facilities. In other words, drive-through facilities are not always the fastest means of doing business. An economic guideline was established in this study to help the customer decide which type of facility to use.

It can also be concluded that many of the service-time and waiting-time characteristics found in this study can be of use in determining adequate storage design characteristics for drive-through facilities. Developing a proper design for the expected number of drive-through patrons is essential to the effectiveness of the drive-through system. Inadequate design can lead to traffic problems that can contribute to congestion on the surrounding street network and to inefficient operation that discourages business.

Based on observations of customer preference, another conclusion of the study is that the drive-through is certainly a convenience for which Americans are willing to pay a premium in user costs. Whether the reason is the desire of customers to remain in the comfort of their automobile or the convenience the drive-through provides of conducting business in more casual attire, the drive-through has made its mark on our society and will continue to provide service for many years in the future.

It has been documented in this study that drive-through facilities consume thousands of gallons of excess fuel on an annual basis. In the event of another serious fuel shortage, the use of drive-through facilities in areas where adequate parking is available should be discouraged as a public policy in an effort to conserve fuel that would otherwise be consumed in an unproductive and wasteful manner.

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Utility Industry Progress Toward Implementing Electric Vehicle Introduction

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ABSTRACT

The work of the Electric Vehicle Development Corporation (EVDC) is summarized. Founded in 1983, EVDC is charting and pursuing a realistic course for electric vehicle (EV) commercialization in the United States. The corporation's first objective is to support the development of an EV for use in commercial fleets. EVDC plans to demonstrate a market-acceptable commercial EV that uses near-term battery and drivetrain technology in the late 1980s. To accomplish this, five interrelated elements are being addressed: market identification, electric van specification, organization participation, electric van development, and financing and promotion. An advanced EV is expected to be introduced in the early 1990s. EVDC is moving from a technology-driven toward a market-driven approach to EV promotion that emphasizes the vehicle's advantages to the end user or consumer. EVDC hopes to accelerate EV promotion through coordinated vehicle design efforts, performance testing, and EV demonstrations, and by inducing special electric utility incentives such as lower off-peak rates. The coordinated participation of various EV stakeholders (the U.S. Department of Energy, the EV User Task Force, manufacturers, and the Electric Power Research Institute) is required to ensure that EVDC's planned EV introduction strategy is successful. Drawing these diverse organizations together is an arena in which EVDC can play an important leadership role.

The Electric Vehicle Development Corporation (EVDC) is a nonprofit organization formed in November 1983 to advance the development and introduction of electric vehicles (EVs). The corporation's nucleus consists of 30 U.S. utilities that serve a collective population of over 70 million consumers. By the end of 1985, EVDC membership is expected to include more than 50 utility companies as well as business and industrial organizations with EV interest.

EVDC's most important role is to chart and pursue a realistic course for EV commercialization in the United States. EVDC has developed a step-by-step approach to accomplish this commercialization and is working with and through other organizations toward effective, rapid attainment of commercialization. The approach is identified, the steps are delineated, and the progress made thus far is summarized.

APPROACH AND OBJECTIVES

EVDC's approach to EV commercialization, together with an implementation strategy, are outlined in the following paragraphs. The first commercialization objective is to develop an EV and support system for use within commercial fleets. This vehicle will utilize near-term battery and drivetrain technology. EVDC plans to demonstrate a market-acceptable commercial EV in the late 1980s. Introduction of EVs into the broader personal transportation market--the second commercialization objective--is tied to the availability of advanced battery and drivetrain technology that can satisfy the more demanding performance requirements of this market segment. The time frame for the introduction of an advanced EV is expected to be the early 1990s.

INTRODUCTION STRATEGY

To accomplish the first objective (fleet EV), the following five interrelated strategy elements are required:

1. Market identification,
2. Electric van specification,
3. Organization participation,
4. Electric van development, and
5. Financing and promotion.

