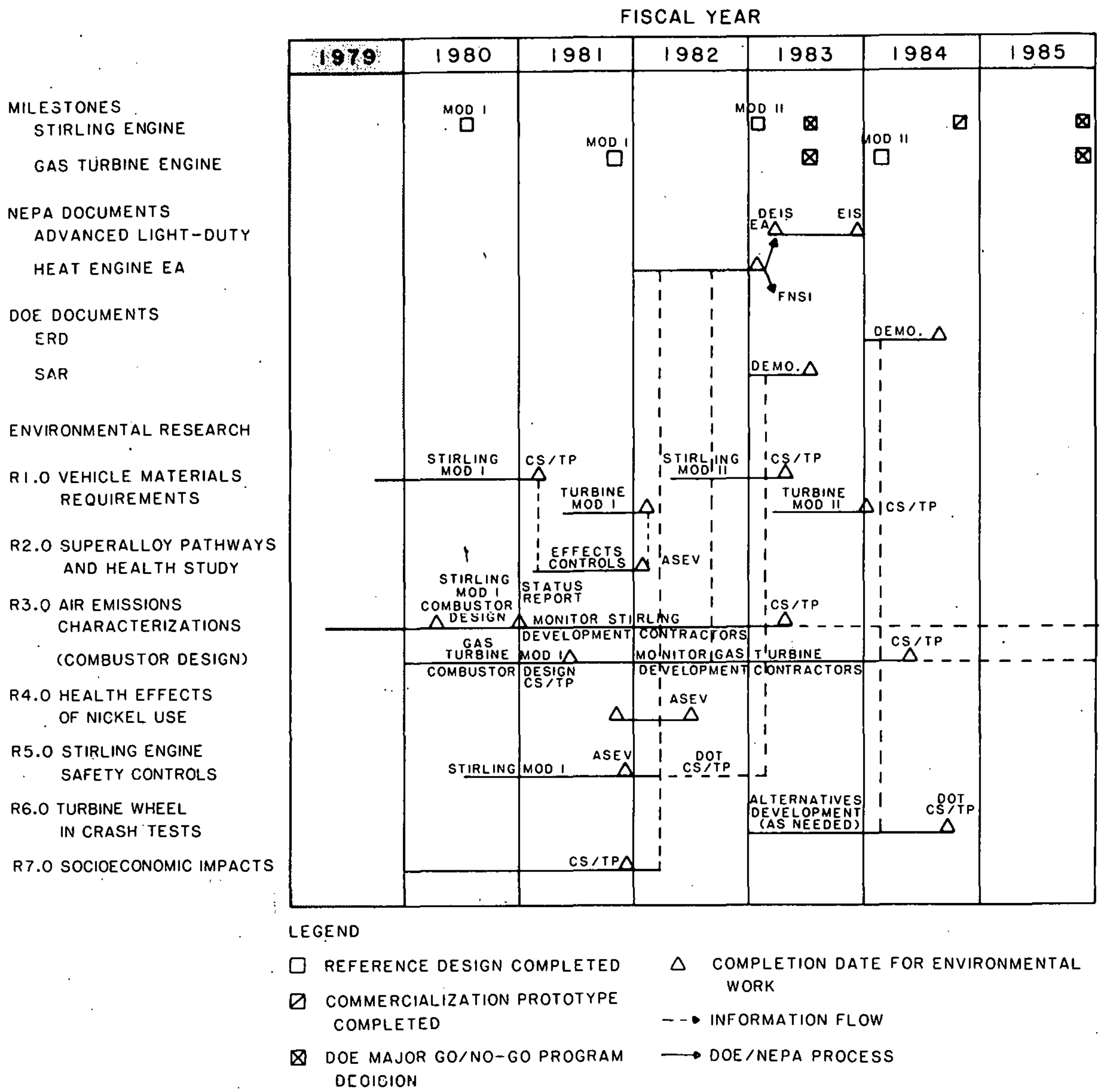


Fig. 4.1 Advanced Automotive Heat Engine Program Milestones, Environmental Studies and Research Plan

"Assesment of Toxicity, Pathways and Health Effects of Increased Superalloy Production and Utilization in Heat Engines" (R2.0), can begin. If CS/TP projects large increases in superalloy production, owing to heat engine commercialization, ASEV will conduct this study within a year and will assess the need for pollution controls by Oct. 1, 1982. This study is estimated to cost $50,000.

"Combustor Design Research" (R3.0) is underway by CS/TP to reduce heat engine emissions. Combustor design has been finalized for the Stirling MOD I reference engine. All progress on controlling exhaust emissions must be monitored by the development contractors. Status reports are due in early FY81 for the ERD and EA. According to program management reports, $500,000 has been dedicated thus far to funding combustor development for automotive Stirling and gas turbine engines.

Also included is "Identification of Health Effects of Nickel Use in Gas Turbine Seals" (R4.0). CS/TP contractors presently are considering nickel-base regenerator seals. When a seal design decision has been made and CS/TP can provide a description of the chemical forms of nickel in the seals, ASEV will, if necessary, characterize the problem and indicate a need for further measurement and study of the health effects, or for alternative seals. ASEV will assist CS/TP in developing environmentally acceptable alternative seals or control technology. Timely resolution of the seal question is critical to the gas turbine engine from both performance and environmental perspectives. At present, nickel-free alternative seals are available as a result of work by the Ford Motor Company and Daimler-Benz AG. Rights to produce these seals for the automotive gas turbine engine have been obtained by DOE contractors (Table 2.1). However, it is not clear whether this seal technology has been committed to the development program. Health effects research in this area may be consolidated with health research for R2.0, at no increase in the cost shown for that project.

"The Design of Control Technologies for Hydrogen and External Combustion" (R5.0) is an important ongoing study for the Stirling engine, which ASEV will monitor. Since hydrogen is still the working fluid, the risk of explosion must be minimized. Methods for distributing hydrogen and recharging the engine must be developed. Adequate controls must be demonstrated by CS/TP before vehicle demonstration. Resolution is required before the EA is complete (Oct. 1, 1982). Under NASA contract management, up to $350,000 has been expended thus far on hydrogen containment studies for the Stirling program. If helium, an inert gas, is substituted for hydrogen as the working fluid (see Sec. 3.2.2), most of this safety research will be unnecessary.

Effects of turbine blade fragments in crashes must be determined so "Design of Gas Turbine Engine to Contain Turbine Wheels" (R6.0) can proceed. CS/TP must show significant progress in housing design before EA is complete on Oct. 1, 1982. Ability of current housing design to contain ruptured ceramic turbine wheel fragments has been demonstrated. Demonstration by the development contractors or DOT that engine housings effectively contain turbine wheels when the integrity of the housing is destroyed will eliminate the need for additional research.

"Socioeconomic Impacts of Heat Engines" (R7.0) will assess institutional, labor, and other barriers, as well as economic and societal effects for both short and long range use. Some aspects of this study are currently underway within CS/TP for gas turbine and Stirling vehicle systems with completion expected in FY81. Expected total cost is $100,000. Balance of trade issues for various materials are of prime concern. The vehicle materials study, R1.0, is required.

An Environmental Assessment for advanced heat engines in light duty automotive applications, which incorporates research concerns R1.0 through R7.0 and other aspects of the introduction of these technologies into the passenger vehicle market, has been scheduled to begin in late FY81.

4.3.2 Turbocompound Diesel Engine Plan

As Fig. 4.2 shows, only air and noise emissions of this technology need to be monitored under "Turbocompound Air/Noise Emissions" (R8.0). CS/TP air and noise reports and the NEPA and ASEV documents are scheduled to assist in the expected FY83 commercialization decision. An EA prepared for this program in FY80 recommended a Finding of No Significant Impact.[26] Recent tests indicate a high probability the noise problem will be resolved in the near term, with more time needed for full investigation of the environmental impacts of diesel particulates and hydrocarbon emissions.

4.3.3 Transportation Bottoming Cycles Plan

Bottoming cycle applications in truck and marine diesels constitute a major environmental concern, owing to the toxicity of the working fluid. As Fig. 4.2 shows, research in this area has begun, and an ERD on working fluids was published in August, 1980.[27] "Identification of Environmental Effects of Transportation Bottoming Cycle Fluids" (R10.0) is scheduled, and research on health effects of working fluids, sponsored by the Office of Health and Environmental Research, is underway. An Environmental, Safety, and Institutional Assessment of the marine diesel bottoming cycle was submitted to CS/TP in April, 1980.[28] By Oct. 1, 1981, candidate control technology options will be fully evaluated by ASEV as part of ongoing controls studies. As appropriate, a full environmental and health effects report will be issued by Oct. 1, 1983. Total research costs will be $350,000. The Office of Advanced Conservation Technologies (CS/AC) may assist in funding continued research.

The air and noise emissions of transportation bottoming cycles must be monitored (R12.0) by CS/TP through its development contractors, and the information made available for the writing of the major environmental documents. This effort and the scheduled study, "Socioeconomic Impacts of Transportation Bottoming Cycles" (R13.0), are being delayed for the marine application, but are scheduled to be completed by FY84 at a cost not to exceed $100,000.

An Environmental Assessment for advanced technologies in heavy duty transportation engines, which incorporates research concerns R8.0, R10.0, R12.0, R13.0 and other issues relevant to the penetration of national vehicle markets by these technologies, is scheduled to begin early in FY81.

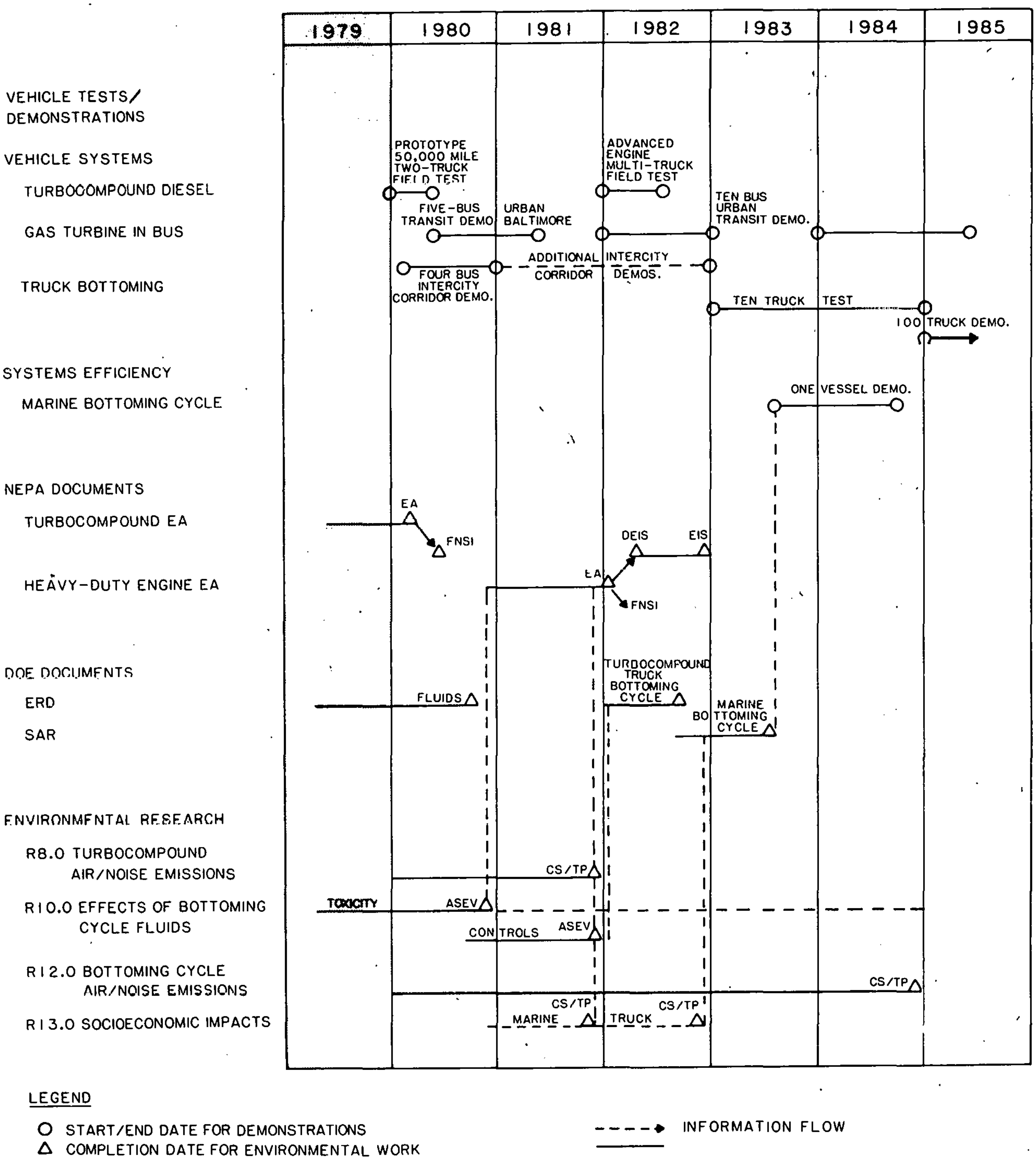


Fig. 4.2 Vehicle Systems/Transportation Bottoming Cycle Demonstration Schedule, Environmental Studies and Research Plan

4.3.4 Alternative Fuels Plan

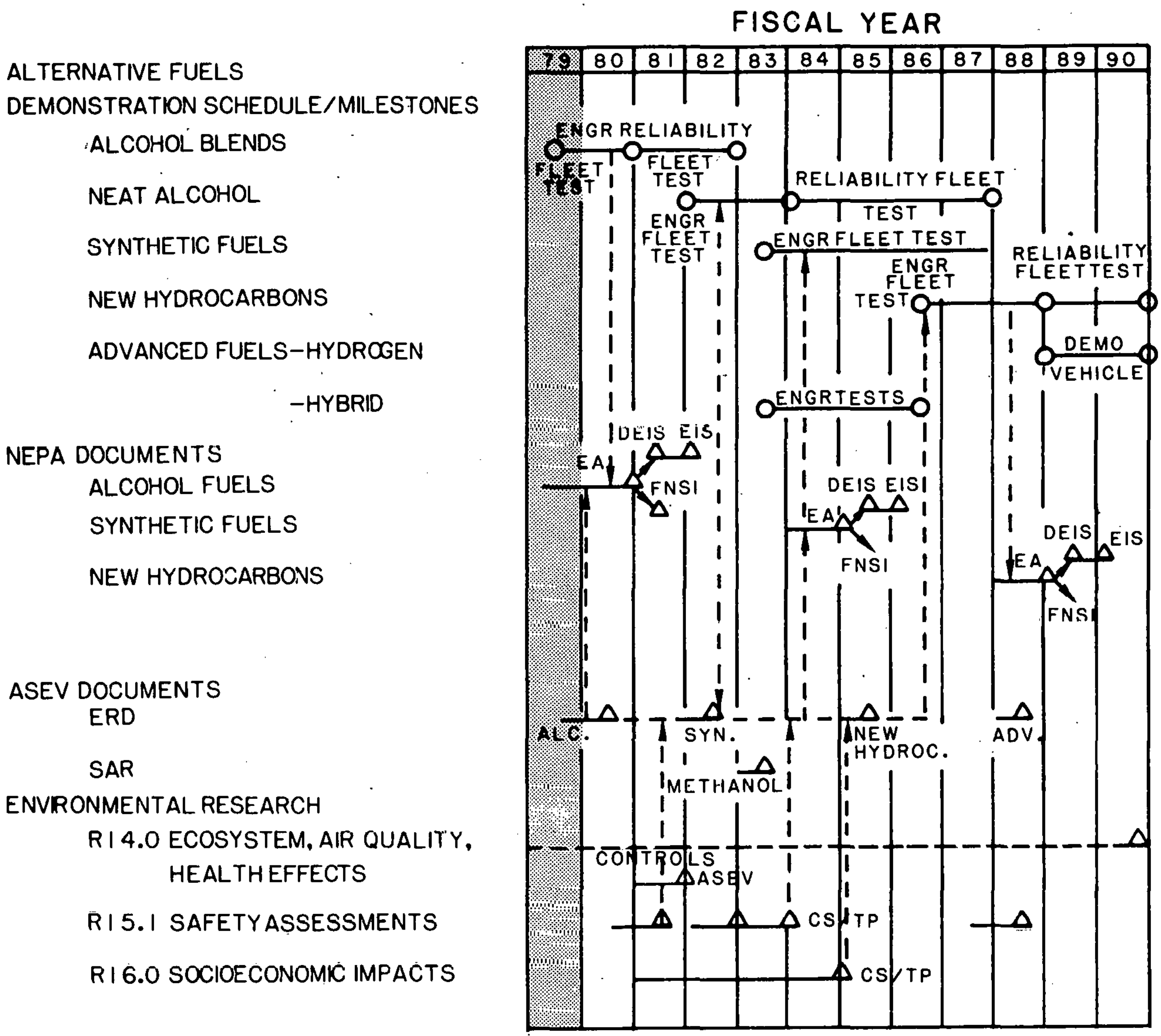
Figure 4.3 shows the schedule for the alternative fuels demonstration, environmental studies, and research. Anticipated commercialization for alcohol and synthetic fuels for transportation is shown in this figure. Commercialization of neat alcohol, new hydrocarbon, and advanced fuels will occur after FY90. An ERD for the use of alcohol fuels in highway vehicles was published in August, 1980, as a joint document with the ORCS working fluids ERD. The alcohol fuels ERD was an end-use assessment of the status of the ecosystem, air quality, health, and safety research. An EA for the use of alcohol blends in highway vehicles was initiated by CS/TP in FY79 and will be completed by the end of FY80.

Alcohol production ERDs and environmental analyses have been conducted by various DOE offices, other than CS/TP, for alcohol and alternative fuels. End-use environmental analyses of synthetic fuels, new hydrocarbons, and advanced fuels have been limited by the lack of specifications for using these fuels in transportation. Research is underway by CS/TP to analyze the composition of synthetic and new hydrocarbon fuels, and to conduct preliminary laboratory engine tests.

Scheduling of NEPA and ASEV environmental studies, shown in Fig. 4.3, has been timed for the demonstration of the alternative fuels. The primary criterion for scheduling the necessary environmental studies is the availability of engine/fuel and environmental effects data. The timing for the environmental studies on new hydrocarbon and advanced fuels is less certain because these programs are long-term and schedule shifts are likely. Environmental, health, and safety studies are also scheduled in Fig. 4.3. Three major generic studies are: (1) "Identification of Ecosystem, Air Quality, and Health Effects of Using Alternative Fuels in Conventional and Advanced Engines" (R14.0), (2) "Alternative Fuels Safety Assessments" (R15.1), and "Socioeconomic Impacts of Alternative Fuels" (R16.0).

Research on ecosystem, air quality, and health effects of alternative fuels (R14.0) is the primary responsibility of ASEV. CS/TP will provide test data and analysis results to support ASEV-directed research. Several alcohol fuel studies currently are being conducted by ASEV. These studies include the characterization of emissions of vehicles fueled with neat alcohol and alcohol blends, biological studies to examine the toxicity of methanol, and the effects of methanol spills on aquatic environments. This research will continue for the next three years. The evaluation of health effects from long-term, low-level exposure to unburned alcohol and formaldehyde will take a long time. For instance, the time required to identify a suitable animal model and conduct multiple life cycle tests could be as much as 8 to 10 years. In addition to the research on alcohols, a major program presently is examining the health effects of synthetic fuels from oil shale, tar sands, and coal. Further research will be required to study the indirect health effects of emissions from vehicles using synthetic fuels. ASEV monitoring reports on the progress of this research will be used to update the status of current environmental concerns and need for further environmental research. Total cost of this research should not exceed $250,000/yr.

"Alcohol Fuels Safety Assessment," identified in the preceding EDP, has been replaced by the more generic "Alternative Fuels Safety Assessments"



LEGEND

- O START/END DATE FOR DEMONSTRATIONS
- Δ COMPLETION DATE FOR ENVIRONMENTAL STUDIES
- — TASK DURATION

Fig. 4.3 Alternative Fuels Demonstration Schedule and Environmental Studies and Research Plan

(R15.1), covering safety research into distribution, storage, and use of alcohol, synthetic, new hydrocarbon, and advanced fuels. Information from this research will be the primary input to the methanol SAR in FY83, and others as needed. A full assessment of the effects and identified control strategies for ethanol and ethanol blends will be needed during FY81 in response to the accelerated commercialization of ethanol. No safety assessments of alcohol fuels currently are being conducted within ASEV. Safety assessments of other fuels are scheduled later, and will be the responsibility of CS/TP.

Assessment of the socioeconomic effects of using alternative fuels is limited. The Assistant Secretary for Resource Applications (ASRA) does not have such a program, as indicated in the preceding EDP. Socioeconomic impacts will be a part of development of specific alternative fuel production facilities under the cooperative agreements program (P.L. 96-126). Previous studies of socioeconomic effects have focused on the supply side of alternative fuels. CS/TP also has not programmed specific evaluations of socioeconomic effects. CS/TP will need to assess institutional and infrastructure requirements and barriers, and social and economic effects of commercializing alternative fuels. Research will continue through FY84, requiring between $150,000 and $200,000.

4.3.5 Electric and Hybrid Vehicle Systems Plan

The EHV plan shown in Fig. 4.4 is complex. Several major environmental documents are complete, or are nearing completion, and similar documents are scheduled through the planning period, owing to expected technical advances and further research on environmental effects, health, and safety. The EHV programmatic EA[68] has shown a need for the "EHV Materials Worldwide Supply and Demand Study" (R17.0), and a study on the effect of these conditions on vehicle prices. Analyses of U.S. industrial capacity and potential recycling methods also are required, and will be made during FY80 to FY82. Expected cost of remaining studies is $100,000.

Two emissions exposure studies will be required when reference vehicle materials are identified. "Effects of Hydrocarbon Off-Gas Emissions from EHVs" (R18.0) will be scheduled as will "Development of Controls for Emissions and Other Hazardous Materials During Flywheel Production" (R19.0). As appropriate, ASEV will assess health effects and report by Oct. 1, 1983. These studies would require $100,000.

