Electric Vehicles Market Assessment and Demonstration Planning for Commercial Applications

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Electric Vehicles
Market Assessment
and Demonstration
Planning for
Commercial Applications

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CHAPTER 1
INTRODUCTION AND OVERVIEW

BACKGROUND

A review of the electric vehicle (EV) literature in the Spring of 1982 concluded that appropriate information needed to justify large scale commitments to further EV market development or demonstration activities was seriously lacking (Berg et al., 1982). Prior research and demonstration results had produced mixed conclusions with respect to EV market potential. More importantly, 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 are the focus of this study, and which may hold the most promise for quantity EV adoption over the next decade.

Further complicating the decision environment is the recent retrenchment in the EV programs of the federal government and portions of the automobile industry. Thus, by mid-1982, and despite the obvious benefits to the electric power industry associated with quantity EV production, it was clear that the prospects for near term EV commercialization might further dim unless significant market potential could be credibly demonstrated and a realistic market development strategy developed.

Successful commercialization of EVs will require two types of commitments: one on the part of major manufacturers and other infrastructure participants, and one on the part of prospective buyers. To achieve this, a market development
strategy must be designed to provide timely, reliable, and appropriate information to both potential suppliers and potential buyers so that commitments made at different points in the commercialization process can be based on their own informed self-interest. Practically speaking this means that suppliers must be convinced of a potential market large enough to be profitable, and potential buyers must be convinced that a dependable and economically attractive vehicle and infrastructure does (or will) exist.

PURPOSE AND APPROACH OF THIS STUDY

In light of the above circumstances, the over-riding goal of this study has been to provide information and guidance useful in the further development of EV programs focused on technology development, market assessment, and demonstration. Each of these three elements is crucial to successful EV commercialization. Taken together they provide an integrated framework for market development.

As suggested by the arrows in Figure 1, both market assessment and demonstration activities are interdependent with the task of technology development. The design of successful demonstrations and the evaluation of market potential must both be based on a realistic assessment of technology performance. Equally important, however, is the need to guide vehicle development decisions on the basis of solid data about market requirements and preferences. Prospects for successful commercialization are likely to be enhanced if, on balance, market requirements guide technological choices, rather
than the reverse in which narrowly taken engineering decisions are allowed to determine market potential.

Within the context of this market development framework, this study had two distinct components:

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

2. An analysis of ongoing EV field test and demonstration programs. This analysis provides information needed to proceed with a new round of carefully designed commercial sector demonstrations which can avoid past mistakes and maximize the opportunities for success.

Figure 1.1

The Three Elements Needed for Successful EV Commercialization

EV Market Assessment

EV Technology Development

EV Demonstration

Fleet Operator Survey

DOE Demonstration Site Operator Interview
While not an engineering-oriented study, both the market and demonstration components provide important vehicle-related information to the EV technology research and development work which must proceed in parallel if quantity EV production is to be a reality within the next decade.

DEFINING THE MARKETS FOR ELECTRIC VEHICLES

This study has focused on over-the-road EV applications within the commercial sector. While not as large as the long-term potential market in the personal transportation sector, nor as well developed as the existing market for off-road EV applications (such as forklifts and golf carts), the potential commercial sector EV market is substantial in its own right. More importantly, commercial applications are likely to provide an opening wedge for later EV acceptance in the residential market.

A rough sense of the magnitude of the personal, commercial, and off-road markets can be obtained from national data. In 1981, there were approximately 124 million registered passenger cars in the U.S., and approximately 34 million:

'Unless otherwise specified commercial sector applications refer to over-the-road vehicles and are defined to include applications within government and other vehicles used primarily for commercial purposes but not necessarily having commercial license plates. The personal transportation sector includes all privately owned vehicles not used primarily for commercial purposes.
trucks. Out of this 158 million total vehicles, roughly 27.5 million are commercial over-the-road cars and trucks, and 2.3 million are government sector vehicles.† Put another way, the personal transportation sector is about 5 times larger than the commercial sector, and the commercial sector is about 10 times larger than the government sector.

Within the personal transportation sector, just under 15 percent of all vehicles are pickups and vans. In contrast, in the commercial sector about 55 percent of all vehicles are trucks, and of those 15 million trucks, about 65 percent are pickups or vans, and about 50 percent travel less than 10,000 miles per year (1977 data). While a breakdown is not available for all of the roughly 12.5 million commercial cars, 35 to 40 percent of all fleet automobile sales in 1981 were compact or subcompact vehicles.

Data on the off-road sector is very sketchy, but it is clearly far smaller than the other sectors. Annual sales of electric forklifts and golf-cart-type transport vehicles are each on the order of 20,000 units per year. This would imply a total of roughly 5 million units for these types of electric vehicles. Put another way, the total

†These numbers are rough estimates only, especially those for the commercial sector. Problems exist due to use of noncomparable definitions among various sources, and a general paucity of accurate data. Sources: Commercial Car Journal, June, 1981; 1977 Truck Inventory and Use Survey, Bureau of the Census, 1978; Automotive Fleet, April 1982; Federal Highway Administration, Highway Statistics.
commercial vehicle sector is about 50 times greater than the current market for off-road electric vehicles.

In defining the market for EVs in any of these sectors, it is useful to distinguish between (1) total vehicles (of all types) in the sector, (2) EV market potential, and (3) EV market penetration. In contrast to total vehicles, EV market potential is limited primarily by technical factors such as vehicle range, speed, and load characteristics. In light of current uncertainties in both EV performance and user trip requirements, estimates of EV market potential contain considerable uncertainty.

EV market penetration refers to the share of the potential market which EVs can be expected to capture after accounting for factors such as limited product information, organizational inertia, and cost or performance comparisons against competing vehicles. Lack of both data and theory make estimates of market penetration even more uncertain and difficult than those of market potential. This study focuses on market potential.
HIGHLIGHTS OF RESULTS FROM THE COMMERCIAL FLEET PILOT SURVEY

A rough sense of the size of the potential in the commercial sector can be gathered from the results of the pilot survey of commercial-sector fleets in the Detroit Edison service area.

The Distribution of Light Duty Over-the-Road Vehicles

For the purposes of this pilot survey, light duty vehicles are defined as cars, station wagons, vans, pickups, or other over-the-road vehicles weighing less than 5000 pounds. Characteristics of these vehicles and their use patterns can be used to identify EV market potential within the Detroit Edison service area.

- **Distribution within Fleets** -- Light duty vehicles are distributed relatively evenly throughout the diverse commercial fleets in the Detroit Edison service area and they are concentrated in mid-size and larger fleets of 3 or more vehicles.

- **Miles Traveled per Day** -- Almost 2/3 of all light duty over-the-road vehicles -- 75% of cars and station wagons and 60% of other vehicles -- are typically driven 60 or fewer miles per day. These lower mileage vehicles average 28 miles/day. And while 60-80 percent of these vehicles must travel more than 60 miles/day on occasion, this typically occurs no more than once per week.

- **Types of Vehicles** -- Of those vehicles typically driven 60 or fewer miles per day, about 1/3 are cars and station wagons, and almost 2/3 are light duty trucks and other non-passenger vehicles.

- **Distribution by Fleet Size** -- Over 3/4 of the lower mileage vehicles are in fleets of 3 or more, and 1/3 are in fleets of 11 or more.
• Routes -- Roughly 60 percent of the lower mileage vehicles do travel on expressways. However, the length of trip is unknown as is the availability of alternative non-expressway routes.

• Availability for Recharging -- Over 85 percent of the lower mileage vehicles are parked for an hour or more at a time during the day. Almost 1/4 of the lower mileage cars and station wagons, and almost 2/3 of the trucks and other vehicles are left on the premises at night.

Market Potential in the Detroit Edison Service Area

Findings such as above can be used to estimate market potential within the sampled population. It should be stressed that the results are based on a very small sample (118 interviews) which is known to exclude at least one segment of the potential commercial market (privately registered vehicles used for commercial purposes), and which is drawn from a service area not necessarily representative of the rest of the nation. Because of this, extrapolation from the pilot survey results to national estimates runs a serious risk of error.

Based on the sampled population within the Detroit Edison service area, approximately 17,000 cars and station wagons and almost 30,000 other light duty vehicles would be amenable to EV substitution based on a mileage constraint of 60 mile per day. Other factors such as expressway use and the potential for opportunity recharging are also important, but their combined effects cannot be predicted from available data. However, assuming the mileage limitation is the most significant long-term barrier to EV substitution,
these results look very promising. Assuming that market potential can be turned into market penetration, even conservative extrapolations of these results to the national level would suggest figures compatible with quantity production of at least 50,000 units per year.

On the other hand, the leap from market potential to market penetration can not be taken for granted. It will depend on a host of economic, technological, and other factors. Not the least of these will be the willingness of commercial fleet operators to consider substituting EVs for their conventional vehicles.

Willingness of Managers to Consider The Use of EVs

The analysis indicates that commercial fleet managers are able to provide meaningful answers about prospective uses of EVs, based on vehicle related information provided to them during the interview. Their willingness to consider using EVs is related to a number of trip pattern and organizational factors. Willingness appears to be positively associated with:

- Fleet size
- Presence of pickup trucks in fleet
- Light load requirements
- Non-unionized drivers
- Presence of several vehicles that are typically driven 60 or fewer miles per day.
- Managers making their own vehicle-purchase decisions rather than having them made higher in the organization.
Multivariate analysis techniques make it possible to identify market segments having higher (or lower) than average likelihood of using EVs. The analysis determined, for example, that willingness to consider EV use was expressed by 86.4 percent (+29.6%) of managers having (a) 2 or more low mileage vehicles, (b) no union drivers, (c) payloads under 500 pounds, and (d) a fleet composed of pickups only. It identified as a second high likelihood market segment is the fleets of service and construction firms sharing characteristics a-c above. In contrast, it indicated that managers of small, high mileage, passenger car fleets were least willing to consider EVs (3.7%).
DEMONSTRATING EV APPLICATIONS AND INFRASTRUCTURE

In-depth interviews were conducted with site managers at 35 DOE sponsored EV demonstration projects which were using EVs in applications comparable to those found in commercial and government fleet settings.

The findings from the site operator interviews are presented in detail in Chapter 4, and are highlighted below in terms of their implications for future EV demonstrations.

Appropriate Commercial Applications for EVs

There is a wide range of commercial sector EV applications which can work well, not just one or two. In general, the key to successful application is a reliable vehicle and thorough maintenance. Examples of successful applications include:

- Delivery and Pickup of parts and other merchandise,
- Inspection of construction sites and municipal housing,
- Mail delivery and courier service,
- Personnel shuttle,
- Parking enforcement,
- Utility meter reading,
- Installation and maintenance of utility and other equipment,
- Inside sports arenas and other large buildings.
Vehicle Specifications Needed for a Demonstration

Most of the vehicle-related problems experienced in the DOE demonstrations were attributable to the prototype nature of the vehicles. These need to be carefully differentiated from problems that would be inherent in quantity production vehicles.

A distinction must also be made between the vehicle specifications needed for successful demonstration and the higher performance specifications eventually required for a commercially viable vehicle. Vehicle-related specifications for a demonstration program would include:

- **A reliable and easy to maintain vehicle.** Long out-of-service periods due to lack of diagnostic skills or equipment, or due to unavailability of parts is not acceptable.

- **A range of vehicle types** including passenger cars, pickups, small vans, and larger volume stepvans, all of which have been used successfully. Many applications do not have heavy load carrying requirements.

- **A minimum range requirement of 35-40 miles** under the full range of operating conditions. Acceleration and load capacity are less crucial to demonstration success.

- **Creature comforts such as heaters, instrumentation, and radios** which must be at least as good as those in conventional vehicles.
Operational Factors Affecting Demonstration Success

Reliable vehicles and appropriate applications are necessary but not sufficient for EV success: operational and organizational factors are at least as important. Foremost among these operational and organizational factors are:

- **Route Type** - Fixed routes work well, but variable routes on which vehicles rarely approach their maximum range work just as well; types of trips taken and routes assigned need not change to accommodate EVs, although that may facilitate cost-effective EV use.

- **Dispatch Understanding** - The person assigning vehicles to trips must know and respect their range limitations.

- **Driver/vehicle assignment** - General pool vehicles typically get less use and less maintenance. Multiple driver assignments (small pools) can work if vehicle responsibility is clearly defined. Assignment of a specific vehicle to a specific driver is best for promoting usage and responsibility.

- **Driver attitude** - Drivers must be open and willing to try EVs; hostile drivers will seriously hurt a demonstration program. Driver enthusiasm must be maintained through both reliable vehicle performance and good management methods.

- **Backup vehicles** - Backup vehicles are necessary to prevent disruptions in operations, but these should be EVs to decrease the incentive for dissatisfied EV drivers creating problems in order to avoid driving the EV.

- **Maintenance Procedures** - Preventive maintenance by knowledgeable technicians is required. Questions over craft union jurisdiction between automotive technicians and electricians need to be resolved. Unavailability and slow delivery of parts can present major problems.
• Cost Uncertainties - The largest cost uncertainties and potential for budget overruns are related to maintenance and battery replacement. These (and other) cost uncertainties cannot be pushed onto the site operators as was done in the DOE program, but must be transferred to the demonstration program sponsor.

Implications for Design of Future Demonstrations

The findings related to EV applications, vehicle specifications, and fleet operations provide a basis for designing future EV demonstrations. Chapter 4 addresses specific conclusions and suggestions as they relate to the four key areas of incentives for user involvement, user recruitment and screening, infrastructure development, and program management resource requirements. Many of these design-related findings are incorporated into the recommendations presented in the next section.
RECOMMENDATIONS

Developing commercial and municipal EV markets will require a carefully planned long-term commitment to a process of technology improvement, demonstration, and infrastructure development. Such a program would have the following goals for the long run development of the EV industry.

1. To demonstrate and communicate successful EV applications within the commercial sector.

2. To identify and solve potential technical, organizational, and attitudinal problems associated with the use of large numbers of electric vehicles in the commercial sector.

3. To provide information, planning, and guidance needed to aid and encourage the full development of the infrastructure required for large scale EV adoption.

This report makes two primary recommendations as steps towards the achievement of these long run goals. Each is discussed briefly below.

RECOMMENDATION 1: Conduct a national level commercial fleet survey to determine EV market potential

RECOMMENDATION 2: Initiate a national-level commercial sector EV demonstration program based on the findings of this study along with a carefully designed implementation plan.

Recommendation 1: A National EV Commercial Fleet Market Survey

While the results of the pilot study are encouraging, they are too limited in detail, precision, and generalizability to be the sole
basis for major policy decisions. It is recommended that the methodology and lessons learned in the pilot survey be applied, with appropriate modifications, to a nationally representative sample.

The Sample.

An establishment-based national sample (in contrast to the vehicle-based approach used in the pilot survey) is suggested with a minimum sample of 300 and preferably as large as 1200. The larger sample would allow for direct estimates of market potential at the regional level. EV market potential estimates could also be made for specific service areas by augmenting the national sample with as few as 50 additional interviews from each area.

Survey Content.

The survey should go into considerably more detail than the pilot study especially in terms of required trip patterns and vehicle costs. In addition, the interview process should provide respondents with more information about the advantages and limitations of EVs so that they can give informed responses to questions concerning:

- their willingness to consider the use of EVs in their fleets,
- the types and characteristics of EVs they would consider most useful,
- the number of EVs which might be substituted for conventional vehicles, and
- the operating cost and purchase price levels which would be required for EVs to be economically competitive.
Recommendation 2: A Second Generation EV Commercial Sector Demonstration

Successful EV commercialization will require a national program of EV demonstration in order to develop both a market for EVs and the infrastructure needed to support that market. A second generation EV demonstration program will have the advantages of improved technology and a better understanding of the potential problems and pitfalls encountered in the operation of EVs in commercial environments.

Program Characteristics.

The complete specification of a commercial sector demonstration program must await completion of a detailed planning analysis which is beyond the scope of this study. However, the current work does suggest a number of specific approaches and principles which should be considered in program development.

1. An incremental approach should be used with the initial demonstrations providing guidance to an integrated series of demonstrations in various regions over the next decade.

2. Reinventing the wheel should be avoided. It will be less expensive and less frustrating to make optimal use of existing demonstration programs and expertise.

3. New applications, technologies, maintenance facilities, etc. should be added incrementally. This means the program must have a strong and well integrated planning component.
4. The program should position itself to be a reliable and trusted information source for users and other potential infrastructure members. This means the program must have both a strong research component and a strong communications component.

5. Some demonstration sites should be established as long term pilot programs which can grow in sophistication and in the richness of the EV infrastructure incorporated into their programs.

6. Economies of scale can be gained by creating centralized facilities (national or regional) to provide parts, trouble shooting, bulk purchases, etc. These services can be phased out as the EV infrastructure grows in size and sophistication.

7. In order to obtain realistic market oriented information it will be necessary to initially "buffer" the program (in terms of technology, maintenance, and economics) in order to simulate operating conditions and reliability levels which would be typical of larger volume production conditions. The amount of buffering should be reduced as quickly as possible as the program moves from simulation towards an increasingly realistic commercial demonstration involving the full range of infrastructure elements and market forces.

8. It will be important to work with both commercial and government organizations to understand the differences in these two operating environments. Primary candidates for successful applications would be municipal inspection and parking enforcement, fixed route mail and courier services, and commercial parts delivery and pickup. After a history of successes, a limited number of "riskier" applications or organizations can be considered for addition to the program.

9. An attractive incentive package must be designed around thoroughly tested vehicles, and must employ financial and organizational arrangements which transfer the vast majority of risks and uncertainties to the primary stakeholders.
in successful EV commercialization. Vehicle leasing arrangements offer a number of advantages in this regard since they are familiar to fleet operators, provide an easy and "invisible" mechanism for subsidizing purchase and maintenance costs, and allow the lessor considerable control over maintenance and training.

Recommended Next Steps

In preparation for a commercial demonstration program several research and planning activities are recommended as immediate next steps.

Recommendation 2.1: Develop an organizational plan detailing the full range of program functions, the role and obligations of all major actors, potential demonstration sites, and cost and funding options.

Recommendation 2.2: Initiate activities for the evaluation and eventual procurement of reliable and appropriate vehicles.

Recommendation 2.3: Initiate the research and planning needed to develop a detailed and attractive incentive package for involvement of commercial fleet operators and needed infrastructure participants.
CHAPTER 2

MARKET POTENTIAL: RESULTS FROM A PILOT STUDY

INTRODUCTION

This chapter and the next present the detailed results of a pilot survey of commercial fleet operators within the Detroit Edison service area (a summary of survey results is found in Chapter 1). The survey provides a basis for estimating EV market potential in business-sector applications within the Detroit Edison area (Chapter 2), and for identifying market segments likely to be most receptive to EV adoption (Chapter 3).

Before presenting the quantitative survey results, background information about the national vehicle fleet and about key definitions and methodologies used in the survey are highlighted. While not all readers will want, or need, detailed methodological information, some familiarity with these issues provides a valuable basis for interpreting the survey results and appropriate limits on their use. A more detailed discussion of methodological issues can be found in Appendix A.

DEFINING EV MARKETS

The National Fleet

When considering EV market potential from the national perspective it is useful to segment the national fleet into three sectors: personal transportation, commercial, and off-road. A rough estimate of the size of these sectors and characteristics of their vehicles can be obtained
from national data. However, the data are incomplete and suffer from noncomparable definitions among different sources. In 1981, there were approximately 124 million registered passenger cars in the U.S., and approximately 34 million trucks. Out of this 158 million total vehicles, roughly 27.5 million are commercial over-the-road cars and trucks, and 2.3 million are government-sector vehicles. Put another way, the personal transportation sector is about 5 times larger than the commercial sector, and the commercial sector is about 10 times larger than the government sector.

Within the personal transportation sector, just under 15 percent of all vehicles are pickups and vans. In contrast, in the commercial sector about 55 percent of all vehicles are trucks, and of those 15 million trucks, about 65 percent are pickups or vans, and about 50 percent travel less than 10,000 miles per year (1977 data). While a breakdown is not available for all of the roughly 12.5 million commercial cars, 35 to 40 percent of all fleet automobile sales in 1981 were compact or subcompact vehicles.

Data on the off-road sector is very sketchy, but it is clearly far smaller than the other sectors. Annual sales of electric forklifts and golf-cart type transport vehicles are each on the order of 20,000 units per year. This would imply a total of roughly 0.5 million units for these types electric vehicles. Put another way, the total

commercial vehicle sector is about 50 times greater than the current market for off-road electric vehicles.

**EV Market Potential vs. Market Penetration**

In turning from the total national fleet to the more limited market for electric vehicles in commercial fleet operations, two different but related issues should be distinguished: the size of the potential market, and possible EV penetration into it. The upper bound on the potential market for commercially used EVs is the total number of commercial vehicles in use — 25 to 30 million vehicles as estimated above. A more practical definition of market potential, and the one used for this study, recognizes that EVs available in the near-term can not substitute for all commercial vehicles because of performance characteristics such as limited range and speed, and recharging requirements.