Market Identification

A review of the EV literature in 1982 concluded that appropriate information needed to justify further EV market development or demonstration activities was seriously lacking. Prior research and demonstration results had produced mixed conclusions with respect to EV market potential. More important, they lacked the methodological rigor and detail needed for planning and investment decisions. This was especially the case with respect to commercial-sector EV applications, which may hold the most promise for quantity EV adoption during the next decade.

In light of this, the Institute for Social Research of the University of Michigan was commissioned by Electric Power Research Institute (EPRI) and the Detroit Edison Company to perform a pilot study on market prospects. This pilot study, conducted in early 1983, had two distinct components:

• A pilot survey of commercial fleet operators in the Detroit Edison service area. This survey provided both an initial estimate of potential EV market size and a methodology through which the size and characteristics of the national market and submarkets could be evaluated in future studies.

• An analysis of ongoing EV field test and demonstration programs. This analysis provided information needed to proceed with a new round of carefully designed commercial-sector demonstrations that would avoid past mistakes and maximize opportunities for success.

Following this pilot study, it was decided to proceed with a full-scale study. An appropriate statistical sample of establishments was drawn from a comprehensive list compiled by Dun and Bradstreet. Fleet managers in establishments throughout the United States (representing 13 million vehicles) were contacted by telephone, and nearly 600 interviews were conducted during 2 months of the fall of 1983. The overall response rate for these interviews was 92 percent. Because scientific sampling procedures were used, it was possible to translate the sample data into estimates for the entire nation with known degrees of precision.

There are an estimated 6 million automobiles and 7 million light-duty trucks and vans in commercial fleets in the United States. As shown in Table 1, almost 20 percent of these vehicles are typically driven less than 30 mi per day (mpd), and almost 50 percent are typically driven less than 60 mpd. In general, light-duty trucks and vans tend to be driven fewer miles per day than automobiles in commercial fleets. Trucks and especially vans thus appear to be the most promising initial target for EV production in quantity.

TABLE 1 Mileage Attributes of Light-Duty Commercial Automobiles and Trucks

	Typical Daily Mileage		
Attribute	<30	30–59	60–89
Estimated number of vehicles (millions)	2.5	3.3	2.3
Percent of all vehicles in commercial fleets	20	26	18
Average miles per day traveled	17	44	72
Percent occasionally driven >30 mpd	56	100	100
Percent occasionally driven >60 mpd	38	59	100
Percent occasionally driven >90 mpd	na	41	60
Average miles driven at >40 mph	na	4.5	9.3

Note: na = data not available.

To evaluate the constraints that future EV range decisions could have on the size of the potential EV market, four substitution criteria were developed to correspond to different levels of potential EV performance. Each existing fleet vehicle whose trip requirements matched a criterion was then considered to have a high substitution potential for the type of EV defined by that criterion. The four criteria were defined as follows:

1. Only vehicles typically traveling less than 30 mpd,
2. All vehicles typically traveling less than 30 mpd plus those traveling between 30 and 60 mpd that are parked for 2 or more hours during the day and that also travel less than 8 mpd at speeds greater than 40 mph,
3. Only vehicles typically traveling less than 60 mpd, and
4. All vehicles typically traveling less than 60 mpd plus those traveling between 60 and 90 mpd that are parked for 2 or more hours during the day and that also travel less than 8 mpd at speeds greater than 40 mph.

Depending on which of the four performance criteria is used, between one-fourth and three-fourths of all vehicles in today's average commercial fleet could be replaced by EVs (see Figure 1). (The number of vehicles falling within each of the substitution criteria increases substantially with the percentage of trucks and vans in the fleet.) In terms of absolute number of vehicles, this translates to between 2.5 and 7 million commercial vehicles.

