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BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

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The Congress Needs To Redirect The Federal Electric Vehicle Program

Electric vehicles represent a technology meriting continued development. Today's vehicles, however, have limited commercial potential because they cost more and perform poorly compared with conventional vehicles.

As a result of considerable interest expressed by several Congressmen, GAO reviewed the Department of Energy's program to develop, demonstrate, and commercialize electric vehicles.

This report recommends that electric vehicle research and development be strengthened, vehicle demonstrations be limited initially to the Federal sector, and loan guarantees for commercial production be delayed. The Congress should make the legislative changes and take other actions needed for program redirection.



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To the President of the Senate and the
Speaker of the House of Representatives

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This report discusses the Department of Energy's efforts to develop and commercialize electric vehicles. We have identified various problems concerning the Department's research and development, demonstration, and small business efforts.

We are sending copies of this report to the Director of the Office of Management and Budget, the Secretary of the Department of Energy, and interested Members and Committees of the Congress.

James B. Heath
Comptroller General
of the United States



D I G E S T

The Government is exploring the commercial potential of electric vehicles as one effort to reduce national oil consumption. Currently, transportation accounts for about half the oil consumed. The Congress, anticipating that such vehicles would reduce oil imports and achieve environmental benefits, passed the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 (Public Law 94-413) to foster commercialization.

Electric vehicles, while similar in design to conventional vehicles, are powered by electrical energy stored in batteries. Hybrid vehicles typically combine an electric propulsion system with an additional power source, such as a small gasoline engine. The secondary power source is used to recharge batteries or provide supplemental power. Hybrid vehicles are more complex and less developed technologically than purely electric vehicles. This report deals primarily with electric vehicles and discusses hybrid vehicles where necessary.

The 1976 act assigned administrative responsibility to the Energy Research and Development Administration, which has since been consolidated into the Department of Energy. The ~~act~~ ^{Congress} authorized \$160 million for a program of research and development, vehicle demonstrations, and production incentives. It sought to protect small businesses and encourage their participation. Program officials have indicated that total program costs could reach one-half billion dollars before the program is completed in 1990. (See p. 2.)

Estimates of oil savings from electric vehicles range widely and depend on the number

EMD-79-6

of vehicles ultimately in use. / There is little data on the appeal of limited range vehicles and uncertainty about their future role in the transportation system. However, the Department expects electric vehicles to achieve a market penetration of 8.6 million vehicles by the year 2000, or approximately 5 percent of the vehicle fleet. / At that *the estimated* level of commercialization, the Department believes 200,000 barrels of oil will be saved each day. /

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Before electric vehicles can be widely commercialized, the following advances will be necessary.

--Improving electric vehicle technology.
(See p. 9.)

--Strengthening the electric vehicle industry. (See p. 9.)

--Establishing an electric vehicle market.
(See p. 10.)

--Creating an infrastructure (basic institutions and facilities necessary for the growth and continuance of electric vehicle use). / (See p. 11.)

/ The greatest barriers to successful electric vehicle commercialization are that they cost more and perform less than conventional vehicles. /

~~GAO found~~ a number of problems with the electric vehicle program and *we found it also* concluded, among other things, that:

--the private-sector demonstration effort is premature,

--research and development needs to be strengthened, and

--the small business program needs reexamination.

PRIVATE-SECTOR DEMONSTRATION
PROGRAM IS PREMATURE

The 1976 act, as amended, authorizes the Department of Energy to demonstrate up to 10,000 electric and hybrid vehicles in the private, Federal, and State and local government sectors. The Department is emphasizing the private sector and plans to demonstrate most vehicles through arrangements with private firms and citizens. (See p. 13.)

GAO believes it is too early to demonstrate the vehicles in the private sector. Such premature demonstrations could adversely affect commercialization. The performance of current electric vehicles is so limited and costs so high that widespread commercialization cannot be realistically expected at this time. (See p. 16.)

GAO also found that costs to conduct the vehicle demonstrations are high. The Department estimates program costs associated with the first group of demonstration vehicles at about \$27,000 per vehicle. (See p. 18.)

Further, GAO believes the current program does not fully guard against potential vehicle safety dangers. In this regard, some Department of Transportation recommendations were not adopted. (See p. 22.)

The current legislatively mandated demonstration schedule, which requires a certain number of vehicles to be purchased each year, does not afford the Department an adequate opportunity to learn from early demonstrations. It limits the ability to use technological advancements resulting from research and development and allows little opportunity to demonstrate hybrid vehicles, which the Department believes have a greater potential to penetrate vehicle markets. (See p. 19.)

Today's vehicles need to be placed in controlled environments where failures due to their immature state of technology will not adversely reflect on the inherent

potential of the electric vehicle concept. The Department may be placing vehicles in uncontrolled situations where any such failures will be highly visible and could damage public acceptance of more advanced vehicles when they become available. (See p. 21.)

GAO believes restricting the initial demonstration program to the Federal sector has merit. Costs may be lower because the Government obtains vehicles for its own use and can eliminate a layer of management planned for the private sector. Risk would be decreased because vehicle use and visibility can be more closely controlled. The demonstration sequence would be more suitable because safety, reliability, and life-cycle cost information can be evaluated and vehicle technology improved before proceeding into other sectors. (See p. 27.)

RESEARCH AND DEVELOPMENT
NEEDS TO BE STRENGTHENED

GAO's review disclosed problems with various aspects of the Department's research and development program. (See p. 34.)

Improving battery performance is one of the most important steps toward developing an electric vehicle which is commercially viable. The Department's near-term battery effort is examining a number of improved battery types, including lead-acid batteries. The Department plans to fund \$7 million in lead-acid battery research and development over the next 3 years. However, it is widely viewed that improved lead-acid batteries have little potential for achieving widespread electric vehicle commercialization. (See p. 35.)

Projects involving the design and construction of two advanced electric cars are also encountering problems. Contracts for developing the cars are being hampered by cost overruns, work scope reductions, and inability to meet certain contract performance goals.

The Department now estimates that designing and constructing the cars will cost about \$13.5 million, almost \$2 million above the initial estimate. In addition, detailed plans for using the products of this research project as catalysts for electric vehicle commercialization have not been developed. (See p. 36.)

Electrified roadways, another research and development project, have potential safety hazards; appear inconsistent with one of the act's primary objectives (using electric vehicles to exploit electric utility off-peak power availability); and are predicated on the successful commercialization of electric vehicles, which has not yet been shown. (See p. 38.)

SMALL BUSINESS PROGRAM NEEDS REEXAMINATION

The act requires the Department of Energy to take actions to assure that small business firms have a realistic and adequate opportunity to participate in the electric vehicle program.

The Department has taken some actions and instituted policies to assist small businesses. Of the \$52 million obligated in the electric vehicle program through September 1978, about \$5.6 million went to small businesses, with about \$2 million going to small electric vehicle manufacturers. (See p. 43.)

The act authorized a planning grant program to assist small businesses in obtaining Government contracts, but the Department has taken 2 years to implement the program. GAO believes the Department's implementation approach may be too restrictive to be very effective. (See p. 45.)

A loan guarantee program was authorized by the act to help primarily small businesses secure capital for research and development, prototype development, and vehicle and component production. The Department is placing emphasis on vehicle and component production. However, the commercial viability of

electric vehicles has not yet been shown. GAO believes that implementing the loan guarantee program for vehicle and component production is premature. (See p. 46.)

RECOMMENDATIONS TO THE CONGRESS

While GAO recognizes that demonstrations are a good mechanism to advance technologies from research and development to the market place, GAO has concluded that, because of the high cost of electric vehicles available today and their current performance limitations, the demonstration program's emphasis on the private sector is premature. In this connection GAO is recommending that the Secretary of Energy limit electric vehicle demonstrations to strictly controlled environments in the Federal sector. When technology improves and vehicle reliability, safety, and reasonably competitive life-cycle costs are shown, demonstrations could be expanded outside the Federal sector.

In order for the Secretary of Energy to effectively act upon this recommendation, the Congress should amend the existing legislation to provide more flexibility in both the timing of vehicle purchases and the number of vehicles to be demonstrated. By providing flexibility in the timing of vehicle purchases, the Department would have more opportunity to learn from earlier demonstrations as well as allow for the effective use of advancements resulting from research and development efforts. (See p. 32.)

Regarding the number of vehicles to be demonstrated, the Congress should provide flexibility by removing the mandatory requirement to demonstrate a specified number of vehicles. Since GAO's recommendation is to restrict initial demonstrations to the Federal sector, GAO questions the appropriateness of demonstrating in the Federal sector the number of vehicles stated in the act.

In connection with providing demonstration program flexibility, the Congress should consider the Secretary of Energy's report pursuant to GAO's recommendation that he develop a reasonable demonstration strategy. (See p. 32.)

GAO is also recommending that the Congress take appropriate actions to ensure that the recommendations enumerated below are effectively carried out (see pp. 32, 42, and 48). These actions are necessary to bring about a much needed redirection of the electric vehicle program.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

The Secretary of Energy should:

- Postpone future ~~private sector, and State and local government sector~~ demonstrations until technology improves and vehicle reliability, safety, and reasonably competitive life-cycle costs are shown.
- Use Federal and ongoing private-sector demonstration programs to identify major technical problems and safety hazards and develop data on vehicle reliability and life-cycle costs.
- Develop and report to the Congress a reasonable strategy for the demonstration program. Include in the report the timing and number of vehicles to be demonstrated based on time phasing which recognizes demonstration experience and research and development advances. (See p. 30.)
- Continue to assign program funding priority to research and development, and
 - (1) reevaluate such projects as lead-acid battery development, which have limited potential to bring about widespread electric vehicle commercialization;
 - (2) establish and pursue strategies for commercializing the products of development efforts; and

(3) reexamine the potential of electrified roadway systems. (See p. 40.)

--Ensure meaningful small business participation in the program by evaluating the results of the first planning grant awards and, if warranted, expand their use to other procurement areas. (See p. 47.)

--Delay issuing loan guarantees for electric vehicle and component production until the vehicles are shown to be commercially viable and information is available to demonstrate a reasonable opportunity for loan repayment. (See p. 48.)

DEPARTMENT OF ENERGY'S COMMENTS

The Department of Energy does not agree with the major conclusions and recommendations in this report. The Department's comments and GAO's evaluation are presented on pages 12, 30, 41, and 48.

A copy of the Department's letter commenting on a draft of this report is contained in Appendix I.

C o n t e n t s

		<u>Page</u>
DIGEST		i
CHAPTER		
1	INTRODUCTION	1
	Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976	2
	Program funding	3
	Scope of review	4
2	POTENTIAL OF ELECTRIC VEHICLES	5
	EV market forecasts	5
	Three market-growth scenarios	5
	Expected EV market	6
	Impact of electric vehicles	6
	Potential oil savings	6
	Environmental improvements	7
	Commercialization barriers	8
	Technological barriers	9
	Industry barriers	9
	Marketing barriers	10
	Infrastructure barriers	11
	Conclusion	12
	Agency comments and our evaluation	12
3	PRIVATE-SECTOR DEMONSTRATION PROGRAM IS PREMATURE	13
	Program description	13
	Technology not sufficiently developed to make widespread commercialization feasible	16
	Problems affecting demonstration program	18
	High program costs	18
	Insufficient time to evaluate and benefit from early demonstration experience	19
	Uncertain contribution to R&D activity	20
	Vehicles unsheltered from envi- ronments with greater failure potential	21
	Safety dangers not fully guarded against	22
	Federal, State, and local government demonstrations could be better planned	25

CHAPTER		<u>Page</u>
3	Demonstration restricted to Federal Government has merit	26
	Advantages of demonstrating EVs by Federal agencies	27
	Opportunities for Federal EV use	29
	Coordinating existing EV use	29
	Conclusions and recommendations to the Secretary of Energy	30
	Agency comments and our evaluation	30
	Recommendations to the Congress	32
4	ELECTRIC VEHICLES NEED A STRENGTHENED RESEARCH AND DEVELOPMENT PROGRAM	33
	Program description	33
	Problems with program implementation	34
	Marginal battery development being funded	35
	Vehicle systems projects experiencing problems	36
	Electrified roadways of questionable R&D value	38
	Conclusions and recommendations to the Secretary of Energy	40
	Agency comments and our evaluation	41
	Recommendations to the Congress	42
5	SMALL BUSINESS PROGRAM NEEDS REEXAMINATION	43
	Background	43
	Past efforts to assist small business have had mixed success	43
	Planning grants too restrictive	45
	Loan guarantees for production, premature	46
	Conclusions and recommendations to the Secretary of Energy	47
	Agency comments and our evaluation	48
	Recommendations to the Congress	48
 APPENDIX		
I	Letter dated January 10, 1978, from the Department of Energy, commenting on this report	50

ABBREVIATIONS

ANL Argonne National Laboratory
DOE Department of Energy
DOT Department of Transportation
EV Electric Vehicle
FMVSS Federal Motor Vehicle Safety Standards
GAO General Accounting Office
GE General Electric
GRC General Research Corporation
JPL Jet Propulsion Laboratory
LRC Lewis Research Center
MPH Miles Per Hour
NASA National Aeronautics and Space Administration
R&D Research and Development

CHAPTER 1

INTRODUCTION

Currently, the Nation consumes over 6 billion barrels of oil a year--about half in transportation. Passenger cars, vans, and small trucks consume 30 percent of all oil used. The 125 million vehicles on our Nation's roads are currently traveling over 1.4 trillion miles a year and burning well over 100 billion gallons of fuel.