Market penetration, the degree to which EVs capture the potential market, must take account of additional market-limiting factors. Some of these are specific to EVs, and some are more general and affect the adoption of many innovations. As illustrated in the following list, factors that influence market penetration tend to be more qualitative and uncertain than those that define market potential. Market penetration will be affected by:

- the costs of purchasing, operating, and maintaining EVs as compared to conventional vehicles;
- the cost of electricity, and the cost and availability of gasoline;
Market penetration depends on the characteristics of EVs relative to ICE vehicles, and the benefits, costs, and risks of acquiring, operating, and maintaining the different types of vehicles.

- the quality and reliability of services provided by the EV infrastructure, e.g., the availability of repair facilities and parts;
- attitudes and perceptions about the benefits of EV adoption, e.g., their quiet and clean operation, low maintenance, and protection against oil cut-offs;
- attitudes and perceptions about the risks of EV adoption, e.g., their not being able to meet all performance requirements, their unproven track record, their uncertain battery life, and the immature nature of the EV infrastructure; and
- organizational and individual resistances to changes made necessary by the adoption of EVs.

This pilot study concentrates on market potential and touches only lightly on likely penetration. The primary reason for this is that potential buyers cannot be expected to provide accurate information about whether they would purchase EVs or conventional vehicles under different sets of circumstances because they do not have, and indeed cannot have, any real experience with EVs in commercial fleet operations.

Determining Market Potential

The following assumptions were made regarding market potential in order to select the types of information to be obtained in the pilot survey. First, as discussed above, it was assumed that the potential EV market is bounded by the size of the

'It should be recognized that even commercial EV users in the DOE EV Demonstration Program have not had experience with EVs in a context which simulates mass market EV quality and infrastructures.'
total commercial vehicle market. Further, it was assumed that EVs, given current and expected near-term technology, could not be easily substituted for conventional vehicles that must routinely be driven over 60 miles per day, or are frequently driven on expressways, or must carry payloads in excess of 500 pounds. It was recognized that the 60 mile constraint is not an absolute because some opportunity charging might be possible for vehicles that are usually parked for an hour or more at a time during the day. Furthermore, fleet managers might be able to change their operations to circumvent some current EV limitations, for example, by modifying existing routes or driver assignments. It was also recognized that organizational considerations, such as union contracts and vehicle procurement procedures, are likely to influence market potential.

AN OVERVIEW OF THE PILOT SURVEY

To make a preliminary estimate of market potential, a pilot survey was conducted in December, 1982. A sample of cars and wagons, trucks, vans, and other over-the-road vehicles weighing less than 5000 pounds within the Detroit Edison service area was drawn from the Michigan Secretary of State's May 1982 list of commercially registered vehicles. Companies registering the vehicles were contacted by telephone and persons responsible for vehicle usage were identified as the appropriate respondents. These respondents were then asked whether the sampled vehicle

*Technical details of sample design and implementation are discussed in Appendix A. The survey questionnaire is included in Appendix C.
(identified by vehicle type and license plate) was used by their establishment or whether it was leased to another establishment or person. If it was leased but in commercial use, the leasing company (if in the Detroit Edison area) was contacted for the interview.

Once the appropriate establishment was reached, the respondent was asked for information about all of the cars and other over-the-road vehicles weighing less than 5000 pounds used by that establishment. These interviews provide the information on which market potential estimates are based. The data base includes:

- The total number of vehicles weighing less than 5000 pounds currently in commercial fleets that use one or more vehicles commercially registered in the Detroit Edison area.

- The number of cars and other vehicles in these fleets that average 60 miles per day or less and the number that average more than 60 miles per day.

- For those cars and other vehicles that average 60 miles per day or less, average mileage, number of stops and restarts per day per vehicle, number assigned to fixed routes, number parked for an hour or more at a time during the day, number frequently driven on expressways, number left on company premises at night, number driven more than 60 miles per day on occasion, and, for those, frequency of such occurrences. For vehicles other than cars, typical payload also was ascertained.

- For cars and other vehicles that average more than 60 miles per day, typical payload, number parked on company premises overnight, and number parked for an hour or more at a time during the day.

- Willingness of establishment to try one or more EVs in its fleet.
• Other attributes of establishments such as industrial category that were collected to enrich data analysis.

Some Technical Aspects of the Pilot Survey Design

To aid the reader in interpreting results from the pilot study, some observations ought to be made about the sampling and interviewing procedures. First, because vehicles (as opposed to establishments) were sampled, one establishment could be drawn into the sample two or more times. Care was taken to assure that no establishment was contacted more than once, and (statistical) weights were constructed and employed to eliminate bias arising from potential multiple selection.

Second, the (sample-based) analysis does not include all vehicles in commercial use in the Detroit Edison area for two reasons. Some establishments in the Detroit Edison area may register or lease all of their vehicles outside of this area. None of these establishments' vehicles would have fallen into the sample. Similarly, some companies have no vehicles with commercial plates, and since only commercially registered vehicles were in the sample, these companies could not be selected. Therefore, the portion of the potential EV market in establishments using no commercially registered vehicles in the Detroit Edison area is not covered by this study.

Both sources of undercoverage identified above reflect the fact that this was a pilot study designed with the dual constraints of a small budget and a short time frame. A larger study could easily avoid the coverage problem, the basic cause of which is that establishments were selected via vehicles rather than directly.
Establishment lists, for example, those constructed by Dun & Bradstreet, are available and could be used as the basis for sampling in a larger study.
PILOT SURVEY RESULTS

The Distribution of Light-Duty Over-the-Road Vehicles by Establishment Type

There are approximately 71,000 cars and other light duty over-the-road vehicles in the fleets of establishments in the Detroit Edison service area using at least one vehicle commercially registered in this area. As seen from Figure 2.1, these vehicles are widely distributed among establishments in different industrial groupings, although their concentration appears to be highest in establishments engaged in mining and construction, and lowest in those providing financial and other services.

The distribution of vehicles among establishments with different fleet sizes (Figure 2.2) indicates that these vehicles, as might be expected, are concentrated in establishments with mid-size and larger fleets.

The Use of Low Mileage Vehicles: Implications for Market Potential

Data from the pilot survey and from the Demonstration Site operators point to optimism with regard to the size of the potential EV market. As shown in Figure 2.3 almost 2/3

Data collected in the pilot survey are summarized in the tables of Appendix B. Only the highlights are given in the body of the text.

These industrial groupings are derived from combining SIC major divisions. A larger sample would permit analysis by less heterogeneous groups.
FIGURE 2.1
INDUSTRIAL DISTRIBUTION OF COMMERCIAL VEHICLES

• LIGHT DUTY OVER-THE-ROAD VEHICLES ARE NOT CONCENTRATED IN THE FLEETS OR ESTABLISHMENTS OF ANY ONE INDUSTRY BUT ARE WIDELY DISTRIBUTED AMONG FLEETS IN THE DECO SERVICE AREA
FIGURE 2.2

DISTRIBUTION OF VEHICLES BY ESTABLISHMENT FLEET SIZE

- THESE LIGHT DUTY OVER-THE-ROAD VEHICLES ARE CONCENTRATED IN MID-SIZE AND LARGER FLEETS

<table>
<thead>
<tr>
<th>VEHICLE CATEGORY</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 VEHICLES</td>
<td>14.9</td>
</tr>
<tr>
<td>3-10 VEHICLES</td>
<td>42.8</td>
</tr>
<tr>
<td>11+ VEHICLES</td>
<td>42.3</td>
</tr>
</tbody>
</table>
(65.4%)* of all light-weight vehicles currently used by companies with at least one commercially licensed vehicle in the Detroit Edison service area are typically driven 60 or fewer miles per day. Among these low mileage vehicles, 1/3 (36.5%) are cars and wagons, and almost 2/3 (63.5%) are light-weight trucks, vans, and other vehicles.

These results are consistent with focus group screening interviews conducted in Ann Arbor, Michigan in July 1982. The focus groups were conducted prior to the pilot survey and provided information useful in developing the survey questionnaire. On average, 52 percent of the 60 fleet managers interviewed stated their passenger cars averaged less than 51 miles per day. In the case of trucks, 65 percent averaged less than 51 miles per day.

Looking only at cars and station wagons in commercial use, about 3/4 (74.7%) do not normally exceed this mileage constraint. The corresponding fraction for trucks and other vehicles is about 3/5 (61.0%). From a market potential perspective, these relatively large percentages are extremely encouraging.

Distribution of Low-Mileage Vehicles by Establishment Industry Type and Fleet Size

In what types of establishments are potentially substitutable vehicles to be found? Looking first at cars typically driven 60 or fewer

*Standard errors are provided in the tables of Appendix B. Those that are not provided can be approximated by the equation \[ \text{s.e.} = \sqrt{\frac{(100-p)p}{n}} \] where \( p \) is the proportion indicated and \( n \) is the number of observations as given in the table.
FIGURE 2.3

TYPES OF VEHICLES IN COMMERCIAL ESTABLISHMENTS

- Almost 2/3 of all light duty over-the-road vehicles are typically driven 60 or fewer miles per day.
- Of those that are typically driven 60 or fewer miles/day, almost 2/3 are light duty trucks and other vehicles.
Low mileage vehicles are used by establishments of all industry types but are concentrated in medium and large fleets.

No one particular type of establishment clearly dominates the use of low-mileage vans, trucks, or similar vehicles.

Low mileage vans, trucks, and similar vehicles are concentrated in establishments with medium-sized fleets.

Low mileage vehicles are used by establishments of all industry types but are concentrated in medium and large fleets. The heaviest concentration is in establishments engaged in manufacturing, transportation, communications, electric, gas and sanitary services (37.9%). The least heavy concentration is in establishments engaged in wholesale and retail trade, and in providing financial and other services. In terms of fleet size, these low-mileage cars and station wagons are most heavily concentrated in establishments with medium-sized fleets of 3-10 vehicles (Figure 2.5).

Turning to the trucks, vans, and other vehicles typically driven 60 or fewer mile/day (Figure 2.6), no one industrial group dominates usage. Considering fleet size (Figure 2.7), establishments with small fleets are heavier users of these vehicles than they are of low-mileage cars and wagons. Once again, however, the heaviest concentration of these vehicles is in establishments with medium-size fleets.

Trip Patterns of Low Mileage Vehicles

Vehicles typically driven 60 or fewer miles per day tend, on average, to be driven considerably less than this. The cars and station wagons in this group average 27.9 miles per day and the other vehicles average 28.6 miles per day.
FIGURE 2.4
DISTRIBUTION OF CARS DRIVEN 60 OR FEWER MILES PER DAY

- CARS TYPICALLY DRIVEN 60 OR FEWER MILES/DAY ARE HEAVILY CONCENTRATED IN ESTABLISHMENTS ENGAGED IN MANUFACTURING, TRANSPORTATION, COMMUNICATIONS, ELECTRIC, GAS, AND SANITARY SERVICES.
FIGURE 2.5
DISTRIBUTION OF CARS DRIVEN 60 OR FEWER MILES PER DAY BY ESTABLISHMENT FLEET SIZE

- More than half of these lower mileage cars are in mid-size fleets and 3/4 of the rest are in large fleets.
FIGURE 2.6
DISTRIBUTION OF OTHER VEHICLES DRIVEN 60 OR FEWER MILES PER DAY

The distribution of low mileage light duty trucks and other vehicles is not concentrated fleets of any particular type of establishment but is somewhat low in the fleets of establishments engaged in wholesale and retail trade.
Low-mileage trucks and other vehicles are concentrated in mid-size fleets although they are more evenly distributed among fleets of different sizes than are low-mileage cars.
(Table 2.1). Because the 60 mile range assumption is likely to be optimistic in the near term, these data are particularly encouraging.

**TABLE 2.1**

Mileage Attributes of Light Duty Vehicles Typically Driven 60 or Few Miles/Day

<table>
<thead>
<tr>
<th></th>
<th>Cars &amp; Station Wagons</th>
<th>Vans, Trucks &amp; Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average number of miles/day</strong></td>
<td>27.9</td>
<td>28.6</td>
</tr>
<tr>
<td><strong>Percent of vehicles driven more than 60 miles/day on occasion</strong></td>
<td>80.2</td>
<td>60.7</td>
</tr>
<tr>
<td><strong>Average number of times per week vehicles is driven more than 60 miles/day</strong></td>
<td>1.0</td>
<td>0.9</td>
</tr>
</tbody>
</table>

A large proportion of low mileage vehicles, however, (80.2% of cars and station wagons; 60.7% of other vehicles) are driven more than 60 miles per day on occasion. The negative implications of these figures on market potential are mitigated by the fact that, on average, the higher mileage requirements occur only about once a week. It is

*Cars used by establishments in the mining and construction industries average noticeably less (17.1 miles/day) as do cars used by establishments with small fleets (20.0 miles/day). There are no appreciable differences among types of establishments or among establishments with different fleet sizes in the usage of other vehicles. For the detailed distributions, see Appendix B Tables B5, B6, B9, and B10.*
likely that many fleet operations could be reorganized to make conventional vehicles available for occasional higher mileage trips. The likelihood of this is enhanced by the fact, already noted, that the majority of the low-mileage vehicles are in medium and large fleets.

Other Characteristics of Low Mileage Vehicle Usage

Expressway Use.

More than half of the low mileage vehicles are driven on expressways where relatively fast acceleration is essential (67.5% of cars and station wagons and 56.6% of other vehicles are driven frequently on expressways -- see Table 2.2). While potentially a negative market factor, this high proportion may simply reflect the fact that the Detroit Edison service area is well-endowed with good, easily accessed expressways. This is not typical of the country as a whole. Moreover, even in the Detroit Edison service area, such expressway use may not be necessary.

A high proportion of cars used by manufacturing and related industries have frequent expressway use (80.0%). However, other types of low-mileage vehicles used by these establishments, use expressways much less (44.6%). The opposite vehicle use pattern exists for wholesalers and retailers who show a smaller than average proportion of cars, but a larger than average proportion of other vehicles having expressway use.
TABLE 2.2
Other Characteristics of Vehicles Typically Driven 60 or Fewer Miles

<table>
<thead>
<tr>
<th></th>
<th>Cars and Station Wagons</th>
<th>Vans, Trucks &amp; Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Frequently Driven on Expressways</td>
<td>67.5</td>
<td>56.6</td>
</tr>
<tr>
<td>Percent Assigned to Fixed Routes</td>
<td>10.5</td>
<td>18.0</td>
</tr>
<tr>
<td>Percent Parked for an Hour or More at a Time During Day</td>
<td>86.0</td>
<td>86.9</td>
</tr>
<tr>
<td>Percent Left on Company Premises at Night</td>
<td>22.4</td>
<td>63.3</td>
</tr>
</tbody>
</table>

**Fixed Routes.**

At first glance, the relatively small proportion of vehicles assigned to fixed routes (10.5% of cars; 18.0% of other vehicles) appears to augur poorly for EV market potential. This assumes that fixed routes within EV mileage limitations pose less risk of total battery discharge than do variable routes. The demonstration site operator interviews, however, suggest that good range management rather than fixed routes per se is the more important factor. Therefore, these data may hold less significance than they would in the absence of EV demonstration experience.

Although only a small proportion of vehicles are assigned to fixed routes, this need not affect potential EV substitution.
Daytime Parking.

The Demonstration Site interviews also suggest that opportunity recharging, while not frequently used, has the potential for extending EV range. Since such charging requires that the vehicles be parked for substantial periods during the day, information was obtained in the survey about the proportion of low-mileage vehicles parked for an hour or more at a time during the day. About 7/8 of the low-mileage vehicles are parked for an hour or more during the day (86.0% of cars and wagons, 86.9% of other vehicles). Many of these stops, however, are likely to be lunch breaks at locations without recharging facilities. Thus, in the near-term especially, it is unclear how frequently opportunity recharging could be undertaken. Nevertheless, the numbers are encouraging. They indicate an infrastructure could be developed to increase opportunities for recharging as they arise. Indeed, improved information on the length and location of long stops will be extremely important for the development of the appropriate infrastructure.

Nighttime Parking.

EVs are typically recharged at night. Thus, it is potentially important that only 22.4% of the low-mileage cars and wagons, in contrast to 63.3% of the other low-mileage vehicles are left on company premises overnight. Since recharging could, in theory, occur either on company premises or at the driver's home, this is not necessarily a market delimiting factor. However, the Site Operator interviews suggest that while EVs can be charged overnight at drivers' homes, driving these
vehicles to work the following day may discharge them enough to seriously limit their available range for day use.¹ Thus, the fact that at least low-mileage cars and station wagons tend to be taken home at night could further delimit the potential EV market.

Driver Characteristics.

It is a generally accepted premise of fleet management that vehicles are better cared for when assigned to specific individuals. In terms of near-term EV technology, it would be particularly advantageous if vehicles could be assigned to specific drivers. Data from the pilot survey point to optimism in this regard. Almost 3/4 of the light-duty over-the-road vehicles currently are assigned to specific drivers.

A concern has also been raised that EV substitution might be impeded to the extent that vehicles are to be assigned to unionized drivers. Even if driver unionization should prove to be a problem, its impact would be limited since only 12% of light duty over-the-road vehicles are reported to be driven by unionized drivers. Furthermore, information gathered in the Site Operator interviews do not indicate that this is a problem area.

Vehicles Typically Driven More Than 60 Miles/Day

Although 60 miles was assumed to be the effective range limit of near term EVs, it was recognized that opportunity recharging could

¹ The problem was exacerbated by the fact that many vehicles used in the demonstrations had extremely short effective ranges.
Mileage and other vehicle use data indicate that the likelihood of substituting EVs for light duty higher mileage ICE vehicles is not very promising. Thus, a limited amount of information about vehicles typically driven more than 60 miles per day was gathered. The market potential implications of these data are not particularly encouraging. Cars and station wagons in this group average 119.5 miles per day, only about half (55.1%) are parked for an hour or more at a time during the day, and only 15% are left on company premises overnight. Vehicles other than cars and station wagons average 95.1 miles per day. Only 60.4% of them are parked for an hour or more at a time during the day. However, 64% are left on company premises overnight.

ESTIMATING MARKET POTENTIAL IN THE DETROIT EDISON SERVICE AREA

The pilot study provides some important insights into market potential in the Detroit Edison service area, although its limited scale does not provide the basis for a comprehensive estimate. These results are presented in Table 2.3. When considering these statistics the reader should recall that this service area may contain fleets with no vehicles commercially registered in the area. To the extent this is the case, the totals are smaller than they would be if the population were defined to contain all firms in the service area. Moreover, to the extent that such fleets exist, are large, and have 'atypical use,' the statistics of Table 2.3 are biased measures of proportions for all firms in the service area. Finally, since the pilot interview was intentionally kept short, information was not collected to estimate the number of vehicles in
the area with more complex combinations of attributes, e.g., expressway driving and parked for an hour or more.

As indicated in Table 2.3, within the Detroit Edison service area an estimated 16,966±1323 cars and station wagons and 29,465±2710 other light duty over-the-road vehicles would be amenable to EV substitution based on the mileage constraint alone." Considering the fact that the Detroit Edison service area represents only a small fraction of the total market from a manufacturer's perspective, these results are extremely encouraging.

It must be remembered that range is not the only factor affecting market potential. For example, market size is dramatically reduced if the potential market is thought of as only vehicles that are never required to go more than 60 miles in a day. Much of the lost ground is regained, however, if the possibility for opportunity recharging is introduced. If a vehicle, in order to be potentially substituted, must typically be driven 60 or fewer miles per day and not be driven frequently on the expressway, the potential again shrinks considerably. It does

"The 95% confidence given are approximations calculated by applying the estimated percentages plus or minus two standard errors to the estimated number of vehicles in the population under consideration. This is only an approximation, however, because a portion of the population was estimated from the sample (and therefore, also has variance), because adjustment was not made in the calculation of the standard error of the proportion for the slight design effect produced by the sample design, and because the population and proportion estimates are likely to have some covariance.
| Estimated Number of Vehicles that Have EV-Substitution Potential Registered in the Detroit Edison Service Area to Fleets With at Least One Commercially Registered Vehicle |
|---|---|
| Number of |  |
| Cars & Station Wagon |  |

<table>
<thead>
<tr>
<th>Typically driven 60 or fewer miles/day</th>
<th>Estimated Number of Cars &amp; Station Wagons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always driven 60 or fewer miles/day</td>
<td>3,359 ± 343</td>
</tr>
<tr>
<td>Typically driven 60 or fewer miles/day and parked for an hour or more at a time during the day</td>
<td>14,590 ± 1284</td>
</tr>
<tr>
<td>Typically driven 60 or fewer miles/day and not frequently driven on expressways</td>
<td>5,514 ± 651</td>
</tr>
<tr>
<td>Typically driven 60 or fewer miles/day and assigned fixed routes</td>
<td>1,781 ± 139</td>
</tr>
</tbody>
</table>

The 95% confidence intervals are approximations calculated by applying the estimated percentage of vehicles with the given characteristic ± 2 standard errors to the estimated number of vehicles in the population under consideration. These are approximate intervals for three reasons. First, a portion of the population was estimated from the sample and therefore, the population estimate itself has variance. Second, the (probability) sampling procedure used produced a small design effect and the estimated standard error of the proportion was not adjusted to account for this. Finally, since both the proportions and the population estimates are sample based, they are likely to have some covariance which is not considered in the calculation.
so even more dramatically if substitutable vehicles not only must meet the mileage constraint but must also be assigned to fixed routes. As the previous discussion indicates, these additional 'caveats,' while important, are clearly not precise enough to be useful in helping to define the potential EV market. However, assuming the mileage limitation is the most significant barrier to EV substitution, and to the extent that any national inferences can be drawn from a single service area, the potential national market looks very promising.
CHAPTER 3
TARGETING THE MARKET

The fact that EVs meet the technical requirements of a large portion of the vehicles in commercial fleets in no way provides assurance that managers would be willing to consider substitution. Whether they would be willing, and the characteristics of establishments and fleets in which willingness are most commonly expressed, are the subjects of this chapter.