Light-duty trucks and vans appear to be the most promising initial market for EV substitution. Overall, trucks and vans represent approximately 80 percent of all vehicles with high substitution potential as defined by the four criteria. These results prompted EVDC to begin an important related future investigation to determine the number of such vehi-

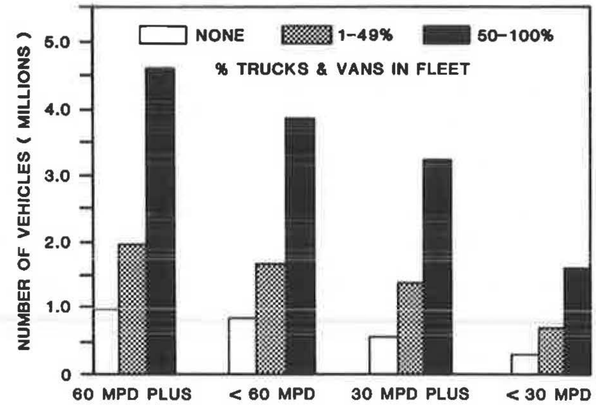

FIGURE 1 EV substitution potential under alternative substitution criteria.

cles that could be used by large fleets (e.g., those of electric utilities, telephone companies, delivery services, and local governments). After it determines the EV market needs of local territories, EVDC can then work toward actually placing the required EVs.

Electric Van Specification

Market identification is linked to the issue of cost competitiveness. The market may exist, but the cost may not be competitive. Therefore, as a preliminary step in product specification, a cost analysis was performed, the results of which are summarized in Figure 2. Under the assumed cost, use, and technology conditions, the total life-cycle costs for conventional and electric vans in the year 1990 are projected to be

- Conventional van--43.1 cents/mi;
- Improved electric van--44.0 cents/mi; and
- Advanced electric van--41.8 cents/mi.

Although these differences should not be considered significant given the number of assumptions incorporated in the analysis, it appears that the improved electric van is projected to cost only slightly more (approximately 2 percent) to own and operate than a comparable conventional van. On the other hand, the advanced electric van is projected to be somewhat less expensive to own and operate than the conventional van.

The total costs in Figure 2 are broken down into four parts. "Amortization" includes depreciation plus interest payments for capital invested in the vehicles and batteries. "Energy" includes fuel and lubricants, or electricity. "Maintenance" includes all maintenance expenses. "Other" includes tires, titling, parking, tolls, and other expenses.

The overall conclusion is that electric vans used in local service fleet applications have the potential to be cost-effective and competitive with conventional vans. Whether and when electric vans become cost-competitive will depend on achieving anticipated technological improvements--primarily in the battery--while simultaneously increasing the reliability of the propulsion system and reducing its maintenance. Cost-competitiveness also critically depends on achieving quantity electric van production to reduce vehicle and component costs. A caveat to keep in mind: if electric vans are to be cost-competitive with commercial vans, their energy and maintenance costs must be less than those for conventional vans. A reduction in operating costs (relative to conventional vans) is necessary to compensate for the additional capital costs associated with the EV and battery. Given the generally higher efficiency, smoother operation, and greater reliability of electric motors and controls compared with the internal combustion engine, the assumption of lower operating cost is realistic. Experience with commercial electric vans in Great Britain has indicated that the service maintenance cost is half that of the internal-combustion engine vans.

Building from the information gained through these initial fleet vehicle market and cost studies, an analysis was made of the relationship of electric van cost and market share to van performance. In this analysis, van performance was described in terms of range, acceleration, top speed, gradeability, and payload. Figure 3 shows an example of the results of this analysis: the relationship between vehicle range and life-cycle cost for a small electric van with a 1,200-lb payload and a large electric van with a 2,200-lb payload is shown. Separate curves are given corresponding to different 0- to 30-mph acceleration capabilities. The relationships shown in Figure 3 correspond to one specific battery type; a total of six alternative batteries were investigated in this analysis.