Domestic oil resources are insufficient to satisfy the Nation's demand. Consequently, the United States is importing a significant share of its oil. In 1977, the United States spent \$46 billion to purchase 3.2 billion barrels of imported oil. Imports of this magnitude have a serious impact on the Nation's balance of payments. Furthermore, such dependence on foreign oil also affects foreign policy and threatens national security by making the Nation vulnerable to oil supply curtailments.

The United States is exploring transportation alternatives that do not rely on oil. Electric vehicles (EVs) are one such alternative. Although similar in basic design to conventional vehicles, EVs are powered by electrical energy stored in batteries. The electricity used to recharge these batteries can be produced using fuels other than oil.

EVs are not recent innovations. In the early 1900s, there were more electric cars than gasoline-powered cars on the road. With advances in gasoline vehicle technology and the availability of inexpensive gasoline, EVs almost disappeared by the late 1920s. EVs could not compete on the basis of overall performance. Because of battery limitations, few EVs could travel over 20 miles per hour (mph) or beyond a range of about 50 miles.

This performance imbalance has continued to the present. Only with concerns about air pollution and oil availability has the Nation's commitment to gasoline-powered vehicles been questioned, and interest in EVs reemerged.

The desire to increase EV performance capability has led to the development of hybrid vehicles. Hybrid vehicles typically combine an electric propulsion system with an additional power source, such as a small gasoline engine. The secondary power source is used to recharge batteries or provide supplemental power. Hybrid vehicles are more complex than purely electric vehicles and are less developed technologically than EVs. Consequently, this report deals primarily with electric

vehicles. Hybrid vehicles are discussed separately when necessary.

ELECTRIC AND HYBRID VEHICLE
RESEARCH, DEVELOPMENT, AND
DEMONSTRATION ACT OF 1976

Recognizing the potential contribution of EVs toward resolving the Nation's energy problems, the Congress passed, on September 17, 1976, the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 (Public Law 94-413). The act stated that expeditious introduction of EVs into the Nation's transportation fleet would substantially reduce the Nation's use of, and dependence on, foreign oil. The act also cited expected environmental benefits since EVs do not emit pollutants.

Although numerous benefits to the Nation were possible, the Congress felt the condition of the EV industry and market was not conducive to commercializing electric vehicles without Federal assistance. Hence, the act was passed to provide such assistance.

Accordingly, the act directed the Energy Research and Development Administration--since consolidated into the Department of Energy (DOE)--to establish and administer a comprehensive EV commercialization program. The act required the program to consist of

- research and development (R&D) to improve EV performance;
- procurement and demonstration of up to 7,500 EVs;
- encouragement of EV use by Federal agencies;
- loan guarantees to qualified borrowers to encourage the commercial production of EVs;
- support for small businesses, including assistance in obtaining Government EV contracts; and
- studies on the best means to promote EV commercialization and the effects of such commercialization on the Nation.

The act was amended February 25, 1978, by the Department of Energy Act of 1978--Civilian Applications (Public Law 95-238). The amendments, among other things, (1) extended the demonstration program schedule 2 years (from 1984 to 1986); (2) increased the number of vehicles to be demonstrated from

7,500 to 10,000; (3) authorized the demonstration of foreign vehicles during the program's first two phases; and (4) modified various provisions of the loan guarantee program.

DOE's strategy for implementing the act has been to contract for virtually all project activities. The R&D project is being managed primarily by the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL) and Lewis Research Center (LRC), as well as DOE's Argonne National Laboratory (ANL). The demonstration project is being managed largely by a private consulting firm, Booz, Allen and Hamilton, Incorporated. Other activities, including conducting numerous studies and loan guarantee analyses and preparing program plans and reports, are also being carried out by contractors. DOE headquarters' responsibilities include establishing goals and objectives, overall planning, preparing budget justifications, and program coordination.

PROGRAM FUNDING

The Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 authorized \$160 million to implement the overall EV program over 5 fiscal years--from 1977 through 1981. DOE had devoted some funding to EV research and development in fiscal year 1976 prior to the passage of the act. From fiscal year 1976 through fiscal year 1978, DOE has expended approximately \$55 million on the program. Past expenditures and future budgets have been allocated as follows:

<u>Program category</u>	<u>Fiscal Year Funding</u>				<u>Total</u>
	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979 (est.)</u>	
	(millions)				
Research and development	\$1.4	\$18.5	\$22.1	\$21.8	\$63.8
Demonstration	-	0.4	5.4	11.7	17.5
Incentives	-	0.1	0.6	2.4	3.1
Studies	0.5	2.0	1.7	0.6	4.8
Program support	-	0.2	.9	1.0	2.1
Total	\$1.9	\$21.2	\$30.7	\$37.5	\$91.3

While it is not DOE's policy to furnish us with estimated program costs beyond the current fiscal year, the EV program

manager indicated that total program costs through 1990 could amount to one-half billion dollars.

SCOPE OF REVIEW

Our review of the electric and hybrid vehicle program was conducted as a result of interest expressed by the Chairman, Subcommittee on Oversight and Investigations, House Committee on Interstate and Foreign Commerce, and other Members of Congress concerning DOE's conduct of the program. Each request directed particular attention to certain DOE procurements. Accordingly, in a separate but related effort, our Office of General Counsel reviewed bid protests arising out of three DOE procurements made in conjunction with the program. In each case, DOE's procurement practices were upheld and the protests denied. 1/

This review was directed toward evaluating DOE's overall program to commercialize EVs. We reviewed applicable legislation, reports, and planning documents. We also interviewed program managers within DOE and other organizations carrying out program responsibilities, officials of other Government agencies, representatives of the automobile and battery industries, and EV producers.

The report addresses the potential for EVs to conserve oil and achieve other environmental objectives. It also assesses DOE's implementation of the three major program segments--vehicle demonstration, R&D, and incentives for small business. Each is discussed separately in the chapters which follow.

1/See National Motors Corporation et al, B-189933, June 7, 1978, 78-1 CPD 416, and Die Mesh Corporation--Reconsideration, B-189933, July 7, 1978, 78-2 CPD 15; Die Mesh Corporation, B-190421, July 14, 1978, 78-2 CPD 36; Die Mesh Corporation, 58 Comp. Gen. 111 (1978), 78-2 CPD 374.

CHAPTER 2

POTENTIAL OF ELECTRIC VEHICLES

The history of the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, shows that the Congress expected EVs to achieve substantial oil savings and pollution reductions. However, currently available analyses suggest that these results will not be achieved. Estimates of oil savings and environmental improvements range widely and depend on the number of vehicles which will ultimately be in use. For enough EVs to enter the Nation's fleet and accomplish even modest results, they will have to overcome many barriers to commercialization.

EV MARKET FORECASTS

Forecasts of EV passenger car use by the year 2000 range from 1.8 million to 30 million vehicles. Estimates from DOE, independent researchers, and others differ markedly because existing marketing data for conventional vehicles does not apply to the limited-range EV. There is uncertainty about the EV's state of development and its future role in the transportation system, and there are varying perceptions of future energy availability.

Three market-growth scenarios

To assist in anticipating EV market penetration problems, DOE constructed three market-growth scenarios for 1986, involving pessimistic, midrange, and optimistic estimates.

The pessimistic estimate predicts market demand of less than 50,000 vehicles a year. This is based on the assumption that even after significant technological improvements, EVs will still cost more money and offer less performance than conventional vehicles. As a result, large auto manufacturers will not have risked funds in high-capacity EV production facilities, and the industry will not be able to support a significant market without permanent subsidies.

The midrange estimate calls for a market potential of 250,000 vehicles a year. This estimate assumes that spectacular technological improvements will occur and EVs will be comparable to conventional vehicles for use in urban settings. The estimate shows, however, that EVs will still cost more, and only one large auto manufacturer will have established a high-volume production facility.

According to the optimistic estimate, EVs' performance will equal conventional vehicles' in urban settings. Their

cost will also be competitive, and the prime market for them will be as a second car for urban families. This estimate also predicts that three of the "Big Four" automakers will be producing up to 1 million vehicles a year.

Expected EV market

DOE program officials believe 40 to 60 percent of the U.S. vehicle fleet could potentially be replaced by EVs. However, they expect an actual market penetration of 8.6 million EVs by the year 2000, or about 5 percent of the anticipated 190-million vehicle fleet. This expectation is based on a vehicle with a 100-mile range and ownership costs comparable to conventional vehicles. The underlying economic analyses, which were done for DOE by independent researchers, considered EV ownership costs, multicar family needs, daily trip requirements, access to recharging facilities, and other variables.

IMPACT OF ELECTRIC VEHICLES

The EVs' impact on oil use and the environment depends on how well they can overcome certain commercialization barriers and be substituted for conventional vehicles in the U.S. transportation fleet. Based on a penetration level of 5 percent, preliminary calculations indicate EVs will not significantly reduce oil imports or pollution levels by the year 2000.

Potential oil savings

In 1977, the Nation consumed an average of 18 million barrels of oil daily--one-half of which was imported. Of this total, 8 million barrels per day were used by oil consuming vehicles--5.6 million by passenger vehicles and 2.4 million by commercial vehicles.

EVs do not combust oil products directly to power the vehicle. Also, since electricity is produced mostly from sources other than oil, the replacement of conventionally powered vehicles with EVs could reduce total oil consumption.

The amount of oil savings is dependent upon the number of conventionally powered vehicles that EVs replace. Estimates of potential oil savings by the year 2000 from EV commercialization range from 57,000 barrels a day to 1.3

million barrels a day, depending on the number of vehicles in use, according to a 1978 Purdue University study. ^{1/} DOE program officials expect a daily 200,000-barrel savings by the year 2000, based on commercialization of 8.6 million EVs. However, such savings would be equivalent to only 2 percent of the oil imports at the 1977 import level

Estimating oil savings from commercializing EVs, however, is even less precise than forecasting EV penetration levels, because additional variables affect these estimates. Projecting how EVs will actually be used and how much fuel will be consumed by the vehicles they replace is imprecise. Automobile fuel economy improvements expected in the next two decades must also be considered. For example, substituting EVs for 40-miles-per-gallon commuter cars will obviously produce less dramatic oil savings than substituting EVs for cars which today get 20 miles per gallon.

Although EVs will save oil, they are not inherently more energy efficient. In terms of energy efficiency, studies generally agree that electric-powered vehicles and gasoline-powered vehicles are nearly the same--each only about 12 percent efficient. Gasoline-powered vehicles lose efficiency mostly within the internal combustion engine, whereas electric-powered vehicles lose efficiency in the generation and transmission of electricity to the vehicle. The EVs' efficiency does not change appreciably whether oil or coal is used to generate the electricity. However, in the future, using more efficient means of generating electricity could give EVs an efficiency advantage over gasoline-powered vehicles.