FLEET MANAGERS' WILLINGNESS TO USE EVS

Fleet managers were asked directly whether a vehicle with the characteristics of an EV would fit into their fleet operations. The question began with a carefully worded preamble which informed the respondent about the characteristics of near-term electric vehicles. While many respondents qualified their answers by saying that the economics of EVs would have to be favorable, nearly half (48%) said they would be willing to use EVs in their businesses.

As shown in Table 3.1, the 48% point estimate represents roughly eighty-five hundred (8,544±1,457) fleet managers in the Detroit Edison service area who would be willing to use an EV. These managers are responsible for approximately twenty five thousand (24,018±4,097) vehicles currently driven 60 or fewer miles per day.

Due to the small sample size of the Pilot Survey and to a sample design which is most efficient for vehicle-level analysis and less efficient for establishment- or fleet-level analysis, the 95% confidence interval for this
Table 3.1
Characteristics of the Fleets of Managers in the Detroit Edison Service Area Who are Willing to Use EVs

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Estimated Number of Managers in Service Area</th>
<th>Total Number of Vehicles in Their Fleets</th>
<th>Number of Vehicles in Their Fleet Driven Less Than 61 Miles/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Cars</td>
<td>4.715 (+804)</td>
<td>12,418 (+2,118)</td>
<td>9,600 (+1,637)</td>
</tr>
<tr>
<td>Trucks and Vans</td>
<td>8.331 (+1,421)</td>
<td>22,127 (+3,774)</td>
<td>14,418 (+4,097)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>8.544 (+1,457)</td>
<td>34,555 (+5,694)</td>
<td>24,018 (+4,097)</td>
</tr>
</tbody>
</table>

*This total excludes double counting of managers of fleets with both passenger cars and trucks and vans.*
estimate is rather large, ranging from 30.2% at the lowest to 65.8% at the upper bound. Even at the lower end of this bound, however, the responses indicate that a large number of commercial fleet operators are willing to consider EV-type vehicles.

Are the Results Reasonable?

In survey research it is always best to be skeptical about what people say in response to interview questions. Indeed, until proven otherwise, it is best to view the interview situation as a stimulus/response experiment. A standard stimulus (the question) is given to all the subjects, and a response (answer) is recorded.

If the 48% figure mentioned above represents reasoned responses, it would be very encouraging from an EV market standpoint. However, 48% is also the magnitude expected if the managers were responding at random (50%). To see which of these alternatives -- reasoned or random responses -- is most consistent with the data, a multivariate analysis was performed on the responses to this question. The idea behind this analysis is to see whether the relationship between 1) the expressed willingness of respondents to use EVs and 2) measures of objective vehicle fleet characteristics, is consistent with what we know to be reasonable.

Testing the Effect of Fleet Size on Willingness to Use EVs

Because new ground is being broken with this Pilot, what relationships are "reasonable" is not completely obvious. However, if anything should
generalize to commercial operations from consumer studies, it is that EVs will not do well as 'only cars'. Thus, the reasonable expectation, all other things equal, would be that managers of single vehicle fleets would be less willing than managers of larger fleets to express interest in using EVs. Furthermore, it stands to reason that the larger the fleet, the more varied the specific vehicle applications will be, and therefore, the higher the likelihood that an EV could fit at least one application in the company. Thus, if managers are answering the question in a meaningful way, the proportion expressing willingness should increase with fleet size, all else being constant.

Figure 3.1 presents the percentage of managers expressing willingness to use an EV-type vehicle in their commercial fleet operations, broken down by size of fleet. The 'unadjusted average' figures represent the simple average percent of managers in each vehicle fleet size group expressing willingness. The 'adjusted average' is the percent expected if the fleet were average (with respect to a series of other characteristics) in all respects except fleet size.

'The technique employed to apply these statistical controls is a form of multiple dummy variable regression called Multiple Classification Analysis (MCA). Explanations of the technique can be found in Andrews, Morgan, and Sonquist (1974) or Hill (1978). In this analysis the controls consisted of industry, fleet composition, the number of vehicles going less than 60 miles per day, the weight of any cargo being carried, the extent of unionization of drivers, and a measure of the extent to which purchase decisions were made by the respondent as opposed to someone 'higher-up'.
FIGURE 3.1
PERCENT OF MANAGERS WILLING TO USE EVs BY FLEET SIZE

- MANAGERS OF LARGER FLEETS ARE MORE LIKELY TO BE WILLING TO USE EVs
size. These adjusted averages are obtained by applying multivariate statistical controls to the percentage estimates.

Both the adjusted and unadjusted percents for single vehicle fleets are considerably lower than those for larger fleets which confirms our expectations. The unadjusted percent, however, is lowest for the very largest vehicle fleets while the adjusted percent is highest for the largest fleets. The reason for the large difference in these two measures of willingness is that the large fleet category is dominated by fleets with passenger cars. As shown below, managers of passenger car fleets (especially those with privately registered passenger cars) are less willing to consider EVs than managers of truck fleets. The statistical adjustment controls for the effects of this association between size and fleet composition, and thus yields percentages which represent the independent effects of fleet size.

In summary, the statistically adjusted relationship between fleet size and willingness to use EVs does take the expected form. This is a good indicator that the respondents did provide reasoned responses when asked about the willingness to use EVs.

Other Factors Related to Willingness to Use EVs

The multivariate approach used above also allows analysis of the effect of other variables on willingness to use EVs such as fleet composition, industry type, and load requirements. The results of the multivariate analysis are presented below.
FIGURE 3.2

PERCENT OF MANAGERS WILLING TO USE EVs BY FLEET TYPE

- MANAGERS OF FLEETS CONTAINING PICKUPS ARE MORE WILLING TO USE EVs THAN THOSE OF FLEETS WITH PASSENGER CARS
Fleet Composition.

Figure 3.2 shows the percentage willing to use EVs broken down by type of fleet. The pattern suggests that managers of fleets composed of pickups (either alone or in combination with other types of vehicles) are most willing to consider EVs, while managers of fleets containing just cars are least willing to do so. This is potentially a very important finding. However, caution is urged at this time since the small sample size within subgroups make the estimates quite imprecise. The 95% confidence interval around unadjusted percent of 'car only' managers willing to use EVs, for instance, ranges from 95% to -27%. However, should it hold up in a larger survey, it would indicate that manufacturers and marketers should concentrate on the development of pick-up type vehicles, rather than on passenger cars.

While the above empirical finding must be viewed as tentative, it is of such potential importance that a case-by-case review of the interviews was conducted to better understand the empirical results.

The car only fleets were dominated by two taxi companies and a large communications company. Since taxis are required by law to take all fares, small, limited range vehicles would not be practical for them. The large communications company, like many public utilities, faces the problem of extended in-service demands for vehicles during emergency situations. Other car-only fleets included professional consulting companies and delivery services in which servicing clients often means traveling long distances.
Pickup-only fleets, on the other hand, are made up of firms like auto-parts stores and construction firms. The trucks are used for picking up parts from other stores once or twice a day in the case of the former, and running to the hardware store when something is needed, in the case of the latter. These trucks are typically driven less than 40 miles a day and the loads are generally very light. Pickups are more practical than passenger cars since the loads are occasionally large and dirty. A limited range vehicle would fit quite nicely in these "gopher" applications. Again, however, we must stress that this finding is tentative.

Type of Industry.

Figure 3.3 presents the percentages of managers expressing willingness to use EVs broken down by industry. Managers in service industries were most likely to express willingness, whereas those in transportation or utilities firms were least likely. The fact that the adjusted percent is lower than the actual in the former, and higher in the latter, is due to fleet composition. Pickups are more prevalent in service industry fleets while passenger cars, vans, and semi-tractor trailers (not included in the sample) dominate the fleets of transportation and utility companies. Managers in manufacturing firms are slightly less likely than those in service establishments to be open to the use of EVs, but this effect is largely the result of the fact that their fleets contain passenger cars. When the effects of fleet composition are statistically
FIGURE 3.3
PERCENT OF MANAGERS WILLING TO USE EVs BY INDUSTRY

MANAGERS OF FLEETS IN MANUFACTURING OR IN SERVICES INDUSTRIES ARE MORE WILLING TO USE EVs

TYPE OF INDUSTRY
controlled (i.e. the average is adjusted), managers in manufacturing companies showed the greatest willingness to use EVs (65%).

**Other Willingness Related Factors.**

With one exception, the effects of the other analytic variables included in the analysis are consistent with our expectations. Managers of fleets in which vehicles carry only light loads are more willing to consider EVs than are those in which vehicles carry heavy loads. Managers of fleets with a large number of vehicles typically driven less than 60 miles per day are more willing to use EVs than are managers of fleets without a large number of such vehicles. If driving conditions are regulated by labor contracts, then managers are less likely to express a willingness to try new vehicle types. Similarly reluctant are fleet managers whose establishments are part of larger corporations in which vehicle procurement decisions are made higher up. The one surprise is that managers of fleets in which trucks and vans are not parked on the company premises over night are more willing to consider using EVs. This effect, however, holds only for trucks and vans, and the effect of the parallel measure for passenger cars is in the expected direction.

**Summary of the Multivariate Analysis**

Statistically speaking, the most important determinant of whether fleet managers would be willing to use an EV was the number of privately registered passenger cars in the commercial fleet. In terms of adjusted percentages, nearly three out of four (74.4%) managers of fleets with no such
cars were willing to use EVs. The percentage drops off rapidly with increases in the number of privately registered passenger cars, and actually becomes negative for fleets with 6 or more of these vehicles. Why the mere existence of these vehicles in commercial fleets should have such an inhibiting effect on managers' willingness to use EVs is not clear. We do know, however, that these vehicles are often assigned to company officers and other key employees as perquisites of their positions: for all intents and purposes such privately registered vehicles are operated as private passenger cars.

Overall, the multivariate analysis explained over 40% of the variance in the dependent variable (23.8% when adjustments are made for the small number of observations). This is quite high for cross sectional analysis (especially since the dependent variable is dichotomous). Given this, and given that the most firm hypothesis -- willingness would increase with fleet size -- was supported by the data, and that most of the other results are reasonable, the commercial fleet managers do appear to have answered the question in a thoughtful fashion. That is, the results are meaningful. Since this question has worked, there is every reason to believe that in future surveys, managers can be asked not only if at least one EV could be used, but how many and what type -- questions not included in the Pilot because of the need to keep the interview short.
IDENTIFYING FIRMS WITH HIGH POTENTIAL FOR EV USE

Given that respondents were able to provide reasoned responses about their willingness to use EVs, these data can be used to identify areas of where recruitment (or marketing) efforts should be targeted. If the objective of a demonstration program is to maximize the the number of commercial fleet operations with EV experience, one could identify firms where management is open to the use of EVs regardless of firm or fleet size. If, on the other-hand, the goal is to place as many EVs into commercial service as possible, the number of potential EV slots within a firm could also be considered.

Figure 3.4 presents the results of just such an analysis based on the manager's willingness to use an EV. The independent, or predictor, variables in the multivariate analysis were:

- number of vehicles driven 60 or fewer miles per day,
- fleet size,
- industry type,
- fleet composition,
- payload requirements,
- unionization of driver,
- organizational position in corporate hierarchy,
- number of low mileage cars and wagons, and
- vehicle location at night.

The analysis was conducted using the most recent version of ISR's Automatic Interaction Detector (AID) algorithm called SEARCH. This program scans the entire set of independent variables to identify firms with high potential for EV use.

The responses about willingness to use EVs can aid in the identification of targets for EV marketing and demonstration programs.

A different multivariate statistical technique was used to determine the characteristics of establishments most amenable to EV adoption from a marketing perspective.
FIGURE 3.4

TYPES OF FLEETS WHICH ARE MOST AMENABLE TO USING EVs

Entire Sample
percent willing=87.6
number of cases=116

F Vehicles Driven
60 or fewer miles per day

percent willing=58.7
number of cases=74

Yes Drivers unionized? No

- Fleet type
- Pickup only
- Vans only

Fewer than 6 Fleet size 6 or more

10.2%
21

50.4%
17

53%
15

- Fleet size
- 6 or more

3.7%
12

55%
37

0.7%
3

- percent willing=35
number of cases=46

- percent willing=55
number of cases=27

- under 500 lb
- Weight of payload
- over 500 lb

- percent willing=67
number of cases=55

- Fleet size
- 6 or more

- Industry
- Pick-up only

- Fleet type
variables to find the unique two-way split (or partition) of the sample which maximizes the observed variance in the dependent variable. The sample is then split into these two groups and the algorithm proceeds to identify and split additional subgroups until either no new partitioning explains a meaningful portion of the remaining variance, or until too few cases remain in any group to warrant further partitioning."

The first, and most important, partition identified by the SEARCH program was between fleets with two or more vehicles typically driven 60 or fewer miles per day versus those with none or only one such vehicle. The proportion of managers expressing willingness to use EVs in the former group was nearly twenty-five percentage points higher than those in the latter group (59.7% versus 35%).

The program next split out nineteen fleets with unionized drivers from the group of fleets with two or more vehicles typically driven sixty

"In principle, the multivariate model estimated in the previous section could be applied to this question by targeting recruitment efforts toward the types of firms having high scores on the explanatory variables positively associated with EV acceptance. However, this model was designed to test hypotheses and may not be the most effective formulation for targeting purposes. This is because the MCA model assumed that the effects of independent variables could be added to obtain an overall score for each firm in the sample. The additivity assumption may not be a reasonable one for our purposes here. The SEARCH program avoids this potential problem.

"This analysis used data from 118 cases. A few fleets with more than 990 vehicles were excluded to avoid domination (and distortion) of the results by these special (although important) cases."
non-union drivers...
light loads...
and fleets with pickup trucks.

Three prime target groups were identified: fleets with two or more short range vehicles, non-union drivers, light payloads, and pickups in the fleet.

or fewer miles per day. In the larger non-union group, the proportion of managers willing to use EVs increased from 59.7% to 67%. The SEARCH algorithm next removed from the nonunionized fleets with two or more short-range vehicles those which typically carry loads in excess of 500 pounds. The proportion of managers willing to use EVs in the resulting group increased to 73%.

In its last step the algorithm partitioned out pickup and pickup/car fleets from all other types of fleets. This yielded a group of fleets characterized as having two or more short range vehicles, nonunion drivers, light payloads, with pickups only or pickups and passenger cars. With over 86% expressing willingness to use EVs, this represents the most promising of the three prime target groups identified by the SEARCH program. As Table 3.2 indicates, this percentage translates to an estimated 3,236 managers responsible for about 11,000 vehicles driven fewer than 61 miles per day in the Detroit Edison service area.

A second target group can be isolated from the fleets with two or more light duty vehicles with nonunion drivers, and light payloads, by partitioning out fleets in the construction, manufacturing and service industries. Over 70 percent (71.5%) of these fleet managers expressed willingness to use EVs, which represents about 800 managers of 2,400 short range vehicles.

Within the group of fleets with at most one low-mileage vehicle, a third potential target group exists with more than 50% of the managers expressing willingness to use EVs. This subgroup is characterized as having pickups or vans only,
<table>
<thead>
<tr>
<th>Target Group</th>
<th>Estimated Number of Managers Willing to Use EVs in Detroit Edison Service Area</th>
<th>Estimated Number of Vehicles in Their Fleet Driven Less Than 61 Miles/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. more than 2 vehicles driven</td>
<td>3236 (±957)</td>
<td>11,244 (±3,327)</td>
</tr>
<tr>
<td>less than 61 mpm;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non union drivers;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>light loads;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pickups only;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. more than 2 vehicles driven</td>
<td>804 (±422)</td>
<td>2,372 (±1,246)</td>
</tr>
<tr>
<td>less than 61 mpm;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non union drivers;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>light loads;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>not pickup only;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>but in manufacturing or service industry.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. One vehicle driven</td>
<td>2,077 (±972)</td>
<td>2,077 (±972)</td>
</tr>
<tr>
<td>less than 61 mpm;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and a fleet composed of pickups or vans only.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
and fleets with at most one vehicle which is either a pickup or a van.

The least promising group had at most one short range vehicle, in a fleet of less than 6 vehicles including cars only or cars, vans, and pickups.

and is estimated to represent about 2,100 managers and an equal number of short range vehicles in the service area.

The group showing the least promise from a recruiting point consists of fleets with at most one short range vehicle, with cars only or cars, vans and pickups; and fewer than 6 vehicles in the total fleet. Fewer than 4 percent of the managers of such fleets expressed a willingness to use EVs."

In summary, multivariate analysis has demonstrated that respondents do appear to give reasoned answers when asked directly about their willingness to use EVs. This provides a promising approach for future EV market assessment research. In particular, responses to this type question can be used to identify promising targets for potential EV sales or participation in demonstration programs.

"It should be noted that the overall results of the SEARCH analysis do indicate non-additivities. The variables which are important for fleets with two or more short range vehicles are different from those which are important for fleets with at most one short range vehicle. Union drivers, payload, and fleet type were most important for the former group, while fleet type and size were important for the latter."
CHAPTER 4
COMMERCIAL SECTOR EV DEMONSTRATION PROGRAMS:
FINDINGS AND RECOMMENDATIONS

INTRODUCTION

This chapter turns from the question of potential market size, to consideration of the role of EV demonstration programs in the development of EVs and their market appeal. In contrast to the market potential analyses presented earlier, the information and analysis of this chapter is more qualitative and prescriptive.

The analysis examines the general lessons learned from the experience of the past several years of EV demonstration programs, and how these lessons can be applied to increase the chances for success of future demonstrations projects.

THE VALUE AND RISKS OF A COMMERCIAL SECTOR EV DEMONSTRATION

Before discussing the specific lessons learned from current EV demonstration programs, it is worth highlighting what a demonstration program can and cannot do and the risks associated with a demonstration.

Information to Aid Decision Making

A demonstration program is typically intended to speed commercialization by showing how a new technology operates under real world, rather than laboratory, conditions. Ideally, information collected during a demonstration program should be

"The authors are indebted to Professor Kan Chen for his contribution to this section on the value and risks of demonstrations."
designed to aid decision-making by all parties needed to bring about commercialization of a new technology. In the case of EVs this includes not just the electric utilities, EV manufactures, and commercial fleet operators, but also all those who constitute the full infrastructure; namely, dealers and leasing agents, maintenance personnel, parts suppliers, insurers, government agencies, etc. Each of these groups has different information needs, procedures, goals, and constraints. A good demonstration will take account of these different perspectives and information needs early in the design process. It will also carefully evaluate the types of information the demonstration should or should not attempt to obtain. The most valuable types of information which can be obtained from an EV demonstration are the attitudes, unexpected problems, reactions to real experience, and possible work reorganizations of all the parties involved in the introduction of EVs. This is "real world" information not obtainable in the laboratory or from abstract theory or models.

In contrast, a demonstration cannot obtain detailed information which needs a great deal of control in data collection. Tight controls of conditions of EVs' use, and traditional "scientific" requirements for data collection, are neither feasible in a demonstration nor desirable. Thus, one should not expect to obtain, for example, laboratory-type information about battery performance under various operating conditions or recharging procedures. Other, more appropriate, research approaches are needed to obtain this type of information.
Infrastructure Development

In addition to information gathering, a successful demonstration aids in infrastructure development. When a new technology is being introduced, potential users tend to wait for emergence of the needed support infrastructure before attempting to adopt the technology, while potential infrastructure members wait for emergence of users in order to justify their investment. This "chicken and egg" dilemma can be reduced by a demonstration program that provides incentives for all the necessary parties and encourages them to coordinate their activities and establish working relationships. In this sense, the program demonstrates both the technology and the infrastructure.

A successful demonstration program creates positive (and realistic) attitudes about the feasibility and desirability of the new technology on the part of both users and infrastructure suppliers. This attitudinal change happens initially to demonstration participants and other early innovators who have first-hand experience, and then spreads indirectly through professional colleagues, friends, news media, etc. As this technology adoption process spreads, new commitments are made and old ones reinforced by both infrastructure participants and potential users.

Risks of a Demonstration

Demonstration programs are not without risks. Perhaps the most important risk is that of technological failure due to premature or inappropriate application. A second source of
failure is poor quality control in the prototype demonstration technology which must be distinguished from problems inherent in the technology itself. Regardless of the cause, however, once a negative impression is made, demonstration participants may be reluctant to try again even after the technology has been improved. It is, therefore, essential to minimize the likelihood of failure by utilizing as trouble-free a technology as possible and by not promising more than the technology can deliver.