The results of this analysis were used to establish a performance specification for cost-competi-

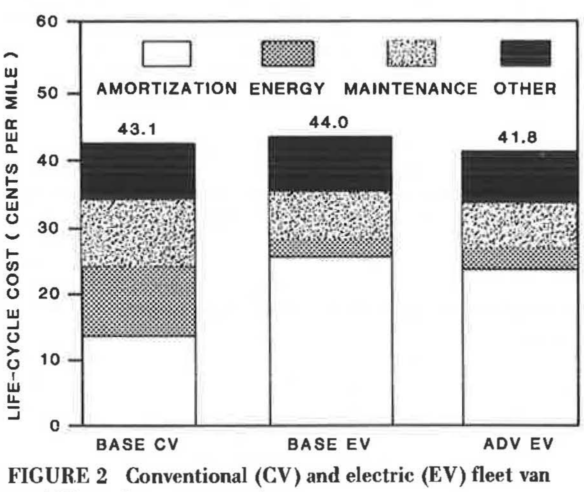

FIGURE 2 Conventional (CV) and electric (EV) fleet van total life-cycle cost comparison.

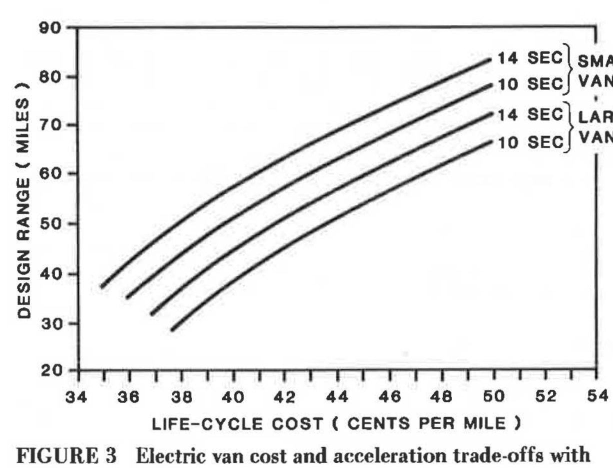

FIGURE 3 Electric van cost and acceleration trade-offs with Chloride EV5T lead-acid battery.

tive, market-compatible electric vans that could be produced in quantity by the late 1980s. The following is a summary of recommended van characteristics.

	Small Van	Large Van
Range (J227aC)	45 mi	60 mi
Payload	1,200 lb	2,000 lb
Acceleration (0 to 30 mph)	10 sec	12 sec
Top speed	55 mph	55 mph

The EVDC Technical Committee, which comprises utilities, governments, the U.S. Postal Service, and other organizations with EV operating experience, played a key role in evaluating the results of the analysis and developing the performance specification. This specification will find immediate application in the joint effort of EPRI and the U.S. Department of Energy (DOE) to develop prototype near-term, market-compatible electric vans for fleet use. The specification will also be used to expand EVDC's efforts to guide the development of EV technology, and to build support for that technology's introduction into practical use.

Organization Participation

The cooperative and coordinated participation of the various EV stakeholders is required if the EV introduction strategy is to be successful. The key stakeholders are EPRI, utilities and trade organizations, DOE, manufacturers, commercial fleets, and infrastructure support organizations.

Drawing these diverse organizations together is a critical challenge; the fact that this had not been done before was a major motivation behind the formation of EVDC. As a first step in this participation process, EVDC has formed a technical advisory committee composed of leaders in EV technology development and application. This committee will provide guidance for future technological activities and will ensure a "right-track" confidence level. More recently, EVDC has established a marketing advisory committee to assist in the effort to commercialize EVs.

Electric Van Development

In response to indications from EV users, and with the results of market and technology assessments, increased emphasis is now being placed on the development of electric vans for fleet applications. EVDC has established a two-phase plan for introducing EVs into commercial fleets.

In Phase 1, EVDC is initiating the Electric Van Market Application Assessment Project that involves the operation of the General Motors CF vans (produced by Bedford with the reliable Lucas/Chloride electric propulsion system and battery) within selected utility companies and service fleets (see Figure 4). This project will provide the experience necessary to establish EV service and support systems that are vital to the commercial introduction of EVs into fleet operations. The project will also seek to overcome negative perceptions of current EV technology and of the technology's near-term outlook by providing utilities with an opportunity to gain operating experience with a proven and reliable EV.