"Identification and Assessment of Transport, Fate, and Effects of Battery Materials" (R20.0) is an active study. ASEV is assessing the potentially hazardous materials in near-term batteries, i.e., electrodes, electrode additives, and electrolytes. A study of ecological and biological effects is complete.[65] This information will serve as a base for a full assessment by ASEV of the health and safety effects of battery materials, to be completed by Oct. 1, 1982, in time for the second set of major environmental documents. Details of these studies are in Appendix A of the current EHV ERD.[73]

Regarding "Arsine and Stibine Release and Control During and Just After Charging" (R21.0), CS/TP is responsible for producing final guidelines by Jan. 1, 1981, based in part on ongoing ASEV toxicological research, including investigation of the effects of arsine and stibine, as part of a

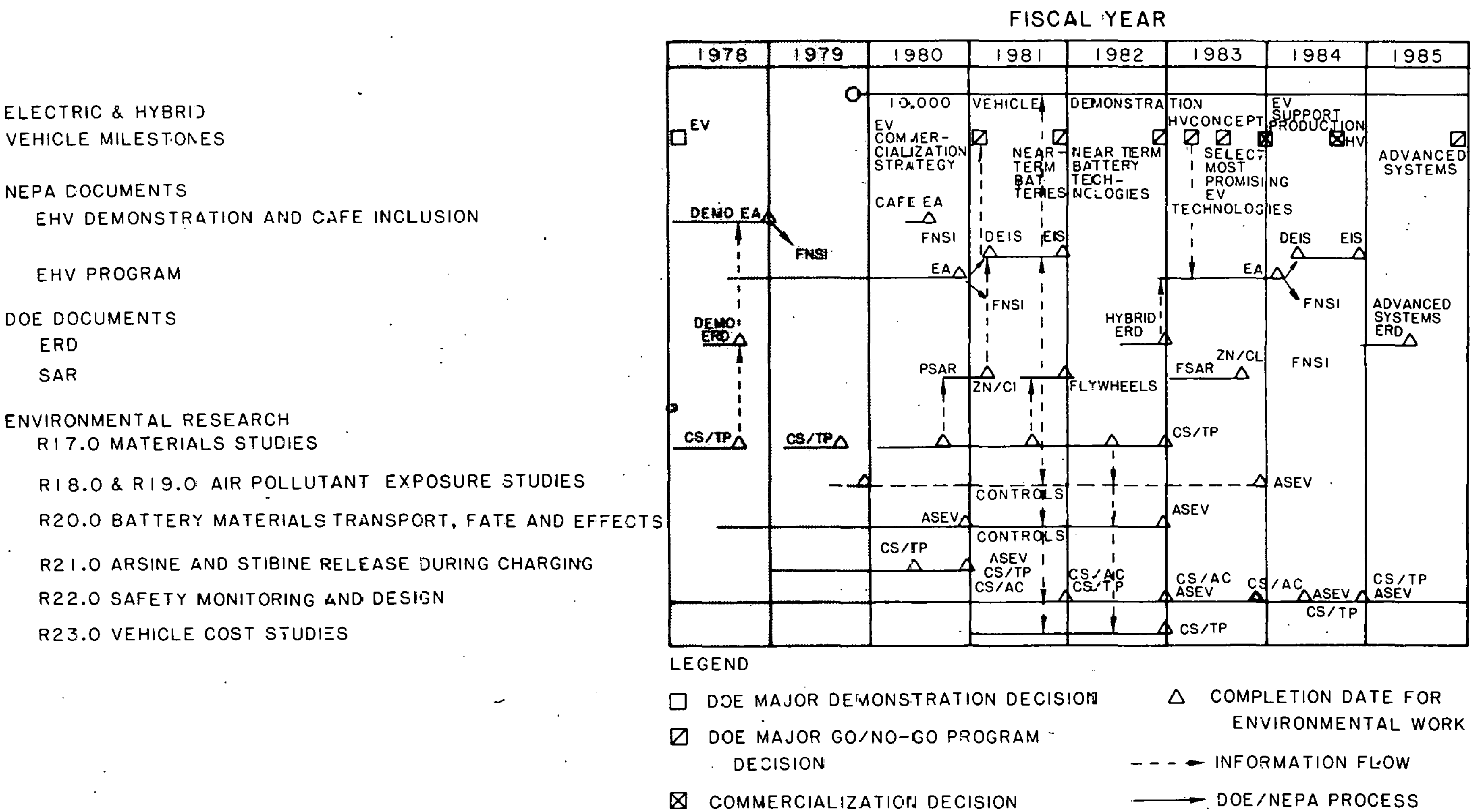


Fig. 4.4 Electric and Hybrid Vehicle Systems Environmental Research and Assessment Plan

larger programmatic effort. Animal exposure studies of stibine will begin in FY81. The current white paper provides interim control guidelines.[84] A summary report on "Stibine/Arsine Monitoring During EV Operation," based on the results of vehicle tests conducted at Argonne National Laboratory and the Long Island Lighting Company, is scheduled for release by Jan. 1, 1981. No additional research currently is scheduled on this specific issue.

Many "General Safety Related Activities" (R22.0) also are scheduled. In general, DOT and CS/TP will continue to establish safety standards. DOT will assist CS/TP in testing and monitoring for compliance throughout the demonstration period. CS/TP, with ASEV, will continue to monitor and evaluate the state of the art including (1) body and chassis structural integrity after repair, (2) charger design to decrease hazards, (3) battery design and packaging to protect against spillage and fire, and (4) hybrid design to assure isolation of the two energy sources during crashes. Progress reports are due Oct. 1, 1982, and April 1, 1984.

Regarding the hazard of chlorine gas escaping from the zinc-chlorine battery, operations of vehicles containing such a battery will be monitored until the SAR is published on April 1, 1981. The SAR will require documentation of battery safety testing.

"Safety Guidelines" (R22.0) for battery and material handling and fire fighting will be established by CS/AC in FY83 for near-term batteries after selection of sucessful battery candidates at the end of FY82. Health effects studies will support formulation of these guidelines.

Several "Vehicle and Component Safety Studies" (R22.0) will be scheduled when reference components are identified. CS/TP will test flywheels for gyro effects under adverse road conditions. As necessary, CS/AC, with CS/TP assistance, will characterize and measure toxic gas released from overheated flywheels, and possible eye injury from vacuum pump oil.[72] If potential safety effects are found, CS/TP will research these effects and report on Oct. 1, 1984. Also as part of R22.0, CS/AC will study and report to CS/TP on Oct. 1, 1981, the results of testing and analysis of catastrophic failure of a sodium-sulfur battery. ASEV will monitor progress. Results of the study may change this battery schedule.

The EHV programmatic EA indicated that further "Vehicle Cost Studies" (R23.0) are required to assure market acceptance. Groundwork for these studies has been laid. Total costs for completion should not exceed $100,000. An EHV market study has been planned for FY81.

4.3.6 Strategy Program Plan

This plan is tentative because dates to implement the strategies resulting from this program are not defined. The environmental research and assessment schedule shows some required work. (Fig. 4.5).

"Impacts of Changes in Airline Operational Techniques" (R27.0) will be assessed by CS/TP as they are proposed. A SAR covering modifications to airline procedures and other intercity passenger issues, as appropriate, will be prepared during FY82, at a cost not to exceed $50,000.

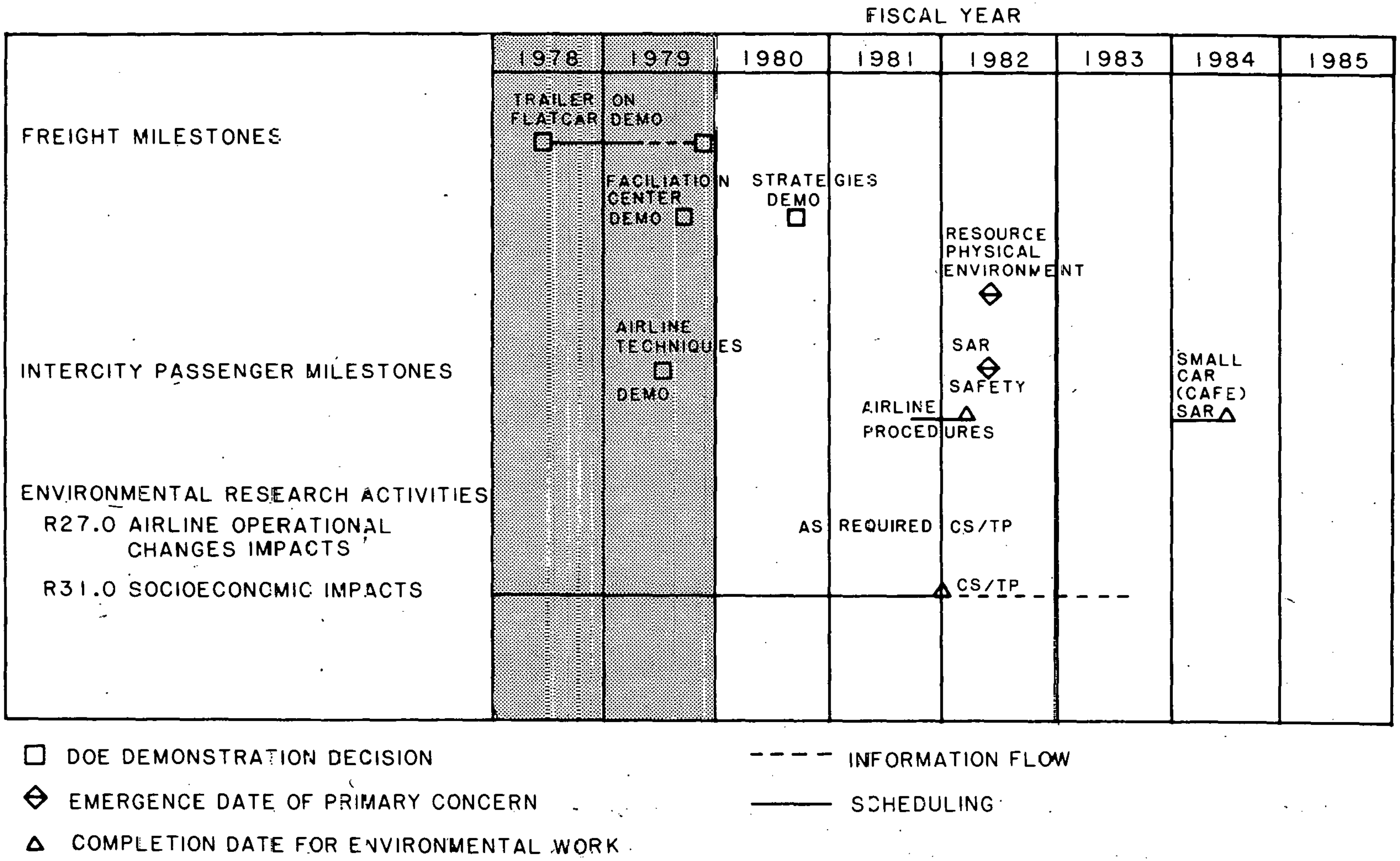


Fig. 4.5 Strategy Programs Schedule for Environmental Studies and Research Plan

A SAR has been scheduled for FY84 to examine the safety risks resulting from downsizing private passenger vehicles to conserve petroleum.

Socioeconomic concerns will be raised as strategies evolve. Each strategy developed for application to intercity passenger, intercity freight, and local freight movement must be assessed. Most important are effects of modal shifts owing to the CS/TP technology program. Modal shifts can be expected because commercialized energy-conserving technologies reduce operating costs and increase the attractiveness of certain modes. Net energy benefits from such shifts may not be positive. For this reason, assessing these changes is scheduled (R31.0) for completion in FY81, at a cost of $50,000 for the intercity passenger study, $80,000 for the intercity freight study, and $20,000 for the local freight study.

Environmental assessments for freight and intercity passenger strategy programs will be scheduled as needed.

4.4 ENVIRONMENTAL COORDINATING COMMITTEE

Environmental research scheduled in this EDP will be monitored by an Environmental Coordinating Committee (ECC). ECCs are special groups constituted under authority of DOE 5420.1[5] and consist of representatives of various DOE offices appointed to assist in the implementation of the DOE EDP system.

The primary function of an ECC is to monitor the status of environmental RDD&A programs to ensure that the intent of the EDP system is achieved, and to promote regular information exchange and coordination between offices responsible for environmental RDD&A. Specifically, an ECC, through appropriate subcommittees, performs the following functions:

- Participates in the preparation and review of EDPs and, after identifying needs for revisions, recommends such revisions.
- Maintains a collective awareness of the content, status, and results of environmental RDD&A efforts, informing management periodically of status and issues.
- Advises management of gaps, redundancies, and potential conflicts in RDD&A efforts and recommends corrective action for management consideration.
- Coordinates the physical and institutional arrangements required between performing offices to conduct respective research efforts.

ECC members are appointed by ASEV and the responsible energy program Assistant Secretaries, such as ASCS, or the Director, Energy Research. In principle, EEC members include one representative from each performing division and such special designees as assigned by appointing officers. The representative from ASEV's Office of Environmental Assessments, Technology Assessment Division, is chairman of the ECC. The ECC can authorize the formation of subcommittees for individual subprograms. The duties and functions of a subcommittee, which reports its findings and recommendations to the ECC, are commensurate with the ECC.

APPENDIX A

ENVIRONMENTAL CONCERN DESCRIPTIONS

INTRODUCTION

This appendix contains tables that describe environmental concerns in the transportation technology, fuel development, and strategy programs. Environmental concerns were collected for each system or subsystem of the taxonomy (see Table B.1 in Appendix B) during a review of the literature and discussions with project planners and engineers and the CS/TP staff. Certain concerns were designated primary, according to criteria in Appendix B.

As was pointed out in Section 3, one major concern is not addressed in the appendix tables for Automotive Technology Development although it is applicable to most of the heat engine technology programs. The concern relates to the effects of continued improvements to private automobiles and heavy duty trucks. Consideration of this concern is not a mandate of Automotive Technology Development. However, strategy programs under Transportation Systems Utilization that could result in shifts among freight and passenger modes are specifically charged with achieving reduced energy consumption, and therefore these programs are accountable for the results of such shifts, whether positive or negative. Relevant concerns are thus recorded in the tables for strategy programs.

The format of the tables in this appendix is:

1. The heading at the top of each page gives the table number, the title describing the program area, and the component of the transportation system under consideration.
2. The first column contains the system or subsystem in the transportation system environment in which the concern was identified.
3. The second column heading describes the specific technology or strategy; the entries in the column are the environmental concerns. Each entry describes the concern and its status or the search for solutions to the problem(s) it poses.
4. The third column is the current rating of the concern, P (primary) or S (secondary).
5. The fourth column contains reference numbers for the reference list at the end of this report.
6. The last column gives the estimated concern emergence date, one of the criteria used to determine concern priority. In general, for dose-response type issues, the emergence date is the date when large demonstrations of several hundred vehicles are planned; for other concerns it is the expected implementation or commercialization date.
7. The page sequence and number of pages in the table are shown at the bottom.

Table A.1. Automotive Technology Development: Advanced Heat Engine Systems Concerns

System/Concern Number	Advanced Automotive Heat Engine Environmental Concern	Concern Status	Ref.	Emergence of Impact
Ecosystem				
A1-24.0 (Gas Turbine)	• Decomposition products of nickel oxide, a substance used in heat exchange rubbing seals as a protective coating, may be harmful to plants as an aerosol. Nickel salts that are soluble in water are toxic to fish. Substitute materials for the NiO seal coatings have been identified but remain proprietary.	S	14 22	1993
A1-2.0 (Stirling) A1-25.0 (Gas Turbine)	• Metals such as chromium, tungsten and cobalt, which are used in superalloys, are generally toxic to humans and to fish and have some negative effect on plant growth. Existing/proposed standards: Chromium, 50 mg/L proposed Water Quality Criterion (WQC), on EPA Toxic Pollutant List. Nickel, .01 mg/L of the 96 hr LC_{50} (Median Lethal Concentration) proposed WQC on Toxic Pollutant List. Threshold Limit Value (TLV) for tungsten: 1 mg/m^3. Significant increases in national production would result in unpredictable effects because synergistic effects of pollutants might occur. The total amount of superalloys required is unknown. Improvements in effluent water quality control could alleviate this problem. Industry must meet standards. Increases in the relative scarcity and costs of these materials have led to substitution of some of them by domestically available metals in current Stirling reference engine.	P	20	1993
Resource				
Mineral/Natural A1-3.0 (Stirling) A1-26.0 (Gas Turbine)	• Increased production and use of aluminum and superalloy metals will be large relative to current U.S. consumption. Aluminum is potentially a large barrier and for this reason this issue is classified as primary for the Stirling only. Although it would impose a weight penalty, cast iron is being considered in place of aluminum for the engine block. The domestic supply of bauxite ore required to meet such an increase is not recoverable under present technology. Full penetration would also lead to significant increases in demand for nickel, tungsten, and chromium, all of which are imported. Lithium, magnesium, silicon nitride and yttrium, which may be used in ceramic-based gas turbine engines, need to be studied for possible impacts, as do thorium, zironium, and tantalum, which may be used in more advanced engines. Separate recycling of certain parts may be required.	P (A1-3.0) S (A1-26.0)	18 21	1993
Capital/Labor A1-4.0 (Stirling) A1-27.0 (Gas Turbine)	• Available industrial capital for assembly line changeover must be identified for commercialization. Preliminary changeover cost estimates have been prepared for the Stirling engine, using Swedish industrial base.	S		1988
A1-27.5 (Gas Turbine)	• With shift to ceramic parts, ceramics industry would require capital for expansion since large-scale increases would be required.	S		1990
A1-28.0 (Gas Turbine)	• With shift to ceramic parts, expansion of ceramic production would require greater numbers of trained personnel in such fields as ceramics engineering. Expansion of materials science programs required at universities and in private enterprise.	S	2	1987
A1-28.2 (Gas Turbine)	• Mass production techniques must be upgraded in the ceramics industry.	S	2	1990
Physical Environment				
Air Quality A1-28.5 (Gas Turbine)	• No emission standards exist for nickel oxide, which may pose health hazards as an aerosol. Alternative seals have been developed and DOE contractors hold production licenses; however, these seals may not be feasible for production engines.	S	14 22	1993
A1-29.0 (Gas Turbine)	• High operating temperatures tend to promote NO_x formation. (Proposed standard 1981, 1.0 gm/mi.) Several design concepts for control of the NO_x emissions, including catalytically modified exhaust gas and variable geometry combustors, have been proposed. Standards will be met by production engine.	S	2 10 12	1993
A1-6.5 (Stirling) A1-30.0 (Gas Turbine)	• Engine has multifuel capability; pollutant emissions from alternative fuels used in these engines, particularly synfuels, may force trade-offs between energy efficiency and emission characteristics in selection of fuels.	S		1993
Water Quality A1-7.0 (Stirling) A1-31.0 (Gas Turbine)	• Manufacture of some engine parts from superalloys may contribute to water pollution from heavy metals. Control strategies are available, but costs to industry to implement them are likely to inhibit commercialization, thus preventing production and fuel savings goals for these technologies being realized.	P	9,13 20	

Table A.1 (Cont'd)

System/Concern Number	Advanced Automotive Heat Engine Environmental Concern	Concern Status	Ref.	Emergence of Impact
Physical Environment (Cont'd)				
Waste Disposal A1-8.0 (Stirling) A1-32.0 (Gas Turbine)	• Metals used in superalloys a hazardous waste problem unless recycled. Current recycling techniques are costly.	S		1993
A1-32.5 (Gas Turbine)	• With shift to ceramic parts, disposal of ceramic parts may pose problems. Study of recycling potential and ultimate fate of disposed parts required.	S		1993
Health				
Occupational A1-34.0 (Gas Turbine)	• Nickel workers experience higher rates of respiratory cancers (TLV-1.0 mg/m^3 for airborne nickel.) Industry must meet OSHA standards.	S	22	1989
A1-32.5 (Gas Turbine)	• With shift to ceramic parts, further research required by NIOSH into health effects of ceramic production on industrial workers.	S		1989
Public A1-11.0 (Stirling) A1-35.0 (Gas Turbine)	• Effects of new pollutant discharges from combustion of nonpetroleum fuels or wear-off of moving parts is unknown until final engine components and suitable fuels are specified.	S	22	1989
A1-35.5 (Gas Turbine)	• Nickel aerosols in the ambient air could pose a health hazard. Nickel may be replaced by alternative materials for engine components.	S	22	1989
Safety				
Occupational A1-12.0 (Stirling)	• Increase in hydrogen manufacture, high pressure storage, and distribution may prove hazardous to workers. Employee education may be required. Industry must work with OSHA to establish appropriate handling standards.	S		1989
Public A1-13.0 (Stirling)	• Hazard potential of hydrogen in accident and engine failure modes is being defined and quantified. Diffusion of hydrogen through seals and metal is a problem. Most hazards can be eliminated through engine design as amount of hydrogen is small. Additional safety experiments for actual engines to account for all synergistic effects must be performed by development contractors. Current assessment of use of helium as a working fluid is to mitigate this concern.	S	6 12	1989
A1-14.0 (Stirling) A1-36.0 (Gas Turbine)	• Vehicle crash tests required to determine whether hazards require design changes. There are potential hazards in both engines if the external combustion system disintegrates. In the gas turbine, fate of high-speed turbine wheel fragments in event of destruction of integrity of engine housing is unknown.	P		1989
Socioeconomic				
Social A1-16.0 (Stirling)	• Public perception of safety of using hydrogen working fluid. Use of helium could obviate concern.	S		1993
Economic A1-17.0 (Stirling) A1-38.0 (Gas Turbine)	• Increase in use of aluminum, and superalloy metals such as chromium, tungsten, and nickel that are primarily imported, may alter balance of trade. Current national stockpiling policy may be sufficient to eliminate problems. However, this concern is considered primary because of potential problem with aluminum requirements of Stirling engine. A material cost and availability study is in progress as part of NASA Lewis Laboratory program.	P	18 21	1993
A1-18.0 (Stirling) A1-39.0 (Gas Turbine)	• Changes in skills required for engine production and shift in industries supplying engine parts may lead to temporary employment dislocations. Identification of industries most affected and careful attention to retraining could lessen this effect. Industry is ultimately responsible for necessary adjustments.	S		1990
A1-19.0 (Stirling) A1-40.0 (Gas Turbine)	• New engine will probably raise initial vehicle cost, but lower its operating cost with an as yet unknown effect on the marketability. Program goal is to have same life cycle cost as for current Otto cycle and diesel internal combustion engine vehicles.	S		1993

Table A.1 (Cont'd)

System/Concern Number	Advanced Automotive Heat Engine Environmental Concern	Concern Status	Ref.	Emergence of Impact
Socioeconomic (Cont'd)				
Institutional				
A1-20.0 (Stirling) A1-41.0 (Gas Turbine)	• Changeover to engine production for new engine is risky for manufacturers. Engine is expected to be more fuel efficient than current engines, free of exhaust smoke and odor; vehicle performance will be similar. However auto manufacturers may require incentives such as early depreciation and tax write offs to produce new engine, since retooling costs would be high.	S		1990
A1-21.0 (Stirling) A1-42.0 (Gas Turbine)	• Retraining of mechanics is required. Service industry will address.	S		1993
A1-22.0 (Stirling) A1-43.0 (Gas Turbine)	• Supplier industries will be required to produce different parts. Changeovers may cause short-term disruption in these industries. Careful identification of affected industries and a substantial technology transfer will lessen this problem. Current development program involves supplier industries, through prime contractors, to initiate needed technology transfer.	S	24	1990
A1-44.4 (Gas Turbine)	• Shift in demand from metal to ceramic parts design and manufacture, coupled with rapid expansion of ceramics industry, may cause problems with trade organizations and distrupt established companies. Retraining programs identifified above may lessen impact. Anticipation of demands by the industry, long-term contracts, and financial assistance to manufacturers may smooth transition.	S		1990
A1-45.0 (Gas Turbine)	• Combined with A1-22.0 and A1-44.4.	S		1990
A1-23.0 (Stirling)	• Industry assessment of public acceptance of vehicles containing hydrogen at high pressures may affect decision to produce vehicle.	S		1990
	Continuously Variable Transmission[a] (Support Program)			
Physical Environment				
Air Quality				
A2-21.0	• First generation transmission dynamometer tests by development contractor showed increased HC, CO, and NO_x emissions with spark ignition engines.	S	8	1990
Noise Pollution				
A2-22.0	• Hydrodynamic CVT development halted owing to noise emissions. Efficient replacement with low noise characteristics has not been demonstrated.	S		1990

[a]Transferred from Table A.2 as a result of redesignation as a support program in advanced heat engine systems development.