Another demonstration risk results from the need to rely on an immature infrastructure. A new and developing infrastructure is more likely to fail in delivery of services than one which has been in place for a while. Another potential risk is the failure to develop any lasting infrastructure. The limited scale of a demonstration, while reducing long term risks, makes realistic economies of scale difficult to achieve and demonstrate. Thus, the commitments required for a self-sustaining critical mass may not be achieved during the life of the program. If this is the case, key parties may back out during or after the demonstration. Once this occurs, it may be difficult to convince the involved parties to move again when conditions are ripe for commercialization.

Other demonstration risks are associated with information validity. A demonstration has a "Hawthorne effect" — some results are due to the added attention accompanying the technology demonstration, not to the technology itself. Participants may feel honored, or lucky, to be involved in an innovative project. They may try
harder, and, as a consequence, like the new technology more. However, after the novelty wears off, they may be less attentive and less willing to put up with inconveniences or deficiencies.' To the extent this factor is operating, a demonstration may not give a completely valid reading of attitudes and performance in real world settings.

Nor are the results of a demonstration program necessarily directly transferable to other sites, market segments or time periods. For example, the results of an EV demonstration which takes place during an oil glut may differ from results which occur if the demonstration took place during an oil shortage. Similarly, results in an area of low electricity rates may differ from those where electric rates are higher. Perhaps most importantly, changes in the external environment, in the technology, or in characteristics of the sites and market segments all impede the transferability of earlier results. Moreover, results from a well established demonstration site, already up the learning curve, may not be applicable to a new site.

In summary, while the risks of a demonstration are potentially serious, many of these risks can be reduced if the technology is reliable and the demonstration design allows systematic comparison of results over time and across multiple sites. These same demonstration design characteristics also contribute to the two

'The opposite effect can also occur. Persons forced to participate in a demonstration may exhibit negative attitudes traceable to the process rather than the technology.
primary goals of a demonstration: providing information to aid decision-making, and infrastructure development.
LESSONS LEARNED FROM THE DOE SITE OPERATORS

The primary source of information for the analysis which follows is a set of detailed interviews conducted with 35 DOE Electric Vehicle Demonstration Program Site Managers. These telephone interviews were conducted in November and December 1982, and lasted about one hour. The purpose of the interviews was to identify the lessons learned by the site operators on issues such as vehicle performance, applications, driver attitudes, maintenance, and so forth. The subset of DOE site operators interviewed was limited to those using vehicles in applications typical of commercial and government sector fleets. The question protocol used during these interviews is included in Appendix C.

In addition to the interviews, the analysis that follows draws on the experience of several other EV demonstration projects in Europe and the U.S. Finally, we have also drawn on the literature assessing the role of demonstration projects across a broad range of technologies and social programs (Marks, Berg, et al., 1982).

The DOE EV demonstrations have experienced many of the same pitfalls and problems encountered by other types of demonstration projects. They have also had some important and promising areas of success. In the following analysis, major factors influencing the success of the DOE programs have been organized into three areas: applications, vehicle performance, and operations. Major cost uncertainties facing EV users have also been identified.
Applications

The DOE site operators interviewed have been using their electric cars and trucks in more than ten different types of commercial and government applications. Almost universally the EVs were put in service without any significant changes in the standard operating procedures of the organizations. In general, only the most basic operational changes in maintenance and driver assignment were made. Potential applications were typically identified by isolating existing vehicle assignments which fell within the expected performance characteristics of the EVs. Rarely were existing vehicle use patterns modified to create new opportunities for using EVs, although the potential for doing so was frequently acknowledged. If an EV was not successful in an application, the vehicle was reassigned.

The list of EV application areas presented in Table 4.1 is impressive both in terms of the breadth of different applications, and the fact that all of the applications were conducted successfully by at least some of the demonstration operators. (For this reason, the order of presentation in Table 4.1 should not be interpreted as a ranking). Indeed, the majority of operators found their EVs to be compatible with most of their assigned applications. More importantly, in almost all cases commensurate with EV range limitations, the applications were entirely compatible with the performance characteristics of a "reliable" EV having a well managed preventative maintenance program and an infrastructure capable of providing for the timely
<table>
<thead>
<tr>
<th>Application</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Transportation</td>
<td>The least successful application when assigned to a general transportation pool. No one person had responsibility for the EVs, so they often went without charging or appropriate maintenance. As a result reliability was low (even for the better performing EVs) and drivers developed negative attitudes. Given a choice, most drivers abandon the EVs for the preferred characteristics of conventional vehicles typically available in a pool setting. When assigned to a specific individual (rather than a pool), reliable EVs did perform well in general transportation uses (subject to range constraints).</td>
</tr>
<tr>
<td>Inspection and Supervision</td>
<td>Typically referred to as the most successful application. Usually assigned to a single inspector or supervisor (without backup) as transport to job sites. Given no conveniently obtained backup vehicle, there is a strong incentive to keep the EV working. Drivers in these roles are often older than average and not under tight time schedule. Similar applications were by energy auditors and by police officers making safety presentations at neighborhood schools.</td>
</tr>
<tr>
<td>Merchandise Delivery and Pickup</td>
<td>With reliable vehicles this was a successful application even when run in a small pool setting. In some cases a conventional vehicle was also needed for longer range trips. Merchandise included parts, baked goods, cafeteria supplies, and milk (in Britain).</td>
</tr>
<tr>
<td>Mail and Fixed Route Courier</td>
<td>A uniformly successful application given a reliable vehicle operated within range constraints.</td>
</tr>
</tbody>
</table>
Table 4.1 (Continued)

Demonstration Program Commercial EV Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shuttle</td>
<td>A relatively common and successful use given a reliable vehicle. Has worked effectively in a small pool setting or when assigned to an individual driver. Typical settings include prisons, zoos, large industrial complexes, and between scattered sites in an urban setting.</td>
</tr>
<tr>
<td>Parking Enforcement</td>
<td>Used quite successfully for this purpose by a number of cities. Limited distances, slow speeds, frequent stops and starts, and high density downtown settings provide an ideal application.</td>
</tr>
<tr>
<td>Utility Meter Reading</td>
<td>Successful applications within both pool and assigned settings. Driver typically drives to an area, walks, and then moves vehicle to next block or neighborhood. One municipal water department abandoned this use due to limited vehicle range.</td>
</tr>
<tr>
<td>Security</td>
<td>Used with apparent success in a pool setting by security personnel within one utility. Typically not acceptable to police departments. One use as a police shuttle between station and jail was abandoned due to poor vehicle reliability.</td>
</tr>
<tr>
<td>Installation and Maintenance</td>
<td>Used with mixed results in both pool and assigned settings. Pool vehicles were often assigned to a specific driver for a particular day or job. These applications are especially sensitive to problems of reliability and range. Trips are often chained in unpredictable and inflexible ways, with little room for delay or postponement. This is especially the case in emergency situations when all fleet vehicles may be pressed into use to restore service to customers. Range limitations have created union conflicts by impinging on driver ability to take on overtime jobs requiring an extra trip beyond</td>
</tr>
</tbody>
</table>
### Table 4.1 (Continued)

**Demonstration Program Commercial EV Applications**

<table>
<thead>
<tr>
<th>Application</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>normal daily range. Range also can affect efficiency if equipment must be frequently transferred between EV and conventional vehicle to accommodate consecutive jobs requiring different travel ranges.</td>
</tr>
<tr>
<td>Indoor Applications</td>
<td>Noise and pollution characteristics were attractive to two sites, but with mixed results. One vehicle assigned to driver at city coliseum proved especially successful in indoor use during games and other events. However, use at Kennedy Space Center within the Vehicle Assembly Building and as shuttle to launch pad was handicapped by vehicle reliability problems attributed in part to the pool status of the vehicles.</td>
</tr>
<tr>
<td>Other</td>
<td>The single most unique application was by a county government which assigned a vehicle to the county cemetery where it was used to lead funeral processions.</td>
</tr>
</tbody>
</table>
Success is partly attributable to the selection of applications with high probabilities of success by operators with a stake in successful EV demonstration.

Delivery of service and replacement parts, i.e., a production quality vehicle and a well developed infrastructure.

This rather optimistic perspective needs to be constrained by two important caveats. First, the particular applications described here were in large part selected by the site operators based on their having a high probability of success. While applications such as these constitute a relatively large (although unknown) proportion of commercial and government vehicle applications, they are not typical of many others. Thus, while relatively optimistic, the implication is not that EVs should be viewed as having the potential for replacing all conventional ICE vehicles. Rather, they should be thought of as potentially desirable supplements in certain types of situations. Second, the operators themselves have typically been selected or self-selected because of their having a stake in the successful demonstration of EVs. That is, they typically have a self-interest in making EVs (or at least the demonstration) work. This same positive attitude cannot be expected within the larger population of potential EV users. Indeed, at the current time, this attitude is not present even among all those needed for an effective EV infrastructure.

General Characteristics of "Successful" Applications

In light of the rather diverse list of EV applications which have "worked" in at least some settings, it may prove useful to identify characteristics of "successful" applications in addition to citing specific examples. This allows both the identification of new application areas
and a more careful discrimination between settings in which the same application either may or may not work.

- The range capability of the EV must exceed the application range requirement by a sufficient margin to allow for the drivers' psychological need to have adequate reserve capacity, for degraded performance due to cold weather, and for differing driver skill levels.

- EVs can be used successfully in applications which on occasion exceed EV range limitations, if and only if:
  - they are supplemented by a few longer range backup vehicles,
  - the longer trips can be prescheduled or flexibly assigned to the backup vehicles,
  - vehicle switching does not also require time consuming shifting of equipment and supplies,
  - the longer-range applications are infrequent and are not required of all fleet vehicles, (e.g., they would not be satisfactory for utility companies that require all available personnel and vehicles to respond to power outages following winter storms),
  - the inability to take on longer range missions does not unfairly handicap drivers in terms of overtime pay, desirable job assignments, efficiency evaluations, etc.

- Vehicle use schedules must be such that eight to ten hours are available for daily recharging. Vehicles driven home at night may not be available for daytime use, and day-use vehicles may not be available for nighttime use.

- Applications must be such that day-to-day EV maintenance is the responsibility of one person. If this condition is met, then it may be possible to assign the vehicle to more than one trained driver via a pool arrangement.
Vehicle Performance

Most of the performance-related concerns and problems identified by operators are attributable to the prototype nature of their vehicles. These prototype problems need to be distinguished from the limitations inherent in a well designed, performance tested electric vehicle, (see Table 4.2). The electric vehicles used in the DOE demonstrations represent a new product subject to problems typical of small manufacturing firms just starting along the learning curve. Many of these vehicles received only limited testing and were often less than adequate in terms of important performance characteristics.

Frequently mentioned performance problems were range and reliability. Two-thirds of the operators interviewed said they were achieving a range significantly less than initially expected (10-25 miles versus 25-45 miles). Limited range forced some operators to eliminate some initially planned applications such as meter reading, police use, and administrative shuttle. Applications were also eliminated because of inconsistent range performance.

Equally serious and surprising were the low reliability and high maintenance requirements (dollars and time) of the poorest-performing vehicles. In more than a few cases, frequent breakdowns coupled with long delays in diagnosis or parts delivery resulted in extraordinarily high maintenance costs on a per mile basis.

The significance of these prototype vehicle performance problems is not so much that they occurred, but that they are "fixable". As the EV industry develops and production volume increases,
<table>
<thead>
<tr>
<th>PROBLEMS OCCURRING IN PROTOTYPE VEHICLES</th>
<th>PROBLEMS INHERENT IN A WELL DESIGNED/TESTED EV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RANGE</strong></td>
<td></td>
</tr>
<tr>
<td>Degradation of performance due to cold batteries - use of heaters or trickle chargers are needed</td>
<td>Vehicle range related to type of battery</td>
</tr>
<tr>
<td>Limitations of vehicle range related to battery use - consistency of use and distance can affect battery memory</td>
<td>Vehicle range related to type of battery</td>
</tr>
<tr>
<td>Reduction in vehicle performance related to age of batteries - older batteries get decreased range</td>
<td>Vehicle range related to type of battery</td>
</tr>
<tr>
<td><strong>DESIGN/OPERATION</strong></td>
<td></td>
</tr>
<tr>
<td>Frequent charger failures resulting in over and under charging</td>
<td>Need to charge vehicles regularly for extended periods</td>
</tr>
<tr>
<td>Frequent battery failures due to quality control</td>
<td>Need to monitor and check batteries</td>
</tr>
<tr>
<td>Controller failures</td>
<td></td>
</tr>
<tr>
<td>Deficient braking system (emergency stops)</td>
<td></td>
</tr>
<tr>
<td>Defective transmission systems (front wheel drive)</td>
<td></td>
</tr>
<tr>
<td>Inadequate suspension systems</td>
<td></td>
</tr>
<tr>
<td>Motor mount failures</td>
<td></td>
</tr>
<tr>
<td>Inadequate exhaust fans</td>
<td>Proper ventilation required during recharge</td>
</tr>
<tr>
<td>Inadequate heating and air conditioning systems</td>
<td>Lack of air conditioning in warmer climates</td>
</tr>
<tr>
<td><strong>RESPONSIVENESS</strong></td>
<td></td>
</tr>
<tr>
<td>Limited load carrying capacity</td>
<td>Need to match vehicle design with load requirements</td>
</tr>
<tr>
<td>PROBLEMS OCCURRING IN PROTOTYPE VEHICLES</td>
<td>PROBLEMS INHERENT IN A WELL DESIGNED/TESTED EV</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td><strong>RESPONSIVENESS</strong></td>
<td></td>
</tr>
<tr>
<td>Limited acceleration and hill climbing performance</td>
<td>Limited acceleration and hill climbing performance</td>
</tr>
<tr>
<td><strong>DRIVERS</strong></td>
<td></td>
</tr>
<tr>
<td>Vehicle performance strongly tied to driver attitude and behavior</td>
<td>Vehicle performance tied to driver attitude and behavior</td>
</tr>
<tr>
<td>Inadequate and poorly located vehicle instrumentation for providing feedback on possible problems and optimal driving patterns</td>
<td>Performance tied to drivers ability to operate vehicle efficiently (shifting, acceleration)</td>
</tr>
<tr>
<td><strong>MAINTENANCE</strong></td>
<td></td>
</tr>
<tr>
<td>Time consuming and inefficient methods for checking battery cells</td>
<td>Consistent maintenance schedule required (battery check)</td>
</tr>
<tr>
<td>Inadequate training and vehicle diagnosis system</td>
<td>Commitment of labor and time commensurate (at least) with conventional vehicles - need for technicians with electronics background</td>
</tr>
<tr>
<td>Insufficient network for parts and supplies, serious delays</td>
<td>Demand and wait for parts and supplies commensurate with conventional vehicles</td>
</tr>
<tr>
<td>Manufacturers warranties not fully honored resulting in lack of confidence and trust</td>
<td>Warranties as good or better than conventional vehicles</td>
</tr>
</tbody>
</table>
these types of problems should diminish rapidly. For example, problems attributable to poor design such as inadequate braking, poor suspension, or plastic fan blades which deteriorate because of battery fumes are not inherent in EV technology. Already many of the site operators have been impressed with improvements in the newer generation vehicles such as better braking and suspension systems, and improved "creature comforts."

On the other hand, some of the performance problems and limitations addressed by the site operators are likely to occur despite improved vehicle design and performance testing. These are limitations and problems which are inherent in current EV technology, and which are not likely to be eliminated in the near term. As such, they are especially pertinent to demonstration planning. In terms of importance, three major factors emerge: vehicle range, vehicle responsiveness, and unique maintenance requirements.

**Range** - Electric vehicles available during the next decade will continue to have limited range as compared with conventional vehicles, although electric hybrid vehicles may mitigate the problem somewhat. However, the DOE Site Operator interviews suggest that the reliability and consistency of the range may prove to be more important than maximum range.

**Vehicle Responsiveness** - Although vehicle responsiveness is dependent on future technology, it is anticipated that future EVs will continue to have less power and acceleration than conventional vehicles. This may prove to be a somewhat less serious limitation than range, but demonstration-based research is needed to determine minimum acceptable levels for vehicle responsiveness.

*Most of these problems can be easily fixed.*
Maintenance - Without proper maintenance, even the best designed and operated EV will eventually perform poorly. The importance of proper maintenance was a clearly evident, although often hard won lesson for the site operators. While future electric vehicles may actually have lower overall maintenance requirements than conventional vehicles, much of the maintenance which is needed will differ from conventional vehicle maintenance in terms of timing, training personnel, equipment, and functions. For example, proper EV maintenance requires better electronic diagnostic skills than are typically found among conventional automotive mechanics, and better diagnostic equipment as well.

Operations

The site operator interviews made it clear that operational and organizational factors can influence the success of a demonstration program as much or more than the choice of applications or vehicle performance. The review of interview results, below, should make it clear that simply having a "good" vehicle will not be sufficient.

Routes

All cases in which vehicles were assigned to fixed routes proved to be successful. However, assignments to variable routes were also successful if the total daily mileage was well within the vehicles' range, and if someone was responsible to see that they were recharged every evening. Short routes were generally successful, although one failure occurred because the routes were so short that no one bothered to recharge the vehicles on a regular basis. Longer routes,
over 40 miles, were successful in cases where the particular vehicle's range was over 45 miles per charge, or where opportunity recharging was done.

In a few rare cases, a driver was assigned an EV for short trips and a conventional vehicle for long trips. In other words, the EV was substituted for only a portion of a route. These applications proved to be successful.

The number of stops and starts was not a factor influencing an application's success or failure.

Dispatch

Many site operators stated a desire for greater control over day-to-day operations of the vehicles, although centralized dispatch and control was not necessary for successful vehicle utilization. More important was an understanding and acceptance of the limitations by whomever was responsible for dispatch. Where dispatchers understood and took responsibility for the vehicles, they were successfully assigned to tasks within their range. Problems arose when dispatchers did not understand the range limitations of the vehicles and tried to push them beyond their capabilities.

Recharging

Vehicle recharging practices made little difference in successful utilization. In most cases, vehicles were recharged overnight, although in some cases, opportunity recharging was successfully used to extend daily range whenever vehicles were parked at recharging stations. In a few cases, vehicles were only recharged after
driving a certain number of miles. Recharging was a problem when the vehicle was driven home at night and then used as a pool vehicle during the day.

Driver/Vehicle Assignments

Many of the site operators stated that the best arrangement was the assignment of a specific vehicle to a specific driver. This follows a generally accepted principle of fleet management that individually assigned vehicles suffer less abuse. In most cases, EVs assigned to specific drivers performed successfully. In those cases where specific driver assignments were less than successful, other factors were responsible (e.g., reliability or dispatchers assigning trips beyond vehicle range). The assignment of specific drivers to specific vehicles even in the absence of such unfavorable factors did not guarantee success, however. Driver attitude was equally important; drivers hostile to the vehicle or demonstration program often found ways to impair vehicle performance.

Vehicles assigned to a small group of drivers (i.e. to more than one driver, but not to a pool) generally performed as well as those assigned to a specific driver. Where one person took responsibility (either a driver or a maintenance person), or where a sense of responsibility was shared by the drivers, the application worked. However, where no one took responsibility for the vehicle, multiple drivers did not work well.

Vehicles assigned to central motor pools were generally used less than were EVs in other applications and they suffered more in terms of
reliability. In pools, EVs were typically not chosen over readily available conventional vehicles. In a few cases, motor pool dispatchers did suggest EV use for suitable trips and this procedure worked well.

**Backup Vehicles**

The availability of conventional backup vehicles was a mixed blessing, although in general it had little impact on EV success. In some cases backups were needed to accommodate poor EV reliability and long delays for parts delivery. One operator without a backup was forced to rent a conventional vehicle when the EV went down. In a few cases, however, the availability of conventional backup vehicles was an incentive for dissatisfied EV drivers to invent or create problems in the EV. As with specific driver assignments, driver attitude, in these instances, was the factor which was most important in determining success or failure.

**Drivers**

As indicated above, the attitudes of the drivers towards the vehicles was one of the biggest factors in determining whether or not EVs were successfully utilized. In every case where drivers volunteered, no problems emerged attributable to driver acceptance. Problems in these cases were due to poor vehicle reliability. Where drivers were not given a choice the record is mixed. In those cases where EVs performed up to expectation, drafted drivers generally accepted them. However, drivers quickly became hostile toward unreliable vehicles and, once a vehicle's reputation was established, driver acceptance vanished.
Driver acceptance tended to decline over time.

Generally, driver acceptance declined over time, and as the novelty of EVs wore off, driver enthusiasm and usage (where there was a choice) declined as well.

In a few cases, driver suggestions and comments were actively solicited by program managers. These information feedback mechanisms served two purposes. First, they allowed management to detect problems before they became critical and to make improvements in both the vehicle operations and the vehicles before problems occurred. Second, they made drivers feel involved in the program and helped to maintain driver enthusiasm. One source of drivers' enthusiasm was their belief that they were actively contributing to a project important to their organization and that someone cared about their thoughts and ideas.