DOE-sponsored studies generally conclude that substituting electric vehicles for conventional vehicles would not require adding more capacity to the Nation's electric utility system than already planned. This assumes that electric vehicle batteries will be recharged at night, when demand for electricity is lowest.

Environmental improvements

Studies conducted for DOE conclude that substituting electric vehicles for conventional vehicles would benefit the environment. Overall air quality would be slightly improved, noise would be slightly reduced, and the need for

^{1/}"Opportunities and Risk Assessment of the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976."

disposing certain waste materials (for example, crankcase oil) would be lessened.

EVs themselves emit no pollutants. Therefore, according to DOE-sponsored studies, any substitution of EVs for internal combustion vehicles will reduce total vehicular emissions, such as carbon monoxide and hydrocarbons. However, when fossil fuels are burned to generate the additional electricity necessary to recharge EVs, pollutants, such as sulfur dioxide, will increase. Other pollutants, such as nitrogen oxides and particulates from tires and brake linings, will remain essentially the same.

The particular mix of pollutants and pollution patterns depends on the combination of fuels used for recharging EV batteries and the location of generating stations in relation to where EVs are used. Significant regional variations may occur even though EVs' overall effect on air pollution will be slight.

A 1978 General Research Corporation (GRC) study concluded that electrifying 10 percent of the vehicles in the 24 major urban areas (with a combined 1974 population of 92.4 million) would reduce vehicular pollutants less than 5 percent by the year 2000. GRC's calculations were based on projected pollution levels which assumed that electric generating plants would continue to burn high-sulfur fuels and that reductions in conventional automobile emissions would occur as planned.

Electric vehicles will also benefit the environment by decreasing noise. Conventional vehicles produce noise principally during acceleration and at high speeds. EVs are substantially quieter during acceleration and do not produce any sound while stopped in traffic. High-speed noise results mostly from tire whine and thus will not be significantly less for EVs. The GRC study concluded that if all future conventional automobiles were replaced with EVs, an approximate 10-percent reduction in overall noise impact would result.

COMMERCIALIZATION BARRIERS

Industry spokesmen and DOE program officials agree that before EVs can be widely commercialized, numerous barriers must be overcome. EV technology must be improved, the EV industry must be strengthened, an EV market must be established, and the basic institutions and facilities necessary for the growth and continuance of EV use--the infrastructure--must be created.

Technological barriers

The large automakers and other industry representatives believe the technological barriers are the most significant blocks to EV acceptance. However, most agree that these barriers are clearly defined. They are embodied in the term "performance"--specifically, the level of performance expected by consumers. Today's EVs are limited in

- range, 1/
- speed, 1/
- acceleration (about half as fast as conventional counterparts up to 31 mph 1/),
- payload (added weight reduces performance),
- climate adaptability (cold weather reduces performance),
- time required to recharge batteries (10 hours 1/), and
- reliability.

Except for reliability, the above limitations relate directly to the need for an improved battery. DOE considers reliability as symptomatic of an immature industry, which the EV industry is.

Industry barriers

The U.S. EV industry is primarily comprised of small EV manufacturers and component suppliers. Its problems are typical of any infant industry, including limited

- capital availability,
- production capacity,
- material and component supply channels,
- manufacturing experience and work force skills, and
- sales network.

1/From minimum EV performance standards promulgated by DOE May 30, 1978. These standards require EVs to have a range of 31 miles and capability of reaching 50 mph.

The Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, included a loan guarantee provision intended to make investment capital available to the EV industry. This provision empowers DOE to guarantee loans for up to \$3 million to qualified borrowers for the development and commercialization of EVs.

Some industry representatives told us that the industry barriers would be largely overcome if one or more of the "Big Four" automakers were to begin high-volume EV production. Although this has not yet occurred, General Motors currently plans to build 35 electric vans for the American Telephone and Telegraph Company, 20 of which are to be demonstrated under the DOE program.

Marketing barriers

Marketing barriers include

- high EV costs--initial outlay costs are about twice that of an EV's conventional counterpart, and periodic battery replacement costs range from \$0.10 to \$1.01 per mile, 1/
- limited EV range and performance,
- limited personal comfort items,
- uncertain resale values,
- limited financing available at rates competitive with those for conventional vehicles,
- higher sales and personal property taxes, and
- poor public perception and acceptance of EVs.

The greatest barriers to marketing EVs are that they cost more than conventional vehicles and deliver less performance and operational flexibility. DOE is looking into these cost-performance barriers. DOE also plans an awareness campaign to improve public acceptance of EVs.

1/From DOE's "State of the Art Assessment of Electric and Hybrid Vehicles," Jan. 1978.

Infrastructure barriers

Numerous infrastructure barriers impact on EV commercialization. They include

- limited availability of recharging facilities (such as convenient electrical outlets at home and work);
- unfavorable highway design (such as steep hills, ramps to highways, and minimum speed laws) which tend to discriminate against EVs;
- vehicle registration and licensing problems;
- safety inspection requirements not applicable to EVs;
- limited EV servicing facilities; and
- questionable vehicle insurability due to a lack of experience data.

DOE believes these barriers may be the most difficult to overcome and plans to obtain information on them through its demonstration program. DOE has also commissioned several studies of these barriers and plans several more. Overcoming these barriers will require substantial coordination among Federal and State agencies.

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While program officials are confident that all important barriers have been isolated, they agree that the relative significance of each is not yet clear. They also believe it is too soon and too difficult to plan precise strategies to overcome individual barriers. However, several industry observers and large automakers we talked with agreed that developing a better battery system was essential and should receive highest priority.

A 1978 Department of Transportation (DOT) study of institutional biases identified 33 factors which would have some negative influence on EV commercialization. One of the study's conclusions was that:

"Limits on current and intermediate technology are a major source of bias against * * * [electric and hybrid vehicles]. These limits lead to biases in such areas as safety standards, sales and property taxes, speed laws and highway design. Major improvements in technology and cost factors would

lead to diminution (or elimination) of these biases."

CONCLUSION

The barriers to commercializing EVs are numerous and difficult to overcome. Those requiring most attention are EVs' relatively low performance capabilities and their high cost. Forecasts of EV market penetration differ markedly. DOE program officials expect a 5-percent penetration, or 8.6 million EVs to be in use, by the year 2000. Commercializing EVs at that level, according to DOE-sponsored studies, will not significantly reduce oil imports or air pollution levels.

Nevertheless, EVs offer a potentially viable transportation alternative that does not rely on oil. In addition, they offer a number of environmental advantages over conventional vehicles. Therefore, we believe the EV concept is worth pursuing and should be given every chance to develop. Such development, however, should entail the establishment of a well-conceived and carefully managed program for demonstrating EVs, coupled with a strong, highly integrated program for improving EV technology through R&D.

AGENCY COMMENTS AND OUR EVALUATION

In commenting on our draft report (see app. I), DOE pointed out that hybrid vehicles are an essential part of the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976. DOE commented that we did not consider the potential of hybrid vehicles in market penetration or petroleum savings. DOE believed the longer range hybrid vehicles will pave the way for acceptance of EVs as second cars.

We agree that the primary emphasis of this report is not directed toward DOE's hybrid vehicle research program. At the time we began our review, DOE was giving little emphasis to developing hybrid vehicles. In recent months, however, DOE has embarked upon what we believe is a shift in emphasis from purely electric to hybrid vehicles.

Furthermore, hybrid vehicles are more complex than purely electric vehicles, and they are at present less developed technologically than EVs. Accordingly, the potential for market penetration, together with inherent potential for oil savings, attributed to these vehicles are relative unknowns.

CHAPTER 3

PRIVATE-SECTOR DEMONSTRATION

PROGRAM IS PREMATURE

The Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 mandated a phased program for demonstrating EVs in three sectors--private, Federal, and State and local governments. Concerns over the prescribed demonstration schedule led to an amendment of the act and major program modifications. Our review, however, disclosed numerous problems and risks associated with the revised approach.

Currently available EVs have such limited performance capabilities that the present demonstration schedule is still too restrictive. Moreover, the program itself faces many problems that reduce its chances of success. We believe these problems could be minimized and chances for a successful EV demonstration enhanced if future private-sector demonstrations were postponed until commercially viable vehicles become available. In the interim, program emphasis should be placed on demonstrating EVs in the Federal sector.

PROGRAM DESCRIPTION

The demonstration program is the most visible element of the Government's efforts to commercialize EVs. The program is planned to include up to 10,000 vehicles that are to be purchased or leased by private firms and citizens, Federal agencies, and State and local governments for personal, commercial, and agricultural uses. DOE will share the cost of purchase, operation, data collection, and program promotion.

Numerous objectives have been set forth for the demonstration program which include

- evaluating the technical and economic practicality of EVs;
- increasing public awareness of EVs;
- determining consumer preferences for vehicle design and performance characteristics and disseminating such information to the researchers and vehicle manufacturers;
- creating an EV second car market;

--stimulating private industry interest in producing EVs; and

--identifying and overcoming infrastructure and other barriers to widespread EV commercialization.

The act established a basic approach to conducting the demonstration program and set up a schedule for its implementation. It first required DOE to promulgate minimum performance standards for vehicles qualifying for purchase under the program. Within 6 months after promulgating the standards, DOE was to contract for 2,500 vehicles. Following this first procurement, the act required DOE to contract for and demonstrate 5,000 more vehicles for a total of 7,500.

In DOE's first annual report to the Congress, dated December 1977, concern was expressed by DOE about the difficulty of conducting the demonstration program in the time frame prescribed by the act. Recognizing the lack of development of EV technology, large-scale EV production capacity, and management capabilities for introduction and demonstration of 2,500 vehicles at a time, DOE, in the annual report, recommended a more flexible schedule that spread out vehicle procurements. In response to these concerns, the Congress revised the schedule in the Department of Energy Act of 1978--Civilian Applications (Public Law 95-238). The original and revised schedules are shown below.

Number of Vehicles To Be Obtained

<u>Fiscal year</u>	<u>Original schedule</u>	<u>Revised schedule</u>
1978	2,500	<u>a/200</u>
1979	-	600
1980	-	1,700
1981-84	<u>b/5,000</u>	<u>7,500</u>
Total	<u>7,500</u>	<u>10,000</u>

a/Approximate.

b/Through fiscal year 1982 only.

DOE has decided to demonstrate each vehicle for 3 years. Consequently, the program will continue to fiscal year 1987. At the height of the program in 1984, DOE expects that 7,000 vehicles may be operational in the demonstration program.

The act requires DOE to arrange for vehicles to be demonstrated by the private sector, the Federal Government, and State and local governments. DOE has chosen to emphasize the private sector because it believes the private sector will have the greatest effect on the commercialization process and that is where the success of the program will be determined. Of the first year's approximately 200 vehicles, 165 are being distributed to private firms and 35 to Federal agencies. None will be demonstrated by State and local governments.

In the private sector, DOE is, in effect, insulating itself from the actual conduct of the program. DOE will not procure, operate, or manage any vehicles itself. Instead, it has contracted with a management consulting firm to plan and execute the private-sector demonstrations. The demonstration manager will recommend selection of, and negotiate cost-sharing contracts with, site operators who will actually obtain and operate the vehicles or distribute them to individual buyers.

DOE plans to employ the use of two types of private sector site operators--fleet operators, and marketing and service operators. Fleet operators, such as public utilities, will substitute EVs for gasoline-powered vehicles in their normal commercial functions, such as delivery services and maintenance and repair work. Marketing and service operators, normally automotive dealerships, will sell or lease EVs directly to individuals or small businesses. For the first demonstration, four fleet operators, and one marketing and service operator have been chosen as shown on the next page.

First Phase Site Operators

<u>Organization</u>	<u>Number of vehicles</u>	<u>Site location</u>	<u>Vehicle use</u>
American Tele- phone and Telegraph Co.	20	Los Angeles, California	Telephone repair and installation.
Consolidated Edison of New York, Inc.	40	New York, New York	Meter installa- tion, parts pickup, etc.
Long Island Lighting Co.	60	Mineola, New York	Meter reading, motorpool, col- lections.
Walt Disney World Co.	20	Lake Buena Vista, Florida	Landscaping, maintenance, motorpool.
E/HV Inc. (Penn Jersey Subaru, Inc.)	25	Pennsauken, New Jersey	Personal use after sales by auto dealership.