Table A.2 Automotive Technology Development: Vehicle Systems Concerns

System/Concern Number	Turbocompound Diesel Engine Environmental Concern	Concern Status	Ref.	Emergence of Impact
Resource				
Capital/Labor A2-2.0	• More skilled mechanics could be required. Industry will address.	S		1985
Physical Environment				
Noise A2-4.0	• Federal noise standards should be met: presently 83dBA @ 50 ft during maximum acceleration; 80dBA in 1982; even more stringent in 1985. Tests and demonstrations will be performed by development contractor. Recent tests indicate compliance with pass-by standards.	S		1985
A2-5.1	• Increased engine backpressures may lead to increased particulate emissions. Emissions will be tested by development contractor.	S	26	1985
Health				
Public A2-6.0	• Potential changes in emissions characteristics may affect public health. Tests and demonstrations will provide necessary information and should be monitored.	S		1985
Safety				
Public A2-7.0	• Due to smaller displacement of this engine relative to standard diesel units and recovery of compression braking energy for drive train use by secondary turbine, braking capability may be reduced in operation. However, this has not been borne out by demonstration. More information will derive from continued testing by development contractor.	S	25 26	1985
Socioeconomic				
Economic A2-9.0	• Initial cost of turbocompound diesel higher. Market may be limited to large fleet owners who consider life-cycle costs. Insurance rates might be higher if safety is a problem. Industry will address.	S		1985
Institutional A2-10.0	• Additional mechanic's skills required. See above under capital/labor.	S		1985
	Gas Turbine in Bus Demonstration			
Socioeconomic				
Institutional (Transit) A2-12.0	• Use of new equipment, upgrading mechanic skills, and keeping of spare parts inventory are likely to be problems in the transit industry when shifting to turbine engine vehicles. Use of alcohol and other non-petroleum fuels may cause problems in transit operations. Demonstrations by DOT and DOE, including operating buses on alternative fuels, will ease transition.	S		1985
	Heavy Duty Truck Bottoming Cycle Environmental Concern[a]			
Ecosystem A2-23.0	• Full effects of release of the working fluid, Fluorinol, a mixture of water and trifluoroethanol (TFE), during truck accident, fluid shipment, or disposal/recycling, on localized terrestrial and aquatic ecosystems are unknown. Toxic effects, including temporary infertility, observed in test animals. Pathways not fully identified, but no direct toxicity risk arises from consuming drinking water contaminated by a four-liter spill resulting from truck accident.	P	27 28	1984
Resource				
Capital/Labor A2-25.0	• Requires more skilled mechanics. Capital costs higher. Problems will be addressed by industry.	S		1984

Table A.2 (Cont'd)

System/Concern Number	Heavy Duty Truck Bottoming Cycle Environmental Concern[a]	Concern Status	Ref.	Emergence of Impact
Physical Environment				
Air Quality				
A2-26.0	• Toxicity of TFE is high (recommended TLV=2.5 ppm). Fluorophosgene, a gaseous thermal decomposition product, is extremely toxic. Problems expected in charging and repairing cycle. Control techniques have been identified for manufacture. Dispersion in accident situations not studied. Results of accidental release during shipment not defined.	P	27 28	1984
A2-27.0	• Cooling of exhaust gases changes emission characteristics. Testing required by development contractor and during demonstration.	P		1984
Water Quality				
A2-28.0	• Manufacturing wastes of TFE undocumented; methods for disposal or recycling working fluid have not been specified. Industry must address this issue during commercialization.	P		1984
Waste Disposal				
A2-29.0	• Standards for removing TFE from system during decommissioning of truck must be set by OSHA.	S		1990
A2-30.0	• Waste products in the manufacture of TFE undocumented; information may be proprietary.	S		1984
Noise Pollution				
A2-31.0	• Early tests indicate compliance with both internal and external federal noise standards for 1982, i.e., all readings at or below 80.0 dBA. More stringent standards are reserved for 1985.	S	31	1984
Health				
Occupational				
A2-33.0	• TFE has produced toxic effects in test animals at various levels due to inhalation, ingestion, dermal absorption. Classified as toxic via ingestion but not toxic via dermal or inhalation pathways by the Manufacturing Chemists Association; however inhalation and contact with skin should be avoided. Can cause severe eye damage. May decompose to fluorophosgene at hot spots in cycle. TLV for fluorophosgene also recommended at 2.5 ppm. Issue of mutagenicity, carcinogenicity currently under study. Additional dose-response and interspecies comparison research is programmed. Control techniques for TFE cycle charging, repair and disposal undefined and must be addressed by industry.	P	27 28 30	1984
Public				
A2-33.5	• Potential changes in emissions characteristics due to exhaust gas cooling may affect public health. Technology demonstration must include emission testing by development contractor.	P		1984
Safety				
Public				
A2-35.0	• Potential impact of spillage during shipment on air and water quality unknown. Fluorophosgene can be formed under high temperature conditions. Fire danger in truck accident less than that for gasoline or diesel fuel due to low flammability.	P	27 28	1984
Occupational				
A2-36.0	• Effects on truck driver during accidental proximity to hot (315°C or 600°F) TFE can include exposure to fluorophosgene and dermal contact with a high potential for toxic effect.	P	27	1984
A2-37.0	• TFE has low flammability, but potential of fire during accident not ruled out. Gasoline and diesel flame hazard is greater.	S	28	1984
Socioeconomic				
Economic				
A2-39.0	• Initial cost of heavy diesel truck with bottoming cycle about 6 percent higher than without. Market likely limited to large fleet owners who consider life cycle costs, which would diminish anticipated petroleum savings.	S		1984
Institutional				
A2-40.0	• Additional mechanic's skills, insurance requirements likely. Industry will address.	S		1984
A2-42.0	• Effect of spillage of hot TFE on pavement maintenance techniques and costs unknown. Total cleanup costs unknown.	S		1984

[a]The Office of Advanced Conservation Technology (CS/AC) is responsible for all concerns involving application of the Organic Rankine Cycle System (ORCS) to conservation strategies in advanced heat engine technology.

Table A.3 Automotive Technology Development: Alternative Fuels Concerns

System/Concern Number	New Hydrocarbons - Environmental Concern	Concern Status	Ref.	Emergence of Impact
	Note: Resolution times are long for these issues; many should be addressed early so that programmatic decisions can be made.			
Ecosystem				
A3-1.0	• Impact of new hydrocarbon fuels on ecosystem will depend on specification and chemical composition of fuels, and how they differ from current petroleum based gasoline, diesel fuels and alcohol blends.	S		post-1990
Resource				
A3-2.0	• New hydrocarbon fuels may affect exhaust emission catalyst designs. Effects on noble metal requirements for converters are unknown. EPA performance testing required as fuels are specified.	S		post-1990
Physical Environment				
Air Quality A3-3.0	• Vehicle exhaust and evaporative emissions cannot be accurately characterized until production fuel/engine systems are specified. Primary emission differences expected, in comparison with conventional gasoline and diesel fuels, stem from chemical composition of fuels derived from coal or oil shale. Emissions from engines operating with new hydrocarbon fuels are likely to contain a higher proportion of aromatic and nitrogen compounds. Impact of these emission changes on photochemical smog formation and composition are currently unknown. Simulation experiments required; cooperative efforts by EPA and ASEV/OHER desirable. New hydrocarbon fuels may result in long-term engine deposits leading to increased hydrocarbon emissions, thus affecting total emissions over operational life of engines. Effectiveness of and effect on current catalytic converter designs are also unknown. Resolution times will be long, particularly as fuels are not yet specified.	P	58	post-1990
Aesthetic Degradation A3-4.0	• New hydrocarbon fuels may have odor characteristics similar to diesel fuel, which are considered undesirable by the public.	S		post-1990+
Public Health				
A3-5.0	• Fuels containing aromatics and heavier hydrocarbons may result in evaporative and exhaust emissions that are more carcinogenic and/or photochemically reactive. Public health impacts resulting from storage, distribution and utilization of these fuels are unknown. ASEV/OHER currently addressing this issue for diesel fuel. DOE Fossil Energy (ASFE) Environmental Division may become involved in this as an end-use issue.	P		post-1990+
Socioeconomic				
Institutional A3-7.0	• Current state and local regulations governing storage and use of photochemically reactive organic solvents (e.g., California Rule 66) may restrict storage and use of certain new hydrocarbon fuels in certain regions, thus affecting national supply/demand situation. Impact unknown until specifications for hydrocarbon fuels are defined.	S	58	post-1990+
	Alcohol			
	Note: Ecosystem, health, and safety concerns will be affected by fact that total volume of transportation fuels and alcohol distribution will increase with substitution of alcohols for gasoline. This is an end-use issue that will intensify with commercialization of coal derived methanol fuels, so ASFE Environmental Division should take an active problem-solving role.			
Ecosystem				
Terrestrial A3-8.0	• Terrestrial impacts in event of acute ethanol or methanol spill are expected to be minimal, of short duration, and confined to small area. Sterilization of soil microbiota may occur. Effects on plant life range from inhibition of seed germination to stimulation of growth. Effects of low level, chronic terrestrial releases are unknown. Owing to the biodegradability of ethanol and methanol, terrestrial impacts are believed to be less severe for these alcohols, compared to gasoline or diesel fuel (see 1980 ERD).	S	27 36 41 57	1987

Table A.3 (Cont'd)

System/Concern Number	Alcohol Fuels - Environmental Concern (Cont'd)	Concern Status	Ref.	Emergence of Impact
A3-8.1	• Contamination of ground water aquifers in event of an acute terrestrial spill leads to possibility of introduction of ethanol and methanol into waste water and drinking water systems. This event is of greater concern in the case of methanol owing to its high toxicity, but because of high miscibility and rapid dilution, only minor negative impacts are expected.	S	42 57	1987
Aquatic A3-9.0	• Preliminary assessments of spills in waterways indicate that damage to small marine and estuarine organisms would probably be minimal except in a very localized area where alcohol concentrations exceed one percent. Ethanol and methanol are miscible in water; in most acute spills, rapid dispersion, dilution and degradation will reduce alcohol concentrations below toxic levels. Effects of low-level chronic aquatic releases are unknown. In general, impacts associated with aquatic releases of alcohols are considered to be less severe than for gasoline or diesel fuel (see 1980 ERD). A large concentration spill in a slow moving or low reaeration rate aquatic system would represent the worst case.	S	27 36 41 51	1987
A3-9.1	• Introduction of ethanol or methanol into waste water treatment and drinking water systems in event of acute or low-level chronic aquatic release should be subject to effective control. Probability of direct aquatic releases needs to be evaluated.	S		1990
A3-10.0	• Methanol is rapidly and biologically degradable by a nonpathogenic bacterium (Pseudomonas fluorescens). Need for and feasibility of utilizing such bacteria to mitigate damage resulting from methanol spills should be considered.	S	36	1990
<u>Physical Environment</u>				
Air Quality A3-11.0	• For vehicles operating with neat ethanol or methanol, NO_x emissions are reduced by about 1/3 with CO generally being unaffected. Actual effect will depend on air/fuel setting and engine type. However, emission of unburned alcohol does increase, compared to other fuels. Total mass of unburned fuels remains about the same or increases somewhat. Preliminary analysis indicates that unburned methanol emissions have about 1/3 the photochemical reactivity of gasoline hydrocarbons. Composition and fate of these emissions needs to be studied in a cooperative DOE/EPA program. Advisability of establishing emission standards for unburned methanol, which is currently unregulated, should be evaluated.	S	34 37 46	1990
A3-12.0	• Aldehyde emissions, primarily formaldehyde, increase with use of neat ethanol and methanol; increases in formaldehyde content on the order of 3 to 6 times the amount found in gasoline combustion emissions have been observed in vehicles without any emission controls. Use of oxidation catalysts has been found to reduce these emissions significantly. Aldehyde emissions also vary with type of vehicle engine being used. Airborne formaldehyde is highly reactive in photochemical smog formation and is an eye irritant. Carcinogenesis is indicated in some rodents. Further analysis of effects of neat alcohols on formaldehyde emission levels in late model vehicles needs to be conducted, preferably as a part of a joint DOE/EPA program. Because of concern over toxicity and reactivity of formaldehyde, emission standards may need to be established; formaldehyde emissions are currently unregulated by EPA. Fate of formaldehyde emissions also needs to be studied.	P	35 38 45 48	1990
A3-12.1	• Carbon canisters currently used in vehicles to absorb fuel vapors appear to be inadequate for neat alcohols. Canister characteristics and design will need to be modified.	S	46 50	1990
A3-12.2	• Magnitude and impact of evaporative losses during storage and distribution of neat alcohols need to be assessed. Mechanisms for controlling evaporative losses need to be defined.	S		1987
Water Quality A3-13.0	• Use of alcohols as a transportation fuel will result in their introduction into waste water treatment systems at higher than trace levels (see concerns A3-8.1 and A3-9.1). Maximum safe alcohol concentrations in treatment effluent are unknown; controls required.	S		1987

Table A.3 (Cont'd)

System/Concern Number	Alcohol Fuels - Environmental Concern (Cont'd)	Concern Status	Ref.	Emergence of Impact
Health				
A3-14.0	• Use of alcohols will generally increase exposure of population to unburned alcohols and their combustion products. TLVs for methanol and ethanol are 200 and 1000 ppm, respectively; the TLV for gasoline will depend on its composition. Although the TLV for gasoline is higher than for methanol, gasoline is generally considered to be equivalent to or more toxic than either ethanol or methanol upon inhalation, skin penetration, skin irritation, and ingestion (with possible exception of methanol via ingestion). Precautions will be necessary to minimize exposure of persons to methanol, in particular during storage, distribution and utilization of the fuel. Risks associated with spills and unburned fuel emissions in tunnels and parking garages need to be evaluated by ASEV. There is some limited evidence that this risk is minimal in comparison to health hazard of exposure to gasoline and gasoline exhaust emissions in these situations. Exposure levels for persons involved in distribution of alcohol fuels, and other occupations which have an increased exposure to unburned alcohols, will need to be established by OSHA (see 1980 ERD, EA). Ongoing ASEV/OHER research will support development of standards.	S	27 42 46	1987
A3-15.0	• Possibility of persons illicitly or inadvertently ingesting fuel grade ethanol exists. By law, ethanol used as a fuel must be denatured. Renaturing for potability is not easy. Renatured ethanol will still contain small amounts of noxious compounds and have an unpleasant taste characteristic of the denaturants, which can be further modified to impart a highly objectional and bitter taste. It is very difficult to completely separate methanol from gasoline or other highly volatile liquids which will be used as additives to neat alcohol fuels. These additives impart a strong odor to alcohol. Mistaken ingestion of methanol remains a possibility. Use of odorants, colorants, and emetics may be required.	S	50 52	1981
A3-16.0	• Toxicity of methanol is believed to depend largely on its products of metabolism, principally formaldehyde and formic acid, which in extreme concentrations can cause severe damage to the liver, retina and brain. Inhalation, ingestion, or dermal absorption of methanol increases exposure to formaldehyde. Because formaldehyde is a combustion product of alcohols, possibility of direct exposure is increased as a result of use of alcohol fuels. Formaldehyde is very toxic, has a TLV of 2 ppm and is not currently regulated; emission standards may be required. Mutagenicity and possible carcinogenicity have been indicated by research. Further research is required to assess the health risks associated with anticipated exposure levels for formaldehyde and methanol. Known health risks associated with use of aromatics (e.g., benzene and toluene) as a component in gasoline must be weighed in the evaluation of the health risks of using alcohols as gasoline substitutes.	P	45 57	1987
A3-17.0	• Information on potential interactions of combined exposure to ethanol and methanol and other compounds in the transportation system, and synergistic effects of methanol and commonly used drugs and chemicals, is insufficient to identify adverse health effects. Interactive effects issues are the most difficult to resolve. ASFE Environmental Division may become involved.	P		1987
A3-18.0	• A WQC (maximum concentration standard) for ethanol and methanol in drinking water may have to be established when alcohol fuels are specified.	S		1983
A3-19.0	• Absorption of methanol and formaldehyde through the skin as a result of distribution and use of alcohol fuels poses a potential health concern. However, because methanol acts as an irritant when applied to the skin, danger of unwitting dermal exposure to hazardous levels and therefore buildup of toxic concentrations within the body is unlikely. Response to dermal exposure will vary depending on individual metabolisms. Further assessment is necessary to establish health risks associated with dermal absorption of methanol and formaldehyde. Control mechanisms for handling need to be established by OSHA (see 1980 ERD).	S	27 51	1987
A3-19.1	• In support of the preceding health concerns, further research is required to raise the level of understanding regarding the human body's accumula-	S	57	1987

Table A.3. (Cont'd)

System/Concern Number	Alcohol Fuels — Environmental Concern (Cont'd)	Concern Status	Ref.	Emergence of Impact
	tion kinetics for methanol and formaldehyde, and dose-effect relationships for different routes into the body, i.e., ingestion, inhalation, and dermal. Related to this is the need to establish the health risks associated with long-term, low-level exposure effects for methanol and formaldehyde, as might occur in the repeated exposure of a service station attendant to these substances.			
Safety				
Public				
A3-20.0	• Because of their broader flammability limits, ethanol and methanol may be more explosive than gasoline in certain situations such as in the vapor space of a tank. Alcohols also have higher flash points than gasoline, which tends to reduce the fire hazard in event of an alcohol spill or leak. Further assessment of effects of use of alcohol fuel additives, e.g., gasoline and light hydrocarbons, needs to be conducted. Prescription and dissemination of safety and fire procedures are needed. Extinguishing agents must be identified.	S	42 56	1983
Occupational/Public				
A3-21.0	• A systematic approach to regulate use of alcohol fuels as cleaning solvents, fire starters, etc., is required. A major safety concern is lack of control over the use of alcohol fuels.	S		1983
A3-22.0	• Since alcohol flame is invisible, a flame colorant is desirable. Use of gasoline or pentanes as fuel additives should alleviate problem.	S	46	1983
Socioeconomic				
Institutional				
A3-24.0	• A systematic review and evaluation of federal, state, and local laws and regulations relating to gasoline and alcohol is required to identify changes which must be made to regulate and tax use of alcohol as a motor vehicle fuel.	S		1983
A3-25.0	• A systematic evaluation of an alcohol distribution system is required to identify infrastructure requirements, timing, and magnitude of effort to implement alcohol as a motor vehicle fuel.	S		1983
	Alcohol Blends			
	Note: Issues are essentially the same as those associated with neat alcohols with problems falling between gasoline and neat alcohols proportionally.			
	The following exceptions, applicable to both 10% and 20% blends, have been identified.			
Physical Environment				
Air Quality				
A3-26.0	• Emission effects of alcohol blends in automobiles are mixed and are strongly dependent on type of vehicle, original air/fuel ratio, type of emission control system, and type of engine as well as blend proportion being used. CO emissions consistently decrease with use of ethanol and methanol blends. NO_x emissions tend to increase while tailpipe HC emissions tend to decrease; total HC emissions (tailpipe plus evaporative) tend to increase. Magnitude of changes in NO_x and HC emissions tends to be less than that experienced with CO emissions. Generally effects of using alcohol/gasoline blends are least significant for vehicles equipped with three-way catalyst exhaust emission control systems. Aldehyde emissions are virtually eliminated with use of the three-way catalyst system and unburned alcohol emissions are also reduced. Net air quality impact of using alcohol blends will be related to vehicle fleet composition. Limited information is available on effect of alcohol blends on heavy truck emissions. Further vehicle testing will establish a better basis for vehicle emission characterizations.	S	42	1983
A3-27.0	• Evaporative emissions from ethanol and methanol blends are significantly higher than from gasoline or neat alcohols as a result of formation of azeotropes. Evaporative emissions increase by as much as 50% to 100%. Evaporative emission effects are not very sensitive to blend proportion. Increases in evaporative losses pose a problem with respect to compliance with evaporative emission standards. Redesign of carbon canisters currently in use or improved blending processes that produce a fuel of more conventional vapor pressure and front-end volatility may be required. Development of other evaporative emission controls will be required.	P	42	1981

Table A.3 (Cont'd)

System/Concern Number	Alcohol Blends - Environment Concern (Cont'd)	Concern Status	Ref.	Emergence of Impact
Water Quality				
A3-28.1	• If recycling does not prove feasible, disposal by burial of alcohol blend storage tank bottoms will require special attention to avoid contamination of fresh water systems. Water phase in tank bottoms will contain alcohol. Handling procedures may need to be updated from those presently applied to gasoline storage tanks.	S	42	1983
Health				
A3-29.0	• Methanol absorption through the skin is somewhat greater for blends with gasoline than for neat methanol as gasoline dissolves fats protecting the skin. As with neat methanol, likelihood of toxic dermal exposure is minimal except in extreme situations because of the irritating effect of the blends when dermal contact is made. Health risks associated with methanol and formaldehyde exposure are not considered as significant as in the case of neat alcohols because of effectiveness of current generation of emission control systems (i.e., three-way catalysts) in reducing aldehyde and unburned alcohol emissions, and because the public will generally not be exposed to neat methanol. Further study of the toxicity and health risks of using higher order alcohols as blend additives and ether blends will be required. ASFE Environmental Division may become involved in this as an end-use issue.	S	44	1987
Safety				
Public				
A3-30.0	• Separation of ethanol from blends and subsequent renaturing for ingestion is possible. Use of modified denaturants should minimize this concern. (Separation of methanol from blends is difficult and separated methanol retains a strong gasoline odor, which should discourage inadvertent ingestion.)	S	50 52	1983
A3-31.0	• Some ethers are known to produce peroxides under certain pressures and temperatures. Since peroxides are insoluble in petroleum ethers, they could accumulate in concentrations that may be explosive. Importance of issue increases when ether blends become likely candidate fuels.	S	54	post-1985
A3-31.1	• Changes in flammability limits and flash points for alcohol blends relative to gasoline are significantly less than for neat alcohol (see concern A3-20.0), but are still a concern.	S		1983

Synthetic Fuels

Note: Testing and analysis of the effects of using synthetic fuels has been limited owing to the limited availability of these fuels. Consequently, general level of understanding of fuel behavior and environmental effects is low. For all issues described below, ASFE Environmental Division participation in scheduling and sponsoring of end-use impact research is advisable.