Phase 2 involves the collaboration of DOE and EPRI in a multiyear joint project to develop an improved prototype fleet EV with a fully integrated powertrain/battery system that could satisfy the market-responsive performance and design specifications developed by EVDC and summarized earlier in this paper. On the basis of emerging near-term technology in the United States and abroad, plans are being followed to develop and fabricate prototypes of fleet market-compatible electric vans that could be field tested in 1986 and 1987. These electric vans would serve as prototypes of commercial fleet EVs that could be produced in quantity in the 1987-to-1988 time frame. Van development is scheduled to start in mid-1985. The following is an outline of related emerging technology.

FIGURE 4 Electric CF van.

United States

• Development of the sealed lead-acid battery, perhaps available in 3 to 4 years, into an inexpensive, long-lived, and dependable battery for EVs.

• Verified performance of the Ni-Fe battery as an alternative battery system for fleet applications.

• Evolution of power electronics technology that will reduce cost, weight, and size; increase efficiency; and make developments such as the ac-drivetrain marketable.

• Modifications of the Eaton Corporation ac-drivetrain system to allow it to be integrated into the Chrysler T-115 minivan.

• Advent of a microprocessor that provides the attendant cost benefits that result from the combined functions of the motor, electronic controller, battery, charger, and other auxiliary components.

• Development by Ford Motor Company of an integrated ac-drivetrain for passenger cars in the 1990s.

Overseas

• Bedford (General Motors subsidiary) CF electric vans are currently being produced using assembly-line methods.

• Lucas/Chloride EV Systems is producing a standardized battery and drive system that will be assembled into light-duty commercial vehicles, including the Bedford CF van.

• Gesellschaft für Elektrischen Strabenverkehr (GES) is producing the CitySTROMer (Volkswagen Golf conversion) with an advanced, integrated propulsion system and improved thermal and electrolyte management systems for the lead-acid battery.

• Lucas/Chloride and Brown-Boveri are each developing a sodium-sulfur battery that is expected to provide much higher performance and range capabilities than those currently available.

Financing and Promotion

Because organizations such as EPRI and DOE are under certain institutional constraints in these activities, this is an arena in which EVDC could play an important leadership role. Most financing has heretofore gone into research and development rather than the actual production of vehicles. In order to have production financing, specific market needs must be demonstrated, as discussed under the "Market Identification" section in this paper. With such market needs and opportunities identified, EVDC can then proceed with an investigation into various alternative financing mechanisms. These include limited partnerships; participation by manufacturers, government, and/or electric utilities; tax incentives; and so forth; and also identifying high-value markets suitable for initial entry.

The promotion of EVs has generally been technology driven. It is important that EV promotion also become market driven. To this end, information must be disseminated regarding specific EV advantages to the consumer or potential user. EVDC can influence and accelerate this process through coordinated vehicle design efforts, performance testing, and EV demonstrations, as well as by inducing special electric utility incentives such as lower off-peak rates. These market-driven promotional activities will in turn enhance prospects for suitable financing.

SUMMARY

EVDC has adopted an overall strategy to accomplish two EV commercialization objectives: the introduction of electric vans into commercial fleets in the late 1980s, and the introduction of advanced EVs into the personal transportation market in the early 1990s. During its first year of operation, EVDC concentrated its efforts on characterizing the commercial fleet vehicle market and developing specifications for an EV that could capture the largest market segment, as well as expanding its membership base. Contact with and coordination of key stakeholders have been strengthened through the establishment of the Technical and Marketing Committee and the initiation of a joint EPRI-DOE electric van development project. EVDC plans to initiate market and infrastructure support development activities in 1985 and to create the technical and financial plans required to implement a large-scale demonstration as the first stage in vehicle commercialization.

EVDC's objectives can be attained only through close cooperation with DOE, the EV User Task Force, manufacturers, and EPRI. EVDC is uniquely structured to accomplish this coordinative role. The EV User Task Force and EPRI senior management have members on the EVDC Board of Directors, and the EVDC Technical and Marketing Committee membership includes DOE, national laboratory staff, and manufacturers. EVDC is committed to work together with all of these organizations to move the technology closer to meeting market needs so that successful commercialization of EVs can be accomplished in the earliest possible time.

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