165

The site operators will purchase vehicles from EV manufacturers that they believe will best meet their needs. However, to qualify for purchase, all vehicles must meet minimum performance standards promulgated by DOE as required by the act. Site operators will not determine if vehicles meet the standards. Each manufacturer will certify its own compliance. At the time of our review, DOE was planning only to spot check the validity of manufacturer certifications. In commenting on a draft of our report, however, DOE officials advised us they recently committed \$900,000 to test the validity of manufacturers' certifications, and they expect to test each type of EV demonstrated during the initial 3 years of the program.

TECHNOLOGY NOT SUFFICIENTLY
DEVELOPED TO MAKE WIDESPREAD
COMMERCIALIZATION FEASIBLE

DOE's program of demonstrating currently available EVs will probably do little to promote EVs' long-term commercialization. Vehicles with current performance limitations and high prices have little potential for entering the Nation's vehicle fleet in large numbers. Cost-performance

relationships must be markedly improved before a commercial demonstration program can realistically achieve success.

In 1976, the Rand Corporation published a study identifying the characteristics differentiating successful and unsuccessful demonstrations of a wide range of technologies. The study concluded that for a technology to be successfully demonstrated, it must be proven and most technical problems resolved beforehand. A 1978 DOE report likewise stated that demonstrating a technology before it is ready is the single most common cause of failure for federally sponsored demonstrations. It also stated that the technology must be economically competitive. EVs available now have not been shown to be either technologically well-developed or cost competitive.

Currently available EVs have limited performance capabilities. As required by the act, DOE published a state-of-the-art assessment of EVs in January 1978. DOE tested a number of vehicles under certain driving conditions. Under one of the testing conditions, DOE reported that only one vehicle could accelerate quickly enough to perform DOE's stop-and-go driving test which most closely approximates suburban driving. In another less rigorous test for urban driving, the vehicles tested achieved ranges of only 20 to 77 miles. In recognition of these limited capabilities, DOE's demonstration program performance standards require vehicles to have a range of only 31 miles.

Vehicles tested were similarly limited in other aspects such as acceleration, sustained high speed operation, grade-climbing ability, and payload capacity. Finally, at the present level of production technology, DOE believes that vehicle reliability problems can also be expected.

The cost competitiveness of EVs on a life-cycle basis has not been conclusively demonstrated. DOE's state-of-the-art assessment states that costs associated with EVs over their lives have been based on a limited number of field tests. The assessment indicates that the assumptions made relative to battery replacement and repair costs lead to a wide range of results which, in turn, make any determination of EV economics inconclusive.

Today's EVs, however, are expensive. Two studies, including DOE's state-of-the-art assessment, concluded that EVs initially cost about twice as much as their conventional counterparts. Passenger vehicles and light vans we examined ranged in price from \$6,800 to \$28,000.

One factor contributing to high EV costs is the inability of EV manufacturers to achieve economies of scale because vehicles are currently produced and sold in such small numbers. The largest manufacturer to date had produced only 2,000 vehicles before ceasing production. Other manufacturers have not produced nearly as many. Major automakers do not normally manufacture a vehicle unless they can expect sales of at least 100,000 vehicles per year.

For obvious reasons, vehicles delivering inferior performance at a cost higher than conventional vehicles have low commercialization potential. Private-sector demonstrations of such vehicles could damage the future acceptability of EVs by showing potential buyers that EVs are not a realistic transportation option. Private-sector demonstrations should be delayed until EVs are shown to be commercially viable.

PROBLEMS AFFECTING DEMONSTRATION PROGRAM

Chances for large-scale commercialization would not be good using currently available vehicles even if the demonstration program were problem free. But it is not. In addition to its high cost, DOE's program faces several problems:

- Insufficient time to evaluate and benefit from early program experience.
- Uncertain contribution to R&D program.
- Unassured sheltering of vehicles from environments with high failure potential.
- Insufficient protection against safety dangers.
- Inadequately organized Federal, State, and local government segments.

High program costs

Current DOE budget estimates show the costs of the demonstration program will be high. In fiscal year 1978, \$5.7 million was budgeted for the demonstration program's first phase of only 200 vehicles. Program costs applied per vehicle will, therefore, be about \$27,000. Of this \$27,000, about \$10,000 per vehicle will be paid to the demonstration management contractor for planning, data compilation, and other services.

To some extent, the cost per vehicle reflects start-up administrative costs, such as establishing the procedures for

collecting, compiling, and reporting operating and cost data. However, such estimated costs per vehicle for the fiscal year 1979 purchase of 600 vehicles are planned to reach about \$20,000, and for the third-phase purchase of 1,700 vehicles, \$16,000. Cost estimates beyond fiscal year 1980 have not been made. Nevertheless, based on available projections, the cost of the first three phases alone, representing only about one-fourth of total vehicle purchases, will be about \$44 million. With costs of this magnitude, the need for each demonstration phase must be carefully analyzed to determine whether demonstrating all 10,000 vehicles is necessary to achieve the program goals.

Insufficient time to evaluate
and benefit from early demon-
stration experience

DOE and the demonstration manager agree that overall program success depends in part on effectively using initial-phase demonstration experience to improve later phases. However, the current demonstration timetable limits DOE's ability to use this experience. It will also limit program use of any technological advancements which result from DOE's R&D efforts.

A restrictive demonstration schedule can be a critical program risk. Too rigid a schedule would reduce the probability of achieving the act's objectives. A hasty demonstration program could affect the EV market for years to come by disappointing the public with poor vehicles.

Recognizing this danger, the demonstration manager had planned to use the first-phase demonstration of 200 vehicles to gain management experience to better administer later phases. However, to effectively use the experiences of the early demonstrations, enough time must be available to incorporate the results into the program.

The current schedule does not allow for this. First-phase site operators were selected in June 1978. They have until October 1979 to order and take delivery of the vehicles they selected. However, requests for proposals for second-phase site operators were issued in September 1978. Under this schedule, the demonstration manager will probably select second-phase site operators who will place vehicle orders before any substantive information is available from the first phase. DOE plans to place many second-phase vehicles with first-phase site operators. This schedule provides no time to properly evaluate either site operator or vehicle performance before new contracts are made. Hence, a chance to benefit from management experience would be missed.

Considering the current schedule, DOE may also have the same problems in the future. Vehicles and site operators will be added each year and, if the delivery schedule remains as restrictive, DOE may be adding vehicles to new-site operators before either can be properly evaluated.

The present schedule also does not give manufacturers enough time to incorporate into their vehicles technological advances resulting from DOE's R&D program. That program is designed to accelerate commercialization by advancing EV technology and performance capabilities, and by expanding feasible vehicle applications. Such efforts take time. For example, the project to design, develop, and construct two advanced electric cars is scheduled for completion in April 1979. Officials state that such cars would then need several years of upgrading, improvement, engineering for production, and testing before they could be commercially produced. By then, the demonstration program could be into its last scheduled vehicle purchase.

Improved batteries are the most important individual component needed for better vehicle performance. However, results from ongoing battery research are also not expected before mid-1981; and even then, more efficient batteries will not be available, except in limited quantities and at extremely high costs.

Learning from first-phase demonstration experiences and obtaining crucial results from the R&D activity demands longer lead times before venturing into later phases. Without incorporating early experience and technological advances, DOE risks damaging future markets.

Moreover, DOE has now begun placing more emphasis on hybrid vehicles. DOE believes that, because of significantly better performance potential, hybrid vehicles offer the potential for much greater market penetration and hence more dramatic oil savings. However, hybrid vehicles are at an earlier stage of development than EVs and will require years of additional R&D before they are ready for market introduction. We believe the current demonstration schedule allows insufficient time to incorporate these higher potential hybrid vehicles into the program. If, as DOE believes, the act's objectives will more likely be achieved with hybrid vehicles, then modifying the demonstration schedule to enable the participation of more hybrid vehicles seems appropriate.

Uncertain contribution to R&D activity

An important objective of DOE's EV demonstration program is to provide R&D program managers with data to help them

target their activities to real-world needs. In this regard, research managers need accurate and complete engineering data on the operating characteristics of the vehicles used. DOE's program may not be collecting such data.

A demonstration program designed to assist R&D efforts is being conducted outside the DOE program. The Electric Power Research Institute, an organization funded by about 500 participating public utilities, is beginning such a program. Using about 40 vehicles, the Institute has developed a program that will test EV energy use characteristics. To obtain the data needed, each vehicle in the program will be heavily equipped with scientific instruments that automatically record the exact operating characteristics of the vehicle and its components.

DOE initially announced that it would not instrument any of its vehicles because it believed that the information would be obtained in other program areas. Officials now state that two or more vehicles at each site will be lightly instrumented. Most operating data will still be obtained manually from the vehicle operators and service personnel. In other EV demonstration programs, at the Electric Power Research Institute and the U.S. Postal Service, managers have recognized that vehicle operators do not satisfactorily collect operating data--let alone engineering data--over an extended period of time.

Since high vehicle cost and limited performance capabilities resulting from immature vehicle technology are the most important barriers to widespread EV commercialization, we believe the initial vehicle demonstrations should be conducted to best serve DOE's R&D efforts. DOE should, therefore, make sure that vehicles are sufficiently instrumented to ensure the availability of data needed by R&D managers.

Vehicles unsheltered from environments with greater failure potential

In a report for DOE, Purdue University recognized the potential risk of introducing technologically immature EVs into situations where demands on the vehicles were beyond their capabilities. In such situations, highly visible failures could result in rejection of the entire EV concept and damage future public acceptance of the vehicles. The report recommended, therefore, that EVs be protected from high-risk environments as an essential ingredient of the early program phases.

DOE has, nevertheless, selected an auto dealer as a first-phase site operator. This dealer will distribute vehicles directly to the public and small commercial firms. While the dealer plans a driver education program, in this situation it will be difficult to control vehicle use and protect vehicles from failures that mask EVs' true potential.

DOE officials agree that this decision involves some risk. They told us, however, that in order to meet the requirements in the act, the program needs to establish a dealership network early to provide an outlet for the increased number of vehicles scheduled for the later phases. They also told us that a dealership network is necessary for long-term development of a vehicle-support infrastructure. Further, they stated their belief that individual fleet operators can use only limited numbers of EVs before their vehicle needs are satisfied. Placing the larger number of vehicles required in later phases with fleet operators only may, therefore, be difficult or require such a large number of participating fleet operators that supervision will become unwieldy. On the other hand, DOE contends that a marketing organization, such as an auto dealership, can (1) accept a continuing supply of vehicles, (2) distribute them more widely, (3) make supervision less burdensome, and (4) reduce the costs associated with many small fleets. Consequently, DOE plans to distribute about 4,000 of the 10,000 total vehicles to the general public through auto dealerships.

Nevertheless, we believe involving the general public in the demonstration program at this time is premature. DOE will be dispersing vehicles of unknown reliability to individuals who are not fully aware of EVs' limited performance capabilities. In doing this, DOE is increasing chances of program failure. Therefore, DOE should not distribute vehicles to the general public until vehicle reliability has been established and the public has been thoroughly educated about what performance they can expect from EVs.

Safety dangers not fully guarded against

Safety hazards associated with EVs are a potentially serious risk to the demonstration program. Since EVs are currently at a critical stage in their development, any adverse safety experiences in the Government-sponsored demonstration program could undermine future EV acceptance. In conducting the program, therefore, all possible precautions should be taken to assure that such problems are avoided. However, DOE has not done so.

In addition to safety concerns relevant to existing conventional vehicles, EVs present other hazards, such as

battery acid spills and electrical shock associated with their unique propulsion system. DOT has not developed safety standards affecting these unique hazards and has no efforts underway to do so. When establishing Federal Motor Vehicle Safety Standards (FMVSS) for conventional vehicles, DOT normally relies on operating and accident experience. Because so few EVs are on the road, however, only minimal data on electric vehicle operating experience or accidents are available. DOT plans to use the demonstration program to gain experience for developing special EV safety standards.

Meanwhile, DOT recognizes that accidents will occur during the demonstration program. In a report to DOE, for example, it estimated that 300 accidents would occur during the demonstration of the first 2,500 vehicles. Consequently, lacking formal standards, DOT recommended that DOE require all vehicles in the demonstration program to meet several suggested safety related performance capabilities.