System/Concern Number	Synthetic Fuels	Concern Status	Ref.	Emergence of Impact
All				
A3-32.0	• Projections of characteristics of synthetic fuels from coal and oil shale depend to a large extent on how closely synfuels match the composition of petroleum-derived fuels. RD&A for conversion of coal and oil shale syncrudes to transportation fuels will determine extent to which fuels are functionally and chemically similar.	S		1990
Physical Environment				
Air Quality				
A3-33.0	• Extent to which toxic trace elements in coal and shale pass through to refined products is unknown.	S	58	1990
A3-34.0	• Coal-derived fuels are likely to have a higher aromatic content resulting in exhaust and evaporative emissions with increased carcinogenic properties. Aromatic content of exhaust gas is approximately proportional to aromatic content of the fuel. Aromatic emissions are not currently regulated. Aromatic compounds in synthetic gasoline can be separated or chemically changed in the refining process. Extent to which aromatic compounds present in syncrudes are destroyed in production and refining processes is unknown. Need for establishing new emission standards covering aromatic compounds requires evaluation by EPA.	P	47 58	1990

Table A.3 (Cont'd)

System/Concern Number	Synthetic Fuels - Environmental Concern	Concern Status	Ref.	Emergence of Impact
A3-35.0	• Increased NO_x, SO_x and sulfate emissions may result as synthetic fuels from coal and shale oil contain higher quantities of chemically bound nitrogen and sulfur than does gasoline. Extent to which bound N and S are removed in the production process is not well defined. Desulfurization of synfuels at the refinery is believed to be feasible.	S	47	1990
Aesthetic Degradation				
A3-36.0	• Synthetic fuels, particularly synthetic diesel fuel, derived from coal and shale may have undesirable odor and smoke properties.	S	58	1990
Health				
A3-37.0	• Aromatic, olefinic, and paraffinic (on Toxic Pollutant List) content of synthetic crudes is capable of causing significant occupational and public health hazards during storage and distribution, and to a lesser extent during storage and distribution of refined products, compared to gasoline, depending on composition. Toxicity and relative risks associated with synfuels not fully known at this time, although considerable research is underway for the ASEV/OHER fossil energy effects research program. Synthetic crudes from oil shale and coal have been found to be skin carcinogens in mice. At one coal liquefaction facility, workers reportedly exhibited a greater incidence of skin cancer than the general population. However, no problems have been encountered at other facilities. Toxicity/carcinogenicity of synfuels appears to vary depending on conversion process, e.g., direct vs. indirect liquefaction as well as characteristics of final fuel. Synfuels may also be mutagenic. Further analysis and exploratory research is required to better characterize health effects of using synfuels and to evaluate extent to which these hazards can be controlled. Full resolution of issue depends on final fuel specifications.	P	43 55 59	1990
Socioeconomic				
Institutional				
A3-38.0	• A systematic review and evaluation of federal, state, and local laws and regulations pertaining to distribution and use of synthetic fuels in transportation applications is required.	S		1990
A3-38.1	• A systematic assessment of synthetic fuels distribution infrastructure requirements and programming of these requirements is needed. Currently, capital requirements are unknown.	S		1990
	Advanced Fuels - Hydrogen			
	Note: All issues listed are secondary because large scale demonstration or commercialization is not expected prior to year 2000.			
Ecosystem				
A3-30.0	• Effects on ecosystem are not under study at present.	S		Post-2000
Physical Environment				
Air Quality				
A3-40.0	• With exception of NO_x, evaporative and exhaust emissions should be environmentally acceptable, i.e., no lead, sulfur, smoke or odor, and very little CO and HC.	S		Post-2000
Health				
A3-41.0	• Hydrogen can be an asphyxiant in confined spaces where it cannot rise and diffuse. Although precautions taken to prevent fire and explosion should be adequate to protect against asphyxia resulting from oxygen deprivation, a warning odorant property may be considered.	S		Post-2000
Safety				
A3-42.0	• Hydrogen is extremely flammable. Flammability limits in air at atmospheric pressure are 4% to 74% by volume. Ignition energy is about one tenth that for gasoline and is spontaneous above 571°C. Techniques to prevent static sparks in H_2 storage and handling areas need to be identified and developed.	S		Post-1990

Table A.3 (Cont'd)

System/Concern Number	Advanced Fuels - Hydrogen	Concern Status	Ref.	Emergence of Impact
A3-43.0	• Detonation of gaseous hydrogen is unlikely in unconfined spaces, since it does not accumulate but rises and disperses readily. Heat radius of burning is small compared to hydrocarbons because absence of carbon results in very low flame radiation. Since hydrogen burns with an invisible flame, a flame colorant may be required. Techniques to detect leaks are undocumented.	S		Post-1990
A3-44.0	• Use of hydrogen as a cryogenic liquid (-253°C or -423°C) may result in burns and freezing of skin or tissue from contact with the liquid, hydrogen vapors, or cold pipes and valves. Also, air liquefies at this temperature, resulting in oxygen enrichment and increased fire hazards. Techniques to minimize or eliminate such hazards need to be identified and developed.	S		Post-1990

Table A.4 Electric and Hybrid Vehicle Systems: Subsystem Concerns

System/Concern Number	Lead-Acid Battery Environmental Concern	Concern Status	Ref.	Emergence of Impact
Ecosystem				
Human/Animal Pathways				
A4-3.0	• Additional quantities of lead introduced. Low solubility after uptake means long retention in tissues. Long-term exposure of low concentrations produces buildup in tissue that can be fatal. Ingestion through urban dust significant. Methods to minimize release of lead need to be developed.	S	61 68	Post-1986
Resource				
Mineral				
A4-4.0	• Current domestic measured and indicated lead reserves are nearly adequate to support demands under High II scenario. Recycling is assumed. No other material appears at this point to be a resource problem.	S	68	Post-1986
A4-5.0	• Alternate processes using less than current 50 gallons of water per battery for manufacturing need to be identified in order to preclude depletion of freshwater resources.	S		Post-1986
Physical Environment				
Air Quality				
A4-6.0	• EPA has issued source emission performance standards for new, modified, or reconstructed lead-acid battery manufacturing facilities. The promulgated emission limits are:	P	61	Post-1986

Facility	Lead Emission Limit
Lead oxide production	5.0 mg per kg of lead produced
Grid casting	0.05 mg per m^3 of exhaust air
Paste mixing	1.00 mg per m^3 of exhaust air
Above processes combined	1.00 mg per m^3 of exhaust air
Lead reclamation	2.00 mg per m^3 of exhaust air
Other operations	1.00 mg per m^3 of exhaust air

Estimates for increases in cost per battery to meet these standards range from $0.30 by EPA to $0.60 by the Battery Council. EV battery packs may contain 15 or more batteries.

System/Concern Number	Lead-Acid Battery Environmental Concern	Concern Status	Ref.	Emergence of Impact
Water Quality				
A4-7.0	• No measurable lead concentrations in lakes and streams. Antimony oxides and sulfides are insoluble. Lead and antimony on Toxic Pollutant List.	S	61	Post-1986
Waste Disposal				
A4-9.0	• Recyclable battery casings should be researched.	S		Post-1986
Health				
A4-10.0	• Lead has toxic effects, forming strong, stable bonds in animal, human tissue; concentrations affect central nervous, gastrointestinal, hematopoietic systems and kidneys. Lead oxide also toxic.	P	61	1982
A4-10.5	• Charging and operation results in release of toxic materials. Stibine (SbH_3), with a TLV = 0.5 mg/m^3, and arsine (AsH_3), with a TLV = 0.2 mg/m^3, are generated during and right after charge over a threshold voltage. Antimony and arsenic are in battery grid structure. Procedures to allow vehicle demonstration and battery testing to proceed without health risk are being carried out. Testing of concentrations continues.	P	84	1980
A4-11.0	• Concern eliminated. Combined with A4-10.5.			
A4-12.0	• Ways humans could be exposed to battery materials and control and handling not yet systematically studied. Specific chemical forms must be determined for toxicity studies.	P		1982
Safety				
A4-13.0	• Sulfuric acid spills under accident conditions could cause burns. Battery manufacturers have considered problem. Not a difficult one if properly designed; standards have not yet been developed.	P		1980

Table A.4 (Cont'd)

System/Concern Number	Lead-Acid Battery Environmental Concern	Concern Status	Ref.	Emergence of Impact
A4-14.0	• Explosion potential of hydrogen generated during charging has been considered by manufacturers and studied by OSHA for closed areas, such as warehouses. Problem not difficult with proper design; standards for design and venting are being developed by DOT. If sealed batteries can be used in vehicles, problem eliminated. DOE standards for demonstration require hydrogen shall be below 4% during operation, charge, and maintenance.	P		1980
A4-16.0	• Operations and maintenance personnel need shock protection from battery pack. Design standards for shock protection or lower operating voltage are being developed by DOT. DOE has promulgated related performance standards.	P		1980
<u>Socioeconomic</u>				
A4-16.5	• Advanced planning would be required for boom towns in battery materials mining areas to maintain municipal services and sufficient housing under higher projected levels of electric vehicle manufacture.	S		1990
	Nickel-Iron Battery			
<u>Ecosystem</u>				
Terrestrial				
Aquatic				
Human/Animal Pathways				
A4-17.0	• Nickel and nickel salts have demonstrated toxic effects on plants, especially citrus, and certain species of fish. Extent of potential impact from battery use unknown; control techniques undefined. Impacts would be localized if recycling is high.	S	86	Post-1986
<u>Resource</u>				
Mineral				
A4-18.0	• See nickel-zinc battery resource concern. Nickel could produce significant resource supply problems.	P	68	
<u>Physical Environment</u>	• See nickel-zinc battery concerns.			
<u>Health</u>	• See nickel-zinc battery concerns.			
<u>Safety</u>				
A4-23.0	• Explosion potential of hydrogen generated during charging is worse than for lead-acid and nickel-zinc but have been considered by manufacturers. If sealed, maintenance-free battery systems can be developed, problem is eliminated. Charging a fleet of vehicles in a closed space presents a special concern. Ventilation shall be adequate to maintain hydrogen below 4% during operation under current standards.	P		1982
A4-24.0	• Battery failure from a short circuit, overheating, or accident may result in electrolyte spillage and fire. Although recognized by manufacturers, no design or fire fighting standards have been set for these hazards.	P		1982
A4-25.0	• Battery pack presents shock hazards to operators and maintenance personnel.	P		1982
<u>Socioeconomic</u>				
A4-26.0	• See concern A7-14.4 for economic issue.	P		
	Nickel-Zinc Battery			
<u>Ecosystem</u>				
Terrestrial				
A4-27.0	• Nickel extremely toxic to citrus plants.	S	85	Post-1986
A4-28.0	• Some zinc needed for plant growth but slightly elevated concentrations are toxic.	S	85	Post-1986
Aquatic				
A4-29.0	• Materials, such as nickel, nickel salts, zinc, are toxic to plants and fish. (0.1 1.0 mg/L zinc lethal to fish). Proposed Water Quality Criterion: nickel, 0.1 mg/L. Extent of potential impact and control techniques unknown. Impacts would be localized.	S		Post-1986

Table A.4 (Cont'd)

System/Concern Number	Nickel-Zinc Battery Environmental Concern	Concern Status	Ref.	Emergence of Impact
Resources				
Mineral A4-30.0	• Large scale commercialization (see High I and II scenarios from programmatic EA) of both nickel-based batteries may be limited by future price and availability of nickel. Both batteries may also face a cobalt supply problem. Current efforts are directed to removing cobalt from the Ni/Zn battery. (See zinc-chlorine battery for resource constraint on which zinc, also affects Ni/Zn battery.) More than 50% of 1976 U.S. nickel supply was imported. Economically recoverable reserves are small. Processes for recycling to battery-grade nickel are not developed. Higher forecast production scenarios with 95% recycling still require up to 210% of BOM projected U.S. demand in 2000. There are no domestic economical reserves of cobalt. From 1972 to 1975 about 75% of U.S. imports came from a government-owned company in Zaire. There is an identifiable cobalt cartel. Higher forecast production scenarios with 95% recycling require up to 63% of the BOM projected U.S. demand in 2000.	P	68	Post-1986
Physical Environment				
Air Quality A4-31.0	• TLV for airborne nickel is 1 mg/m^3, for zinc chloride fume, 1 mg/m^3, for zinc oxide fume, 5 mg/m^3.	S		Post-1986
A4-32.0	• Primary zinc smelters are significant sources of SO_2, which has harmful health and welfare effects. A New Source Performance Standard for primary zinc smelter roaster emissions of SO_2 has been promulgated (40 CFR 60 subpart Q). These sources are difficult to control; control technology needs improvement, and may be expensive.	S	77	Post-1986
Water Quality A4-33.0	• Nickel salts used in metal plating are toxic and soluble. High concentrations of zinc cause film formation and unpleasant taste in drinking water. Control technologies are undefined. Nickel and zinc are on Toxic Pollutant List. Proposed WQC is 0.1 mg/liter for nickel and 5000 mg/liter for zinc.	S	86	Post-1986
Waste Disposal A4-34.0	• Development efforts on recyclable battery case materials unknown.	S		Post-1986
Health				
A4-35.0	• Manufacture of material uses nickel and nickel carbonyl. TLV for nickel is 0.35 mg/m^3. Nickel carbonyl is a known carcinogen but extent to which it is produced by chemical action is unknown. No known adverse effects of high zinc levels in water. Mercury with known toxic effects is being phased out as a battery additive. TLV for mercury is .05 mg/m^3 on Toxic Pollutant List. More information required as material handling increases. Existing industrial controls may be sufficient.	P	86	1982
Safety				
A4-36.0	• Explosion potential from hydrogen generation has been considered by battery manufacturers. If sealed, maintenance-free batteries can be developed, problem is solved. Ventilation shall maintain hydrogen below 4% during operation under present standards.	P		1982
A4-37.0	• In an accident, electrolyte spillage and fire hazard from zinc electrode in dry battery after loss of electrolyte are problems. Also failure of battery during operation from a short circuit or overheating could create fire hazard. No design or fire fighting standards have been developed, although problem has been recognized by manufacturers. DOE has issued performance standards.	P		1982
A4-38.0	• Operators and maintenance personnel need shock protection from battery pack. Design standards for shock protection or lower operating voltage do not now exist. DOE has issued performance standards.	P		1982
Socioeconomic				
A4-39.0	• See concern A7-14.4 for economic issue.	P		

Table A.4 (Cont'd)

System/Concern Number	Iron-Air Battery Environmental Concern	Concern Status	Ref.	Emergence of Impact
	Note: Little or no information available except as follows.			
Safety				
A4-44.0	• Explosion potential from hydrogen generation has been considered by battery manufacturers. This problem should be difficult to resolve.	S		1985
A4-45.0	• In an accident, electrolyte spillage and fire hazard from iron electrode in dry battery after loss of electrolyte are problems. Runaway reaction of iron electrode creates an extremely hot, smoldering fire that is difficult to extinguish; also failure of battery during operation from a short circuit or overheating could create fire hazard. No design or fire fighting standards have been recognized by manufacturers. DOE has promulgated its first related performance standards.	P		1985
A4-46.0	• Operators and maintenance personnel need shock protection from battery pack. Design standards for shock protection or lower operating voltage do not now exist. DOE has promulgated its first related performance standards.	P		1985
	Zinc-Air Battery			
Ecosystem				
Terrestrial A4-48.0	• Some zinc is needed for plant growth but slightly elevated levels are toxic.	S	86	1990
Aquatic A4-49.0	• Low concentrations (0.1-1.0 mg/l) of zinc can be lethal to fish and toxic to plants. Extent of potential impact and control techniques unknown.	S		1990
Resource				
Mineral A4-50.0	• "Rolling" reserves of zinc could be a significant part of world reserves for full national and international electric vehicle use. Design to minimize material use and maximize recyclability has not been evaluated. Development of additional reserves has not been systematically studied.	S		1990
Physical Environment				
A4-51.0	• TLV of zinc oxide is 5 mg/m^3; TLV of zinc is 1.0 mg/m^3.	S	77	1990
Air Quality A4-52.0	• Primary zinc smelters are significant sources of SO_2 which has harmful health and welfare effects. These sources are difficult to control; control technology needs improvement (see Concern A4-32.0).	S		1990
Water Quality A4-53.0	• High concentrations of zinc cause unpleasant taste and film formation in potable water. Control technologies undefined.	S	86	1990
Waste Disposal A4-54.0	• Nonrecyclable casings will generate a large solid waste volume if used extensively. Development efforts on recyclable case materials unknown.	S		1990
Safety				
A4-56.0	• In an accident, electrolyte spillage and fire hazard from zinc electrode in dry battery after loss of electrolyte are problems. Runaway reaction of zinc electrode creates an extremely hot, smoldering fire that is difficult to extinguish. Also failure of battery during operation from a short circuit or overheating could create fire hazard. No design or firefighting standards have been developed, although problem has been recognized by manufacturers. DOE has issued performance standards.	P		1985
	Zinc-Chlorine Battery			
Ecosystem				
Terrestrial A4-58.0	• Some zinc is needed for plant growth but slightly elevated concentrations are toxic.	S	86	Post-1986
Aquatic A4-59.0	• Zinc and chlorine are toxic to plants and fish (0.1-1.0 mg/l zinc is lethal to fish). Extent of potential impact and control techniques undefined.	S	86	Post-1986

Table A.4 (Cont'd)

System/Concern Number	Zinc-Chlorine Battery Environmental Concern	Concern Status	Ref.	Emergence of Impact
Resource				
Mineral				
A4-60.0	• Zinc is a significant component of the Ni/Zn and Zn/Cl battery. The U.S. currently consumes about one-fifth of the total world supply, yet produces only 8% of the world primary supply. New recycling technologies are required for 95% recycling to occur. High I and High II scenarios, which contain Ni/Zn but no Zn/Cl batteries, require up to 41% in 2000 of the BOM U.S. demand estimate, thus exceeding domestic production by a greater amount than is currently projected.	P	68	Post-1986
Physical Environment				
Air Quality				
A4-61.0	• Threshold Limit Value (TLV) for airborne chlorine is 3 mg/m^3, for zinc chloride, 1 mg/m^3, and for zinc oxide, 5 mg/m^3.	S	88	1985
A4-62.0	• Chlorine gas is highly toxic. Manufacture of chlorine by mercury cell method results in release of mercury. Many (but not all) companies converting to diaphragm cell method. Primary zinc smelters are a significant source of SO_2 (see Concern A4-32.0). Mercury and SO_2 have harmful health and welfare effects. Emission control technology and/or process modifications need further improvements.	S		1985
Water Quality				
A4-63.5	• Industry must comply but cost may be prohibitive. High concentrations of zinc cause unpleasant taste and film formation. Control technologies are undefined (see concern A4-33.0); manufacturing industry must meet effluent standards.	S		Post-1986
Waste Disposal				
A4-64.0	• Nonrecyclable battery case will generate a large solid waste volume. Development efforts underway on recyclable case. Other information required by CS/AC.	S		Post-1986
Safety				
A4-67.0	• Hydrogen is generated during charging. For demonstration, hydrogen to be below 4% during operation. In an accident electrolyte spillage and fire hazard from zinc electrode in dry battery after loss of electrolyte are problems. Runaway reaction of zinc electrode creates an extremely hot, smoldering fire that is difficult to extinguish. Also failure of battery during operation from a short circuit or overheating could create fire hazard. No design or firefighting standards have been developed, although problem has been recognized by manufacturers. DOE has issued performance standards.	P		1980
A4-69.0	• Release of chlorine gas in accident, especially when battery is fully charged and accident is accompanied by fire, and seepage of chlorine gas from garaged auto would prove extremely dangerous and potentially fatal. Testing has been limited thus far, but has shown a basis for concern. Current battery must be vented every day. Available information is limited.	P		1980

	Sodium-Sulfur Battery			
Ecosystem				
Terrestrial				
A4-70.0	• High concentrations of sodium harmful to soil and plants. Industry must control discharges.	S		Post-1990
Aquatic				
A4-71.0	• Sodium raises pH of water. Toxic to plants and fish. Extent of potential impact and control techniques unknown. Manufacturing industry will address.	S		Post-1990
Physical Environment				
Waste Disposal				
A4-74.0	• Nonrecyclable battery cases will generate a large solid waste volume if used extensively. Weight is a limiting factor for metallic cases, so industry may be forced to use nonbiodegradable and nonreusable materials.	S		Post-1990

Table A.4 (Cont'd)

System/Concern Number	Sodium-Sulfur Battery Environmental Concern	Concern Status	Ref.	Emergence of Impact
Health				
A4-75.0	• Sodium hydroxide aerosol, which is caustic and toxic in high concentrations, could be released in a failure or accident.	S		1986
Safety				
Occupational A4-76.0	• Operators and maintenance personnel need shock and burn protection from battery pack. Design standards for shock protection, high temperature protection, or lower operating voltage do not now exist.	S		1986
Public A4-77.0	• In an accident, release of high temperature electrolyte and toxic substances, such as sulfur and SO_2 in a fire, are problems. Also failure of battery during operation from a short circuit or overheating could create fire hazard. No design or firefighting standards have been developed although problem has been recognized by manufacturing industry.	S		1986
A4-78.0	• Sodium creates severe explosion problems if brought in contact with water during maintenance, accidents, or fire fighting. Manufacturers recognize this problem, but it will be difficult to remedy. Sodium control procedures and design standards do not now exist. This may be a significant barrier to commercialization.	P		1986
	Lithium-Metal Sulfide Battery			
Ecosystem				
Terrestrial A4-79.0	• Lithium toxic to citrus fruit.	S	86	Post-1990
Aquatic A4-80.0	• Lithium chloride toxic to fish at very high concentrations (3000 mg/L). Industry must control effluents.	S		Post-1990
Resource				
Mineral A4-81.0	• Lithium resources are poorly known and production is very low. U.S. should be self-sufficient under any future scenario but EA High I and High II scenarios pose a serious gearing up problem since they would require a projected 1285% increase in annual demand by 2000.	S	68	Post-1990
A4-81.1	• Aluminum comprises a significant proportion of the Li/S battery, and of motors, controllers, chargers, and vehicle body and chassis. No resource problem is expected under High I and High II production scenarios by 2000 but the high consumption of electrical energy for primary aluminum metal production may become a major constraint beyond 1984-1990, when the Bonneville Power Administration has announced it will not renew its contracts with the aluminum industry.	S	68	Post-1986
Physical Environment				
Waste Disposal A4-83.0	• Nonrecyclable battery cases will generate large solid waste volume if used extensively. Development efforts on recyclable case materials unknown.	S		Post-1990
Solid Waste A4-83.5	• Solid waste production in lithium mining from pegmatites is substantial and in the High I and II scenarios could require over 200 acres of disposal land fill annually by 2000.	S	68	1990
Safety				
A4-85.0	• In an accident, release of high temperature electrolyte and toxic substances, such as sulfur and SO_2, in fire are problems. Also failure of battery during operation from a short circuit or overheating could create fire hazard. No design or fire fighting standards have been developed although problem has been recognized by manufacturing industry.	S		Post-1990
A4-86.0	• Operators and maintenance personnel need shock and burn protection from battery pack. Design standards for shock protection, high temperature protection, or lower operating voltage do not now exist.	S		1986
Socioeconomic				
Economic A4-87.0	• Concern on impact to world markets resolved by 1980 EA. Domestic reserves now appear adequate to needs of High I and High II production scenarios.		68	
A4-87.5	• Under the High II market penetration scenario, the lithium industry will need to grow 1285% between 1990 and 2000. This would cause capital and labor problems for the industry and could cause boom-town problems in mining areas.	S	68	Post-1990

Table A.4 (Cont'd)