Problems emerged in a few cases where drivers felt that their participation in the demonstration resulted in their having to do tasks beyond their normal workload. These complaints were typically raised by drivers drafted into the program and assigned EVs instead of conventional vehicles for transportation on their normal jobs. They did not arise among drivers whose primary function was driving such as mail delivery persons and couriers. One demonstration manager suggested paying a bonus to EV drivers on grounds that driving an EV did, indeed, involve a second job.

Union affiliation generally did not affect driver attitudes.

Union affiliation played almost no part in driver acceptance of the vehicles. No union complaints were raised about EVs as a "second job". However, union concerns did arise in two cases. One involved battery fumes in the
passenger compartment due to faulty battery chargers, and the other that members assigned to EVs were forced to turn down overtime assignments because of the vehicles' range limitations.

All site operators required drivers to be trained in the use of EVs. No one mentioned training as causing any problems, although a few site operators complained that the training originally provided by the manufacturers was inadequate. The importance of good training is highlighted by the report of one site operator who indicated that vehicle range doubled once the drivers gained experience in proper shifting and acceleration of the vehicles. While driver-related range variation also occurs in conventional vehicles, it may prove to be a greater problem for EVs.

**Maintenance**

In almost all cases, the vehicles were given scheduled preventive maintenance. In one case, maintenance scheduling was left to the drivers whose sense of responsibility was so high that they regularly brought the vehicles in at the first sign of trouble. In another case at the other extreme, the vehicles were in for repairs so often that the maintenance personnel did their routine checks then. A routine battery checking and watering procedure was followed universally, although the frequency varied. Reliability problems at one site were dramatically reduced when preventative maintenance was put on a rigorous biweekly schedule.
Except in cases where there were only a few vehicles at the site, a certain portion of the maintenance staff's time was dedicated to the EVs. Maintenance staffs typically received specialized training on EV repairs, although in more than a few cases this training was less than adequate, especially with respect to problem diagnosis.

In a few cases the issue of craft union work rules concerning automotive repair personnel working on electrical systems were raised. These concerns were handled either by allowing the automotive repair personnel to work on the electric portions of the vehicles or by dividing the responsibilities between electricians and automotive repairmen.

In many cases, maintenance personnel made specific improvements to the vehicles. In a few cases, design changes and specification requirements were given to the manufacturer prior to purchase and no further modifications were made by the users.

In general, site operators relied on vehicle manufacturers for replacement parts. This was often a source of serious problems because parts were often difficult to obtain or slow to arrive. Operators not reporting parts problems generally did not have serious repair problems to begin with. One operator made a special effort to develop the local EV infrastructure by having local battery and electric repair shops stock replacement parts.
Summary of Operational Factors

Type of Routes - Fixed routes are one way of assuring that the vehicle does not exceed its range limitations; variable routes where the vehicle rarely if ever approaches its maximum range work just as well; types of trips taken and routes assigned need not change to accommodate EVs.

Dispatch Understanding - The person assigning vehicle to trips, either the driver or the dispatcher, must know and respect the range limitation.

Driver/vehicle assignment - General pool vehicles get little use unless pool dispatch pushes use of vehicles. Multiple driver assignments (small pools) work if responsibility for the vehicles is taken by a person or persons. One to one assignment of a specific vehicle to a specific driver is best for promoting usage and responsibility.

Backup vehicles - Backup vehicles are necessary to prevent disruptions in operations in case of breakdowns but should be EVs to decrease the incentive for sabotage.

Driver attitude - Drivers must be open and willing to try; hostile drivers will kill a demonstration program. Driver attitude is a function of vehicle performance; unreliable vehicles will destroy driver acceptance. Driver enthusiasm must be maintained, either through vehicle performance or management methods.

Maintenance Procedures - Preventive maintenance by knowledgeable technicians is required. Questions over craft union jurisdiction between automotive technicians and electricians need to be resolved. Unavailability and slow delivery of parts can be major problems. Local repair and parts supply infrastructures should be developed where possible.
Cost Factors

Part of the DOE site operator interviews focused on three vehicle-related costs: purchase, operations, and maintenance. Special emphasis was given to the relative magnitudes and sources of cost uncertainties since such uncertainties are likely to influence the willingness and ability of potential EV users to participate in future demonstration programs. For the purposes of this analysis, actual dollar costs are of less interest since the EVs used were limited-production prototype vehicles. Furthermore, since many demonstrations were quite new, some respondents lacked detailed and accurate cost data, especially for operations and maintenance on a cost per mile basis.

The cost uncertainties faced by the DOE EV demonstration operators were the direct result of the incentive and cost sharing approaches employed by DOE. In most cases, the DOE paid for all or part of the vehicle purchase, local infrastructure setup costs (e.g., charger installation, remodeling), a modest maintenance and parts budget, and in some cases a small public relations program. The site operators typically provided management and maintenance labor, energy costs, and maintenance costs beyond the DOE-budgeted amount.

Given the serious reliability and limited battery life problems which occurred, the DOE funding arrangement left the site operators covering those costs which have the greatest

*Detailed records of these costs are being kept by the site operators, however, and should eventually be available through DOE.*
uncertainties and potential for serious budget overruns, i.e., maintenance and battery replacement. This was all the more burdensome since the manufacturers' warranties were in some cases weak or not honored due to their poor financial situation of the past several years.

An additional cost uncertainty faced by a purchaser is vehicle resale value at retirement. While of less concern for the DOE site operators than for other potential buyers (since purchase costs were supported by DOE), this does affect the long range costs of their involvement with the DOE EV program. The problem stems not just from a lack of demand and organized markets for used EVs, but also from the fact that improvements in EV design and technology could quickly make older-generation EVs obsolete.

Of less concern to the DOE site operators (and by implication to future demonstration programs), were the operating costs of the vehicles. These tended to be reasonably good and in the general ball park of conventional vehicle costs. With improved batteries and time of day pricing, the operating costs (excluding maintenance and purchase costs) could prove quite attractive.
GENERAL RECOMMENDATIONS AND GUIDELINES FOR FUTURE EV COMMERCIAL SECTOR DEMONSTRATIONS

The experience of the DOE site operators provides the basis for making a number of recommendations for future commercial sector demonstration programs. These recommendations concern the broad range of problems facing an EV demonstration program, such as incentives for user involvement, screening of potential participants, vehicle specifications, infrastructure development, and program management.

The reduction of risks and uncertainties is essential as an incentive for potential users to become involved in a demonstration project.

Incentives for Commercial EV User Involvement

In creating incentives for user involvement in EVs, a primary goal must be to reduce the uncertainties and risks faced by the potential user. Ideally, these can be reduced through the use of well designed and thoroughly tested vehicles in the context of a well planned demonstration program. Even these steps, however, will not reduce potential users' risks and uncertainties to acceptable levels over the next decade. Whereas the federal government may have been counted upon in the past to share a significant portion of this risk burden, such a strategy looks far less promising in the immediate future.

During the next few years especially, it will be necessary to employ financial and organizational arrangements which transfer the vast majority of risks and uncertainties to the primary stakeholders in successful EV commercialization. At the present time this group is largely comprised of electric utilities and a few battery manufacturers. However, assuming
quantity production of EVs proves to be viable from a technological, economic, and marketing standpoint, the list of stakeholders should grow to include vehicle manufacturers, parts suppliers, and others.

**Leasing as a Strategy for Risk Reduction**

In the short term, one of the most promising risk- and uncertainty-reducing strategies will be for EV users to lease their vehicles from the demonstration program sponsor. Vehicle leasing arrangements are increasingly common within the commercial sector and would offer a number of advantages.

- Because a lease arrangement is familiar and straightforward from the users' standpoint, it eliminates one source of potential novelty and anxiety from the larger demonstration program. It may also offer tax and cash flow advantages to the user organization.

- The lease could be priced below the cost for a conventional vehicle of equivalent size, thereby providing a financial incentive for participation. By negotiating or systematically varying this "discount" it would provide useful marketing information about acceptable price levels for commercially viable EVs. Since the lessee would be paying roughly the mass market price level for a commercialized EV, the much higher actual limited production vehicle costs would be invisible. This is in contrast to the subsidized purchase arrangement that was used for most DOE site operators. The difference is important from a marketing information standpoint, since user evaluations (and media coverage) would be more likely to reflect expectations based on the mass market (lease) value of the vehicle, rather than the inflated prototype cost. It would also help avoid the unsophisticated and unflattering image produced by a $20,000 EV with slow acceleration, limited range, etc. The
difference between lease price and actual cost would have to be absorbed by the lessor as a part of the demonstration costs.

- As with many lease arrangements, maintenance costs would be born by the lessor, thus removing a major source of risk and uncertainty for the EV user. Leasing would also provide the lessor the distinct advantage of better ability to control the timing, amount, and types of maintenance. Since the actual costs of maintaining the prototype vehicles would be invisible to the user, the marketing information benefits mentioned above would apply to maintenance as well as purchase price considerations. Different maintenance contract arrangements could be negotiated depending on the needs of the user organization. For example, a small firm having no garage facilities might wish to include the simple checking of battery water levels under the contract, while a larger firm might wish to have its fleet mechanics do this. A firm without adequate backup vehicle coverage might wish to include a backup vehicle guarantee within the contract, or may be willing to pay a small premium for evening or weekend maintenance which would minimize disruption of work schedules due to routine maintenance.

- The vehicle lessor could also provide driver training. This would allow for better control and influence of driver orientation and attitude. It could also aid in the early screening of drivers whose attitudes or lack of driving skills might rule out their participation in the program or flag them for extra training or monitoring.

- The lease arrangement, in contrast to a purchase approach, would allow either party to cancel the lease agreement (perhaps with a contractually agreed penalty). For users, this option reduces the cost, inconvenience, and potential embarrassment if their decision to participate turns out to be a bad one. From the demonstration sponsors standpoint (the lessor), it allows for the controlled and relatively painless elimination from the program of applications or organizations whose continued involvement would not be beneficial to program goals.
The idea of a cancellation penalty may be a useful mechanism for insuring that both sides have a stake in making the arrangement work. On the other hand, the penalty must not be large enough to become a serious disincentive for program participation.

It should be recognized that from the lessors perspective there are downside risks of removing vehicles from particular applications or organizations. While there is much to be learned from failures and from taking risks which push back the boundaries of what is "practical", negative experiences are rife with opportunities for alienated individuals or organizations, damaged reputations, and negative media attention. A good rule here might be to maintain a ratio of roughly 80 percent high-probability-of-success applications and 20 percent riskier applications. This would allow for occasional stories about "failures" to be more than balanced by many cases of successful applications. It will also be important to limit the number of problematic applications since they are likely to require a disproportionate share of overall budget and staff time to correct problems.

Recruitment and Screening of Participating Organizations

As reported earlier, there is a relatively wide range of applications and organizations in which EVs can be expected to perform well. Within these general categories, however, the task remains of identifying, recruiting, and screening specific applications and organizations. While the design of an organizational recruitment process is beyond the scope of this study, one could be built around a carefully managed media program and personal contacts. The key to the process is not so much in finding candidates, but in having an attractive incentive package and an
ability to identify (and sometimes screen out) those organizations and applications which have a high risk of failure.

A screening process ought to take into account the following types of factors.

- Organizations which have a stake in a successful EV industry will also have a stake in working to make a demonstration successful. Similar incentives hold true for organizations which might (on their own or with encouragement) incorporate a large media or public relations component into their use of the vehicles. (Note, however, that there are risks in adopting a high media visibility approach during the early, error prone, phase of a new program.)

- Organizational arrangements in which vehicles can be assigned to individual drivers are preferable.

- Organizations must have routes well within EV range limits and EVs must be idle for sufficient time periods to allow for recharging.

- Drivers should be open-minded about trying EVs. Organizations in which EVs are forced upon reluctant drivers should be carefully monitored or avoided.

- Organizations which maintain close communications between drivers and dispatchers or operational manager are preferable to those in which close communications are lacking.

The above criteria help to define what might be considered "ideal" candidates for EV use. However, one function of a demonstration program may be to show that many less than ideal EV applications are nonetheless cost effective and viable. Indeed, the demonstration program may want to systematically push back the boundaries of practical EV applications. To do this, the above criteria must be viewed as general guidelines.
within which selected exceptions are made and tested. The number and extent of the exceptions must be judged against the costs of individual failures to the goals of the larger program. For example, more radical exceptions might be delayed until after a solid record of successful applications has been established.

Vehicle Specifications

It is important to draw a distinction between the vehicle specifications required for a commercially viable vehicle, and those required to conduct a successful demonstration program. The specification of characteristics of a commercially viable vehicle must await improved data on market segments and preferences. It is possible, however, to specify some minimum standards for demonstration vehicles which will reduce the risk of technological failure.

- Both passenger vehicle and truck configurations are desirable. Within the truck category, successful applications can be demonstrated for small pickups and vans, and for larger load capacity stepvans.

- The vehicles must perform reliably when called upon for their assigned tasks. Obviously this requires well designed vehicles to start with. However, this may not be enough given the current state-of-the-art and the prototypical nature of the vehicles. Within a demonstration program, it may be possible and necessary to perform additional preventive maintenance which is essentially invisible to the EV user. The point is not to "trick" the user, but rather to simulate as closely as possible the vehicle performance that users could expect from a mass produced vehicle. Nor is the point to sweep serious problems under the rug. To the contrary, this approach allows them to be caught early and corrected.
Vehicle range must be at least 35 to 40 miles per charge under all conditions, not just optimal ones. This range should provide an adequate and impressive pool of applications for demonstration. To the extent that the reliable range is higher, additional applications and more flexible operating conditions can and should be evaluated. It should be recognized that longer range vehicles may encounter different operating conditions and problems than those with shorter range limits, e.g., charger location and vehicles taken beyond range.

Creature comforts such as heaters and radios must be as good as those in conventional vehicles. Other factors which affect the driving experience, such as the location of instrumentation and the requirements for record keeping must be made as convenient as possible. For example, voltage, rpm, and amperage gauges needed to develop efficient driving patterns should not require the driver to look away from the road frequently.

Vehicles must meet all applicable safety standards, and should appear to the user to be "intuitively" safe in terms of handling and recharging. Safe operation should not require extraordinary performance or alertness on the part of the user. This is not just because of its effect on user attitude, but also because safety-related accidents and mistakes, should they occur, could be devastating to the program.

Performance characteristics such as acceleration and load capacity are, for demonstration purposes, somewhat less important than the above factors. While improved characteristics will be desirable (if not essential) in terms of mass market appeal, it should be possible to conduct successful demonstrations with current state-of-the-art performance. That is, as long as economic, safety, and functional criteria are being met, it appears from the current DOE demonstrations that users will live with (or plan around) acceleration and load limitations.
Infrastructure Requirements and Development Process

In considering the requirements and development process for a successful EV infrastructure, it is useful to think in terms of a complete transportation system including vehicle users and the entire EV infrastructure. Within this overall system perspective, it is not just the vehicles and applications which must be demonstrated, but the entire infrastructure. Major infrastructure components are listed below.

- Vehicle manufacturers and their suppliers, e.g., batteries, brakes, motors, electronic components, etc.
- Electricity suppliers
- Suppliers & installers of charging stations
- Maintenance personnel and facilities
- Aftermarket parts suppliers
- Insurance companies
- Federal Regulatory Agencies (e.g., EPA, DOT)
- State and local government authorities
- Dealers for vehicle sales
- Vehicle leasing companies
- Marketing and media
- Driver education

For successful commercialization, it will be necessary to develop and demonstrate the complete EV transportation system which includes EV users and the EV infrastructure.

For purposes of developing the full EV transportation system, the philosophy described earlier in the discussion of leasing can be usefully extended to specific infrastructure
In demonstration programs, the entire infrastructure, not just the vehicles, must be demonstrated. To reduce risks due to an immature infrastructure, and to assure the existence of components not yet commercially viable, the demonstration program sponsor may have to take on a large infrastructure role initially and gradually relinquish it to appropriate parties as commercialization unfolds.

Initially, the demonstration program sponsor may have to provide some support services normally provided by the infrastructure. By taking on these additional duties, the sponsor protects itself against those risks of failure which, because of an immature infrastructure, are inherent in a demonstration program.

Yet, the program sponsor must eventually relinquish its infrastructure role if commercialization is to occur. Indeed, from an EV industry standpoint, one important role of a demonstration program is to aid in the creation of the needed infrastructure. If the program sponsor does not actively promote infrastructure development, it may not come into being. By creating a self-supporting infrastructure of organizations with a stake in commercialization, the sponsor minimizes the risks of failure due to the infrastructure collapsing at the end of the program.

The infrastructure can be created by gradually transferring select support functions conducted internally to the appropriate external organization, such as transferring the function of maintaining a parts inventory from the program sponsor to the local electric parts suppliers. This transfer should be gradual, with redundant capability temporally retained internally to guard against failure. Furthermore, by establishing certain components first, the transfer of functions to other components can be facilitated. For example, the transfer of EV maintenance to
commercial auto repair shops will be easier if a parts distribution network has already been established, thereby assuring parts supplies to the repair shops.

In terms of demonstration program design, infrastructure development requires that one "demonstrate" commercial viability to more than just a narrowly defined group of users and vehicle manufacturers. Demonstrations should provide other needed infrastructure members with decision-relevant information about markets, costs, implementation problems, and so forth. Thus, the appropriate image is not of a single (or even just a few) demonstration(s), but more of a developmental process involving a carefully integrated and sequenced series of demonstrations. The demonstration program is not an isolated event which succeeds or fails on a one time basis, but a process in which infrastructure commitments (and sophistication) increase over time based on information and experience gained in earlier phases.

Program Management Resource Requirements

It is beyond the scope of this report to make detailed estimates of demonstration program costs or staffing requirements. Such analysis would be one objective of research recommended later in this report. Nonetheless, it is important to recognize that a demonstration approach which systematically attempts to build and demonstrate the full EV infrastructure (rather than just applications), will require a greater commitment of funds, time, and management resources than
would one or more specific demonstration projects. Program management would be required for the following activities.

- Day-to-day management of ongoing demonstration activities.
- Management of feedback and evaluation mechanisms designed for two-way communication flows between infrastructure members (including vehicle users) and demonstration program managers.
- Analysis, planning, and implementation of new application areas.
- Evaluation, planning, and introduction of new technologies into the demonstration program.
- Planning and management of activities designed to expand formal involvement and commitments of additional EV infrastructure members.

CONCLUSIONS

The experience of the DOE site operators has provided a wealth of information concerning the operation of and potential for an EV demonstration program. The interviews revealed a wide range of potential uses of EVs in commercial applications. Combined with the preliminary market assessment data provided by the pilot survey described in Chapter 2, the experiences of the site operators show the existence of a significant potential market for EVs.

This market, however, will not develop of its own accord. It must be nurtured and guided based upon the types of insights and experience gained from past and future demonstration programs. Users must be buffered from the risks associated with the introduction of any new technology.
Incentives must be structured so as to induce potential commercial EV users to participate and, more importantly, to remain in the program. Vehicles must be built to the specifications needed by potential users. Most importantly, the entire infrastructure needed for successful commercialization of EVs must be developed along with the market. Through a carefully planned series of demonstrations, both EV users and the infrastructure participants can gain the information, experience, and commitments needed for successful commercialization.
CHAPTER 5

RECOMMENDATIONS FOR A NATIONAL LEVEL COMMERCIAL SECTOR EV PROGRAM

THE POTENTIAL IMPORTANCE OF DEVELOPING THE COMMERCIAL SECTOR EV MARKET

The pilot survey of commercial sector fleets, presented in Chapters 2 and 3, while not definitive, has demonstrated significant potential demand for electric vehicles by establishments in a wide range of industry types and sizes. Furthermore, interviews with DOE Demonstration Program site operators, presented in Chapter 4, have shown that "reliable electric vehicles can perform well in a wide range of commercial and municipal government applications. While worth developing in their own right, these potential commercial markets may also prove to be a crucial opening wedge for EVs in the personal vehicle market.

To develop the commercial and municipal EV markets will require a carefully planned long term commitment to a process of technology improvement, demonstration, and infrastructure development. Such a program would have the following goals for the long run development of the EV industry:

1. Demonstrate and communicate successful EV applications within the commercial sector.

2. Identify and solve potential technical, organizational, and attitudinal problems associated with the use of large numbers of electric vehicles in the commercial sector.

3. Provide information, planning, and guidance needed to aid and encourage the full development of the infrastructure required for large scale EV adoption.
SUCCESSFUL COMMERCIALIZATION REQUIRES COMMITMENTS FROM BOTH EV USERS AND THE EV INFRASTRUCTURE.

THE MARKET DEVELOPMENT FRAMEWORK MUST REFLECT THE DUAL NATURE OF THE DEVELOPMENT TASK AND PROVIDE RELIABLE AND TIMELY INFORMATION TO BOTH POTENTIAL USERS AND THE INFRASTRUCTURE.
A FRAMEWORK FOR EV MARKET DEVELOPMENT

At the most basic level, successful commercialization of EVs in the commercial sector will require two types of commitments, one on the part of major manufacturers and other infrastructure participants, and one on the part of buyers convinced of the benefits of EV use for particular applications. To achieve this, a market development strategy or framework must be adopted which provides timely, reliable, and appropriate information to both potential suppliers and potential buyers so that commitments made during the commercialization process can be based on their own informed self-interest. Practically speaking this means that suppliers must be convinced of a potential market large enough to be profitable, and potential buyers must be convinced that a dependable and economically attractive vehicle and infrastructure does (or will) exist.