DOE adopted some, but not all, of DOT's recommendations. For instance, DOE agreed to require that all demonstration vehicles meet all existing FMVSS applicable to EVs, such as passenger protection during crashes. Some other recommendations were not adopted. For instance, DOT suggested minimum levels of acceleration and hill-climbing ability to ensure safe interaction of EVs on public roadways. DOE's performance requirements fall short of DOT's recommendations, as shown below.

<u>Performance factor</u>	<u>DOT recommendation</u>	<u>DOE standard for passenger vehicles (note a)</u>
Time to reach 31 mph	12 seconds	15 seconds
Minimum speed on 10-percent grade	20 mph	15 mph

a/DOE's recommended performance standards published in the Federal Register for public comment in February 1978, required the vehicles to be capable of accelerating to 31 mph in 12 seconds as DOT suggested. These recommended standards also required the vehicles to be capable of achieving 15 mph on a 15-percent grade. DOE, based on public comment and analysis of the state-of-the-art vehicle test data, determined that the acceleration and gradeability requirements would have to be relaxed to assure that vehicles would be available for the first phase of the demonstration program.

These requirements are substantially below the capabilities of comparable conventional vehicles. For example, gasoline-powered vehicles DOE tested accelerated to 31 mph in about 7 seconds, or less than half the time of DOE's minimum standard. Moreover, the Center for Auto Safety, a non-profit public interest organization, has determined that DOE's performance standards are so low that vehicles built to meet such standards may present safety hazards to their occupants and others. According to DOE, the Center for Auto Safety offered no evidence to support its claim that less than equivalent acceleration would be a safety hazard.

Although DOE requires that EVs meet all applicable FMVSS, there is no assurance that compliance with such standards will be met. Manufacturers will themselves certify that their vehicles meet all safety requirements. DOE has contracted with the Department of the Army at \$15,000 per vehicle to test vehicle compliance with the performance standards, but these tests will not address safety. DOE has a \$400,000 interagency agreement with DOT to conduct partial safety tests on vehicles certified by the Army. DOT will test six to eight vehicles for compliance with braking, windshield defrosting, and 30-mph frontal impact standards. Testing costs per vehicle are estimated at \$21,000 plus the cost of the vehicle. The testing will not address rear, side, or roof impact due to collisions. Because additional vehicles must be destroyed, DOE claims such testing would be substantially more expensive.

Even vehicles that do not meet applicable FMVSS may still qualify for participation in the demonstration program. While DOT regulations require vehicle manufacturers to certify their vehicles' compliance with all FMVSS, manufacturers can obtain waivers for standards their vehicles do not meet. DOE's performance standards permit vehicles in the demonstration program if the manufacturer has such a waiver. As of June 1978, two prominent EV manufacturers had active waivers from DOT. DOE states that DOT's waiver privilege is intended to allow vehicles in early development to be market- and road-tested.

DOE also recognizes that accidents may occur during the program, but it has not followed DOT's recommendations for dealing with them. DOT recommended that a procedure for conducting detailed accident investigations be established to provide the data needed to formulate realistic safety standards. DOE has not done this because it believed DOT's suggestion would be too expensive to implement. Under DOE's approach, the demonstration manager is to be notified by telephone in case of an accident and a determination will be made

by the site operator on whether an independent investigation is necessary.

Federal, State, and local
government demonstrations
could be better planned

The act directs DOE to demonstrate vehicles in Federal, State, and local governments, as well as in the private sector. To date, DOE has emphasized the private sector. Little progress has been made in introducing EVs into the governmental sector.

Federal Government

DOE's program to demonstrate EVs in Federal agencies has not been well executed. Initially, DOE planned to place 35 vehicles with two agencies as part of its first-phase demonstration in fiscal year 1978. DOE advised us that it was unable to secure the participation of Federal agencies because

- other agency funds were not available,
- the agencies believed definitive information about EVs was lacking, and
- DOE did not have sufficient staff to adequately support a Federal demonstration program.

Consequently, while conducting our review, DOE dropped the plan in favor of a plan to give, at no cost to the agencies, five vehicles each to seven different agencies. This strategy was also changed. In commenting on a draft of our report, DOE officials said they now intend to provide \$60,000 to each of seven agencies for demonstrating five EVs each.

Five vehicles may not be enough for efficient operation. Managers outside the Federal program told us that maintenance facilities and mechanic and driver training programs must be provided at each site, regardless of the number of vehicles. They told us that about 20 vehicles are necessary to efficiently operate a garage having technically qualified personnel and equipment to properly service and repair the demonstration vehicles. DOE officials agree that more vehicles should be placed at each site, and they plan to distribute additional vehicles to the chosen agencies in subsequent years.

With the confusion to date, DOE has progressed little toward initiating EV usage in the Federal sector. This has occurred despite the act's directive (section 11) that all

Federal agencies study and arrange for the introduction of EVs into their fleets. Federal fleets represent valuable proving grounds for introducing, testing, and using EVs. We believe DOE should accelerate its efforts to ensure that this opportunity is exploited to its fullest potential.

State and local governments

Planning for the State and local government demonstration program has also not been well developed. DOE has only established preliminary contacts with these governments. It has not determined which governments have a bonafide interest in conducting a meaningful EV demonstration program. As with the Federal program, DOE officials say this lack of progress is due to a lack of DOE personnel.

Without assistance from a Federal program, we noted few State and local efforts underway. Until recently, only one staff member had been assigned to manage DOE's entire demonstration program, including the State and local government segments. DOE has now assigned management responsibility for its State and local demonstration to its San Francisco Operations Office. The field office is seeking formal proposals from State and local governments to participate in the program and it expects to make its selections during the early part of 1979.

We believe, however, that demonstrations in State and local governments present many of the same risks as those that will occur in the private sector. Here too, the unsheltered demonstration of vehicles with limited performance and potentially inferior reliability could disappoint vehicle users. It could also unnecessarily jeopardize future acceptance of more advanced vehicles when they become available. Consequently, we believe vehicle demonstrations in State and local governments may also be premature.

DEMONSTRATION RESTRICTED TO FEDERAL GOVERNMENT HAS MERIT

Demonstrating the EVs available today will present problems no matter what the setting. In terms of promoting widespread commercialization, few gains can be expected from a nationwide commercial demonstration of EVs that cost more and deliver less performance than conventional vehicles. To the contrary, such demonstrations could allow failures resulting from immature EV technology to damage commercialization prospects for better vehicles when they become available.

We believe, however, that a small, well-controlled Federal Government EV demonstration program would be beneficial.

Such a demonstration would provide a continuing market for vehicle manufacturers, allowing them to improve their vehicles. The program would also offer a real-world testing environment for determining where technological advancements are most needed. Operating data are needed to more efficiently direct R&D efforts. Finally, we believe a small demonstration is needed to show the Federal Government's commitment to EVs as a potentially important transportation option. Such a program would also help educate the public about future EV usefulness. Accordingly, the demonstration would provide the most realistic means of moving EVs from the research laboratory into the area of potentially practical vehicles.

Advantages of demonstrating EVs by Federal agencies

We believe the most appropriate setting for a controlled, continuing EV demonstration effort is within the Federal Government. Restricting the initial EV demonstrations to the Federal sector offers certain advantages over the existing plan which emphasizes private-sector demonstrations, such as

- potentially lower costs,
- reduced risk, and
- more suitable demonstration sequence.

Potentially lower costs

EV demonstrations in Federal agencies potentially would be less costly. Vehicles used in the demonstration would enter agencies' fleets as operating vehicles and enable them to reduce purchases of other nonelectric vehicles. Thus, in addition to obtaining data about EVs, the Federal Government would also obtain vehicles which it could use to help fill existing Government vehicle needs.

Second, by restricting the program to Federal agencies at this time, and temporarily reducing the number of vehicles involved, DOE could probably lower its management costs. Under the current program, DOE is paying a contractor \$10,000 per vehicle to manage its private-sector demonstration program. DOE is managing the Government sector programs itself.

Reduced risk

For several reasons, a Federal agency demonstration through the selective use of Federal fleets is also a less risky way of testing and evaluating EVs. First, vehicle use

can be better controlled. DOE officials told us that the only way to demonstrate the mandated 10,000 vehicles is through auto dealership networks. Under these circumstances, DOE has little control over how the vehicles are used or maintained. Moreover, failures resulting from use of vehicles in inappropriate ways will be highly visible and could be damaging to the future of EVs. Depending on how they are used, vehicles demonstrated in private commercial fleets could also be highly visible. Here, too, failures due to technological immaturity could affect future perceptions of the inherent value of the EV concept.

In Federal agencies, DOE could assure that vehicles would not be used in situations where they could not be expected to perform satisfactorily. Also, failures during testing would not be as visible.

Second, in planning its private-sector demonstration, DOE has identified a number of possible events that could adversely affect its program. A number of these would be avoided with a Federal agency demonstration. For instance, DOE recognizes that some of its site operators may drop out of the program before completing their 3-year responsibilities. This situation could pose contractual problems that create a negative image for EVs. In Federal agencies, this problem would not occur.

More suitable demonstration sequence

Finally, we believe a demonstration restricted to the Federal Government is a necessary preliminary/preparatory step to introducing EVs into the private sector. Before actively promoting EVs, DOE needs more information on their safety, reliability, and life-cycle cost.

Currently, neither DOE nor DOT has sufficient operating experience to precisely identify the safety hazards unique to EVs. We believe such information is necessary before large numbers of these vehicles are placed with the public.

DOE also has little information on vehicle reliability. In its report for DOE, Purdue University states that at the current level of technology, frequent vehicle reliability problems can be expected. Once again, such information should be well in hand before sponsoring commercial use of large numbers of vehicles.

Finally, it is also important to have meaningful life-cycle cost information that shows in which applications EVs can be successfully used. A controlled Federal agency EV demonstration could develop the data and identify feasible

vehicle uses before involving the vehicles in more visible private-sector demonstrations.

Opportunities for Federal EV use

Opportunities for EV use by Federal agencies exist today. As of September 1977, the Federal Government owned over 370,000 passenger vehicles and light trucks. In our report entitled, "Potential for Using Electric Vehicles on Federal Installations" (LCD-76-206, Mar. 3, 1976), we noted that EVs could be substituted for many of the vehicles used within Federal installations.

Despite these opportunities, one important obstacle to Federal EV use may exist. Recent General Services Administration appropriations bills--most recently Public Law 95-429 for fiscal year 1979--limit the cost of sedans purchased by Federal agencies to \$3,400 and the cost of station wagons to \$3,800. The cost ceiling does not apply to vans, trucks, or buses. DOE is currently studying the applicability of these cost limitations to the EV program and their impact on Federal EV purchases.

Coordinating existing EV use

As an important step in conducting its demonstration program DOE needs to determine what Federal agencies are already using EVs and to coordinate with those agencies having practical operating experience. Certain agencies have such experience. The U.S. Postal Service, for example, is operating over 350 electric jeeps and vans in mail delivery functions. This experience has provided valuable lessons on the special vehicle maintenance requirements, especially battery charging and watering. It has also helped develop driving techniques needed to deal with the vehicles' low-performance capabilities.

The U.S. Park Service has also independently replaced conventional vehicles with electric vehicles in several on-road and off-road applications. The Park Service offers a valuable testing environment in that it operates facilities in every U.S. region, over all types of terrain, and in all climates.

DOE in the past has not had effective contacts with either the Postal Service or Park Service in order to gain from their experience. DOE now plans to involve the Park Service in its demonstration program. We believe DOE should also improve its coordination with the Postal Service and any other agencies with EV experience to more effectively conduct its demonstration program.

CONCLUSIONS AND RECOMMENDATIONS TO THE SECRETARY OF ENERGY

Demonstrations are generally considered to be an effective mechanism for advancing technologies from R&D to the market place. However, care must be taken to ensure the technology is ready. The EVs available today are not adequately developed to realistically expect DOE's demonstration program to achieve widespread EV commercialization. Obviously, vehicles delivering inferior performance at a cost higher than conventional vehicles have low commercialization potential. Further, DOE faces many problems with its present program that could jeopardize future public EV acceptance. These problems include the use of vehicles in unsheltered environments and the failure to fully guard against potential safety dangers associated with EV use. Consequently, we believe that realistic benefits are too low and risks too high to proceed with the demonstration program as currently planned. With present vehicle technology, the Federal Government can best encourage EV commercialization through its own leadership.