System/Concern Number	Off-Board Charger Environmental Concern	Concern Status	Ref.	Emergence of Impact
Resource				
Mineral A4-88.0	• Copper, germanium, indium, silicon and selenium used, although use of latter is unlikely. Systematic studies of available supplies and potential shortages are presently being investigated by CS/AC. See Concern A4-81.1 for the lithium-metal sulfide battery.	S	72	Post-1985
Physical Environment				
Air Quality A4-89.0	• Copper smelters are significant sources of SO_2. New Source Performance Standard revision in preparation. Plastics manufacturing results in significant hydrocarbon emissions. Disposal of unit by incineration leads to potentially toxic emissions. Copper TLV is 0.2 mg/m^3 for metallic copper fume and 1 mg/m^3 for dusts and mists. Emission rates from manufacturing have been studied extensively; certain processes are difficult to control. Emission control technology, especially type that does not require natural gas afterburners, needs improvement. Industry must comply with promulgated standards but costs may be prohibitive.	S	-	1982
Waste Disposal A4-90.0	• Disposal of chargers as entire units will generate a large solid waste volume.	S		Post-1986
Safety				
A4-91.0	• Chargers present burn and shock hazards to operators and maintenance personnel, and toxic gas may be released during failure or overload melt down of case and semiconductors. Increased use of chillers, such as fluorinated hydrocarbons, occurs during manufacture and servicing. Problems are recognized by manufacturers. Efforts to identify alternative materials or develop design standards are not known.	P		1986
	On-Board Charger Environmental Concern			
All				
A4-93.0	• Same as off-board charger except that increased use of epoxies to seal unit for vibration reduction may have undefined effects.	S		
Safety				
A4-94.0	• Release of toxic gases under failure, fire, or vehicle accident. Rate of release unknown. Availability of alternative nonflammable or nontoxic materials not known.	P		1980
	Controller			
	• Same as on-board charger.			
	Electric Motor			
	Note: Only one new concern in standard production, use, and disposal:			
Physical Environment				
Electromagnetic Interference A4-97.0	• Speculation that extensive use could create radio frequency interference. Some studies underway.	S		1980

Table A.4 (Cont'd)

System/Concern Number	Electric Motor Environmental Concern	Concern Status	Ref.	Emergence of Impact
Health				
Public				
A4-97.1	• Copper aerosol from motors is a new health concern. Little is known about this aerosol formation, especially concerning EHVs.	P		1980
A4-97.5	• Ozone generation from electric motors, particularly DC motors, should be analyzed before large numbers of EVs are introduced. No studies are known. AC motors are not expected to generate ozone.	S		1990
Socioeconomic				
Institutional				
A4-98.0	• Firefighting guidelines to minimize shock hazards to firefighters need to be specified.	P		1980
	Regenerative Braking			
All				
A4-99.0	• Same concerns as for other components, i.e., charger, controller, and electric motor.			
	Flywheel[a]			
Ecosystem				
A4-100.0	• Effects of composite materials on ecosystem, e.g., Kevlar, E-glass, S-glass, boron, graphite, on ecosystem undefined.	S		Post-1986
Resource				
A4-101.0	• Resource constraints on composite materials expected to be small. This concern may be eliminated in future EDPs.	S	9 78	Post-1986
Physical Environment				
Air Quality				
A4-102.0	• Manufacture of composite flywheels results in hydrocarbon emissions. Emission rate undefined.	S		Post-1986
Water Quality				
A4-103.0	• Impact of composite materials undefined although some materials, such as boron and graphite, have small impacts.	S		Post-1986
Waste Disposal				
A4-104.0	• Composite flywheels are nonbiodegradable and nonrecyclable after failure and could present a disposal problem.	S		Post-1986
Noise Pollution				
A4-105.0	• Flywheel may create discrete frequency or narrow-band noise levels.	S	88	1982
Health				
Occupational				
A4-106.0	• Hazards of manufacture of composite materials undefined.	P		1985
Safety				
Public				
A4-107.0	• Failure of flywheel requires a containment shield to prevent injury to passengers. Major containment problem seems to be the transfer of angular momentum and the possible explosion of dust created by composite rotor failure. Safety standards not yet set and not enough testing has been done. Flywheel needs warning indicators against failure conditions from overspeed, low oil pressure, or excessive temperature. Possible eye injury due to vacuum pump oil coating cornea. Toxic gas releases from overheated composite materials, owing to malfunction, must be controlled.	P	9,62 72,74 78	1982
A4-108.0	• Fire hazard with composites and with bearing lubrication oil.	P	66	1982
A4-109.0	• Flywheel failure can result from relatively small manufacturing defects and from small deterioration in materials during use.	P	62,66 74	1982

Table A.4 (Cont'd)

System/Concern Number	Flywheel[a]	Concern Status	Ref.	Emergence of Impact
A4-110.0	• Gyroscopic torque of flywheel assumed to be a minor problem under normal road conditions, but little has been done to determine adverse effects on wet or icy roads.	P	9 78	1982
Socioeconomic				
A4-111.0	• Monitor flywheel manufacturing quality control measures to insure against premature failure.	S		1985
	Electric Vehicle Body/Chassis Environmental Concern			
Resource				
Mineral A4-112.0	• Materials for fiber-reinforced plastics may require extensive use of petrochemical feedstocks. Competing demand for these resources from conventional vehicles. Availability of other suitable materials unknown.	S		Post-1986
Physical Environment				
Air Quality A4-113.0	• Manufacture results in significant emissions of hydrocarbons, which have harmful effects on public health and welfare due to contributions to oxidant formation. It is known that some processes result in emissions that can be controlled by gas-fired afterburners only. Emission control technology needs improvement. Industry responsible for controls, but costss may be prohibitive.	S		Post-1985
A4-114.0	• Estimated background emissions from current ICE vehicle from paint, vinyl upholstery, etc., is 1 gram per emission test. Vehicle chassis may "off-gas" hydrocarbons. Rate of release undefined. Availability of alternative material is unknown.	S		1985
Waste Disposal A4-115.0	• Development efforts on recyclable materials undefined.	S		Post-1986
Health				
Occupational A4-116.0	• Occupational hazard in exposure to abrasives, fine particulate matter, epoxies, resins, and evaporative hydrocarbons in fabrication and repair of fiberglass or other fiber-reinforced plastics not clearly determined. Further investigation into existing regulations needed to guide industry in the adoption of appropriate safety measures.	P		1984
Safety				
Public A4-117.0	• Currently available plastic bodies may provide inadequate crash protection. Patchwork repair of fiber-reinforced body shells may weaken overall body strength. Extent of weakening and availability of suitable repair materials and procedures unknown. DOE performance standards require that FMVSS be met.	P		1985

[a]Most of the flywheel concerns are being or will be addressed by CS/AC in its analysis of flywheel applications in different technologies.

Table A.5 Electric and Hybrid Vehicle Systems: Electric Vehicle Concerns

System/Concern Number	Electric Vehicle Environmental Concern	Concern Status	Ref.	Emergence of Impact
	Note: Many of the environmental concerns related to the electric vehicle are covered under subsystem concerns (Table A.4). Environmental concerns related to the electric vehicle as a component of the transportation system are included later in Table.A.7. Immediately below are concerns which relate specifically to vehicle performance, operation, and maintenance.			
Health				
Public				
A5-1.0	• Operation may create occupant exposure to low concentrations of toxic materials. For example, battery charging may result in gas emissions seeping into passenger compartment. Complete assessment of toxic materials involved unknown. Design, operation, or replacement standards not developed. See especially Concern A4-10.5.	P		1980
Safety				
Public				
A5-2.0	• All vehicles produced under guidance of the DOE program should be quite safe, meeting FMVSS and special EHV standards. However, lower performance "neighborhood" cars, benefitting from DOE RD&A advances may be produced. Hazardous conditions, owing to vehicle performance (e.g., low acceleration and poor merging capability),, component failure (e.g., regenerative braking, battery, etc.) and vehicle response characteristics may result. While the DOE program is not directly funding research for these vehicles, DOE work on batteries and vehicle components will allow these vehicles to be developed.	P		1984
A5-3.0	• Involvement in an accident presents special crash worthiness and crash-avoidance problems including weight differential between standard electric and lighter internal combustion engine vehicles, isolation of vehicle occupant from battery pack in event of breakaway, and fire fighting needs (e.g., dry chemicals instead of water). DOE performance standards are also required to protect against shock and battery materials spillage. Modified FMVSS need to be developed by DOT.	P		1984
A5-4.0	• Maintenance presents shock and burn hazards. Standards are needed.	S		1981
A5-5.0	• Electric vehicles are quiet, so pedestrians may not hear them approaching. Minimum noise standards may be necessary.	S		1981

Table A.6 Electric and Hybrid Vehicle Systems: Hybrid Vehicle Concerns

System/Concern Number	Hybrid Vehicle Environmental Concern	Concern Status	Ref.	Emergence of Impact
	Environmental concerns are largely the same as for electric vehicle except differences in terms of public acceptability and safety are unknown.			
Physical Environment				
Air Quality				
A6-2.0	• Emission characteristics of hybrids are heavily dependent on components, throttle response method, and power control schedule. Emissions can be increased over conventional vehicles if not properly considered. Commercialized hybrids must meet emission standards.	S	9 78	Post 1986
Safety				
A6-3.0	• Hybrid vehicles are more complex than conventional and straight electrics. Duplication of control systems must not exceed driver ability. Development of control systems must be monitored. Controls and sensors may be needed to insure safe vehicle performance.	S	62 74	1982
A6-4.0	• Potential for explosion and fire in two energy storage systems (e.g., gasoline and battery electrolyte).	P		1982
A6-5.0	• Preliminary "failure tree" has been prepared for battery-flywheel but not for other concepts. No systematic analysis of failure modes for hybrids has been made.	P		1982

Table A.7 Electric and Hybrid Vehicle Systems: Total System Concerns

System/Concern Number	Electric and Hybrid Vehicle System Environmental Concern	Concern Status	Ref.	Emergence of Impact
Ecosystem				
A7-1.1	• Ecosystem impacts can be evaluated on a specific site basis. EHV use will introduce metals into environment during all phases of battery and vehicle production, recycling, and disposal. Mining results in erosion, sedimentation, and nitrate residues. SO_x from manufacture and electricity generation results in acid rain and known ecological damage. Further DOE and EPA studies are underway. These problems are not resolved without economic costs and the future cost of EHVs may reflect them.	S	68	Post-1986
Physical Environment				
Air Quality				
A7-4.0	• Vehicle materials production and vehicle industry processes are potentially pollution-intensive. The table below gives the ratio of several air pollutants generated by production of EHVs to those generated by the production of the same number of conventional vehicles for the High II scenario. Magnitude of these emissions reflects, at least in part, government participation in and encouragement of EHV commercialization.	P	68	Post-1985

Pollutant	1990	2000
CO	3.6	1.8
SO_x	5.3	4.4
NO_x	1.9	1.6
HC	1.5	1.5
Part.	1.7	1.7

System/Concern Number	Electric and Hybrid Vehicle System Environmental Concern	Concern Status	Ref.	Emergence of Impact
A7-5.0	• EV operation will reduce all regulated pollutants in urban areas. This is probably true of hybrids but data is insufficient for this to be assured. Exception is SO_x emissions produced where fossil fuel is used to generate electricity. Overall national impact from even the highest production and operation scenario (High II) is small, but impact varies by urbanized area, depending on type of fuel used to generate electricity. Table gives ratio of EHV to conventional vehicle air emissions from vehicle operation for same miles of travel for the High II scenario. See concerns A4-32.0, A4-89.0 and A4-113.0.	P	68 76	Post-1985

Pollutant	1990	2000
CO	0.04	0.1
SO_x	10.5	10.6
NO_x	0.7	0.6
HC	0.05	0.07
Part.	0.5	0.5

System/Concern Number	Electric and Hybrid Vehicle System Environmental Concern	Concern Status	Ref.	Emergence of Impact
Water Quality				
A7-5.5	• High incremental pollutant levels may be expected in specific geographic areas, especially in vicinity of mining and heavy manufcturing centers.	S	68	Post-1985
Solid Waste				
A7-6.0	• Solid waste generation owing to mining, manufacture, and vehicle disposal is expected to be small. High incremental loads may be expected in specific geographic areas. In particular, lithium mining may generate high loads.	S	68	Post-1985
Socioeconomic				
Social				
A7-12.0	• EHVs would substitute in markets with suitable vehicle missions through 2000. Many of these are markets for commercial vehicles. Social impact should be small. Low performance vehicles are outside scope of DOE program, but DOE RDD&A will indirectly assist development of these vehicles, which may have mobility impacts. These vehicles would result from severe liquid fuel shortages and would have specialized uses. This is not a negative concern and may be deleted in future EDPs.	S	68	1985

Table A.7 (Cont'd)

System/Concern Number	Electric and Hybrid Vehicle System Environmental Concern	Concern Status	Ref.	Emergence of Impact
A7-13.0	• Complexity of hybrid system and its impact on drivers and repair personnel have not been evaluated.	S		Post-1986
Economic				
A7-14.0	• Vehicle capital and operating costs must be competitive with alternatives. Studies comparing life cycle costs and market penetration have not been encouraging.	P	68 76	1985
A7-14.2	• Only five industries will have employment changes induced by EHVs in high production scenarios of over 10,000 workers in 2000. Largest change is in battery industry which could increase by nearly 40,000 employees over a no-EHV future. Most of this increase would occur in the 1990s with no guarantee that it could be readily absorbed into the industry.	S	68	Post-1985
A7-14.4	• U.S. balance of trade impacts of EHVs could be significant. For Ni/Fe and Ni/Zn batteries in particular, imported metals are being substituted for imported oil. Under certain plausible metal and oil price scenarios, net impact on balance of trade would be negative.	P	68	Post-1990
A7-14.6	• Local governments may have difficulty maintaining services in boom towns created by new and revived metals mining.	S	68	Post-1990
A7-14.8	• Small manufacturers of vehicles and components will be financially encouraged by DOE during next 5 years. However, capital formation during 1980s will be difficult for these small firms, as will obtaining necessary, and quite expensive, product liability insurance. Whatever financial viability is built up in these small firms during first part of decade will be shaken by EHV mass production by existing large manufacturers in late 1980s.	S	68	Post-1981
A7-15.0	• Fire fighting guidelines to minimize shock hazards to fire fighters need to be specified. DOE and site operators have agreements.	P		1980
A7-16.0	• Extensive supporting infrastructure needed, including qualified sales, repair and maintenance personnel, facilities, and services. Demonstration is designed to resolve problems.	S	68	Post-1986
A7-17.0	• Registration, inspection, driver licensing, taxing, and insurance requirements undefined. Labor union policies and actions not fully predictable.	S	68	1985
A7-18.0	• Even under High II scenario, impacts on electric utilities are expected to be minimal. Most vehicles will be charged overnight (off peak). By 2000 under High II scenario, EHV battery charging will result in only five utilities exceeding projected demand by greater than 10%. Utilities will have to include EHVs in their planning.	S	68	Post-1990
A7-19.0	• EHV commercialization could lead to significant gearing up and transition problems for battery, zinc, nickel, cobalt, lead, lithium, and motor vehicle industries.	P	68	1984

Table A.8 Transportation Systems Utilization: Systems Efficiency Technology Concerns

System/Concern Number	Marine Bottoming Cycle Environmental Concern	Concern Status	Ref.	Emergence of Impact
	Note: Demonstration program should supply information on many of these concerns and issues. Working fluid likely to be fluorinol.			
Ecosystem				
A8-1.0	• Localized effects of release of working fluid during shipment or equipment failure unknown. Toxicity studies underway, funded by ASEV.	P		1983
Physical Environment				
Air Quality				
A8-4.0	• Cooling of exhaust gases changes emission characteristics. Testing required during demonstration.	P		1983
A8-5.0	• Toxicity and other characteristics of proposed working fluids have been identified. Results of release during catastrophic failure must be understood.	P	27	1983
Water Quality				
A8-6.0	• Wastes from manufacturing of working fluid undocumented; specification may be proprietary. Industry must address.	P		1983
Waste Disposal				
A8-7.0	• Standards for removing working fluid from system during vessel decommissioning must be set by OSHA.	S		Post-1986
Noise				
A8-8.0	• Increase in noise levels may occur. Compatability with OSHA noise regulations should be demonstrated and development monitored during demonstration.	S		1983
Health				
Occupational				
A8-9.0	• Long-term effect of working fluid during cycle charging, slow leak, and repair unknown. Dermal and inhalation exposure hazardous.	P	27	1985
A8-10.0	• Noise levels and controls unknown. Monitoring needed during demonstration.	P		1982
Safety				
A8-11.0	• Air and water quality impacts of spills of working fluid unknown.	P	27	1985
A8-12.0	• Results of working fluid spills from equipment failure, including air, skin contact, and fire problems, can include exposure to fluorophosgene and dermal contact of high potential toxicity. Boiler design standards important. Research plan identified.	P		1985
Socioeconomic				
Economic				
A8-13.0	• Initial cost of engine with bottoming cycle higher. Market may be limited to fleet owners who consider life cycle costs, which would diminish expected programmatic petroleum energy savings.	S		1983
Institutional				
A8-14.0	• Additional operating personnel skills may be required. Industry will address.	S		1983
A8-15.0	• Compatibility with current operating and maintenance patterns unknown. Demonstration should provide some answers. Effects on insurability unknown. Industry will address.	S		1983
	Medium Speed Diesel Alternative Fuels Program			
	Note: Alternative fuels include off-specification diesel fuel compositions, alcohol, synthetic, and gaseous fuels. Generally, environmental concerns listed in Table A.3 for new hydrocarbon fuels, alcohol, alcohol blends, and synthetic fuels also apply to this program. Emergence date of impacts is about 1985. In particular, air quality and health impacts should be monitored. As this program is formalized, updates of EDP will identify specific concerns.			

Table A.9 Transportation Systems Utilization: Strategy Program and Vehicle Performance Concerns

System/Concern Number	Freight Environmental Concern	Concern Status	Ref.	Emergence of Impact
	Note: Concerns specific to transport of energy materials are not included here.			
Resource				
A9-1.0	• Highway requirements arising from possible increased truck traffic not fully assessed.	S		Post-1985
Physical Environment				
A9-2.0	• Air pollution, noise concerns and aesthetic degradation arising from potential changes in modal shifts need study.	S		Post-1985
Safety				
A9-3.0	• Safety impacts which may arise from changes in operating techniques need study.	S		Post-1985
A9-4.0	• As a result of potential modal shifts increased numbers of trains passing through towns will present physical barriers, particularly to emergency vehicles, unless grade separations are constucted.	S		Post-1985
A9-5.0	• As a result of potential modal shifts, increase numbers of trains passing through towns will add to potential for accidents at grade crossings.	S		Post-1985
Socioeconomic				
A9-6.0	• Institutional, labor, and economic impacts, arising from changes in operating procedures, intra- and intercity freight consolidation, intermodal cooperation, and modal shifts, need study. Impacts on labor union contracts and local laws should be considered.	S		Post-1985
	Intercity Passenger Environmental Concern			
Physical Environment				
A9-16.0	• Air quality and noise impacts may arise from changes in operating techniques. Should be studied on a case by case basis.	S		Post-1985
Safety				
A9-17.0	• Safety impacts, which may arise from changes in operating techniques, such as aircraft towing at airports and aircraft takeoff and landing procedures, need study.	P		Post-1982
Socioeconomic				
A9-18.0	• Social, institutional, labor, and economic impacts, arising from modal shifts in the intercity passenger market and from strategies to improve operating efficiencies of intercity passenger modes, need to be studied and monitored.	S		Post-1985
	Vehicle Performance Environmental Concern			
Safety				
A9-19.0	• As internal combustion engine vehicles continue to be downsized and aerodynamically improved to meet CAFE, safety concerns will arise in collision situations involving these lighter weight vehicles with heavy trucks, electrics, and hybrids. Monitor.	P		1986

APPENDIX B

ENVIRONMENTAL CONCERN CLASSIFICATION, IDENTIFICATION, STATUS, STANDARDS, AND RESEARCH REQUIREMENTS

B.1 ENVIRONMENTAL CONCERN CLASSIFICATION, IDENTIFICATION, AND STATUS

This section describes the methods by which environmental concerns are classified, identified, and designated primary or secondary. Secs. 3.2 to 3.5 describe the primary concerns for specific transportation projects.

B.1.1 Environmental Concern Classification

The taxonomy of transportation program environmental concerns is shown in Table B.1. Environmental systems that may be affected by changes in transportation systems include ecosystem, resources, physical environment, health, safety, and socioeconomic systems. There are subsystems within each system.

Transportation system changes that can affect environmental systems can occur anywhere in the transportation system (see Fig. B.1). The transportation system includes vehicles, vehicle subsystems and components, system and vehicle operations, guideways, operators, passengers, freight, and the supporting infrastructure. Transportation programs involve many of these transportation system elements and indirectly affect the remainder.

In order to categorize environmental concerns for the EDP, concerns first were identified for each technology and strategy program. Then they were classified by the environmental subsystems of Table B.1.

Table B.1 Environmental Concern Taxonomy

Environmental Systems and Subsystems
ECOSYSTEM
• Terrestrial
• Aquatic
• Human/Animal Pathways
RESOURCE
• Mineral
• Natural (Land, Water)
• Capital/Labor
PHYSICAL ENVIRONMENT
• Air Quality
• Water Quality
• Waste Disposal
• Noise Pollution
• Aesthetic Degradation
HEALTH
• Occupational
• Public
SAFETY
• Occupational
• Public
SOCIOECONOMIC
• Social
• Economic
• Institutional

B.1.2 Environmental Concern Identification and Status

This subsection describes the process for identifying environmental concerns and for determining the need for research on the concern during the next two fiscal years. Figure B.2 diagrams the process.

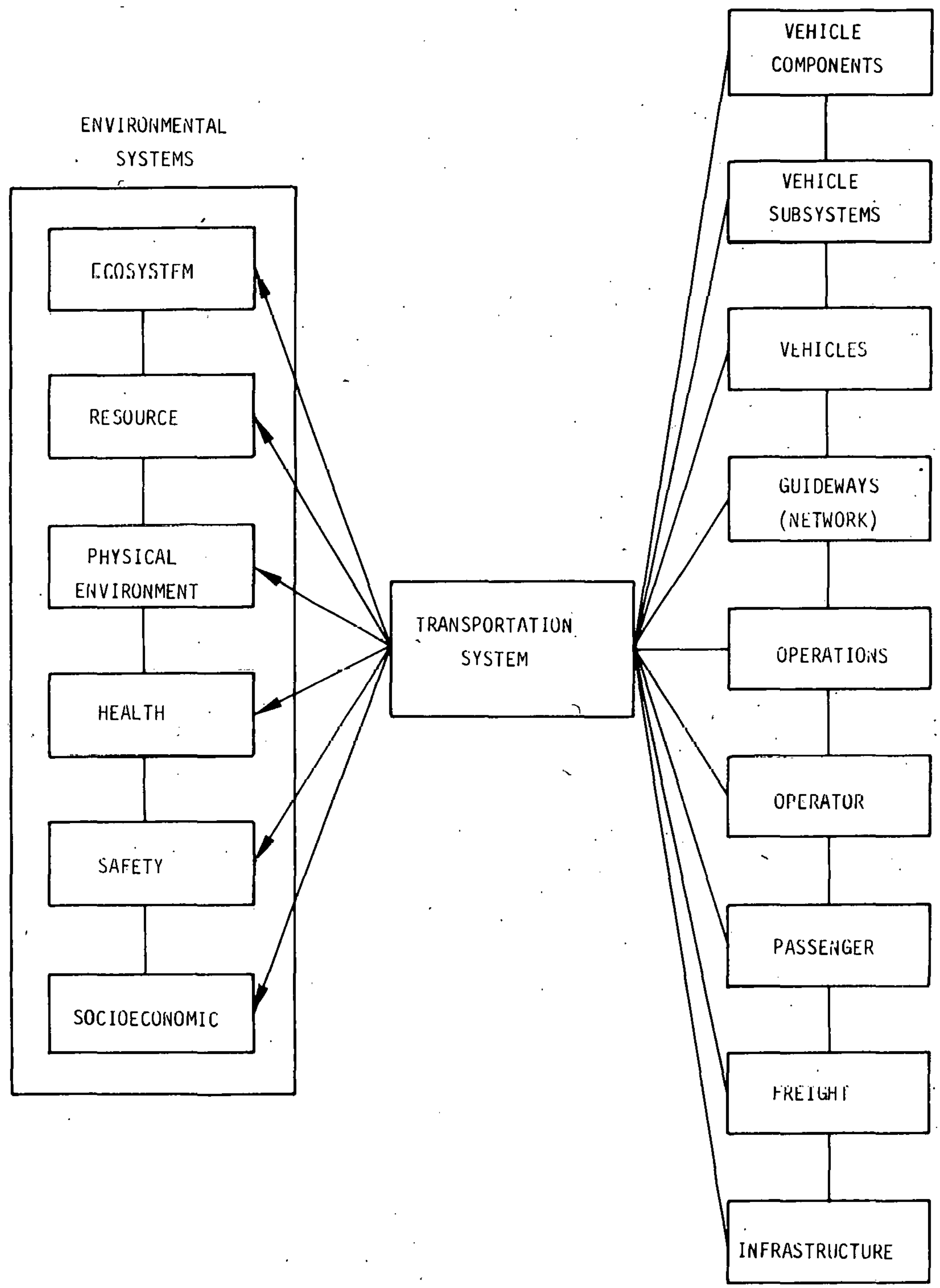


Fig. B.1 Impact of Transportation System on Environmental Systems

First, attributes of each strategy, technology, or fuel that might result in an environmental concern are reviewed and identified by a multidisciplinary team which sorts them into programmatic and environmental concerns.