The Market Development Framework, shown in Figure 5.1, reflects the dual nature of the market development task and is designed to provide both suppliers and buyers with the different (though related) information each requires. It is crucial to recognize that at the present time we have neither the "chicken nor the egg," and that the two must be created together. To do this, both types of information are necessary. The upper portion of the figure shows the market assessment activities needed to gain supplier commitments, and the lower portion shows the demonstration activities needed to convince buyers of the viability of EVs in the commercial sector. Not shown on this figure, but an equally important element in successful commercialization, are the
The research described in this report has been designed to provide information for both levels of this framework. The pilot survey of commercial fleet operators in the DECO service area (the box in the upper left corner) has provided both an initial estimate of potential market size and a methodology through which the national market and submarkets can be evaluated. The analysis of ongoing EV field test and demonstration programs has provided information needed to proceed with a new round of carefully designed commercial sector demonstrations. The lessons learned from the demonstration experience of the past several years will provide a much firmer basis for minimizing the risks of failure and maximizing the opportunities for success.
RECOMMENDATIONS

The results of this study are viewed as promising enough to justify commitment to a long range program of national commercial market assessment and demonstration. Such a program is seen as a necessary step if the EV industry is to be positioned during the next decade to take advantage of the potential market opportunity which would result from a combination of improved EV technology and a renewed period of increasingly tight and expensive petroleum supplies.

This section provides a preliminary description of two program areas recommended as logical and necessary next steps in a national EV program: a national survey of the commercial fleet market, and an integrated series of commercial fleet EV demonstrations.

A National EV Commercial Fleet Market Study

RECOMMENDATION 1:

Conduct a national level commercial fleet survey to determine EV market potential

Rationale

The size of the national market (total domestic demand) will be a major factor determining whether different types of EVs can be produced in sufficient quantity to realize the substantial economies of scale necessary for EVs to compete successfully with comparable ICE
A substantial national market is essential if economies of scale in EV production are to be realized. Although the pilot study points to the existence of a sufficient market, these results can be viewed only as tentative.

The Pilot Survey of Commercial Fleet Operators suggests that the potential market for EVs in commercial use is substantial, with small trucks being a prime candidate for successful adoption. These observations must be interpreted with caution, however, because the Pilot was conducted with a small sample drawn from a limited geographic area that may not be representative of the nation as a whole with regard to vehicle usage. The stakes are simply too large to base major policy decisions on data with the limited precision and generalizability of the pilot study. A logical next step, therefore, is to apply the methodology used in the Pilot (with appropriate modifications incorporating what has been learned) to a study based on a nationally representative sample.

**Recommended Approach**

**Sample.** The sample for the Pilot Survey was drawn from vehicle registration lists which turned out to present both coverage and currency problems for the Pilot survey. These problems, which are detailed in Appendix A, would undoubtedly be more severe in the case of a national sample. Fortunately, the national study suggested here does not have to rely on drawing a sample of vehicles from registration lists. An efficient

"Even the domestic market might be too narrow a perspective, but it is likely that sufficient domestic demand is a necessary threshold for production. Moreover, for the purposes at hand, it is not realistic to broaden the scope of analysis to include the international sector."
alternative would be to draw a sample from a list of business establishments such as that maintained by Dun and Bradstreet.

This approach is relatively inexpensive and has the additional advantage of flexibility. If, for instance, a particular utility is especially interested in obtaining data about market potential in its own service area, that utility could be included with certainty in the sample. Moreover, the sample could be designed to permit inferences not only about the nation as a whole but about subsets of it such as geographic regions. While the exact details of design cannot be specified until decisions about desirable levels of precision have been made, it appears that a sample as small as 300 could provide reasonably precise estimates at the national level. A sample size of 1200 would be more respectable in comparison to most national surveys and would also provide a large enough sample to make direct regional estimates such as for the 9 regions of the National Electric Reliability Council (NERC). Regional estimates could also be made with samples less than 1200 through synthetic estimation techniques. The precision and accuracy of this approach, however, would be less certain.

EV market potential estimates could be made for specific service areas by augmenting the national sample with as few as 50 additional interviews from each area for which estimates are desired. The precision of these estimates would depend on the both number of augmentation interviews and the size of the national sample.
A national survey would be designed to obtain detailed information that would permit pinpointing attractive potential markets.

**Survey Content.** With regard to content, the primary way in which the pilot survey questionnaire should be modified is in terms of quantity of information obtained from and given to respondents. The pilot study questionnaire was intentionally short. For a national study, however, more detailed (nested) questions should be asked about vehicle use patterns. These would provide more information to manufacturers about electric vehicle performance characteristics which will be required for EVs to compete successfully with conventional vehicles.

**EV Information Provided to Respondents.** In addition, more information about EVs should be given to respondents either before or during the interview. Both the focus groups and pilot survey showed that many commercial fleet operators, while open to the EV concept, have at best limited (and often inaccurate) knowledge about current and expected future EV performance and technology. This serves to heighten the perennial marketing and survey research problems inherent in making reliable inferences about future attitudes and behaviors. The more aware respondents are of the actual advantages and limitations of EVs, the more meaningful will be their responses to questions such as:

> "For example, there is a need to know the proportion of vehicles that are typically driven 60 miles or less per day, and frequently go on expressways, and typically are parked for an hour or more at a time, etc. This type of "nested" information cannot be derived from the relatively short questionnaire used in the pilot study."
• their willingness to consider the use of EVs in their fleets,

• the types and characteristics of EVs they would consider most useful,

• the number of EVs which might be substituted for conventional vehicles, and

• the operating cost and purchase price levels which would be required for EVs to be economically competitive.

Information about electric vehicles can be given to respondents over the telephone, as was done in a limited way in the pilot survey. However, it may prove more efficient and effective to provide this information by mail prior to the interview. It may also be useful to identify in the letter the types of detailed questions to be asked, so that fleet managers can have gathered relevant data about their fleet operations prior to the interview. Our experience leads us to believe that an introductory letter encourages response. Response rates in recent ISR business studies which have relied on introductory letters have been very high (80 to 90 percent for personal interviews).

A Second Generation EV Commercial Sector Demonstration

RECOMMENDATION 2:

A national level commercial sector EV demonstration program should be initiated based on the findings of this study along with a carefully designed implementation plan.
Rationale

The objective of the DOE Site Operator interviews was not to find fault with the DOE program, but to learn from it. As presented in Chapter 3, there is a good deal to learn which can aid in the effective design of a second generation of EV demonstrations focused on EV applications in the commercial sector. It is believed that commitment to a program of this type will be an essential element in successful EV commercialization. A second generation EV demonstration program will have the advantages of improved technology and a better understanding of the potential problems and pitfalls encountered in the operation of EVs in commercial environments.

Recommended Approach

An Integrated Series of Demonstrations. An incremental approach is recommended in which the initial demonstrations would serve as a source of guidance for an integrated series of demonstrations in various regions of the country over the next decade. Thus, the first few demonstrations would have the dual responsibility of conducting successful programs and providing guidance based on their experience. Some, although perhaps not all, of the earlier programs should be established as long term pilot programs which can grow in sophistication and in the richness of the EV infrastructure incorporated into the program. These pilot demonstration sites would be able to develop the larger and more experienced research, planning, evaluation, and
communications programs required for a successful national level effort, but which are not practical for most individual demonstration sites.

**Feasibility and Planning Study.** It is recommended that a small feasibility and planning study be undertaken to examine the cost implications and funding options for such a long term program. Other objectives of this study would be to identify potential sites for the initial demonstrations, and an organizational and management structure which would provide an appropriate mix of centralized coordination and control along with decentralized creativity and flexibility.

**Program Characteristics.** The complete specification of a commercial sector demonstration program must await completion of a detailed planning analysis which is beyond the scope of this study. However, the current work does suggest a number of specific approaches and principles which should be considered in program development.

- **Outside demonstration activities with commercial operators should not be initiated until internal field testing has shown that reliable vehicle performance can be expected under all anticipated operational conditions. Achieving this level of reliability is likely to require a well planned preventative maintenance program, as well as improved batteries. An appropriate near term strategy might be to begin commercial demonstration activities by retrofitting with improved batteries a portion of the more reliable vehicles currently being used by existing demonstration programs. This would allow for a relatively fast startup of a small program which would be incrementally...**

A feasibility and planning study should be undertaken to evaluate cost, location and other aspects of the proposal demonstrations.

**The current study suggests that...**

**Outside demonstrations should await reliable performance for the vehicles being demonstrated...**
centralized facilities should be created to provide parts, maintenance and other services until the infrastructure can support such services independently...

the program should be offered initially to simulate conditions that will be typical when volume production occurs...

and should provide guidance for and cooperation between electric utilities and the developing EV industry.

expanded as evaluation, procurement and testing proceed for other commercially attractive vehicles such as pickups, small vans, and large volume stepvans.

An attempt should be made to gain economies of scale by creating centralized facilities (national or regional) to provide individual demonstration sites with services such as parts, trouble shooting, bulk purchases, etc. These services can be phased out (or down) as the demonstration programs and EV infrastructure grow in size and sophistication.

In order to obtain realistic market-oriented information it will be necessary initially to "buffer" the program (in terms of technology, maintenance, and economics) in order to simulate operating conditions and reliability levels which would be typical of larger volume production conditions. This approach is discussed more fully in Chapter 4. The amount of buffering should be reduced as quickly as possible as the program moves from simulation towards an increasingly realistic commercial demonstration involving the full range of infrastructure elements and market forces.

The program should position itself to be a reliable and trusted information source for users and other potential infrastructure members who will be making EV-related use and production decisions over the next decade. This means the program must have both a strong research component and a strong communications component.

Similarly, the program should position itself to be a source of guidance and cooperation with respect to electric utilities and the developing EV industry.

New applications, technologies, maintenance facilities, etc. should be added incrementally and only if consistent with long range information needs and program goals. This means the program must have a strong and well integrated planning component. The passage from planning to operations is a major potential failure point. Major program additions should be
implemented by transition teams incorporating personnel with planning, research, and operational responsibilities.

• In developing the national program, "reinventing the wheel" should be avoided. It will be less expensive and less frustrating to make optimal use of existing demonstration programs and expertise.

• Initial selection of commercial operators should be clustered so that maintenance can be carried out at one or more centralized maintenance facilities within driving range of the vehicles. The existence of, or commitment to, such facilities may be an important element in developing a package of incentives and risk reduction strategies needed to attract commercial fleet operators to the program.

• The program should consider positioning itself to lease vehicles under the type of subsidized lease arrangement discussed in Chapter 4.

• Operator and application selection should be built around the type of recruiting and screening process described in Chapter 4. It will be important to work with both commercial and municipal organizations to understand the differences in these two operating environments. Initial selections should optimize the likelihood of success based on the operational considerations presented in Chapter 4. Primary candidates for successful applications, (though certainly not the only ones which should be considered), would be municipal inspection and parking enforcement, university mail delivery, and commercial parts delivery and pickup. After a history of successes, a limited number of "riskier" applications or organizations can be considered for addition to the program.

Recommended Next Steps

In preparation for a commercial demonstration program, several research and planning activities are recommended.
Recommendation 2.1:

Develop an organizational plan detailing the full range of program functions, the role and obligations of all major actors, potential demonstration sites, and cost and funding options.

Recommendation 2.2:

Initiate activities for the evaluation and eventual procurement of reliable and appropriate vehicles.

Recommendation 2.3:

Initiate the research and planning needed to develop a detailed and attractive incentive package for involvement of commercial fleet operators and needed infrastructure participants.
REFERENCES


APPENDIX A

PILOT SURVEY METHODOLOGY
APPENDIX A

PILOT SURVEY METHODOLOGY

SAMPLE SELECTION

The sample employed for the Pilot Survey of Commercial Fleet Managers was a probability sample of firms with light duty over-the-road vehicles, at least one of which was commercially registered to an address in the Detroit Edison service area. For the purposes of sample selection and interviewing, a light duty vehicle was defined as any over-the-road vehicle under 5000 pounds curb weight. This number was chosen because, based on examination of registration records, it best distinguished passenger cars, pickups, and vans from other over the road vehicles such as wreckers, step vans, hearses, and dump trucks.

Firms were selected with known probability proportional to the number of commercially registered vehicles, from the State of Michigan's Secretary of State's commercial vehicle registration list which had been subsetted to include only vehicles registered to businesses in the Detroit Edison service area. So as to insure a balanced representation of fleets with light duty trucks or vans and passenger cars, actual selection was performed by combining two independent subsamples -- one based on selection via ownership of a passenger car and the other based on selection via the ownership of either a pickup truck or a van. Randomization was insured by beginning each selection from a random start point and selecting every 65th passenger car on the subsetted list and every 305th truck or van (again starting from a randomly selected point.

The selection probability for each firm is the sum of the probability that the firm would fall into the sample via ownership of a passenger car and the probability of its falling into the sample via ownership of a truck or van. For a particular firm, the first probability is simply the
product of the number of commercially registered passenger cars it owns and the overall sampling rate of such cars (1/65), while the second is the product of the number of trucks and vans it owns and the sampling rate of trucks and vans (1/305). Given this design, unbiased estimates of both vehicle-level and establishment or fleet level population parameters can be obtained using sampling weights equal to the reciprocal of the selection probabilities discussed above.

It should be noted that there are three classes of commercial establishments which may be operating vehicles in the Detroit Edison service area that would not fall into the sample by design. The first consists of those which only operate privately registered passenger cars. There is no law requiring businesses to license business-owned passenger cars as commercial vehicles. As these licenses are somewhat more expensive than private license plates, many firms will not. If such a firm has even one commercially registered vehicle, however, then it has a chance of falling into the sample. The second class of establishment which may be operating in the Detroit Edison service area, but which would not be included in our sample frame are those who register all of their vehicles to some address outside the Detroit Edison area. We do not know how substantial a number of commercial fleets this might be. Future samples can be designed that would allow estimation of the extent of this problem. The third class of firms not falling in the sample frame consists of those which have begun commercial operations since May of 1982. We know that there are fewer of these firms than there are of firms which have gone out of business since that date.
SAMPLING PROCEDURES EMPLOYED IN THE FIELD

In order to maintain the sampling properties which were incorporated in the original sample design, certain rules had to be followed during initial contact of respondents. Since the sampled vehicle may or may not be operated from the address at which it was registered, there may or may not have been a knowledgeable respondent at the address of registration. The rule we employed in identifying eligible respondents were that:

1) the respondent must be 'responsible' for some aspect of the fleet operations;

2) the respondent must be able to answer specific questions about the day-to-day operations of the sampled vehicle; and

3) the vehicle must be operated from, or based at, an address in the Detroit Edison Company service area.

These rules resulted in more than one interview per company in the few cases in which all company vehicles were registered at one address but two or more selected vehicles were assigned to distinct sub-fleets in the Detroit Edison service area. A more frequent occurrence, however, was that several vehicles were sampled from one fleet. In this case, if the manager could speak to the detailed operations of each vehicle, one interview was taken which represents several sampled vehicles. To maintain the representativeness of the data the sampling weight, in such cases, was multiplied by the number of sampled vehicles to which the interview pertains. (This must be done both for vehicle and establishment level analysis.)

In a number of cases the sampled vehicle was registered to a leasing company and was actually operated by someone else. In these cases the lessee was asked for the name and address of the leasee who was subsequently interviewed if:

1) the vehicle was being used as a commercial vehicle; and
2) the vehicle was operated from an address in the Detroit Edison Service area.

By the time we actually started interviewing, the SOS list was six months old and some listings were as many as 18 months old. During these months, a fair number of vehicles had been sold or retired. If the sampled vehicle was no longer owned by the company of registry then we inquired about the vehicle to which the company had transferred the license plates (if it was a light duty over the road vehicle). If the license plate itself had been retired, we did not conduct an interview.

SAMPLE CONTROL

Standard Survey Research Center (SRC) sample control procedures were employed in the Pilot Survey of Commercial Fleet Managers. A coversheet (See Attachment A.1) was filled out for each sampled vehicle. This coversheet included entries for name and address of the company owning the vehicle and vehicle identification information from the registration list. After this information was entered, a sequential ID number was assigned to each coversheet and all the information was entered into the SRC's sample control log computer program.

Each morning during the data collection period, the SRC telephone interviewing Facility Supervisor gave each interviewer a set of the coversheets for interviewing. The interviewer then attempted contact with the appropriate respondent and all contact information was recorded on the coversheet along with a code describing the result of the contact/interview attempt. At the end of each interviewing day the information recorded on the coversheet, for that day, was entered into sample log control program and a report such as shown on in Attachment A.2 was generated for the EV project staff. Once an interview was successfully
completed for a particular sampled vehicle a new sequential ID number was coded on both the coversheet and the interview schedule.

In order to maintain the confidentiality promised respondents at the beginning of the interview, this sequential ID is the only link maintained between the interview information (contained on the interview schedule) and company identification information (listed on the coversheet). The interviews and coversheets are kept in separate files until all legitimate uses of the company identification information have been made, at which time the coversheets are destroyed.

Upon completion of interviewing a final result code was recorded on each coversheet and the information was entered into the sample control log program and a final field progress report was prepared.

RESPONSE RATES

A questionnaire was successfully completed for one hundred and forty-four of the two hundred and sixty-two coversheets sent to the field. Only forty-eight of the remaining one hundred and eighteen coversheets, however, can be legitimately considered nonresponse. There were no telephone listings anywhere in Southeastern lower Michigan for thirty-five of the companies listed on the coversheets. There are several reasons for this. Some firms do not have telephone listings at all, while others register their vehicles under one version of the company name and list their telephone under another. Furthermore, some of the addresses of registration are post office boxes for firms whose telephones are listed outside Southeastern Michigan. In addition to the thirty-five coversheets for which no telephone listing could be found, thirty coversheets pertained to vehicles owned by companies which had gone out of business since the SOS list had been compiled. This is a
reflection of the very poor state of the local economy during the latter half of 1982. Finally, five sampled vehicles were registered to firms in the Detroit Edison service area but were found to be operated by branches outside the area.

Once these 70 non-interviews are removed from the base, the response rate is 71% (144/192). Of the 48 true non-response coversheets, thirty-one were refusals. This number is much higher than we would expect in a full-scale interview effort because, due to limited time in the field, standard refusal conversion procedures employed by SRC were not attempted in this Pilot. We believe that we could convert at least half of these initial refusals into successful interviews simply by sending letters of introduction to them. Indeed, a number of the persons who refused stated that they would be willing to answer the questions once they had an explanation of the study in writing for their files. The only cases in which non-response was found to be a persistent problem was commercial leasing firms who did not want to release the names and addresses of lessees. A number of these could probably be converted, however, by sending the lessor a letter which they could then forward to the lessee encouraging them to contact our interviewers.

PROBLEMS AND LIMITATIONS OF THE SAMPLING APPROACH

As explained earlier, the sample for the Pilot Survey was drawn from vehicle registration lists which turned out to present both coverage and currency problems. The problems of this approach would undoubtedly be more severe in the case of a national sample. With regard to coverage, two issues emerged. First, the geographic area selected for the study (the Detroit Edison service area) did not coincide with the area covered by the list (the State of Michigan). The registration tape contained records for 890,453
vehicles, but there were only about 50,000 commercially registered light duty over-the-road vehicles operated by businesses in the Detroit Edison service area. Therefore, nearly a million records had to be subsetted down to 50,000, a task which was both time consuming and expensive. In a national study, this problem would be multiplied by at least the number of geographic areas selected in the first stage of sampling.

Second, not all commercially operated vehicles are commercially registered. This was dealt with in the pilot survey by simply defining the population of inference (that population about which we could make valid statistical statements) as firms using at least one commercially registered vehicle. To include all firms would have required drawing a sample from still another list (vehicles without commercial registration), a procedure which would have produced insurmountable subsetting problems given the time and budget allocated to the Pilot. Although redefining the universe was appropriate for the Pilot, such redefinition would not be satisfactory for a national study. Finally, an additional coverage problem would exist for a national study that was not present for the Pilot: not every area of the country has machine-readable registration lists. Absence of computerized lists would, for reasons of practicality, require excluding these areas from the study.

Adding to the difficulties encountered in the Pilot was the fact that business turnover is quite rapid (especially during a recession), so that the registration lists were somewhat out-of-date by the time the study got into the field. Since vehicles were sampled, it was difficult (and often impossible), to locate sampled units if the establishment that had registered them had either moved or gone out of business. Unfortunately, currency problems
exist with any list, but tracking problems are likely to be less serious if businesses or business locations rather than vehicles are sampled.