Accordingly, we recommend that the Secretary of Energy

- postpone future private-sector, and State and local government-sector demonstrations until technology improves and vehicle reliability, safety, and reasonably competitive life-cycle costs are shown;
- use the Federal and ongoing private-sector demonstration programs to identify major technical problems and safety hazards, and develop data on vehicle reliability and life-cycle costs; and
- develop and report to the Congress a more reasonable strategy for the demonstration program in terms of timing and number of vehicles needed to be purchased, using optimal time phasing, which would take advantage of demonstration experience and expected R&D advances.

AGENCY COMMENTS AND OUR EVALUATION

In its letter commenting on a draft of this report (see app. I), DOE took exception with our recommendation to postpone private-sector demonstrations. DOE argued that private-sector demonstrations will have the greatest impact on the commercialization process.

DOE did not agree with our reasons for postponing private-sector demonstrations and believed its experience supports an opposite conclusion. Its strategy, DOE noted,

is to introduce current technology vehicles into the market sectors where they are competitive.

DOE also did not agree with our belief that the planned EV demonstration schedule will not permit the use of experience gained in initial phases to improve later phases. It characterized our recommendation as "stop-and-go market stimulation" and contends it would result in a disjointed program and destroy the credibility of the Government program with the EV industry.

We agree that private-sector demonstrations have the greatest impact on the commercialization process. However, because of this impact, we believe it is essential that only safe, reliable, and competitive vehicles be demonstrated. Otherwise, the demonstration may set back or adversely affect the ultimate goal of EV commercialization. The bases for our divergent views lie in our respective opinions as to the readiness of EVs for commercialization at this time. We believe that, for the reasons cited in our report, EVs are not yet ready to be demonstrated in the private sector through a Government-sponsored program. We believe it would be more appropriate to restrict at least the initial demonstrations to the Federal sector. When improved vehicles that are shown to be safe, reliable, and cost competitive become available DOE could then properly extend the demonstration program into the private sector.

With regard to modifying the current demonstration schedule, we do not believe that adding flexibility to provide adequate time to evaluate demonstration results would result in a disjointed program. Our recommendation in this regard does not necessarily mean that DOE should not annually purchase vehicles. Rather, time should be allowed for DOE to evaluate site operators before placing additional vehicles with them. This approach would not eliminate the addition of new site operators and purchases of vehicles during the time needed to obtain information on which to evaluate the existing site operators. In addition, DOE's fiscal year 1980 budget submission indicates that the third-phase demonstration is being reduced from 1,700 to 700 vehicles. As part of the rationale for this reduction, it states that it is vital to allow industry time to assimilate the results from early demonstration operations. We believe that this holds true for DOE as well.

We do not believe our recommended changes should be viewed as a lessening of the credibility of the Government's EV program. To the contrary, our recommendations are intended to strengthen the Government's commitment to pursue

the viability of EV's as a transportation alternative through a better controlled, more rational demonstration approach.

RECOMMENDATIONS TO THE
CONGRESS

In light of DOE's disagreement with our recommendations, the Congress needs to ensure that the EV program is effectively redirected. Such redirection could be accomplished as part of legislation resulting from congressional deliberations on the DOE fiscal year 1980 authorization and appropriation requests, or as part of the Congress' other legislative and oversight activities.

In order for the Secretary of Energy to effectively act on our recommendations, the Congress should also amend the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, as amended, to provide greater flexibility in both the timing of vehicle purchases and the number to be demonstrated. By providing greater flexibility in the timing of vehicle purchases, DOE would be able to make optimum use of results obtained from the initial demonstrations as well as allowing for the demonstration of advancements which result from R&D efforts.

In regard to the number of vehicles to be demonstrated, the Congress should provide greater flexibility by removing the requirement to demonstrate a specified number of vehicles. The act calls for demonstrating 10,000 vehicles in varying amounts over 8 years in three sectors: (1) private, (2) Federal, and (3) State and local government. Since our recommendation is to restrict demonstrations at this time to the Federal sector, we question the appropriateness of demonstrating the number of vehicles stated in the act.

In connection with providing demonstration program flexibility, the Congress should consider the Secretary of Energy's report pursuant to GAO's recommendation that he develop a reasonable demonstration strategy.

CHAPTER 4

ELECTRIC VEHICLES NEED A STRENGTHENED

RESEARCH AND DEVELOPMENT PROGRAM

EVs' performance and cost limitations must be overcome before DOE can expect to foster widespread commercialization through a demonstration program. The R&D program should be emphasized to bring about the needed technological advancements.

The Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, specifically requires R&D into electric and hybrid vehicle systems and energy storage systems to achieve the goal of reducing oil imports. While DOE's R&D program is directed toward carrying out the intent of the act, certain problems may be inhibiting the program's contribution to eventual EV commercialization.

PROGRAM DESCRIPTION

DOE's goal is to commercialize electric and hybrid vehicles. The R&D program contributes to achieving this goal through projects in the following areas:

- Battery development.
- Vehicle systems development.
- Component development.
- State-of-the-art assessments.
- Other EV research activities.

The battery development projects concentrate on improving commercially available battery technologies. DOE has other ongoing battery research efforts with advanced batteries and new concept energy storage systems. ANL is the project manager for DOE's battery energy storage systems work directed toward EVs. As of June 1978, DOE awarded eight contracts to improve three alternative batteries--lead-acid, nickel-zinc, and nickel-iron. Battery development costs amounted to approximately \$11 million through fiscal year 1978.

Vehicle systems development projects study the vehicle in its entirety and work toward making the various parts of the overall vehicle compatible. The primary emphasis of this project is the design, development, and construction of two

advanced electric cars. This work is being done by the General Electric Company (GE) and the Garrett Corporation. These projects will be followed by similar design efforts for hybrid vehicles. JPL was designated technical manager for the GE and Garrett projects and program manager for hybrid systems projects. Vehicle systems development costs amounted to approximately \$11 million through fiscal year 1978.

Component development projects focus on improving off-the-shelf components, in such areas as electric motors, motor controllers, transmissions, and instrumentation. The project is just beginning and will involve a variety of projects, all of which will be done by contractors. About 20 separate contracts were underway by the end of fiscal year 1978. LRC has been designated as the program manager for the component development projects. Component development costs amounted to approximately \$3.6 million through fiscal year 1978.

State-of-the-art assessments characterize the present electric and hybrid vehicles and serve as a baseline for comparing technological improvements. Several different vehicles are tested each year to determine the status of current vehicle technology. LRC was responsible for the assessments in 1977, and JPL and an Army installation shared the responsibility in 1978. State-of-the-art assessments costs amounted to approximately \$2 million through fiscal year 1978.

Other EV research activities include development of an electrified roadway concept and studies such as regenerative braking. These activities, amounting to approximately \$3.5 million through fiscal year 1978, are being conducted at various laboratories.

PROBLEMS WITH PROGRAM IMPLEMENTATION

We found the following problems with DOE's implementation of the R&D program:

- Marginal battery development efforts are being funded.
- Vehicle systems projects are experiencing cost overruns, contract scope reductions, and performance shortfalls. Moreover, detailed plans to use these vehicles to facilitate EV commercialization have not been developed.
- Developing electrified roadways is of questionable value at this time.

Marginal battery development
being funded

DOE and many in the EV industry view improving EV batteries as the most important step toward developing a vehicle capable of achieving widespread EV commercialization. As part of its overall battery research program, DOE plans to spend about \$28 million during fiscal years 1978-81 for improving commercially available batteries, about one-fourth of which is to be spent on improving lead-acid batteries.

For various reasons, we believe DOE's research on lead-acid batteries is an ineffective use of limited R&D funds. According to several studies, lead-acid batteries will not have the performance capabilities to achieve widespread EV commercialization. For example, a 1974 Massachusetts Institute of Technology study pointed out that EVs using lead-acid batteries can never penetrate more than a negligible fraction of the passenger car market.

Battery manufacturers and the major automakers also agree that lead-acid batteries have limited potential. Battery manufacturers with whom we spoke believed that lead-acid batteries can only satisfy the requirements of limited-use vehicles. They believed that such batteries could not be used to successfully market passenger or commuter vehicles because the power demands for acceleration and other performance characteristics cannot be met. The automakers we spoke with informed us that widespread commercialization will not be realized as long as EVs are powered by lead-acid batteries.

Research on lead-acid batteries also runs counter to DOE's own battery research philosophy. This philosophy is to support high-risk, long-term battery R&D projects which are less likely to be undertaken by private industry. Lead-acid batteries, which are widely available, are neither high-risk nor long-term. Moreover, these batteries are the focus of battery manufacturers' research for use in industrial applications (e.g., forklifts) and limited-performance EVs (e.g., golfcarts).

While DOE agrees that lead-acid batteries will not be the ultimate battery needed to bring about widespread EV commercialization, it initiated the program to accelerate development of improved batteries in a time frame consistent with the EV demonstrations as stipulated in the act. The three batteries--lead-acid, nickle-zinc, and nickle-iron--selected for near-term development were considered the only ones sufficiently mature to be used in the early demonstration phases. DOE believed improving these systems would help achieve interim goals and aid in assessing EVs' long-range viability.

The program was established over concerns expressed by ANL in a September 30, 1977, letter to DOE, that the entire battery R&D program was directed toward the delivery of batteries to meet demonstration schedules, rather than to serve commercialization objectives.

According to various studies, other battery concepts such as sodium-sulfur, zinc-chlorine, and lithium-metal-sulfide have more potential in meeting EV demands. For example, a 1977 Lawrence Livermore Laboratory study, "Energy Storage Systems for Automobile Propulsion," identified several promising candidates which could help achieve widespread EV commercialization. The Purdue University study also concluded that other battery systems exhibit superior performance over lead-acid batteries and, therefore, should be developed for powering EVs.

DOE, in addition to the near-term EV battery program, directs R&D funds toward exploring battery concepts, including those suggested by the studies. Having several potential applications, this research is considered to be longer-term and higher-risk. According to DOE, many of these projects may well have application to EVs. It was estimated that funding for the advanced and exploratory batteries with potential EV usage amounted to about \$12 million during fiscal year 1978.

We believe the EV battery R&D program should be redirected toward batteries which have the potential capability to supply the power requirements of a commercially viable EV and should not be geared solely toward meeting the act's established demonstration schedule.

Vehicle systems projects experiencing problems

Vehicle systems development is the largest part of DOE's R&D efforts to date. Within this area, the most important element is the effort to develop advanced EVs through contracts with GE and the Garrett Corporation. The efforts under each of the contracts are directed toward the design and development of two test vehicles incorporating advanced technology. The contracts stipulate four-passenger cars similar to today's sub-compact vehicles with specific performance goals which include: (1) a cruising speed of 55 mph, (2) a maximum of 6 hours to recharge the batteries, (3) a maximum initial purchase price of \$5,000 (1975 dollars) and life-cycle cost of \$0.15 per mile, and (4) meeting all FMVSS in effect on the contract award date (April 1977). The major innovations of Garrett's approach include a new drive-train design incorporating a flywheel and a unitized plastic body

and frame. GE's major innovations include advanced EV electronics and a car body with low wind resistance.

At present, the projects are experiencing difficulties, including:

- Almost \$2 million in cost overruns.
- Contract scope reductions, including elimination of certain safety tests to minimize cost overruns.
- Performance shortfalls.

In addition, DOE has no plans for using the vehicles to facilitate EV commercialization.

Cost overruns, contract scope reductions, and performance shortfalls hamper vehicle systems projects

Cost overruns are occurring within both the GE and Garrett contracts. Together, these amount to about \$2 million out of a combined initial contract price of \$11.7 million. The initial contract price for the Garrett cars was \$5.8 million. DOE's estimate for completing the contract is now just under \$7 million. The initial contract price for the GE cars was \$5.9 million, whereas DOE's current estimate for completing the contract is \$6.5 million.