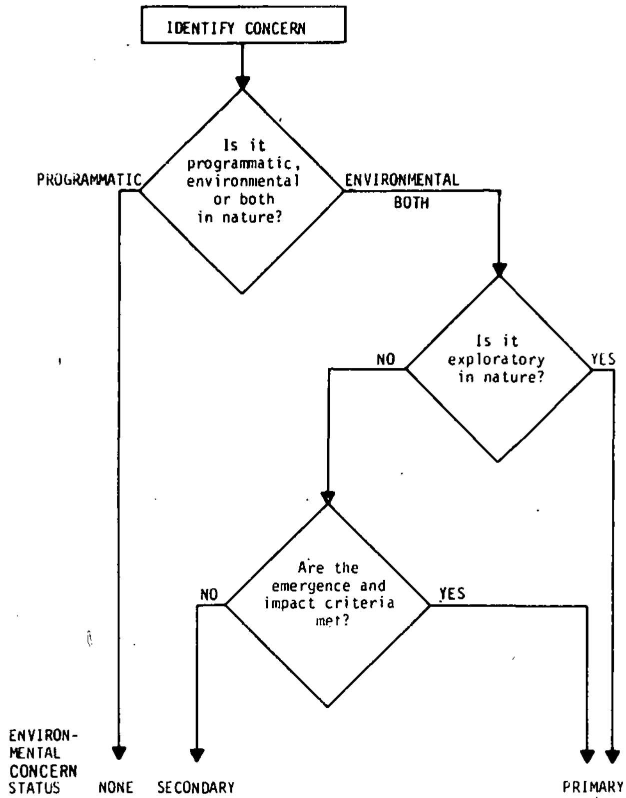


Fig. B.2 Determining Status of Environmental Concern

Programmatic concerns arise from development of the technology and are direct impediments to its demonstration and commercialization. They are dealt with directly by the transportation technology development program and include economic feasibility, i.e., capital available for production shifts, life cycle costs, and market penetration; industrial and commercial regulations and some other institutional barriers; compliance with existing emission, safety, and noise standards; energy conservation, and changes in energy sources.

Environmental concerns arise from impacts of the technology demonstration and commercialization on the environmental system structured above in the issue taxonomy. However, these two types of concerns overlap (see Fig. B.3). EDP covers environmental concerns and concerns in the overlap area, but not programmatic concerns.

Concerns are developed from factual information where such information is available. Description of the concern includes the status of understanding of the environmental effect, and its control. Appendix A lists concerns according to the taxonomy of Table B.1.

PROGRAMMATIC CONCERNS	OVERLAP	ENVIRONMENTAL CONCERNS
Technical Feasibility Component Reliability	Meeting Existing Emission Standards Materials Availability	Health Impacts Impacts on Other Transportation Modes Impacts on Lifestyles

Fig. B.3 Example of Overlap of Programmatic and Environmental Concerns

B.1.2.1 Exploratory Concerns

Appendix A shows the status of an environmental concern as primary or secondary. Primary status is determined as follows: If the concern is exploratory in nature, arising from a lack of sufficient understanding to explain or estimate underlying cause/effect relationships, or to adequately quantify the environmental issues, the concern is assigned primary status, and exploratory research is required.

B.1.2.2 Status Designation Criteria

If the concern results from issues for which there is understanding of cause/effect relationships, or for which the magnitude of potential effects can be estimated, a set of four criteria are used to determine concern status.

The four criteria are: (1) emergence of impact of concern before 1985, (2) relatively long lead time required to resolve concern through environmental assessment, research, development, and demonstration, (3) moderate to high severity of impact of concern (dose-response), and (4) relatively large human or animal population at risk. A concern is designated as primary if it meets criteria (1) or (2) and (3) or (4).

The first criterion, an estimated date for the emergence of each impact, is listed in Appendix A. For most dose-response type impacts, this date is the time of a large demonstration, as of several hundred vehicles. For others, the date is the estimated time of implementation or commercialization. If a concern will affect a large population or will have severe effects on a few persons, and if a long time is needed to resolve the concern, it is designated primary. If a concern is not exploratory and does not meet the other criteria, it is designated a secondary concern.

B.2 ENVIRONMENTAL CONCERN RESEARCH STATUS, STANDARDS, AND REQUIREMENTS

This section describes the research status of environmental concerns, the standards and goals applicable to these concerns, and the environmental research required. Secs. 3.2 through 3.5 specify the level of understanding and research required for the primary environmental concerns of specific transportation projects.

B.2.1 Environmental Concern Research Status

Before an environmental research and assessment plan can be developed, the level of understanding of an environmental concern must be established. For this purpose, five levels of understanding have been defined and a hierarchy of environmental research and assessment types corresponding to each level of understanding has been designated, as shown in Table B.2. The lowest level of research and assessment, level 0, is essentially no understanding of the concern. The highest level, level IV, results in concern resolution. Depending on the findings at any given level, the primary concern for which understanding and resolution is sought may be discarded because the impact was found to be negligible or require further research and assessment, usually at the next level. Often, if the environmental research or

Table B.2 Hierarchy of Understanding of Primary Concerns and Research or Assessment Required Prior to Resolving Concerns

Level of Understanding and Research or Assessment	Environmental Research or Assessment Performed at this level	Comment on Research or Assessment	Understanding of Primary Concern Resulting from this Research or Assessment Level
0	Concern identification.	No relevant environmental research; completed.	Concern identified but no understanding of impacts or severity.
I	Environmental problem characterization and measurement.	Characterization through preliminary analysis.	Superficial understanding of environmental issues but no specific relevance to transportation system effects.
II	Transport and fate of environmental agents.	Transport defined (pathways to plant, animal, man, physical environment).	Qualitative understanding of impacts on environmental systems but not those specifically caused by or affecting the transportation system.
III	Environmental effects evaluation; integration of transportation and environmental systems.	Environmental effects defined (ecological, natural resources, physical environment, health safety, socioeconomic,transportation).	Detailed understanding of the effects on all systems/subsystems.
IV	Environmental problem resolution. Environmental research or assessment is replaced by final engineering and/or implementation.	Environmental regulation or standard adopted. Research or assessment to meet needs by means of environmental control technology, technological design, or strategy modification or by an alternative.	Sufficient design, control technique, modification or alternative available.

assessment shows an impact to be quite severe, a programmatic decision to discontinue development is required, and a study of alternatives (level IV) may be begun. Before a technology or fuel is commercialized or a strategy is implemented, level IV (problem resolution) must be accomplished for each remaining primary concern. This research process, from level I through IV, is usually performed in sequence, although relevant results at any level may eliminate the the need for further research. Table B.2 relates the level of understanding of the primary concern to the research or assessment level completed. The level numbers are used in the tables in Section 3. Note that the understanding of exploratory concerns is at or below level II.

The status of the research or assessment of each concern is the starting point for determining the environmental research and assessment schedule, for developing a research strategy, and for designating priority research. The environmental status of some concerns is unclear and thus judgements are made on the basis of the best available information. An objective of the Environmental Development Plan is to chart the progress of each environmental concern up the ladder of understanding from exploratory research to final resolution, or concern elimination, while indicating the substance of successive rungs in the sequence. It is expected that knowledge of an environmental concern will increase systematically over time, although irregularities will occur as priorities and budgetary emphases are shifted toward research in a particular area with probable impacts in the short term (e.g., diesel fuel) and away from other areas for which probable impact emergence is more remote. In general, research is scheduled so specific investigations emerge from exploratory assessments, and these in turn suggest final disposition of the concern. The EDP/EA/EIS process requires this prior to commercialization or implementation.

B.2.2 Environmental Standards

Certain pollutants are regulated and many occupational health and safety standards exist. These standards, which automatically serve as standards for environmental concerns that arise in transportation projects, are specified in Tables 3.1 through 3.4. Where standards and regulations do not exist and limits are appropriate, Tables 3.1 through 3.4 include specifications for these limits, with their due date. These limits depend upon the level of understanding of the environmental concern and are specified as general or specific emissions goals, guidelines, standards, or limits.

B.2.3 Environmental Research Requirements

Research tables in Section 3 describe the environmental research required to resolve each primary concern for all the transportation technologies and projects. The type of research and assessment required to set a standard or assist in a policy decision is defined. If understanding of a concern is at a low level, only the initial environmental research and assessment can be set; i.e., only the first required studies are listed, since they may resolve the concern, or show the technology as not worth further work.

This research is used by DOE to (1) give direction to a development program for specific technologies and projects; (2) determine what further environmental research is required; (3) assist in setting standards or designing guidelines or regulations; (4) select design, technological or system alternatives, or (5) decide if a technology or project development should be discontinued. In brief, research reports provide DOE decision-makers with the status of environmental concerns and the progress being made in their resolution.

APPENDIX C

MARKET PENETRATION AND ANNUAL PETROLEUM SAVINGS OF TRANSPORTATION TECHNOLOGIES AND PROGRAMS

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Market penetration and petroleum savings estimates are regularly developed for DOE transportation projects as part of internal program planning and budgeting. To date, several such estimates have been developed by Argonne National Laboratory staff with the assistance of CS/TP program managers. Reflecting alternative scenarios of baseline transportation energy demand by mode, technology/program performance, and funding, these estimates are documented in internal memoranda submitted to the Office of Transportation Programs and in the recent Oak Ridge National Laboratory (ORNL) draft report for ASCS, "Energy Saving Impacts of DOE Conservation and Solar Programs" (DOE, July 1980).

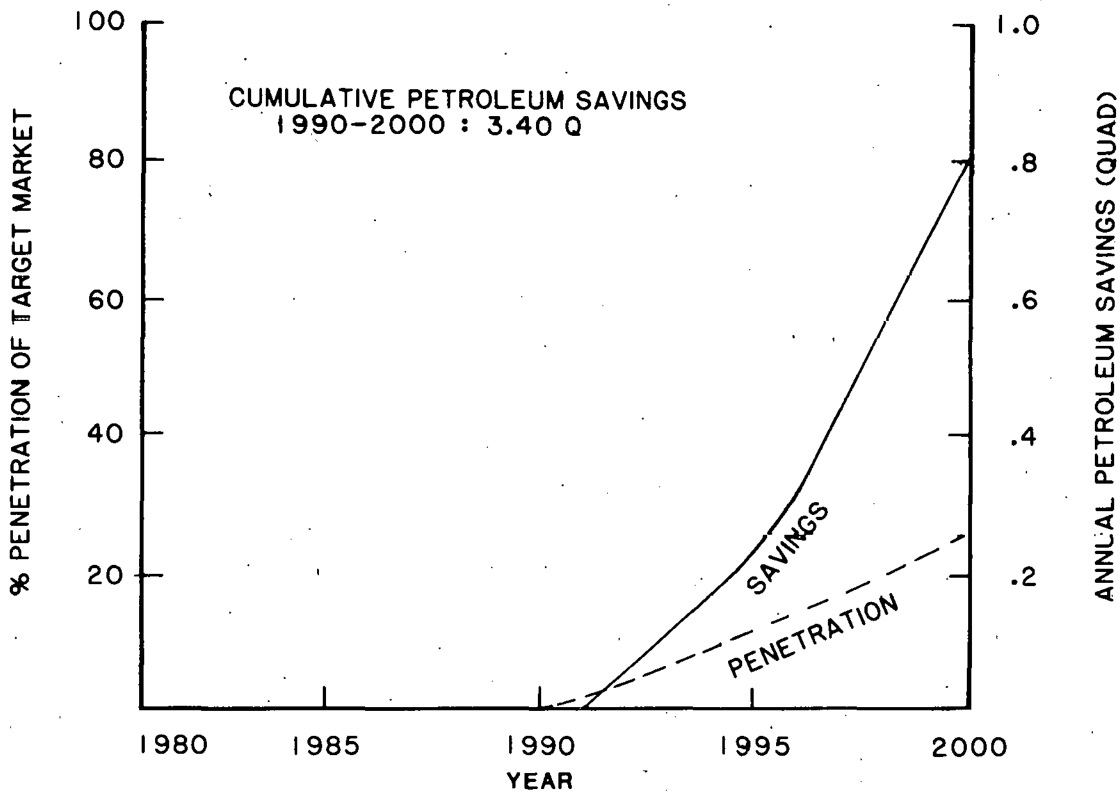
The following 11 summary charts show estimates developed in August 1980 for this document. They differ from charts in the ORNL report in that they incorporate (1) the baseline scenario documented in "Projections of Direct Petroleum Savings by Mode: 1975-2000 Baseline" by Rita E. Knorr and Marianne Millar, ANL CNSV-4 (August 1979); (2) updated vehicle utilization data obtained from the 1977 Nationwide Personal Transportation Survey (NPTS), and (3) savings estimates for years prior to 1982, which were excluded earlier.

These estimates reflect program goals and commercialization schedules that are consistent with those assumed by this EDP during the period of its development. Revised estimates, which are to be documented in the spring of 1981, reflect generally more conservative performance expectations, extended RD&D time frames, and consequently less successful market penetration.

For the major programs described in this EDP, the charts indicate anticipated target markets, market penetrations, and other assumptions used to estimate potential petroleum savings, and the resultant annual and cumulative petroleum savings through 2000. While all programs are assumed to achieve technical success, market success -- as indicated by penetration -- is more problematical. As indicated on the program charts, production capacity can be the factor limiting market success prior to 2000. Occasionally, competition from other new technologies or from less expensive conventional technologies is assumed to constrain market penetration. These factors are currently introduced via exogenous assumptions. Ultimately, they will be incorporated into the estimation procedure through technology-specific market models.

Note that these savings estimates differ from previous estimates, and future projections may be expected to differ from these estimates. As stated above, ongoing CS/TP evaluation efforts are refining existing models and developing new models to deal with such issues as eventual market success and penetration. As these improved tools become available, market penetration and savings estimates will be updated and published by DOE/ANL.

TP DIVISION: Automotive Technology Development
Subprogram: Advanced Automotive Heat Engine
Target Market: Mid- and full-sized autos and larger light trucks



Assumptions

Introduction Date: 1990

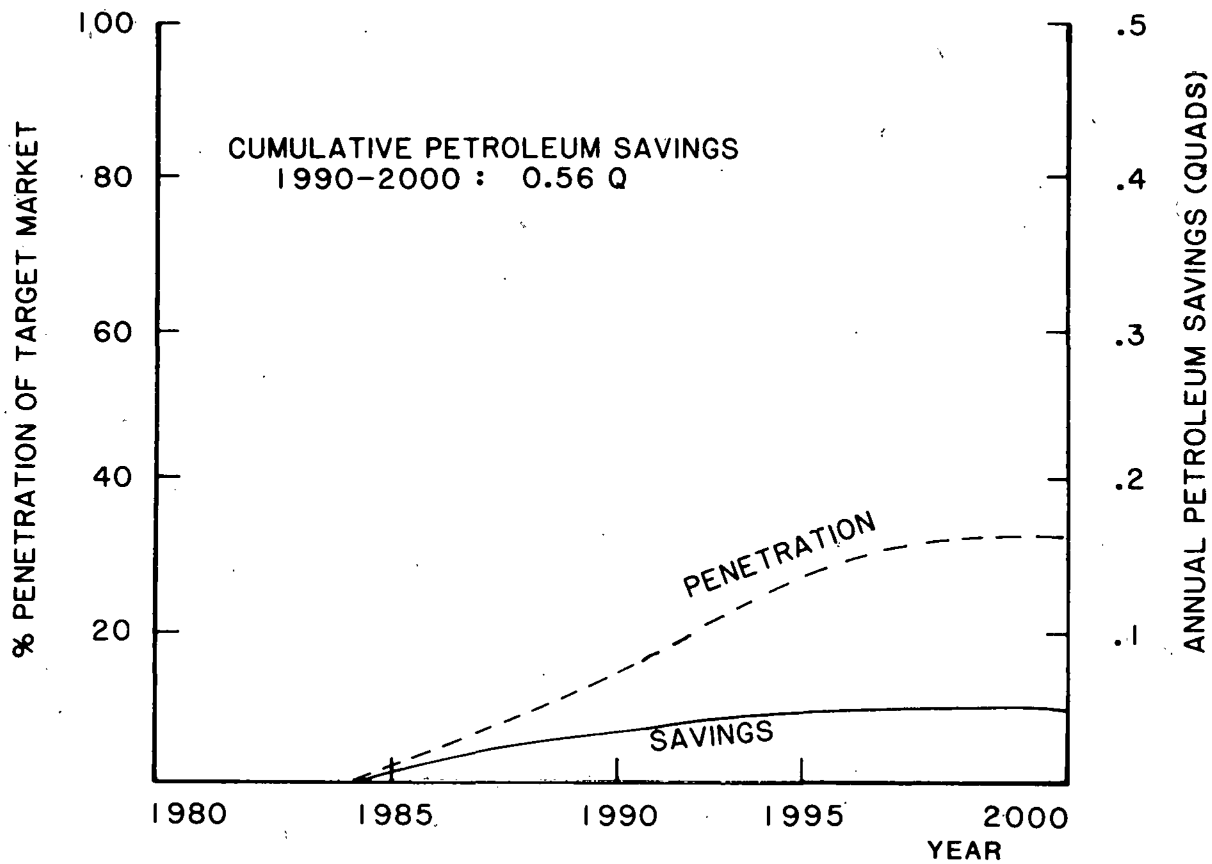
Petroleum Savings Potential: 30% improvement in fuel economy, as required by "Automotive Propulsion Research and Development Act of 1978."[11] Stirling engine has potential of up to 45% improvement.

Other Assumptions

1. Penetration is constrained by the supply of engine production lines which are assumed to increase linearly. Production, not penetration, is thus the critical variable.
2. Penetration begins with the large auto and light truck markets. Mid-sized production lines appear around 1995. If current downsizing succeeds, Stirling penetration into smaller sizes is possible.
3. Advanced heat engine vehicles will exhibit the same life cycle and use characteristics as the vehicles they replace.

Fig. C.1 Petroleum Savings Expected from Advanced Automotive Heat Engine Program (This is a program plan estimate. It assumes TP program goals and associated commercialization schedule, as stated in this EDP, are achieved.)

TP DIVISION: Automotive Technology Development
Subprogram: Turbocompound Diesel Engine
Target Market: Class 7 and 8 trucks in intercity operation



Assumptions

Introduction Date: 1984

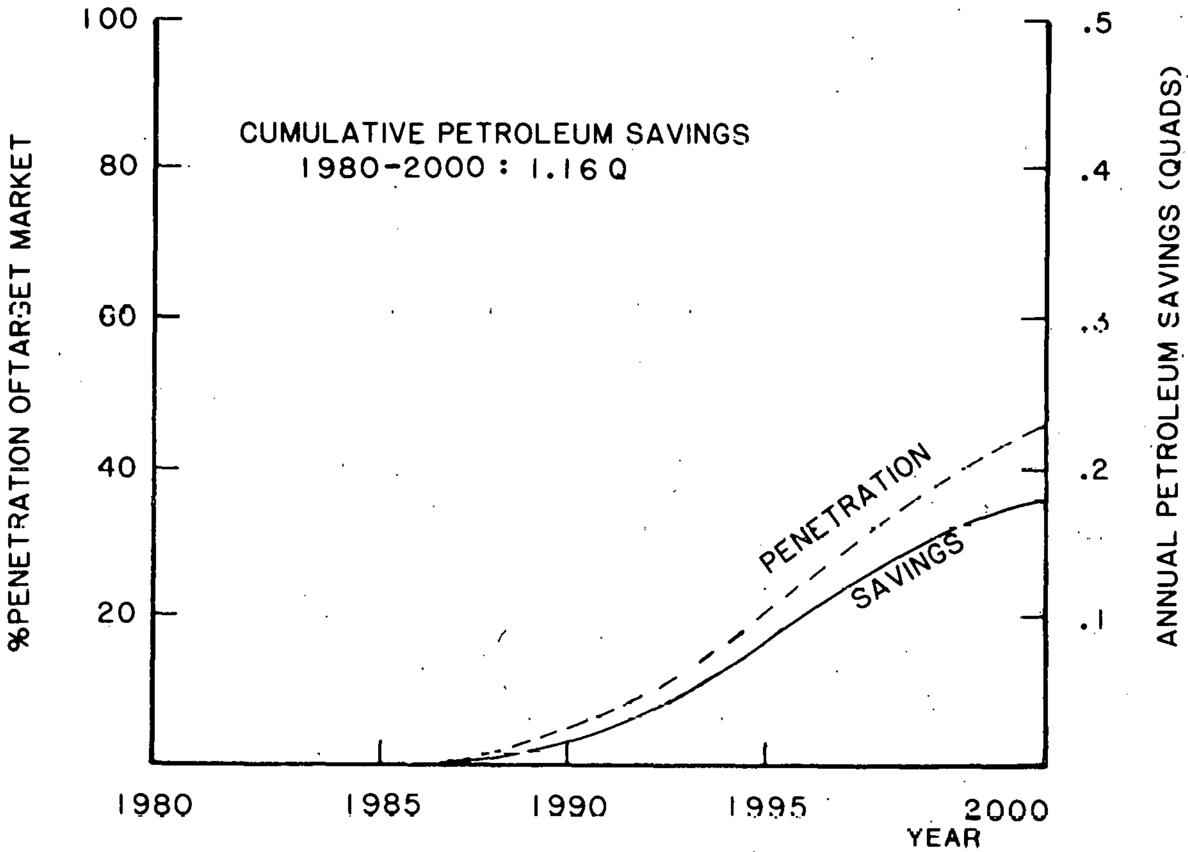
Petroleum Savings Potential: 6% improvement in diesel fuel economy

Other:

1. Penetration constrained by competition from bottoming cycle and conventional "fuel saver" diesel engines.
2. Vehicles with turbocompound engines will remain in the intercity fleet. Hence, fuel savings will continue as vehicles age.
3. In all other respects vehicles with turbocompound diesel engines will exhibit the same life cycle and use characteristics of the vehicles they replace.