While the vehicle registration list approach was useful and appropriate for the limited goals and resources of the pilot study, an establishment based approach, such as that described in Chapter 5, is suggested as technically superior and more efficient for use with a national EV market potential study.
1. Telephone ______________________

Hello, I'm calling from the Survey Research Center at The University of Michigan. We are doing a study of commercial vehicle use and would like to know who in this establishment is responsible for your company vehicles. Do you have a fleet manager?

1. YES

   A3a. What is the fleet manager's name?

5. NO

   A3b. Who would be the best person to speak to about your vehicles—things like what type of vehicles you have, what they're used for, and how much they're driven?

   ______________________

   ______________________

4. At what number would (NAME) be reached?

   [ ] SAME NUMBER AS ABOVE   [ ] NEW NUMBER ______________________

5. CALL RECORD

   Call Number 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17

   Date

   Time

   Result

   Iwer No.

**ALL REFUSALS AND NONINTERVIEWS MUST BE EXPLAINED ON BACK.

6. Length of Interview: ________ (Minutes)

7. Length of Edit: ___________ (Minutes)
B1. Hello, (R'S NAME). I'm calling from the Survey Research Center at The University of Michigan. We are doing a study of commercial vehicle use and need some information about the types of vehicles your company uses and their use patterns. Are you the best person to speak to about this?

1. YES

Bla. Who would be the best person?

________________________
NAME

________________________
TITLE

________________________
PHONE

Thank you. REPEAT B1 WITH NEW R.

B2. Does your company lease vehicles to others?

1. YES

5. NO TURN TO P. 2, B3

B2a. I need some information about the (YEAR-MAKE) with license place number (NUMBER). Is this vehicle used by your company, or is it leased to another company?

1. OWN COMPANY

2. LEASED TO OTHER COMPANY

3. VEHICLE NO LONGER IN SERVICE

4. PRIVATE INDIVIDUAL

TURN TO P. 2, B3

TURN TO P. 2, B3

TERMINATE INTERVIEW

B2b. Could you please tell me the name and address of the company to which it is leased?

________________________
NAME OF COMPANY

________________________
ADDRESS

________________________
PHONE (IF KNOWN)

THANK R AND TERMINATE INTERVIEW. FILL OUT SECONDARY (PINK) COVER SHEET WITH NAME OF THIS COMPANY
Are all the vehicles your company uses operated from one location or are they operated out of more than one location?

1. ONE LOCATION
2. MORE THAN ONE LOCATION

B3a. (Hello, [R'S NAME]. I'm calling from the Survey Research Center at The University of Michigan. We are doing a study of commercial vehicle use and need some information about the types of vehicles your company uses and their use patterns.)

I will need information about the (YEAR-MAKE) with license plate number (NUMBER) and any other vehicles that are operated from the same location as it is. Are you the best person to talk to about this?

1. YES
5. NO

B3b. Who would be the best person?

NAME

TITLE

PHONE

Thank you. REPEAT B3a WITH NEW R

4. Is the (MAKE-YEAR) with license plate number (NUMBER) still in use?

1. YES
5. NO

TURN TO P. 3, B5

B4a. Is the plate number (NUMBER) being used?

1. YES
5. NO

B4b. What is the year, make and model and approximate weight of the vehicle that is currently using that license plate?

YEAR
MAKE
MODEL

APPROXIMATE WEIGHT

IF MORE THAN 5000 POUNDS, TERMINATE INTERVIEW.
B5. I will be asking questions about the (YEAR-MAKE) with license plate number (NUMBER), and any other vehicles that are operated from the same location as it is. In what city are these vehicles located? 

________________________ CITY

B6. INTERVIEWER CHECKPOINT

☐ 1. SAME CITY AS ORIGINAL LABEL ➔ TURN TO P. 1, C1
☐ 2. DIFFERENT CITY THAN ORIGINAL LABEL

B6a. And what is the zip code there? _______________________

CHECK LIST OF ZIP CODES IN DETROIT EDISON SERVICE AREA

B7. INTERVIEWER CHECKPOINT

☐ 1. ZIP CODE IN LIST ➔ TURN TO P. 1, C1
☐ 2. ZIP CODE NOT IN LIST ➔ TERMINATE INTERVIEW
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CALL & APPOINTMENT NOTES

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<th>NAME</th>
<th>NOTES</th>
<th>DAY/DATE</th>
<th>TIME: AM/PM</th>
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TABLE I: STUDY TOTALS - COLUMN HEADING DEFINITIONS

<table>
<thead>
<tr>
<th>Column</th>
<th>Definition</th>
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<tbody>
<tr>
<td>TOT SAMP</td>
<td>Total sample size</td>
</tr>
<tr>
<td>OUT</td>
<td>Coversheets outstanding (excluding outstanding refusal conversion coversheets)</td>
</tr>
<tr>
<td>INT</td>
<td>Complete interviews</td>
</tr>
<tr>
<td>PINT</td>
<td>Partial interviews</td>
</tr>
<tr>
<td>REF</td>
<td>Refusals (31, 34, 35, 51, 52, 53, 55, 56)</td>
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<tr>
<td>NIO</td>
<td>Non-interviews other than refusals (62, 63, 65, 67, 68, 69)</td>
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<td>NON WORK</td>
<td>Non-working numbers (73, 74, 75, 76, 82, 84)</td>
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<tr>
<td>NON RES</td>
<td>Non-residential numbers (85)</td>
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<tr>
<td>NS RES</td>
<td>Non-sample residential numbers (86)</td>
</tr>
<tr>
<td>NER</td>
<td>Coversheets with no eligible respondent (91)</td>
</tr>
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</table>
| RESP RATE       | Response rate: 
|                 | \[
|                 | \frac{(INT + PINT)}{(OUT + INT + PINT + REF + NIO)} \]                      |
| COMP RATE       | Completion rate: 
|                 | \[
|                 | \frac{(INT + PINT + REF + NIO)}{(OUT + INT + PINT + REF + NIO)} \]          |
| INT LEN         | Average interview length                                                  |
| EDIT LEN        | Average edit length                                                       |
| REF CONVERSION  | Refusal conversion counts and rates                                       |
| TOT             | Total number of coversheets refusal conversion indicated                   |
| OUT             | Refusal conversion indicated coversheets outstanding (31)                 |
| INT             | Successful refusal conversions (01, 05)                                   |
| REF             | Unsuccessful refusal conversions (51, 52, 53, 55)                         |
| NVR             | Initial refusal never reached for conversion (34)                        |
| OTH             | Finalized RC indicated coversheets with unusual final result codes (not 01, 05, 31, 33, 51, 52, 53, 55) |
| RATE            | Refusal conversion rate: 
|                 | \[
|                 | \frac{(RC INT)}{(RC INT + RC REF + RC OUT)} \]                           |

TABLE I: STUDY TOTALS

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<th><strong>TOTAL SAMPLE</strong></th>
<th>TOT SAMP</th>
<th>OUT</th>
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<th>PINT</th>
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<th>NON RES</th>
<th>NS RES</th>
<th>NER</th>
<th>RESP RATE</th>
<th>COMP RATE</th>
<th>INT LEN</th>
<th>EDIT LEN</th>
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<td>0</td>
<td>0.473</td>
<td>0.581</td>
<td>13.7</td>
<td>6.1</td>
<td>24</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PINK</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
<td>1.000</td>
<td>34.2</td>
<td>12.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
TABLE II: FIELD HOURS - COLUMN HEADING DEFINITIONS

A HOURS . . . ALL TASKS ASSOCIATED WITH LONG DISTANCE TELEPHONE INTERVIEWING (DIALING, MAKING APPOINTMENTS, INTERVIEWS, EDITING FOR BOTH PRODUCTION AND PRETEST INTERVIEWS THAT ARE LONG DISTANCE. "A" TIME IS USED TO APPORTION THE TELEPHONE BILL.)

B HOURS . . . ALL OTHER INTERVIEWER TIME (STUDYING INSTRUCTIONS, LOCAL INTERVIEWING, TAKING PRACTICE INTERVIEWS, STICKING LABELS ON COVERSHEETS, ETC.)

C HOURS ..... TELEPHONE FACILITY CLERICAL (TELEPHONE FACILITY NON-INTERVIEWERS DOING CLERICAL WORK)

D HOURS . . . SHIFT SUPERVISION (WORK ASSIGNMENTS, MONITORING, ETC.)

E HOURS . . . GENERAL FACILITY MAINTENANCE (RECRUITING, TRAINING, ETC.)

F HOURS ..... FIELD OFFICE CLERICAL (TYPING QUESTIONNAIRES, SAMPLE CONTROL)

G HOURS ..... FIELD OFFICE PURCHASING AND ACCOUNTING

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOURS</td>
<td>165.5</td>
<td>54.0</td>
<td>11.9</td>
<td>5.1</td>
<td>4.3</td>
<td>0.0</td>
<td>0.0</td>
<td>240.8</td>
</tr>
</tbody>
</table>

MINUTES PER INTERVIEW

- INTERVIEWER HOURS/(SUPERVISOR + CLERICAL HOURS): 10.305 \( \frac{(A+B)}{(C+D+E+F+G)} \)
- INTERVIEWER HOURS/TELEPHONE FACILITY SUPERVISOR HOURS: 10.305 \( \frac{(A+B)}{(C+D+E)} \)
- INTERVIEWER HOURS/TOTAL HOURS: 0.9115 \( \frac{(A+B)}{(A+B+C+D+E+F+G)} \)
APPENDIX B

DETAILED RESULTS FROM FLEET OPERATOR SURVEY
Table B1

Distribution of Vehicles, by Industrial Classification of Establishment

<table>
<thead>
<tr>
<th>Vehicles in Different Types of Establishments</th>
<th>Manufacturing, Transportation, Communications.</th>
<th>Electric, Gas, and Sanitary Services</th>
<th>Wholesale and Retail Trade</th>
<th>Financial &amp; Other Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Cars driven 60 miles/day or less</td>
<td>23.9</td>
<td>23.0</td>
<td>40.0</td>
<td>14.1</td>
</tr>
<tr>
<td></td>
<td>(3.9)</td>
<td>(3.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cars driven over 60 miles/day</td>
<td>8.1</td>
<td>7.3</td>
<td>4.5</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>(2.5)</td>
<td>(2.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other vehicles driven 60 miles/day or less</td>
<td>41.5</td>
<td>42.9</td>
<td>30.9</td>
<td>38.7</td>
</tr>
<tr>
<td></td>
<td>(4.6)</td>
<td>(4.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other vehicles driven over 60 miles/day</td>
<td>25.5</td>
<td>26.8</td>
<td>24.6</td>
<td>37.5</td>
</tr>
<tr>
<td></td>
<td>(4.1)</td>
<td>(4.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>117</td>
<td>29</td>
<td>28</td>
<td>32</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors.
<table>
<thead>
<tr>
<th>All vehicles</th>
<th>Establishments with Indicated Number of Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Establishments</td>
</tr>
<tr>
<td>All vehicles</td>
<td>100%</td>
</tr>
<tr>
<td>Cars driven 60 miles/day or less</td>
<td>23.9 (3.9)</td>
</tr>
<tr>
<td>Cars driven over 60 miles/day</td>
<td>8.1 (2.5)</td>
</tr>
<tr>
<td>Other vehicles driven 60 miles/day or less</td>
<td>41.5 (4.6)</td>
</tr>
<tr>
<td>Other vehicles driven over 60 miles/day</td>
<td>26.5 (4.1)</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors
# Table B3

The Distribution of Vehicles Among Establishments in Different Industrial Classes

<table>
<thead>
<tr>
<th>Type of Establishment</th>
<th>Manufacturing</th>
<th>Transportation</th>
<th>Communications</th>
<th>Electric</th>
<th>AM Mining &amp; Gas.</th>
<th>Wholesale &amp; Retail Trade</th>
<th>Financial &amp; Other Services</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Establishments</td>
<td>100%</td>
<td>29.2</td>
<td>25.3</td>
<td>26.4</td>
<td>19.1</td>
<td></td>
<td></td>
<td>117</td>
</tr>
<tr>
<td>All vehicles</td>
<td>100%</td>
<td>25.8</td>
<td>37.8</td>
<td>17.0</td>
<td>19.3</td>
<td></td>
<td></td>
<td>62</td>
</tr>
<tr>
<td>Cars driven 60 miles/day or less</td>
<td>100%</td>
<td>33.1</td>
<td>13.0</td>
<td>37.1</td>
<td>16.8</td>
<td></td>
<td></td>
<td>53</td>
</tr>
<tr>
<td>Cars driven over 60 miles/day</td>
<td>100%</td>
<td>29.5</td>
<td>21.7</td>
<td>35.6</td>
<td>13.3</td>
<td></td>
<td></td>
<td>67</td>
</tr>
<tr>
<td>Other vehicles driven 60 miles/day or less</td>
<td>100%</td>
<td>29.2</td>
<td>25.6</td>
<td>19.8</td>
<td>25.4</td>
<td></td>
<td></td>
<td>74</td>
</tr>
<tr>
<td>Other vehicles driven over 60 miles/day</td>
<td>100%</td>
<td>29.5</td>
<td>21.7</td>
<td>35.6</td>
<td>13.3</td>
<td></td>
<td></td>
<td>67</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors.
<table>
<thead>
<tr>
<th>Establishment</th>
<th>All Vehicles</th>
<th>1-2</th>
<th>3-10</th>
<th>11 or more</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>100%</td>
<td>14.9</td>
<td>42.8</td>
<td>42.3</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>(3.3)</td>
<td>(4.6)</td>
<td>(4.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cars driven 60</td>
<td>100%</td>
<td>11.0</td>
<td>56.7</td>
<td>32.3</td>
<td>61</td>
</tr>
<tr>
<td>miles/day or</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>less</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cars driven</td>
<td>100%</td>
<td>3.2</td>
<td>22.8</td>
<td>74.0</td>
<td>52</td>
</tr>
<tr>
<td>over 60 miles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other vehicles</td>
<td>100%</td>
<td>23.2</td>
<td>41.7</td>
<td>32.1</td>
<td>74</td>
</tr>
<tr>
<td>driven 60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>miles/day or</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>less</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other vehicles</td>
<td>100%</td>
<td>17.6</td>
<td>41.6</td>
<td>40.8</td>
<td>67</td>
</tr>
<tr>
<td>driven over</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 miles/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors.
### Table 1
Selected Use Characteristics of Cars and Station Wagons in Commercial Fleets that are Driven 60 or Fewer Miles/Day, by Industrial Classification of Establishment

<table>
<thead>
<tr>
<th>Type of Establishment</th>
<th>Manufacturing, Transportation, Communications</th>
<th>Electric, Gas, &amp; Sanitary Services</th>
<th>Wholesale &amp; Retail Trade</th>
<th>Financial &amp; Other Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Establishments</td>
<td>Mining &amp; Construction</td>
<td>Sanitary Services</td>
<td>Snitary Services</td>
</tr>
<tr>
<td>Average number of miles driven per car per day</td>
<td>27.9</td>
<td>17.1</td>
<td>34.3</td>
<td>33.4</td>
</tr>
<tr>
<td>Average number of times/week cars are driven more than 60 miles/day</td>
<td>1.0</td>
<td>0.9</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Percent driven more than 60 miles/day on occasion</td>
<td>80.2 (5.1)</td>
<td>60.5</td>
<td>89.5</td>
<td>94.0</td>
</tr>
<tr>
<td>Percent assigned to fixed routes</td>
<td>10.5 (3.9)</td>
<td>0.0</td>
<td>14.6</td>
<td>12.2</td>
</tr>
<tr>
<td>Percent parked for an hour or more at a time during the day</td>
<td>86.0</td>
<td>67.9</td>
<td>93.9</td>
<td>84.0</td>
</tr>
<tr>
<td>Percent of cars frequently driven on expressways</td>
<td>67.5 (5.9)</td>
<td>62.4</td>
<td>80.0</td>
<td>45.0</td>
</tr>
<tr>
<td>Percent of cars left on company premises at night</td>
<td>22.4 (5.3)</td>
<td>36.4</td>
<td>7.1</td>
<td>26.0</td>
</tr>
<tr>
<td>n</td>
<td>62</td>
<td>17</td>
<td>17</td>
<td>13</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors
### Table 14

*Selected Use Characteristics of Cars and Station Wagons in Commercial Fleets that are Driven 60 or Fewer Miles/Day, by Establishment Fleet Size*

<table>
<thead>
<tr>
<th></th>
<th>All Establishments</th>
<th>1-2 Vehicles</th>
<th>3-10 Vehicles</th>
<th>11 or more Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of miles driven per day per car</td>
<td>27.9</td>
<td>20.0</td>
<td>29.9</td>
<td>27.1</td>
</tr>
<tr>
<td>Average number of times/week cars are driven more than 60 miles/day</td>
<td>1.0</td>
<td>0.3</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Percent driven more than 60 miles/day on occasion</td>
<td>80.2 (5.1)</td>
<td>80.2</td>
<td>91.9</td>
<td>59.5</td>
</tr>
<tr>
<td>Percent of cars assigned to fixed routes</td>
<td>10.5 (3.9)</td>
<td>0.0</td>
<td>12.7</td>
<td>10.3</td>
</tr>
<tr>
<td>Percent of cars parked for an hour or more at a time during the day</td>
<td>86.0 (4.4)</td>
<td>99.0</td>
<td>95.5</td>
<td>64.5</td>
</tr>
<tr>
<td>Percent of cars frequently driven on expressways</td>
<td>67.5 (5.9)</td>
<td>59.4</td>
<td>70.9</td>
<td>64.2</td>
</tr>
<tr>
<td>Percent of cars left on company premises at night</td>
<td>22.4 (5.3)</td>
<td>40.5</td>
<td>15.4</td>
<td>28.4</td>
</tr>
<tr>
<td>n</td>
<td>62</td>
<td>8</td>
<td>30</td>
<td>24</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors.
Table B7
Selected Use Characteristics of Cars Typically Driven More than 60 Miles/Day

<table>
<thead>
<tr>
<th>Type of Establishment</th>
<th>All Establishments</th>
<th>Mining &amp; Construction</th>
<th>Gas. &amp; Sanitary Services</th>
<th>Wholesale &amp; Retail Trade</th>
<th>Financial &amp; Other Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of miles driven/day</td>
<td>119.5</td>
<td>158.2</td>
<td>153.7</td>
<td>86.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Percent left on company premises overnight</td>
<td>15.0</td>
<td>2.1</td>
<td>60.7</td>
<td>10.3</td>
<td>23.2</td>
</tr>
<tr>
<td>Percent parked for an hour or more at a time during the day</td>
<td>55.1</td>
<td>67.1</td>
<td>49.8</td>
<td>23.3</td>
<td>96.3</td>
</tr>
<tr>
<td>n</td>
<td>53</td>
<td>16</td>
<td>9</td>
<td>12</td>
<td>16</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors
Table B8
Selected Use Characteristics of Cars Typically Driven More Than 60 Miles/Day

<table>
<thead>
<tr>
<th>Establishment with Fleets Having</th>
<th>All Establishments</th>
<th>1-2 Vehicles</th>
<th>3-10 Vehicles</th>
<th>11 or more Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of miles driven/day</td>
<td>119.5</td>
<td>123.6</td>
<td>111.4</td>
<td>121.9</td>
</tr>
<tr>
<td>Percent left on company premises overnight</td>
<td>15.0 (4.9)</td>
<td>100.0</td>
<td>11.4</td>
<td>12.5</td>
</tr>
<tr>
<td>Percent parked for an hour or more at a time during the day</td>
<td>55.1 (6.8)</td>
<td>19.7</td>
<td>76.5</td>
<td>50.1</td>
</tr>
<tr>
<td>n</td>
<td>53</td>
<td>3</td>
<td>19</td>
<td>31</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors
<table>
<thead>
<tr>
<th>Type of Establishment</th>
<th>All Establishments</th>
<th>Mining &amp; Construction</th>
<th>Wholesale &amp; Retail Trade</th>
<th>Financial &amp; Other Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of miles driven per day per vehicle</td>
<td>28.6</td>
<td>29.8</td>
<td>28.2</td>
<td>30.3</td>
</tr>
<tr>
<td>Average number of times per week vehicles are driven more than 60 miles/day</td>
<td>0.9</td>
<td>1.0</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Percent driven more than 60 miles/day on occasion</td>
<td>60.7</td>
<td>60.6</td>
<td>46.5</td>
<td>75.0</td>
</tr>
<tr>
<td>(5.7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent assigned to fixed routes</td>
<td>18.0</td>
<td>10.6</td>
<td>11.4</td>
<td>23.8</td>
</tr>
<tr>
<td>(4.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent parked for an hour or more at a time during the day</td>
<td>86.9</td>
<td>100</td>
<td>73.5</td>
<td>82.2</td>
</tr>
<tr>
<td>(3.9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent frequently driven on expressway</td>
<td>56.6</td>
<td>68.8</td>
<td>44.6</td>
<td>79.9</td>
</tr>
<tr>
<td>(5.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent left on company premises overnight</td>
<td>63.3</td>
<td>50.7</td>
<td>82.5</td>
<td>62.6</td>
</tr>
<tr>
<td>(5.6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>74</td>
<td>19</td>
<td>15</td>
<td>20</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors.
Table B10
Selected Use Characteristics of Vehicles Other Than Cars in Commercial Fleets That are Driven 60 or Fewer Miles/Day