Areas experiencing major cost growth in the Garrett contract include the flywheel, transmission and drive assembly, and the vehicle structure. Two of these involve drastic departures from existing technologies. The unitized plastic body and frame, and a lightweight composition flywheel have never been produced before. Significant areas of cost increase in the GE contract include additional engineering and manpower costs related to the car's body and frame, as well as increases affecting development of the car's battery charger and controller.

In an effort to hold down costs, DOE deleted or reduced a number of requirements which were originally part of both the Garrett and GE contracts. On the Garrett project, nine items totaling an estimated \$295,000 have been reduced or omitted. These include maintenance manuals, independent economic cost analyses, and durability testing. DOE also chose 23 items for reduction or omission in the GE project, amounting to approximately \$535,000. These items included studies to assess the car's reliability and maintainability, and a report identifying the requirements for spare parts.

Scope reductions also include the elimination of certain safety tests. For instance, final safety tests to demonstrate handling, braking, and crashworthiness have been omitted. In addition, a safety-reporting requirement has been discontinued for the Garrett car. JPL officials stated, however, that safety tests are being performed on individual Garrett car components.

In addition to costing more than originally anticipated, neither the Garrett nor the GE cars will achieve all their design goals. Even though the contracts are over half-completed, currently available information shows that both the Garrett and GE cars will be unable to meet the 6-hour maximum battery recharge time. The goals of producing the vehicles for \$5,000 also may not be attainable. In addition, the cars will not meet two of the FMVSS that were in effect in April 1977. DOE officials informed us, however, that the FMVSS not being met are not significant.

No plans for using GE and
Garrett cars to facilitate
EV commercialization

The major objective of the GE and Garrett projects is to develop the performance potential and economic viability of advanced EV designs to show that the EV concept is a promising commercialization candidate in the near-term. Although the vehicles have been designed and development is nearing completion, detailed plans have not been developed for using the cars as catalysts for EV commercialization.

DOE plans to exhibit the cars widely, and also use them as research test-beds. DOE hopes that consumers and EV manufacturers will recognize their technical feasibility, and that some of their technological advancements will be adopted by the industry.

However, no detailed follow-on strategy has been developed to use the results of the GE and Garrett efforts. Specific plans should include: (1) analyses of the commercial producibility and economic viability of the cars' concepts, (2) industry's interest in and problems with making use of the technological advancements, and (3) how the technology of improved components can be transferred to EV producers.

Electrified roadways of
questionable R&D value

Under an electrified roadway concept, EVs would be propelled on high-speed highways with batteries replenished by electrical current transferred from cables embedded in the

roadway. EVs would continue to use battery power to operate on city and suburban streets which connect with the highways. Such roadways would extend vehicle range and permit the high-speed travel to which today's drivers are accustomed. The cost of such a system, as estimated in a DOE-sponsored report, is about \$700,000 to electrify each mile of two-lane roadway. Through fiscal year 1978, DOE spent \$490,000 on this project, and work is continuing.

For several reasons we believe funding research on this concept is questionable. For example, the system seems inconsistent with one of the act's objectives--improving electric utility efficiency by using available generating capacity more efficiently. Presently, most utilities have capacity built to satisfy peak-hour power demands, which lies idle during off-peak (primarily night time) hours. The act expected that EVs would be charged during off-peak hours and hence provide a means of leveling power requirements during a given 24-hour period.

Widespread construction and use of electrified roadways would worsen rather than improve utilities' capacity utilization problems. EVs would presumably use electrified highways most during morning and evening rush hours. These periods coincide roughly with the peak periods as they are now. By increasing power demand during peak periods, EV use would then require that additional capacity be available which would lie idle during off-peak hours.

Further, electrified roadways may present safety problems. A DOE study noted possible safety hazards, including exposure to high voltage and magnetic effects on heart pacemakers. Some concern has also been expressed that roadway debris attracted magnetically to the electric cable, could become airborne projectiles when struck by an EV.

Finally, developing electrified roadways at this time assumes that battery-powered vehicles will become a common form of transportation in the near future. We agree that EVs present a transportation alternative that should be explored, but their future is not yet certain. We note, however, that DOE is placing more emphasis on the development of hybrid vehicles because of their potential for greatly extending vehicle range. Therefore, we believe it is premature to develop an electrified roadway concept, predicated on the commercialization of EVs, which itself has not yet been shown.

Accordingly, we believe devoting research funds to developing electrified roadway systems at this time appears questionable because of their negative effects on utility

efficiency, potential safety hazards, and the uncertain commercialization of EVs.

CONCLUSIONS AND RECOMMENDATIONS
TO THE SECRETARY OF ENERGY

Improving EV batteries is viewed as the most important step to creating a commercially viable EV. DOE's battery program appears, however, to be directed toward developing at least one battery with little chance of bringing about widespread EV commercialization. We believe battery candidates competing for available research dollars should be carefully evaluated to determine their potential for supplying the power requirements needed for widespread commercialization of EVs.

With respect to the vehicle systems development program, we found that the overall objective of the GE and Garrett projects was to develop the performance potential and economic viability of advanced EV designs. DOE has not developed a detailed follow-on strategy for using the cars as a catalyst for EV commercialization. We believe it is important to use these R&D products to further EV commercialization.

Negative effects on utility efficiency, potential safety hazards, and the uncertain commercialization of EVs all raise doubts about the practicality of electrified roadway systems. We believe this project offers limited potential for entering the Nation's transportation system and thus devoting EV research dollars to develop such a system at this time appears questionable.

Finally, while DOE is currently giving its R&D efforts highest funding priority, we are concerned that the importance given to R&D relative to other EV program categories in recent years has been declining. We believe that the ultimate success of EV commercialization is dependent on technology advancements which must come from DOE's efforts and other R&D efforts. Consequently, the R&D program should receive the highest funding priority within the EV program until such time as a commercially viable vehicle is achieved.

Therefore, we recommend that the Secretary of Energy

- Continue granting R&D the highest funding priority within the EV program.
- Redirect the EV battery development program toward batteries potentially capable of ultimately bringing about widespread EV commercialization.

--Evaluate the effects of the vehicle systems development projects and develop a strategy for using their technological advancements.

--Reexamine the potential of electrified roadway systems in relation to other competing EV R&D efforts.

AGENCY COMMENTS AND OUR EVALUATION

In commenting on a draft of this report (see app. I), DOE disagreed with our recommendation to evaluate the need for lead-acid battery development. DOE pointed to a GRC study conducted for them which states that:

"A range of only 75 km (46 miles) between recharging would suffice for the urban driving of secondary drivers on 95 percent of the days they drive. This is within the reach of today's electric cars."

DOE felt that lead-acid batteries would be an important power source for commercial vehicles for many years to come.

DOE emphasized that there are differences between lead-acid batteries for EVs and those for forklifts and golf cars. DOE believes that the lead-acid battery research program is properly directed toward meeting the power requirements of commercially viable EVs.

Based on our review of the vehicles surveyed in GRC's study and DOE's state-of-the-art assessment, it is our belief that it is unclear as to whether the vehicles currently available can meet 95 percent of second car needs. GRC's criteria for meeting such needs require a range of 46 miles and freeway driving capability. The GRC's study also states that freeway driving requires at a minimum the ability to accelerate from 0 to 39 mph in at least 10 seconds for safety reasons. None of the cars cited as representative in GRC's own survey could accelerate quickly enough to meet the freeway driving minimum. Further, none of the cars in DOE's state-of-the-art assessment could meet these requirements. Therefore, we do not believe that it has been shown that vehicles having the limited capabilities of today's commercially available EV's can indeed meet 95 percent of second car needs.

Moreover, we have frequently heard debate as to whether consumers will buy vehicles meeting 95 percent of their driving needs. Automobile manufacturers we talked with pointed out that since they never had to market limited-range vehicles there is little marketing data available to argue conclusively. However, we believe the issue is sufficiently

unsettled to leave some doubt as to the commercial viability of such a limited-range EV, even as a second car.

Further, assuming today's lead-acid battery technology could have potential for penetrating this market, we believe it would be more advantageous to use battery R&D funds to further the development of other battery systems which show potential to penetrate an even greater segment of the U.S. vehicle market.

Our discussions with battery manufacturers and researchers led us to conclude that the packaging of lead-acid batteries to meet specialized needs (EVs, golf cars, forklifts, etc.) was mostly the balancing of certain tradeoffs (power, energy, life, etc.) and not a problem requiring technological breakthroughs. Establishing production facilities to meet relatively low-volume needs appeared to be a greater obstacle. We were told by a representative of one battery manufacturer that if his company were to enter the EV battery market, it would not invest in a lead-acid battery facility, but it would build a more advanced battery system which would have a broader market and a more promising future.

RECOMMENDATIONS TO THE CONGRESS

In light of DOE's disagreement with our conclusions and recommendations on the EV battery development program and DOE's lack of comments regarding our other R&D recommendations, the Congress should take appropriate steps to ensure that DOE redirects its R&D program in accordance with our recommendations. The Congress' ongoing deliberations on the DOE fiscal year 1980 authorization and appropriation requests provide an excellent opportunity to ensure (1) the EV battery development program focuses on those batteries capable of ultimately bringing about widespread EV commercialization and (2) the funding priority for R&D is continued. Through these deliberations or other congressional oversight activities, the Congress could also ensure that our recommendations on vehicle systems development and electrified roadways are effectively carried out. Specifically, the Congress should direct the Secretary of Energy to establish and pursue a strategy for commercializing the products of development efforts and to fully justify--to the Congress' satisfaction--the requested funding for electrified roadway development in relation to other competing R&D efforts.

CHAPTER 5

SMALL BUSINESS PROGRAM

NEEDS REEXAMINATION

The Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 includes provisions to protect and encourage small business involvement in the EV program, and to ensure their participation in the commercialization process. Our review of selected aspects of the act's provisions showed that (1) the planning grant program intended to aid small businesses has taken about 2 years to be implemented and that once it is implemented, it may be too restrictive to be very effective and (2) loan guarantees for EV and component production may be premature.

BACKGROUND

The U.S. EV industry is comprised primarily of small entrepreneurs, each attempting to build and market vehicles. Limited capital availability, small production capabilities, and small R&D efforts characterize the industry. These enterprises, however, have accounted for most of the EVs on the road today.

The act requires DOE to encourage and protect small businesses by taking such steps as necessary to ensure that they have a realistic opportunity to participate in the program. Among other things, the act directs DOE to

- make planning grants available to small businesses requiring financial assistance in developing and submitting proposals for Government contracts, and in entering into such contracts, and

- issue loan guarantees to primarily small businesses to ensure capital availability.

PAST EFFORTS TO ASSIST SMALL BUSINESS HAVE HAD MIXED SUCCESS

DOE has taken actions and instituted policies to assure small business participation in the EV program. Through interagency agreements and memoranda, DOE directed its primary R&D managers--LRC, JPL, and ANL--to give contracting preference to small businesses. Also, each R&D manager and DOE headquarters has specialists available to assist small businesses in Government contracting. Further, DOE has a policy of examining planned procurements to determine if small businesses could perform the required tasks. If DOE makes

such a determination, it may restrict the procurement to small businesses only.

To date, these efforts have resulted in mixed success. In early 1977, DOE attempted to provide approximately \$500,000 to small EV manufacturers through the purchase of two improved EVs from each of five manufacturers. This was commonly referred to as the "2 x 5 procurement." DOE intended to involve small businesses in the program and at the same time stimulate the production of EVs. Although this procurement action ultimately led to DOE's awarding contracts to four small business firms in June 1978, it resulted in a number of negative feelings among EV manufacturers toward the program. These negative feelings were primarily attributed to the following factors.

- Only four, instead of the intended five, small business firms were awarded contracts.
- Several of the 38 manufacturers submitting proposals had perceived irregularities in the overall procurement process and accordingly some initiated protest actions.
- Some of the successful proposers believed that DOE's decision to delay contract awards until after the completion of a lengthy protest process was detrimental to their financial status.

As of July 1978, of the \$45 million obligated in the program, only \$2.5 million (or 5 percent) had gone to small businesses. For fiscal year 1977, DOE reported that 11.3 percent of the former ERDA's total obligations went to small businesses. However, of the \$52 million obligated under the EV program through September 1978, about \$5.6 million went to small businesses, with about \$2 million going to small EV manufacturers.