Fig. C.2 Petroleum Savings Expected from Turbocompound Diesel Engine Program (This is a program plan estimate. It assumes TP program goals and associated commercialization schedule, as stated in this EDP, are achieved.)

TP DIVISION: Automotive Technology Development
Subprogram: Diesel Truck Bottoming Cycle
Target Market: Class 7 and 8 trucks in intercity operations



Assumptions

Introduction Date: 1987

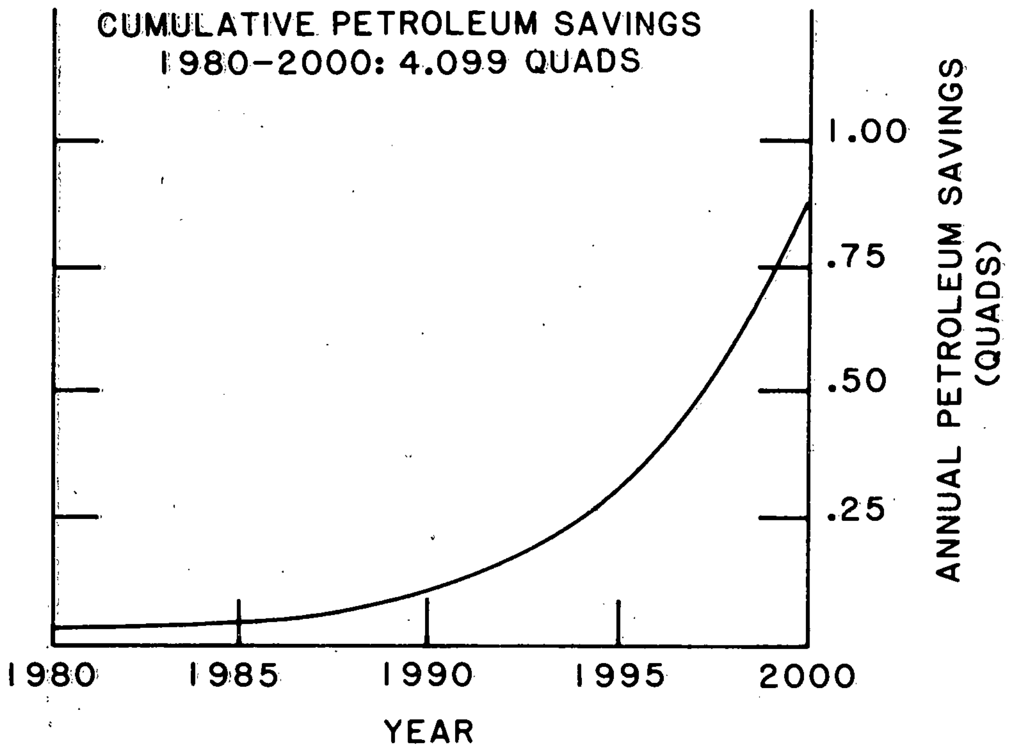
Petroleum Savings Potential: 15% improvement in fuel economy

Other:

1. Penetration is constrained by competition from turbocompound and conventional "fuel saver" diesel engines.
2. Vehicles with bottoming cycles engines will remain in the intercity fleet. Hence, fuel savings will continue as vehicles age.
3. In all other respects, vehicles with bottoming cycles will exhibit the same life cycle and use characteristics of the vehicles they replace.

Fig. C.3 Petroleum Savings Expected from Diesel Truck Engine Bottoming Cycle Program (This is a program plan estimate. It assumes TP program goals and associated commercialization schedule, as stated in this EDP, are achieved.)

TP DIVISION: Automotive Technology Development
Subprogram: Alcohol Fuels
Target Market: Gasoline-powered highway vehicles



Assumptions

Introduction Date: Ethanol blends presently in production
Methanol and higher order alcohol blends -- post-1985

Petroleum Savings Potential: Nominal gasoline displacement by 10% to 20% mixed alcohol blends is 6%, and is regionally selective.

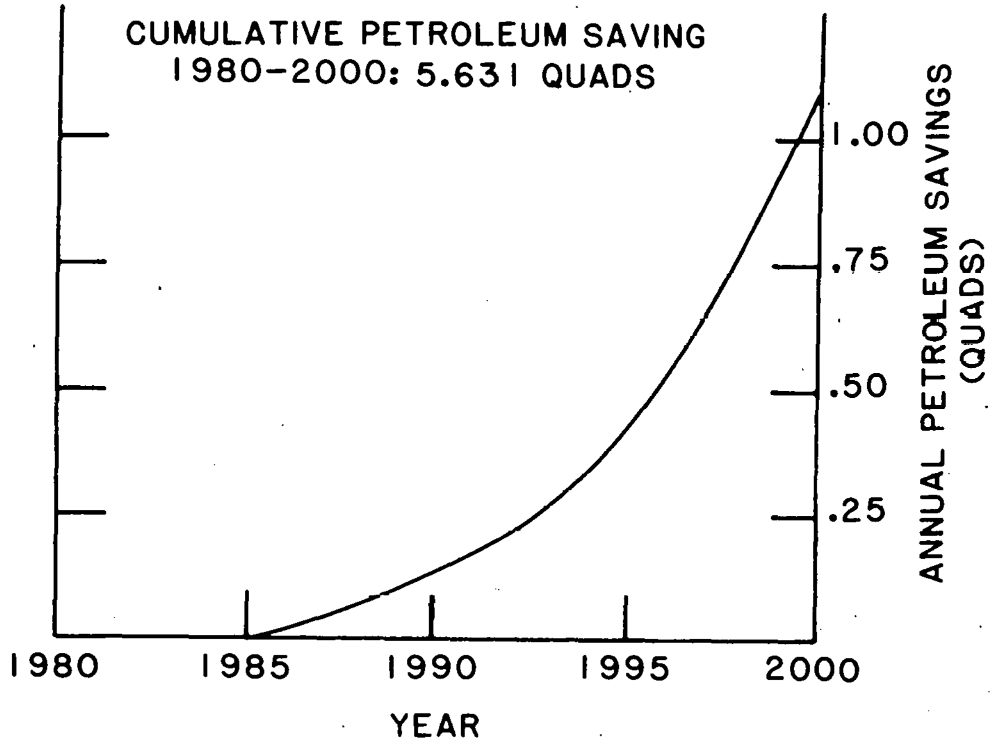
Penetration: Gradual buildup in production; major alcohol is ethanol; approximately 80% penetration of a nominal 6% blend by 2000.

Other:

1. Only alcohol/gasoline blends are considered; methanol will be mixed with ethanol and other high order alcohols.
2. Demand for alcohol is supply-constrained.
3. All fuel-grade alcohol produced is assumed to be used as a transportation fuel supplement.
4. Savings of 0.75 barrels of crude oil achieved for each barrel of alcohol used in blend because blends have lower heating value than gasoline.

Fig. C.4 Petroleum Savings Expected from Alcohol Fuels Program

TP DIVISION: Automotive Technology Development
Subprogram: Synthetic Fuels
Target Market: Highway and nonhighway transportation modes



Assumptions

Introduction Date: 1986

Petroleum Savings Potential: 50% to 100% of petroleum fuels, gasoline, and distillates used by transportation sector.

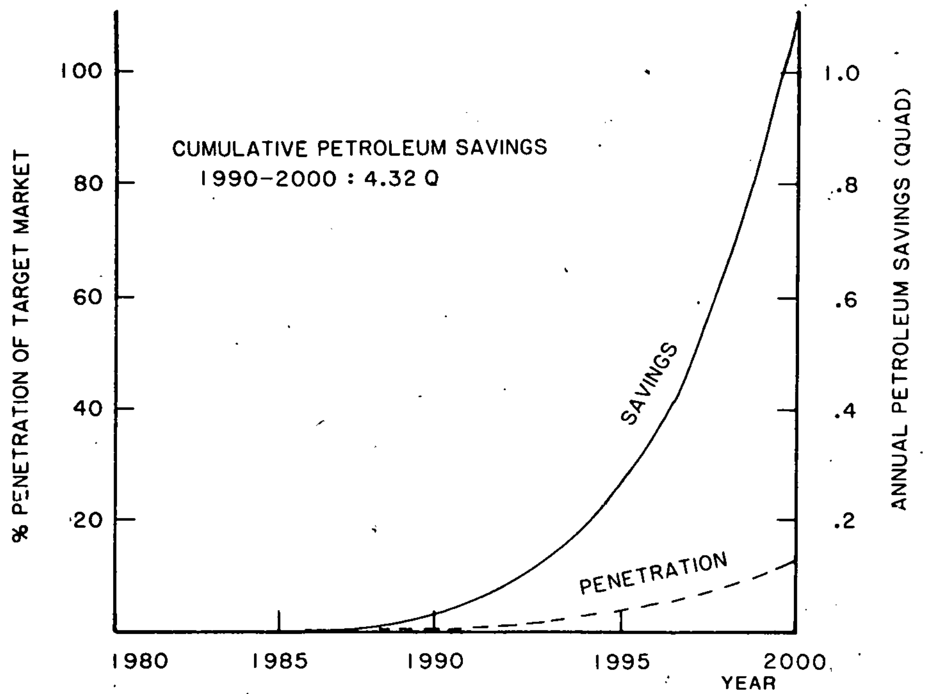
Penetration: Gradual production buildup; less than 5% penetration achieved by 2000.

Other:

1. Of total synfuels production, 18.75% (25% of 75%) will be used for transportation, the rest, in liquid or gaseous form, for utility and industrial applications.
2. Demand for liquid synfuels will be supply-constrained.
3. One barrel of syncrude assumed equivalent to 0.88 barrel crude oil for gasoline and distillate production, owing to energy conversion penalty for syncrude pretreatment.

Fig. C.5 Petroleum Savings Expected from Synthetic Fuels Program

TP DIVISION: Electric and Hybrid Vehicles System
Subprogram: Electric and Hybrid Vehicle Commercialization
Target Market: All light duty vehicles



Assumptions

Introduction Date: Electrics in 1985, hybrids in 1988.

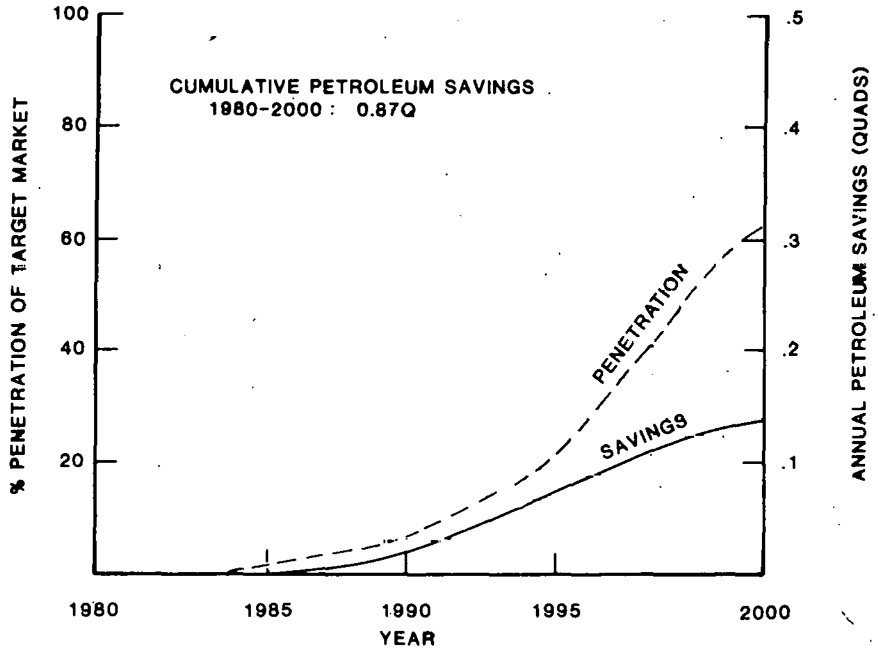
Petroleum Savings Potential: 100%, minus that portion of electric power generated by petroleum for electric vehicles. For hybrids, petroleum-equivalent fuel efficiency is approximately twice that of the internal combustion engine vehicles they replace.

Other:

1. By 2000, approximately one-sixth of electric power generation, including incremental generation necessitated by EHV demand, will come from petroleum sources.
2. Current power generation and transmission losses will persist through 2000, so approximately 10500 Btu will be needed to produce each kWh of EHV operation.

Fig. C.6 Petroleum Savings Expected from Electric and Hybrid Vehicle Commercialization Projects (This is a program plan estimate. It assumes TP program goals and associated commercialization schedule, as stated in this EDP, are achieved.)

TP DIVISION: Transportation Systems Utilization
Subprogram: Nonhighway Organic Rankine Bottoming Cycle
Target Market: Marine push/tow boats in the 8500 bhp range, diesel rail locomotives, and gas pipeline prime movers



Assumptions

Introduction Date: Rail, 1990; marine, 1983; pipeline, 1985

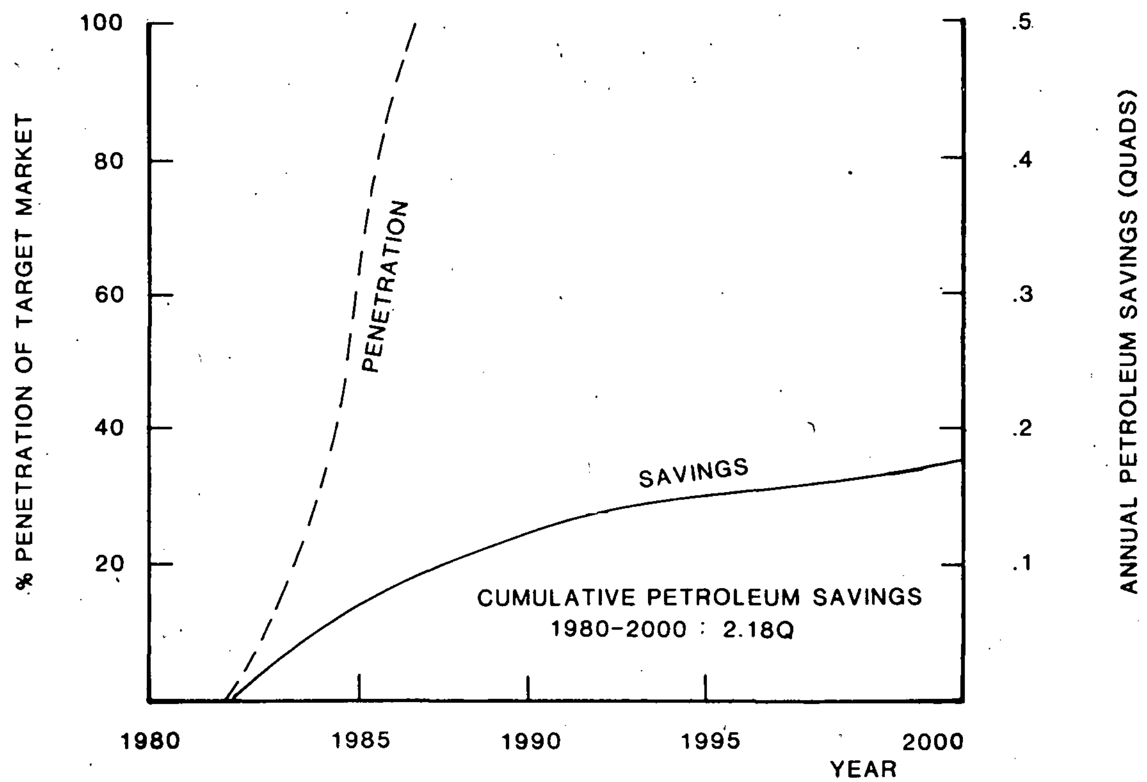
Petroleum Savings Potential: 15% efficiency improvement in all applications

Other:

1. For marine applications, most new vessels and existing vessels less than 20 years old will be bottomed.
2. Owing to present excess capacity and relatively slow growth in natural gas demand, pipeline system capacity in 2000 will be only slightly greater than current capacity. Thus, most bottoming cycles will be retrofits of existing equipment.
3. Pipeline bottoming assumed to be limited to pipelines in contiguous 48 states.
4. Both existing and new rail diesel-electric locomotives will be bottomed.

Fig. C.7 Petroleum Savings Expected from Nonhighway Organic Rankine Bottoming Cycle Program (This is a program plan estimate. It assumes TP program goals and associated commercialization schedule, as stated in this EDP, are achieved.)

TP DIVISION: Transportation Systems Utilization
Subprogram: Aircraft Maintenance
Target Market: U.S. certificated aircraft in passenger and cargo service



Assumptions

Introduction Date: Airframe maintenance, 1982; engine and instrument maintenance, 1983

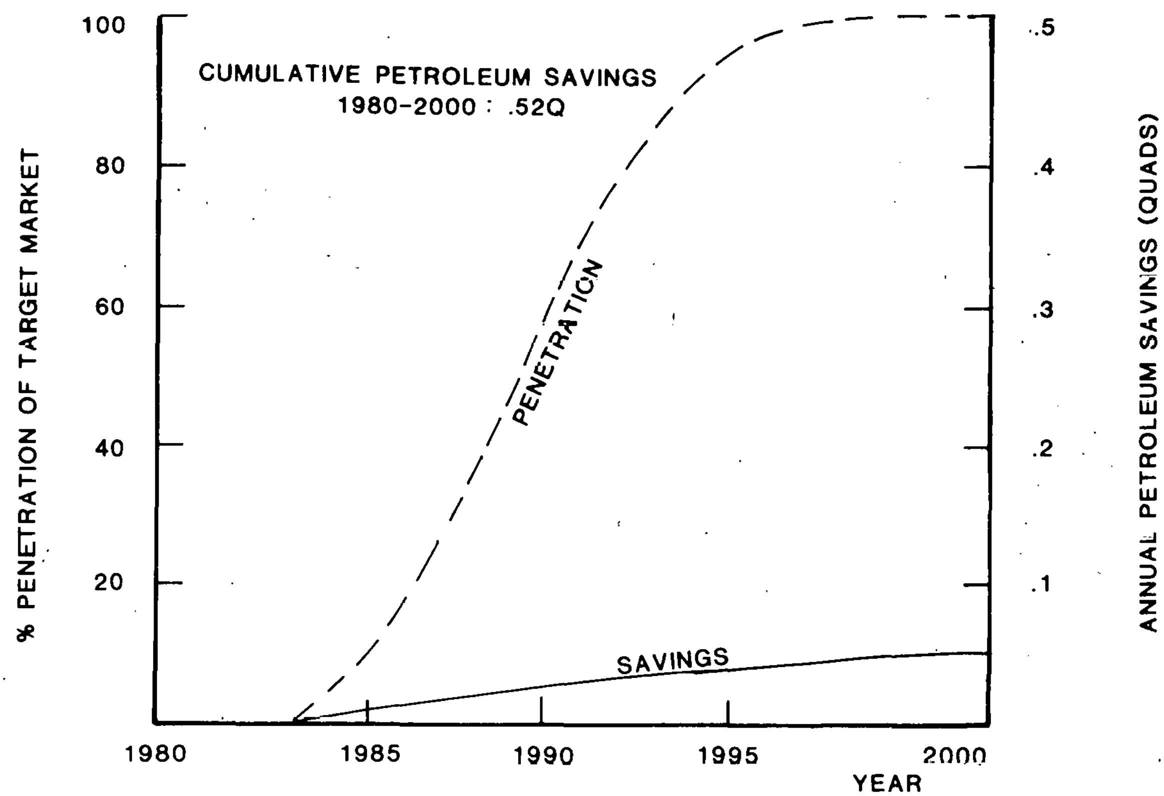
Petroleum Savings Potential: 5.3% reduction in fuel consumption

Other:

1. Rapidly increased labor costs will be offset by fuel savings.
2. Program is expected to demonstrate cost effectiveness about 1982; introduction will be immediate.
3. Owing to cost savings potential, penetration will be complete within five years.

Fig. C.8 Petroleum Savings Expected from Aircraft Maintenance Project (This is a program plan estimate. It assumes TP program goals and associated introduction date are met.)

TP DIVISION: Transportation Systems Utilization
Subprogram: Aircraft Towing
Target Market: Commercial aircraft at 20 busiest U.S. airports



Assumptions

Introduction Date: 1983

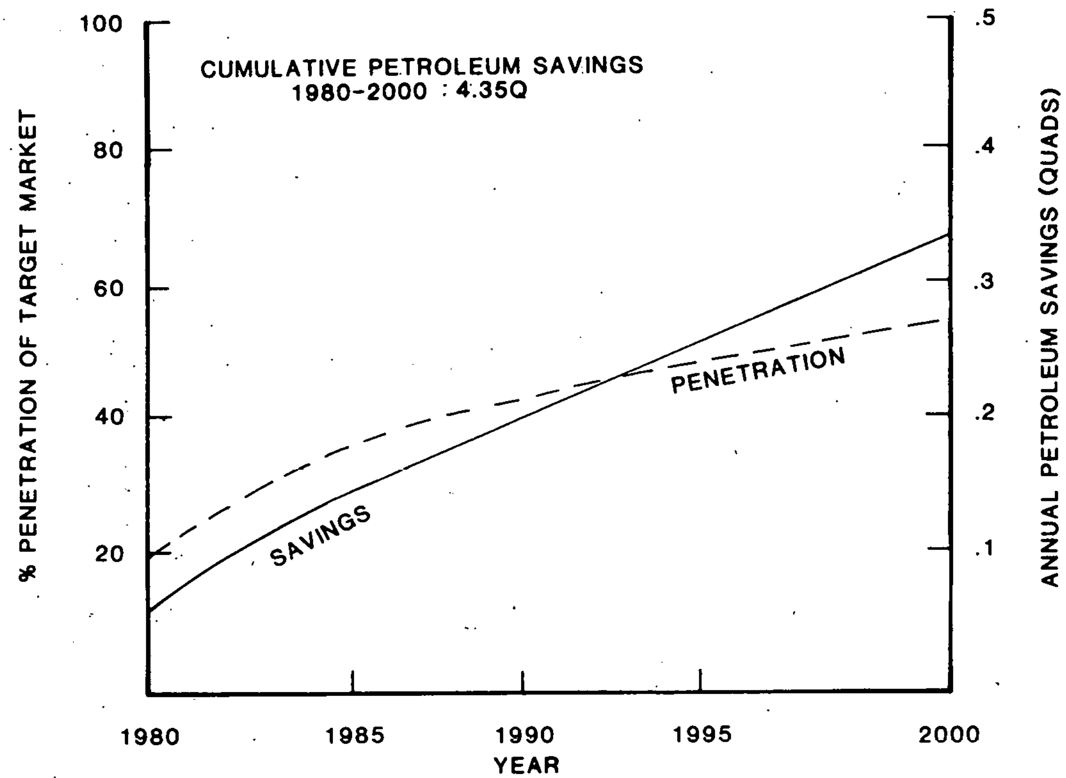
Petroleum Savings Potential: 2.7% reduction in fuel consumed at target airports

Other:

1. Energy consumption at the 20 busiest airports will represent a constant share of total U.S. air carrier consumption.
2. At airports with towing facilities, all U.S. domestic, international, passenger, and cargo fixed-wing commercial aircraft will be towed.
3. Percent penetration is equivalent to the percent of target airports at which implementation is achieved.
4. Penetration is constrained solely by rate at which high-speed tugs can be built.
5. Towing will be by high-speed tugs, so there will be no additional ground congestion, fuel consumption, or schedule disruption.