While DOE has not been entirely effective in assisting small businesses to date, there are indications that small businesses may receive increased support in the future. DOE has begun tracking small business involvement in the program each quarter. DOE is also considering another 2 x 5 type of procurement during fiscal year 1979. It will not be reserved entirely for small businesses, however.

In connection with the new 2 x 5 effort, DOE is considering holding procurement seminars to aid small businesses which are having difficulty entering into DOE contracts. DOE is also preparing a small business procurement digest that

clarifies the procurement process for small businesses wishing to participate in the EV program.

Finally, DOE hopes that small EV manufacturers will be assisted through R&D program results, even if they are not involved in the actual R&D work being done. It believes that products resulting from the program will eventually be available for use by small EV manufacturers. For example, JPL developed a general purpose computer program to predict an EV's performance characteristics under various designs and component configurations. The program is available to small EV manufacturers and others through a nationwide timesharing network.

PLANNING GRANTS TOO RESTRICTIVE

The Congress sought to encourage small business participation in the EV program by providing funds through the use of planning grants to assist in obtaining Government contracts. However, the planning grant program may be too restrictive to be very effective. These grants are being used primarily for obtaining unsolicited proposals.

The act was passed September 1976, but the first planning grants were not issued until September 1978. During the 2 years that elapsed since the passage of the act, DOE (1) contracted for a study of planning grants, (2) prepared procedures for administering the grants, and (3) developed a mechanism to solicit responses from small businesses. There was also about a 6-month delay in starting this effort because, according to program officials, there was a lack of staffing.

Meanwhile, the EV program has proceeded, and over \$52 million has been obligated, with \$5.6 million going to small businesses. Some small businesses, which may not have sufficient resources to prepare acceptable proposals, did not have the benefit of the planning grants intended by the Congress.

The grants appear to be of limited value. These grants, amounting to about \$10,000 each, are being used primarily for preparing unsolicited proposals. The only instance where planning grants could be used to respond to a competitive R&D program procurement is when a grant happens to be requested in the same technical area as an issued or pending solicitation. Since planning grants are issued at only one time during the year, the likelihood of such a coincidental occurrence is remote. DOE considered 4 of the 27 grants awarded in September 1978 to be responsive to a competitive procurement.

The planning grants also cannot be used for obtaining contracts to furnish vehicles under the demonstration program or for obtaining loan guarantees. While recognizing these limitations, DOE officials stated that it would be unworkable to structure the program otherwise. They believe that if planning grants were used for responding to specific requests for proposals, the time between the issuance of such requests and the due date for submission of responses would have to be lengthened to accommodate the issuance of the planning grants, thus the procurement process would be delayed.

We believe the planning grant program, as currently structured, will not be very effective in bringing about small business participation in the overall program. DOE should evaluate the results of its initial efforts, along with the planning grant concept, and consider expanding the planning grant program to incorporate other procurements, and not just unsolicited proposals.

LOAN GUARANTEES FOR PRODUCTION, PREMATURE

In 1976, the Congress recognized that many EV manufacturers did not have sufficient capital to participate in introducing their vehicles into the transportation fleet. Basically, DOE is authorized to guarantee the repayment of loans for up to 90 percent of the project's total cost, with a maximum guarantee of \$3 million--provided the total guarantees outstanding do not exceed \$60 million at any one time. DOE has received authority from the Congress to guarantee about \$9 million in loans for fiscal year 1979.

Loan guarantees were included in the act to assist in meeting capital needs. Loan guarantees are authorized for

- R&D,
- prototype development,
- capital equipment construction, and
- initial operating expenses associated with EV development and production.

DOE has contended that loan guarantees for research and prototype development are not appropriate. DOE officials told us that few R&D products are ever commercially viable, and consequently, it is doubtful that firms in the EV industry could secure bank loans for R&D projects even with Federal guarantees. We agree with DOE that without a reasonable

chance of repayment loan guarantees for R&D should not be issued.

We believe also that it is premature to emphasize loan guarantees for vehicle and component production. EVs available today have not been shown to be commercially viable. They can travel only about 20 to 77 miles before needing recharging. Their ability to accelerate, climb hills, and operate at high speeds is also limited. Further, at the present level of technology, vehicle reliability problems can be expected. Finally, studies show that EVs initially cost about twice as much as conventional vehicles, and their life-cycle costs are uncertain. The ability of loan guarantee recipients to repay these loans from proceeds of the sale of their EVs is, therefore, questionable.

In these circumstances, evaluating a loan guarantee applicant's marketing strategy, as part of an assessment of repayment capability, will be crucial. However, little data exists on which to make such evaluations. As stated earlier, automakers told us they have had no experience in marketing limited-range vehicles and, as a result, have limited information on the demand for today's limited-performance electric vehicles. Until such data is available, we believe DOE will be unable to realistically evaluate a loan guarantee applicant's marketing claims and thereby assess the potential for loan repayment.

In this connection, we believe DOE should not issue loan guarantees for vehicle and component production until it can be reasonably assured that EVs are commercially viable and that a reasonable opportunity for loan repayment exists.

CONCLUSIONS AND RECOMMENDATIONS TO THE SECRETARY OF ENERGY

While the Congress sought to protect and encourage small business involvement in the EV program, DOE's efforts to date have met with mixed success. The planning grant program has taken 2 years to be implemented and, as presently structured by DOE, in effect precludes the use of grants for procurements in areas other than unsolicited proposals.

We believe the loan guarantee program for vehicle and component production is premature because the commercial viability of EVs has not been shown.

Accordingly, we recommend the Secretary of Energy

--Study the planning grant program results and, if warranted, develop a mechanism to expand the program to

include procurements in addition to unsolicited proposals.

--Delay issuance of loan guarantees for vehicle and component production until EVs are shown to be commercially viable, and information is available to demonstrate a reasonable opportunity for loan repayment.

AGENCY COMMENTS AND OUR EVALUATION

DOE, in commenting on a draft of this report (see app. I), disagreed with our recommendation to postpone issuing loan guarantees for the production of electric vehicles and components. It contended that the loan guarantee program is needed because banks will not make loans to borrowers for commercially unproven products. DOE further pointed out that its loan guarantee program regulations prohibit issuing loan guarantees unless there is "reasonable assurance of loan repayment." DOE concluded that the commercial viability of the products offered for sale by the borrower must be established to a reasonable degree before approving a loan guarantee application.

We agree with DOE's contention that banks will not normally make loans for commercially unproven products and that the commercial viability of the products must be established before a loan guarantee can be approved. We believe further, however, that EVs have not yet been shown to be commercially viable, nor that a market actually exists. It will be extremely difficult to evaluate loan guarantee applications to ensure loan repayment. We believe that loan guarantees should be postponed until such time that EVs are commercially viable and information is available to realistically evaluate a borrower's marketing claim.

RECOMMENDATIONS TO THE CONGRESS

Because of DOE's disagreement with our position on loan guarantees, the Congress should direct the Secretary of Energy to limit vehicle and component production loan guarantees to those cases where EVs' commercial viability can be clearly shown and a reasonable opportunity for loan repayment exists. This can be accomplished during the Congress' monitoring of DOE's loan guarantee program or through the annual congressional legislative and oversight review of DOE's authorization and appropriation requests.

In addition, since DOE did not address our recommendation pertaining to planning grants, the Congress may wish to

monitor DOE's planning grant program to ensure that it achieves optimum success in bringing about small business participation in the overall program.



Department of Energy
Washington, D.C. 20545

January 10, 1978

Mr. J. Dexter Peach, Director
Energy and Minerals Division
General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

We appreciate the opportunity to review and comment on the GAO draft report entitled "Electric Vehicles Need Improvement Before They Can Be Successfully Commercialized." Informal comments on an initial draft report were submitted to members of your staff on December 1, 1978. Some of our comments, but not all, were incorporated into a revised draft report. Our views with respect to the revised draft report and the recommendations contained therein follow:

The GAO draft report, while agreeing with most of the findings, policies, and requirements of the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, as amended in 1978, disagrees with a key feature of the law - the required initiation of a chain of demonstration efforts involving the private sector. We do not agree that the demonstration of electric vehicles in the private sector is premature. The law requires DOE to arrange for vehicles to be demonstrated in the private sector and by the Federal Government, and State and local governments. Contrary to the opinions expressed by the draft report, we believe that the private sector demonstrations will have the greatest impact on the commercialization process. Our view is reinforced by a recent press release by AT&T that indicated that 20,000 of its vehicle fleet could be replaced by electric vehicles with performance capabilities available today and an additional 20,000 vehicles as this performance improves.

We do not agree with the view that scarcity of data, limited range vehicles, the need to improve technology, etc., should postpone the demonstration effort in the private sector. Our experience to date supports an opposite conclusion. The DOE program intent is to introduce current technology vehicles into those market sectors where they are competitive and expanding those market sectors as new technology becomes available. To increase the probability of commercialization, the commercial demonstration effort in parallel with research and development is the preferred plan as envisioned by Congress in the Act.

Director , Energy & Minerals Division

Although the law is titled the Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976, the draft report fails to consider any potential of hybrid vehicles in market penetration or petroleum savings. The hybrid research and development part of the DOE program is important and the potential for market penetration and petroleum savings could be equal to or greater than electric vehicles. Electric and hybrid vehicles are not mutually exclusive transportation options. DOE believes that the two technologies are synergistic, i.e., infrastructure developed for electric vehicles would be applicable to hybrid vehicles and acceptance by the public of longer range hybrid vehicles would pave the way for acceptance of electric vehicles as second cars. DOE objects to the omission of the potential impact of hybrid vehicles in the GAO report.

We do not agree with the GAO statement concerning the commercialization potential for lead/acid batteries. A General Research Corporation (GRC) report states: "A range of only 75km (46 miles) between recharges would suffice for the urban driving of secondary drivers on 95 percent of the days they drive. This is within the reach of today's electric cars." DOE feels that lead/acid batteries will be an important power source for commercial vehicles for many years to come.

The draft report states lead/acid batteries are widely available and that research for electric vehicles is unnecessary. However, batteries for electric vehicles are significantly different than for forklifts or golf cars. We disagree that research on lead/acid batteries for electric vehicles is not required and believe that its battery R&D program is directed toward batteries that have the power requirements of a commercially viable electric vehicle. We also take exception to the unsupported opinion stated on page 53 that the R&D is "geared toward meeting an artificially established demonstration schedule."

The demonstrations of electric vehicles will not be complete until the end of 1980. Some of the site operators will receive a second allocation of vehicles in 1979 or 1980 to extend the experience and data flow for several more years. Data from the field experience is fed into the need for R&D and problem solving in batteries, chargers, component problems, etc. Product improved vehicles developed by R&D should be utilized in the demonstration fleet. The stop-and-go market stimulation suggested by the draft report would result in a disjointed program. It would destroy the credibility of the Government program with battery, component and electric vehicle manufacturers that are starting to develop a viable electric vehicle industry. We therefore

Director, Energy & Minerals Division

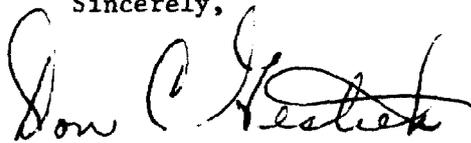
disagree with the draft report that the annual demonstration of electric vehicles does not permit the use of experience gained in initial phases to improve later phases.

In regard to the loan guaranty program, it is needed because the banks will not make loans to borrowers for commercially unproven products. It was the original intent of Congress to support the infant industry by capital assistance. We therefore disagree with the report statement, "The loan guaranty program is premature because.... The commercial viability of electric vehicles has not yet been proven."

The GAO position on delaying the loan guaranty for vehicles and components until they are commercially competitive again shows a lack of understanding of the program. Under Loan Guaranty Program Regulations, DOE may not issue a guaranty unless there is "reasonable assurance of loan repayment." Therefore, the commercial viability of the products offered for sale by the borrower must be established to a reasonable degree before approving a loan guaranty application.

Members of your staff have been furnished additional comments of an editorial nature for consideration in the preparation of the final report. We will be pleased to provide any additional information you may require.

Sincerely,



Donald C. Gestiehr
Acting Director
GAO Liaison

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