Fig. C.9 Petroleum Savings Expected from Aircraft Towing Project (This is a program plan estimate. It assumes TP program goals and associated introduction date are met.)

TP DIVISION: Transportation Systems Utilization
Subprogram: Voluntary Truck and Bus
Target Market: Class 7 and 8 heavy-duty trucks in intercity operations, and transit and intercity buses



<u>Assumptions</u>

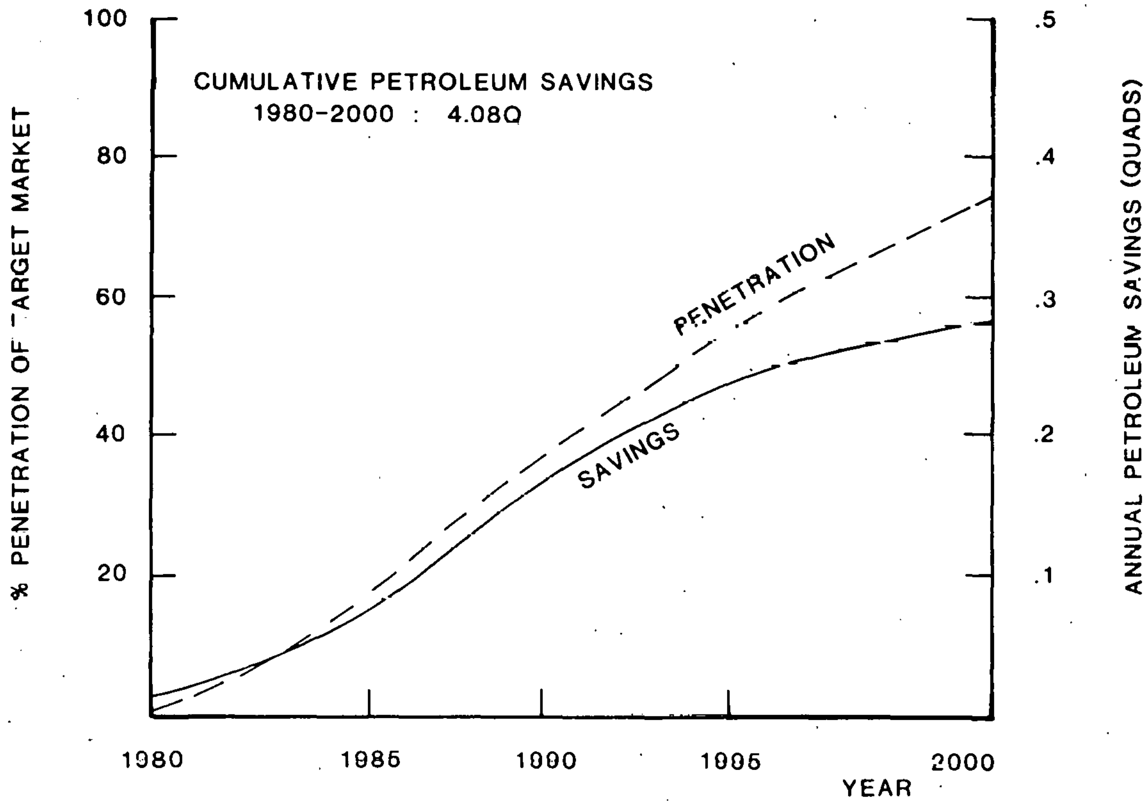
Introduction Date: Pre-1980

Petroleum Savings Potential: 20% improvement in fuel economy

Other: Market will be primarily over-the-road vehicles since these vehicles are more likely to experience greater per unit savings.

Fig. C.10 Petroleum Savings Expected from Voluntary Truck and Bus Program (This is a program plan estimate. It assumes TP program goals are achieved.)

TP DIVISION: Transportation Systems Utilization
Subprogram: Driver Awareness
Target Market: Drivers of fleet and nonfleet autos and light trucks



<u>Assumptions</u>

Introduction Date: Pre-1980

Petroleum Savings Potential: 5% improvement in fuel economy

Other: While immediate post-training improvements may exceed 5%, regression in performance over time is assumed to result in an average improvement for all drivers of approximately 5%.

Fig. C.11 Petroleum Savings Expected from Driver Awareness Program (This is a program plan estimate. It assumes TP program goals are achieved.)

GLOSSARY

AAR - Association of American Railroads

ACT - Office of Advanced Conservation Technology (ASCS)

AFUP - Alternative Fuels Utilization Program (DOE)

ANL - Argonne National Laboratory, University of Chicago

ASCS - Assistant Secretary for Conservation and Solar Energy

ASEV - Assistant Secretary for Environment

ASFE - Assistant Secretary for Fossil Energy

CAFE - Corporate Average Fuel Economy

CS/AC - See ACT

CS/TP - Conservation and Solar Energy/Office of Transportation Programs

CVT - Continuously variable transmission

DEIS - Draft Environmental Impact Statement

DOC - Department of Commerce

DOE - Department of Energy

DOL - Department of Labor

DOT - Department of Transportation

EA - Environmental Assessment

ECC - Environmental Coordinating Committee

EDP - Environmental Development Plan

EHV - Electric and hybrid vehicle

EIS - Environmental Impact Statement

EPA - Environmental Protection Agency

ERD - Environmental Readiness Document

ESAPP - Energy Systems Acquisition Project Plan

EV - Electric vehicle

FAA - Federal Aviation Administration (DOT)

FHWA - Federal Highway Administration (DOT)

FMVSS - Federal Motor Vehicle Safety Standards

FoNSI - Finding of No Significant Impact (also FNSI)

FRA - Federal Railroad Administration (DOT)

GRC - General Research Corporation

ICE - Internal combustion engine

JPL - Jet Propulsion Laboratory (NASA)

LLL - Lawrence Livermore Laboratory, University of California (DOE)

MarAd - Maritime Administration (DOC)

NAAQS - National Ambient Air Quality Standards

NAE - National Academy of Engineering

NAS - National Academy of Sciences

NASA - National Aeronautics and Space Administration

NATO - North Atlantic Treaty Organization

NEPA - National Environmental Policy Act

NHTSA - National Highway Traffic Safety Administration (DOT)

NIOSH - National Institute for Occupational Safety and Health (DOL)

NPTS - National Personal Transportation Survey

NSF - National Science Foundation

OHER - Office of Health and Environmental Research, ASEV (DOE)

ORBC - Organic Rankine bottoming cycle

ORCS - Organic Rankine cycle system

OSHA - Occupational Safety and Health Administration (DOL)

PEP - Project Environmental Plan

PNA - Polynuclear aromatics, hydrocarbon structures found in synthetic fuels (also PAH)

RDD&A - Research, Development, Demonstration, and Assessment

SAE - Society of Automotive Engineers

SANDIA - Sandia Laboratories, Sandia Corporation

SAR - Safety Analysis and Review

SRI - SRI International

TFE - Trifluoroethanol

TLV - Threshold limit value

TOFC - Trailer on Flat Car

TP - See CS/TP

TSC - Transportation Systems Center (DOT)

UMTA - Urban Mass Transportation Administration (DOT)

WQC - Water quality criterion

REFERENCES

GENERAL

1. *Annual Operating Plan*, Office of Transportation Programs, DOE/ASCS (Oct. 1979).

2. *Assessment Report: Automotive Technology Status and Projections*, volume 2, Jet Propulsion Laboratory, JPL 78-71 (June 1978).

3. Council on Environmental Quality, *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act*, 43 FR 55978-56007 (40 CFR Parts 1500-1508) (Nov. 1978).

4. *Compliance with the National Environmental Policy Act; Final Guidelines*, 10 CFR 1021 (1980).

5. DOE Order 5420.1, *Environmental Development Plans* (Aug. 1978).

6. *DOE Highway Vehicle Systems Contractors Coordination Meeting*, Summary Reports, DOE/CS/TP (May 1975 through April 1979).

7. *The National Environmental Policy Act of 1969*, Public Law 91-190 (Jan. 1970).

8. Shackson, R.H. and H.J. Leach, *Using Fuel Economy and Synthetic Fuels to Compete with OPEC Oil*, Mellon Institute (1980).

AUTOMOTIVE TECHNOLOGY DEVELOPMENT

Advanced Automotive Heat Engine

9. *Advanced Gas Turbine Engine Systems Development Project: Energy Systems Acquisition Plan*, (draft), CS/TP (June 1980).

10. *Assessment of the State of Technology of Automotive Stirling Engines*, Report No. NASA CR-159631, Mechanical Technology Inc., for DOE, DOE/NASA/0032-79/4 (Sept. 1979).

11. *The Automotive Propulsion Research and Development Act of 1978*, Public Law 95-238 (Feb. 1978).

12. *Automotive Stirling Engine Development Program*, Mechanical Technology Inc., Proc., 5th International Symp. on Automotive Propulsion Systems, Dearborn, Mich. (April 1980).

13. *Automotive Stirling Engine Development Project: Energy Systems Acquisition Project Plan*, (draft), CS/TP (Aug. 1980).

14. Bourke, R.C., *Environmental Aspects of Uses of Nickel Oxide as an Industrial Gas Turbine Seal Material - Status Report*, Detroit Diesel Allison Div., General Motors Corp., Indianapolis, Ind., revised (June 1977).

15. Brogan, J.J., *DOE Heat Engine Program Overview for 1980*, 17th Summary Report, DOE Highway Vehicle Systems Contractors Coordination Meeting, Dearborn, Mich. (Oct. 1979).

16. *Ceramic Materials and Components for Small Automotive Gas Turbine Engine, Technology Assessment and Implementation Plan FY76-81*, ERDA, Planning Directorate, Army Materials and Mechanics Research Center, Watertown, Mass. (April 1975).

17. Helms, H.E., *Advanced Gas Turbine Powertrain Systems Development Project*, Detroit Diesel Allison Division, General Motors Corp., Proc., 5th International Symp. on Automotive Propulsion Systems, Dearborn, Mich. (April 1980).

18. Hill, L.G., Argonne National Laboratory, unpublished information (1980).

19. Martini, W.R., *International Developments in Stirling Engines*, Proc., 5th International Symp. on Automotive Propulsion Systems, Dearborn, Mich. (April 1980).

20. *New Source Performance Standards for the Electrolytic Ferroalloys Segment of the Ferroalloy Manufacturing Point Source Catetgory*, EPA, Report No. EPA 440 (1-75), 038-a, Group I, Phase II, Washington, D.C. (Feb. 1975).

21. Proc., Conf. on Advanced Materials for Alternative-Fuel-Capable Directly-Fired Heat Engines, sponsored by Assistant Secretary for Fossil Energy, DOE, and Electric Power Research Institute (Division of Fossil Fuel and Advanced Systems), Castine, Maine (Dec. 1979).

22. Schulz, R.B., *Potential Health Hazard of Nickel Compound Emissions from Automotive Gas Turbine Engines Using Nickel Oxide Base Regnerator Seals*, EPA (April 1974).

23. Trela, W., *Status of Ford Program to Evaluate Ceramics for One-Piece Stator Applications in Gas Turbine Engines*, 17th Summary Report, DOE Highway Vehicle Systems Contractors Coordination Meeting, Dearborn, Mich. (Oct. 1979).

24. Withrow, J.D., *Engine Options for the Car of Tomorrow*, IEEE Spectrum, *14*:11 (1977).

Vehicle Systems

25. Brands, M.C., *Vehicle Testing of Turbocompound Heavy-Duty Diesel Engine*, Proc., 5th International Symp. on Automotive Propulsion Systems, Dearborn, Mich. (April 1980).

26. *Environmental Assessment: Turbocompound Diesel Engine Program*, DOE ASCS/Transportation Programs (forthcoming).

27. *Environmental Readiness Document: Transportation Programs, FY80*, DOE/ASEV/Office of Environmental Assessments (DOE/ERD-0027, Sept. 1980).

28. *Institutional Assessment for Study of Validation of Application of Rankine Bottoming Cycle Technology to Marine Diesel Engines*, Report No. AED-UCO EO-8, General Electric Co., for DOE (April 1980).

29. Ross, R.J., *Gas Turbine Transit Bus Demonstration Program*, Booz-Allen and Hamilton, Inc., 17th Summary Report, DOE Highway Vehicle Systems Contractors Coordination Meeting, Dearborn, Mich. (Oct. 1979).

30. Silberstein, S., *Trifluoroethanol*, National Center for Analysis of Energy Systems, Brookhaven National Laboratory, Upton, N.Y. (Oct. 1978).

31. Thermo Electron Corp., *Diesel Organic Rankine Cycle Compound Engine for Long Haul Trucks: Final Report Jan. 1979 to Dec. 1979*, Report No. TE 4257-1-81 (DOE/CS/52832-2) for DOE (May 1980).

Alternative Fuels

32. Adelman, H., *Alcohols in Diesel Engines - A Review*, SAE Paper 790956 (Oct. 1979).

33. *Alcohols: A Technical Assessment of Their Application as Fuels*, American Petroleum Institute, pub. no. 4261 (July 1976).

34. *Alcohol Fuels for Automobiles: Performance, Emissions, Environment*, Univ. of Santa Clara (Calif.), DOE Highway Vehicle Systems Contractors Coordination Meeting, Dearborn, Mich. (April 1979).

35. Baker, R.E., et al., *Utilization of Methanol as an Automotive Fuel*, International Symp. on Alcohol Fuel Technology, Methanol and Ethanol. Wolfsburg, West Germany (Nov. 1977).

36. Berger, B.J., *Environmental Aspects of Methanol as Vehicular Fuel: Health and Environmental Effects*. 1974 Engineering Foundation Conf., Henniker, N.H. (July 1974).

37. Bertilsson, B.M., *Methanol-Containing Fuels: Evaluation of Environmental and Health Constraints*. Proc., 3rd International Symp. on Alcohol Fuels Technology, vol. 3, Asilomar, CA (May 1979).

38. *Comparative Automotive Engine Operation When Fueled with Ethanol and Methanol*. DOE Report No. HCP/W1737-01 (May 1978).

39. Cottingham, P.L., *Diesel Fuels From Oil Shale*. Monograph on Alternate Fuel Resources, Proc., AIAA Symp. (March 1976).

40. Cottingham, P.L., *Motor Gasoline From Oil Shale*. Monograph on Alternate Fuel Resources, Proc., AIAA Symp. (March 1976).

41. D'Eliscu, P.N., *Environmental Consequences of Methanol Spills and Methanol Fuel Emissions on Terrestrial and Freshwater Organisms*. Proc., 3rd International Symp. on Alcohol Fuels Technology. vol. 3, Asilomar, Calif. (May 1979).

42. Argonne National Laboratory, unpublished information (Nov. 1980).

43. *Environmental Readiness Document: Oil Shale*. DOE Report No. DOE/ERD-0016 (Sept. 1978).

44. Ferry, D.G., et al., *Toxicity of Methanol/Petrol Mixtures*. Proc., 3rd International Symp. on Alcohol Fuels Technology, vol. 3, Asilomar, Calif. (May 1979).

45. *Formaldehyde: An Assessment of Its Health Effects*. Committee of Toxicology, National Academy of Sciences (March 1980).

46. Hagey, G., and A.J. Parker, *Methanol and Ethanol Fuels - Environmental, Health and Safety Issues*. Proc., International Symp. on Alcohol Fuel Technology, Methanol and Ethanol. Wolfsburg, West Germany (Nov. 1977).

47. Hildebrand, R.E., *Transportation Fuels from Coal and Oil Shale*. DOE, DOE Highway Vehicle Systems Contractors Coordination Meeting, Dearborn, Mich. (April 1979).

48. Holt, E.L., et al., *Control of Automotive Sulfate Emissions*, SAE Paper No. 750683 (June 1975).

49. *Identification of Probable Automotive Fuels Composition: 1985-2000*. Southwest Research Institute, DOE Report No. HCP/W3864-01/2, UC-96 (May 1978).

50. Keller, J.L., et al., *Methanol Fuel Modification for Highway Vehicle Use*, Union Oil Company of Calif., DOE Report No. HCP/W3683-18 (July 1978).

51. Moriarity, A.J., *Toxicological Aspects of Alcohol Fuel Utilization*. Proc., International Symp. on Alcohol Fuel Technology, Methanol and Ethanol, Wolfsburg, West Germany (Nov. 1977).

52. Nakaguchi, G.M. and J.L. Keller, *Ethanol Fuel Modification for Highway Vehicle Use*, Union Oil Company of Calif., DOE Contract No. EY-76-C-04-3683 (July 1979).

53. *Project Planning Document, Highway Vehicle Alternative Fuels Utilization Program (AFUP)*, DOE Report No. DOE/CS-0093 (July 1979).

54. Reynolds, R.W., et al., *Methyl Ethers as Motor Fuel Components*, 168th National Meeting, American Chemical Society, Div. of Petroleum Chemistry, Inc., Atlantic City, N.J. (Sept. 10, 1974).

55. Sauter, Diane Y., *Synthetic Fuels and Cancer*, Scientist's Institute for Public Information, New York (Nov. 1975).

56. *Status of Alcohol Fuels Utilization Technology for Highway Transportation*, Mueller Associates, Inc., DOE Report No. HCP/M2923-01 (June 1978).

57. Timourian, H. and F. Milanovich, *Methanol as a Transportation Fuel: Assessment of Environmental and Health Research*, Lawrence Livermore Laboratory Report UCRL-52697 (June 1979).

58. *Utilization Concerns of Potential Transportation Fuels*, National Transportation Policy Study Commission, unpublished staff working paper (April 1979).

59. Wakamiya, W., et al., *Assessment of Synfuel Transportation to Year 2000*, Pacific Northwest Laboratory Report No. PNL-2768, UC-71 (March 1979).

ELECTRIC AND HYBRID VEHICLE SYSTEMS

60. Bernard, M.J., *Problems in Predicting Market Response to New Transportation Technology*, 4th International Conf. on Behavioral Travel Modeling, Eibsee, West Germany (July 1979).

61. *Code of Federal Regulations*, vol. 45 no. 9, p. 2795 (Jan. 1980).

62. David, D.D., et al., *Battery-Flywheel Hybrid Electric Power System for Near-Term Application*, Lawrence Livermore Laboratory Report UCID 17098 (April 1976).

63. *Determination of Effectiveness and Feasibility of Regenerative Braking Systems on Electric and Other Automobiles*, Lawrence Livermore Laboratory, for DOE/TP (Feb. 1978).

64. Dickson, E.M., and B.L. Walton, *A Scenario of Battery/Electric Vehicle Market Evolution*, Cress Report No. 46, SRI International (Dec. 1977).

65. *Ecological and Biomedical Effects of Effluents from Near-Term Electric Vehicle Storage Battery Cycles*. Report No. ANL/ES-90, DOE/ASEV Office of Health and Environmental Research (May 1980).

66. *Economic and Technical Feasibility Study for Energy Storage Flywheels*, ERDA, Report 76-65 (Dec. 1975).

67. *Economic and Technical Feasibility Study for Energy Storage Flywheels*, Lawrence Livermore Laboratory, for DOE STOR, Report No. HCP/M1066-01, Washington, D.C. (May 1978).

68. Argonne National Laboratory, unpublished information (Dec. 1979).

69. *Electric and Hybrid Vehicle Program Plan* (review draft), Transportation Systems Groups, Lawrence Livermore Laboratory, for DOE, Report No. TSG-030378-3, Washington, D.C. (May 1978).

70. *Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976*, Public Law 94-413, as amended (Feb. 1978).

71. *Environmental Assessment for the Inclusion of Electric and Hybrid Vehicles in Corporate Average Fuel Economy Standards*. DOE/EA-0108, DOE ASCS/Transportation Programs (May 1980).

72. *Environmental Development Plan for Energy Storage Systems*, DOE/EDP 0015 (March 1978) and Webster, W., U.S. Dept. of Energy, Office of Advanced Conservation Technology, unpublished information (1980).

73. *Environmental Readiness Document for Electric and Hybrid Vehicles*, DOE/ERD-0004 (Sept. 1978).

74. Forsberg, H.C., et al., *Energy Storage Systems for Automotive Propulsion: 1979 Study* (3 vols.). Lawrence Livermore Laboratory Report No. UCRL-52841 (Dec. 1979).

75. Gleb, G.H., *Cost and Emission Study of a Heat Engine Battery Hybrid*, TRW Systems Group (April 1972).

76. Hamilton, W., *Electric Automobiles*, McGraw-Hill, New York (1980).

77. Hopper, T.G., and W.A. Marone, *Impact of New Source Performance Standards on 1985 National Emissions from Stationary Sources*, Research Corp. of New England, Wethersfield, Conn. (Oct. 1976).

78. *Hybrid Vehicle Potential Assessment* (10 vols.) Jet Propulsion Laboratory, Pasadena, Calif. (Sept. 1979).

79. *Institutional Factors in Transportation Systems and Their Potential for Bias Toward Vehicles of Particular Characteristics*, DOT-TSC, for ERDA, Report No. CONS/1043-1 (Aug. 1977).

80. *Introduction to ERDA Electric and Hybrid Vehicle Demonstration Project*, ERDA Electric and Hybrid Vehicle Research, Development, and Demonstration Project Office (March 1977).

81. Kirk, R.S., and P.W. Davis, *A View of the Future Potential of Electric and Hybrid Vehicles*, 7th Energy Technology Conf. and Exp., Washington, D.C. (March 1980).

82. LaBelle, S.J., *Environmental Assessment for Electric and Hybrid Vehicles Demonstration Project, Performance Standards and Financial Incentives*, Argonne National Laboratory Report No. ANL/EES-TM-22 (DOE/EA-0075) (Oct. 1978).

83. Argonne National Laboratory, unpublished information (Sept. 1978).

84. LaBelle, S.J., et al., *Procedures for Safe Handling of Off-Gases from Electric Vehicle Lead-Acid Batteries During Overcharge*, Argonne National Laboratory Report ANL/CNSV-TM-28 (Feb. 1980).

85. Maclaughlin, T.F., *Applicability of Safety Standards to Electric and Hybrid Vehicles*, SAE Paper No. 780156 (1978).

86. McKee, J.E., and H.W. Wolf, eds., *Water Quality Criteria*, Resources Agency of Calif., State Water Resources Control Board, Pub. No. 3-A (1963).

87. Rowlett, B.H., and R. Murrah, *Electric-Powered Passenger Vehicle Design Study*, Garrett AiResearch Mfg. Co. (Dec. 1976).

88. *Threshold Limit Values for Substances in Workroom Air*, American Conf. of Government Industrial Hygienists, adopted by ACGIH for 1972.

89. Upton, C.W., and C.E., Agnew, *An Analysis of Federal Incentives to Stimulate Consumer Acceptance of Electric Vehicles*, Mathtech, Mathmatica, Inc. (Sept. 1977).

90. *Biological Effects of High Voltage Electric Fields*, IIT Research Institute, for Electric Power Research Institute (EPRI), EPRI 381-1, Chicago, Ill. (Nov. 1975).

TRANSPORTATION SYSTEMS UTILIZATION

91. *Institutional Assessment for the Study of the Validation of the Application of Rankine Bottoming Cycle Technology to Marine Diesel Engines: Final Report*, General Electric Co., Cincinnati, Ohio. CS/DOE Contract No. EM-78-C-01-4224 (July 1980).

92. *Joint FHWA/FRA Report on Community and Grade Crossing Impacts of Rail Transport of Coal*, (draft) DOT FHWA/FRA (Nov. 1978).

93. *Transportation Briefing Book*, U.S. FEA (now DOE) (undated).