<table>
<thead>
<tr>
<th>Establishment</th>
<th>All Establishments</th>
<th>1-2 Vehicles</th>
<th>3-10 Vehicles</th>
<th>11 or more Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of miles driven per day per vehicle</td>
<td>28.6</td>
<td>29.9</td>
<td>29.1</td>
<td>27.0</td>
</tr>
<tr>
<td>Average number of times/week vehicles are driven more than 60 miles/day</td>
<td>0.9</td>
<td>0.6</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Percent driven more than 60 miles/day on occasion</td>
<td>60.7</td>
<td>92.2</td>
<td>61.9</td>
<td>36.3</td>
</tr>
<tr>
<td>Percent assigned to fixed routes</td>
<td>18.0</td>
<td>10.5</td>
<td>18.1</td>
<td>23.3</td>
</tr>
<tr>
<td>Percent parked for an hour or more at a time during the day</td>
<td>86.9</td>
<td>92.2</td>
<td>84.6</td>
<td>82.0</td>
</tr>
<tr>
<td>Percent frequently driven on expressways</td>
<td>55.6</td>
<td>70.0</td>
<td>56.6</td>
<td>46.7</td>
</tr>
<tr>
<td>Percent left on company premises overnight</td>
<td>63.3</td>
<td>62.2</td>
<td>59.9</td>
<td>68.7</td>
</tr>
<tr>
<td>n</td>
<td>74</td>
<td>14</td>
<td>37</td>
<td>23</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors.
### Table B11

Selected Use Characteristics of Vehicles Other Than Cars Typically Driven More than 60 Miles/Day by Industrial Classification of Establishment

<table>
<thead>
<tr>
<th>Type of Establishment</th>
<th>All Establishments</th>
<th>Mining &amp; Construction</th>
<th>Sanitary Services</th>
<th>Wholesale &amp; Retail Trade</th>
<th>Financial &amp; Other Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of miles driven/day</td>
<td>95.1 (2.6)</td>
<td>97.1</td>
<td>86.0</td>
<td>90.6</td>
<td>115.0</td>
</tr>
<tr>
<td>Percent left on company premises overnight</td>
<td>64.0 (5.9)</td>
<td>50.9</td>
<td>90.6</td>
<td>65.5</td>
<td>48.6</td>
</tr>
<tr>
<td>Percent parked for an hour or more at a time during the day</td>
<td>60.4 (6.0)</td>
<td>83.9</td>
<td>48.9</td>
<td>40.7</td>
<td>77.6</td>
</tr>
</tbody>
</table>

**n**

|      | 67 | 18 | 13 | 23 | 13 |

Numbers in parentheses are standard errors.
<table>
<thead>
<tr>
<th>Establishment Fleet Size</th>
<th>All Establishments</th>
<th>1-2 Vehicles</th>
<th>3-10 Vehicles</th>
<th>11 or more Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of miles driven per day per vehicle</td>
<td>95.1 (2.6)</td>
<td>88.9 (5.9)</td>
<td>90.8 (5.9)</td>
<td>102.1 (6.0)</td>
</tr>
<tr>
<td>Percent left on company premises at night</td>
<td>64.0 (5.9)</td>
<td>75.6 (5.9)</td>
<td>65.3 (6.0)</td>
<td>57.5 (6.0)</td>
</tr>
<tr>
<td>Percent parked for an hour or more at a time during the day</td>
<td>60.4 (6.0)</td>
<td>48.6 (6.0)</td>
<td>68.2 (6.0)</td>
<td>57.6 (6.0)</td>
</tr>
<tr>
<td>n</td>
<td>67</td>
<td>11</td>
<td>26</td>
<td>30</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors.
<table>
<thead>
<tr>
<th>Type of Establishment</th>
<th>All Establishments</th>
<th>Mining &amp; Construction</th>
<th>Gas &amp; Sanitary Services</th>
<th>Wholesale &amp; Retail Trade</th>
<th>Financial &amp; Other Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of Vehicles Assigned to Specific Drivers</td>
<td>71.8 (4.1)</td>
<td>73.4</td>
<td>68.4</td>
<td>72.1</td>
<td>72.8</td>
</tr>
<tr>
<td>Proportion of Vehicles Driven by Unionized Drivers</td>
<td>12.0 (3.0)</td>
<td>16.0</td>
<td>14.0</td>
<td>10.7</td>
<td>5.7</td>
</tr>
<tr>
<td>n</td>
<td>118</td>
<td>29</td>
<td>26</td>
<td>33</td>
<td>30</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors.
Table B14

Vehicle-Driver Attributes, by Establishment Fleet Size

<table>
<thead>
<tr>
<th>Establishment Fleet Size</th>
<th>Proportion of Vehicles Assigned to Specific Drivers</th>
<th>Proportion of Vehicles Driven by Unionized Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Establishments</td>
<td>71.8 (4.1)</td>
<td>12.0 (3.0)</td>
</tr>
<tr>
<td>1-2 Vehicles</td>
<td>53.0</td>
<td>10.6</td>
</tr>
<tr>
<td>3-10 Vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 or more Vehicles</td>
<td>69.5</td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td>80.7</td>
<td>14.2</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors
APPENDIX C

INTERVIEW QUESTIONNAIRES
1. VEHICLE ID [ ] [ ] [ ]

2. Interviewer's ID No. ____________________________

3. Date ____________________________

4. Length of Interview ________ (Minutes)

5. Length of Edit ________ (Minutes)

THE FOLLOWING STATEMENT MUST BE READ TO EVERYBODY

This interview is completely voluntary. If we should come to any question you would prefer not to answer, just tell me and we'll go on to the next question. Any information you provide will be considered confidential and will not be associated either with you or your organization.

6. INTERVIEWER CHECKPOINT

☐ 1. ONE ORIGINAL COVER SHEET FOR THIS INTERVIEW
☐ MORE THAN ONE ORIGINAL COVER SHEET FOR THIS INTERVIEW

NUMBER OF ORIGINAL COVER SHEETS FOR THIS INTERVIEW

ADDITIONAL VEHICLE ID'S

2nd VEHICLE ID _______ _______ 5th VEHICLE ID _______ _______

3rd VEHICLE ID _______ _______ 6th VEHICLE ID _______ _______

4th VEHICLE ID _______ _______
SECTION C: NUMBER OF VEHICLES IN FLEET

EXACT TIME NOW: ____________

How many light duty, over-the-road vehicles such as passenger cars, and vans and trucks weighing less than 5000 pounds were in this establishment's vehicle fleet last May (1982)?

___________ NUMBER IN MAY

Cl. How many of the vehicles in the fleet in May were owned? ______ NUMBER OWNED

C1b. How many were leased from another company? ______ NUMBER LEASED

And how many are currently in the fleet? ______ NUMBER CURRENTLY

INTERVIEWER NOTE: THE TOTAL OF C2a-C2d SHOULD EQUAL C2

C2a. How many of the vehicles currently in your fleet are passenger cars? ______ NUMBER \{ C3

C2b. How many are trucks weighing less than 5000 pounds? ______ NUMBER \{ C4

C2c. How many are vans? ______ NUMBER \{ C4

C2d. And how many other types of vehicles?

_______ NUMBER

IF C2d GREATER THAN 0

C2e. What type of vehicle (is that/are they)?

__________________________________________
C3. INTERVIEWER CHECKPOINT: PASSENGER CARS

☐ 1. C2a IS "0" → GO TO C4
☐ 2. ALL OTHERS

C3a. Thinking just about the ______ passenger car(s), (how many typically are/is it typically) driven 60 miles or less a day?

CARS LESS THAN 60 MILES/DAY

CARS 60+ MILES/DAY

C3b. (How many/Does it) typically average more than 60 miles a day?

C4. INTERVIEWER CHECKPOINT: OTHER VEHICLES

☐ 1. C2b, C2c, AND C2d ARE "0" → TURN TO P. 3, SECTION D
☐ 2. ALL OTHERS

C4a. Now thinking about the ______ light-duty vehicles other than passenger cars, the vans and trucks weighing less than 5000 pounds, (how many are/is it) typically driven 60 miles or less a day?

OTHER VEHICLES LESS THAN 60 MILES/DAY

C4b. (And how many of the ______ vans, light-duty trucks and other vehicles/Does it) typically average more than 60 miles a day?

OTHER VEHICLES 60+ MILES/DAY
SECTION D: PASSENGER CARS

D1. INTERVIEWER CHECKPOINT: CARS LESS THAN 60 MILES PER DAY

☐ 1. C3a IS "0" OR BLANK ➔ TURN TO P. 4, D9
☐ 2. C3a IS _____

D2. Thinking only about the _____ passenger car(s) that average(s) 60 miles or less a day, about how many miles a day on the average (are they/is it) driven?

D3. How many times during the day (are/is) the car(s) stopped so that (their/its) engine(s) must be restarted?

D4. (How many are/Is it) assigned to (a) fixed route(s)?

D5. (How many are/Is it) usually parked for an hour or more at a time during the day?

D6. (How many are/Is it) frequently driven on expressways?

D7. (Are/Is) the vehicle(s) generally left on company premises overnight or (do/does) the driver(s) take (them/it) home?

D8. (How many/Does it) need to be driven over 60 miles per day on occasion?

IF D8 GREATER THAN 0

D8a. How often (do they/does it) need to be driven that far?

_______ TIMES PER _______ PER CAR
D9. INTERVIEWER CHECKPOINT: CARS MORE THAN 60 MILES PER DAY

☐ 1. C3b IS "0" OR BLANK — TURN TO P. 5, SECTION E
☐ 2. C3b IS ________

D10. Now let's think about the ______ passenger car(s) that average(s) more than 60 miles per day. About how many miles a day is (the average car in this group/this car) driven?

_______ MILES/DAY

D11. (Are/Is) the vehicle(s) generally left on company premises overnight or (do/does) the driver(s) take (them/it) home?

1. COMPANY PREMISES
2. DRIVER'S HOME

D12. (How many are/Is it) usually parked for an hour or more at a time during the day?

_______ NUMBER PARKED
SECTION E: OTHER VEHICLES

E1. INTERVIEWER CHECKPOINT: OTHER VEHICLES (TRUCKS, VANS, ETC.) LESS THAN 60 MILES/DAY

☐ 1. C4a IS "0" OR BLANK → TURN TO P. 6, E11
☐ 2. C4a IS __________

E2. Now thinking only about the __________ truck(s), van(s), (and/or) other vehicles, that average(s) 60 miles or less a day, about how many miles on a day on the average (are: they/is it) driven?

E3. How many times during the day (are/is) the vehicle(s) stopped so that (their/its) engine must be restarted?

E4. (How many are/Is it) assigned to (a) fixed route(s)?

E5. (How many are/Is it) usually parked for an hour or more at a time during the day?

E6. (How many are/Is it) frequently driven on expressways?

E7. How much does the payload typically carried by the vehicle(s) weigh?

E8. What type of things are usually carried?

E9. (Are/Is) the vehicle(s) generally left on company premises overnight or (do/does) the driver(s) take (them/It) home?

E10. (How many/Does it) need to be driven over 60 miles per day on occasion?

IF E10 GREATER THAN 0

E10a. How often (do: they/does it) need to be driven that far?

_______ TIMES PER _______ PER VEHICLE
E11. INTERVIEWER CHECKPOINT: OTHER VEHICLES (TRUCKS, VANS, ETC.) MORE THAN 60 MILES/DAY

☐ 1. C4b IS "0" OR BLANK —→ TURN TO P. 7, SECTION F

☐ 2. C4b IS ________

E12. Now let's think about the ________ truck(s), van(s), (and/or) other vehicle(s) that average(s) more than 60 miles per day. About how many miles a day is (the average vehicle in this group/this car) driven?

_______ MILES/DAY

E13. How much does the payload typically carried by the vehicle(s) weigh?

_______ WEIGHT OF AVERAGE LOAD

E14. What type of things are usually carried?

______________________________________________________

______________________________________________________

E15. (Are/Is) the vehicle(s) generally left on company premises overnight or (do/does) the driver(s) take (them/it) home?

1. COMPANY PREMISES 2. DRIVER'S HOME

E16. (How many are/Is it) usually parked for an hour or more at a time during the day?

_______ NUMBER PARKED
SECTION F: DRIVER CHARACTERISTICS

F1. Now thinking about all \( \text{(NUMBER FROM C2)} \) vehicles in your fleet—how many are assigned to a specific driver?\text{NUMBER ASSIGNED DRIVER}

F2. INTERVIEWER CHECKPOINT

☐ 1. ALL VEHICLES IN FLEET ASSIGNED SPECIFIC DRIVER \( \text{GO TO F4} \)

☐ 2. NOT ALL VEHICLES ASSIGNED SPECIFIC DRIVER

F3. How difficult would it be to assign specific drivers to the vehicle(s) that are/is not currently assigned (a) specific driver(s)—would it be very difficult, not very difficult, or very easy?

1. VERY DIFFICULT

2. NOT VERY DIFFICULT

3. VERY EASY

F4. Is driving the primary duty of those who drive your vehicles or is it incidental to their doing their jobs?

1. PRIMARY

3. INCIDENTAL

F5. How many of the vehicles are driven by unionized drivers? \text{NUMBER DRIVEN BY UNIONIZED DRIVERS}

IF F5 GREATER THAN 0

F5a. To which union or unions do the drivers belong?

________________________

________________________

________________________

________________________
GL. Some businesses are using electric vehicles on an experimental basis in their fleets. If electric vehicles:

- were as reliable as conventional vehicles,
- had a range of 60 miles,
- could be recharged in 6 hours,
- could go 60 miles per hour, and
- could carry a load of 500 pounds plus 2 to 4 passengers,

do you think your company would be willing to use one or more of them?

1. YES  3. MAYBE  5. NO  8. DON'T KNOW

GLa. Why is that? __________

GLb. Would it be possible to assign a specific driver to each electric vehicle?

1. YES  5. NO

GLc. Why is that? __________

TURN TO P. 9, SECTION H
SECTION H: COMPANY CHARACTERISTICS

H1. Finally I have a few questions about the place where you work. Is it part of a larger organization for instance, a headquarters, branch, or subsidiary?

1. YES

5. NO → TURN TO P. 10, H2

H1a. Is it the headquarters, a branch, a subsidiary, or what?

1. HEADQUARTERS

2. BRANCH

3. SUBSIDIARY

OTHER (SPECIFY): ________________

H1b. Are decisions regarding the purchase, leasing, or use of vehicles made where you work or are they made in another part of the organization?

1. WHERE WORKS

3. BOTH

5. ANOTHER PART
H2. I'm going to read you a list of industrial categories. Please tell me which one of these following categories best describes the primary activity at the place where you work. (CHECK ONLY ONE. IF RESPONDENT MENTIONS MORE THAN ONE, ASK WHICH ONE COMPRISRES THE LARGEST PART OF THE COMPANY'S BUSINESS.)

☐ 01. Agriculture, Forestry, or Fishing ➔ TURN TO P. 11, H3

☐ 02. Mining ➔ TURN TO P. 11, H4

☐ 03. Construction ➔ TURN TO P. 11, H5

☐ 04. Manufacturing ➔ TURN TO P. 13, H9

☐ 05. Transportation ➔ TURN TO P. 11, H6

☐ 08. Wholesale Trade

☐ 09. Retail Trade ➔ TURN TO P. 11, H7

☐ 10. Finance and Banking ➔ TURN TO P. 11, H8

☐ 63. Insurance (63, 64)

☐ 65. Real Estate

☐ 13. Providing Services ➔ TURN TO P. 13, H9

☐ 14. Public Administration

☐ 15. SOMETHING ELSE
AGRICULTURE

H3. Does it engage primarily in ...........

- 01. Agricultural production (01-02)  
- 07. Providing agricultural services  
- 08. Forestry, fishing, hunting or trapping (08-09)  
- 98. or something else  

MINING

H4. Does it engage primarily in ...........

- 13. Oil and gas extraction  
- 10. Mining of minerals such as coal or metals  
- 98. or something else  

CONSTRUCTION

H5. Does it engage primarily in ...........

- 15. Building construction  
- 16. General or Special trade contracting (16-17)  
- 98. or something else  

TRANSPORTATION

H6. Does it engage primarily in ...........

- 41. Local & Suburban Passenger Transportation such as buses or local railways  
- 40. Other Railroad Transportation  
- 42. Motor Freight Transportation and Warehousing  
- 44. Water Transportation  
- 45. Air Transportation  
- 47. Transportation Services such as packing, forwarding, or arranging transportation  
- 98. or something else  

TURN TO P13, H9
### RETAIL TRADE

**H7. Is yours .........**

- **☐ 53. A department, clothing or food store (53, 54, 56)**
- **☐ 55. An automobile dealership or gasoline service station**
- **☐ 58. An eating or drinking place**
- **☐ 57. A furniture, home furnishing or appliance store**
- **☐ 52. A building materials, hardware or garden supply store, or mobile home dealer**
- **☐ 98. or something else**

→ **TURN TO P. 13, H9**

### FINANCE

**H8. Is your company best defined as a .........**

- **☐ 60. Bank**
- **☐ 61. A credit agency other than a bank**
- **☐ 62. A company engaged in securities or commodities trade**
- **☐ 67. A holding or investment office**
- **☐ 98. or something else**

→ **TURN TO P. 13, H9**
H9. Would you please tell me more about what they make or do at this location (of your business).

0. That is all the questions I have. Thank you very much for your time.

1. EXACT TIME NOW: __________
APPENDIX C.2
DOE SITE OPERATOR INTERVIEW

Questions for DOE site operators

1. Vehicles

What types of electric vehicles -- make and model -- do you have?

What is the average range of the vehicles in summer? in winter?
   average recharge time in summer? in winter?

Where have the uncertainties over costs been
   initial purchase?
   battery replacement?
   operations?
   maintenance?

Approximately what has been the $/mile in summer? in winter?
   kw/mile in summer? in winter?

What are the strengths and weaknesses of the vehicles?

What have been the major surprises and problem areas with the vehicles?

2. Applications

What is each of the vehicles used for?

Are they fixed route or variable?
   length of route?
   miles per day?
   number of stops/starts?
   load, # passengers?

How well have each of these applications worked?

3. Operations

Who controls the day to day operations, who does what, i.e. is dispatch centralized or by department?

Did you change your operations in any way to adapt to the EVs?

When are vehicles recharged, when returned to base, each evening or at stops along route?

Where are the vehicles garaged, i.e. indoor or outdoor?
Have any problems occurred with this garaging arrangement?

Are any vehicles taken home over night? If yes, what types of problems has this created?

Do you have backup vehicles for the EV's?
4. Drivers

How are drivers assigned, i.e., specific drivers assigned to specific vehicles or are vehicles assigned to a pool?

How were drivers selected?

What type of training have drivers received?

Who drives the vehicles, i.e., are they primarily drivers or do they drive to get to and from their work?

Are drivers union or non-union?

What were the drivers' initial attitudes toward the vehicles? How have these changed?

If given the choice, do drivers choose an EV or a conventional vehicle?

What have drivers liked most and least about the vehicles?

5. Maintenance

Who is responsible for maintenance?

When is maintenance done, regularly or when drivers say repairs are needed?

How often and what type of scheduled maintenance is done?

What type of training did service personnel receive?

How reliable have the vehicles been?

What types of repairs?

Have you made any improvements to the vehicles? What type?

What types of parts do you keep in stock?
6. Data collection
What types of data do you collect about the vehicles and drivers?
How was the data collection organized, who did what?
What problems did you encounter in collecting the data?
How did you overcome these problems?
What data do you wish you had collected, but did not?
Is the data available?

7. Organizational factors
What has been the reaction of others in the organization not participating, e.g. upper management, other departments, toward the program?
What types of information programs were setup to inform others in the organization about the demonstration program?
What types of information programs were setup to inform the public about the program?

How was the initial decision to participate in the DOE project made, who made it?
What was the nature of the agreement between you and DOE, i.e., who paid for what?

8. Lessons learned
What has been the biggest problem with your EV program?
What technical improvements in the vehicle do you feel are needed?
If you had to do it all over again, what 2 or 3 things would you do differently?
Are you planning on continuing to use your EV’s?
If yes, in what way?
If no, what would have to change to make you try them again?
and what incentives, financial or otherwise, would you need?
Let us assume that EVs can be made to perform as reliably as conventional vehicles but that this range and other limitations remain as they are today.

1. Now that you have had the opportunity to operate an electric vehicle as part of your fleet, do you think it would be possible (on the basis on performance characteristics) to use electric vehicles in place of one or more regular vehicles in your fleet? (relative costs should not be a consideration at this point)

   YES  NO
   1a. Why not? __________________________________________

   TERMINATE SEQUENCE

2. Do you think you could substitute one vehicle or more than one?

   ONE  MORE THAN ONE
   2a. How many? __________________________________________

3. Would you be willing to substitute (an EV/EVs) for (an ordinary vehicle/ordinary vehicles) if, considering everything, they cost about the same per mile driven?

   YES  NO
   3a. If an EV cost 5% more would you be willing to make the substitution?  

   YES  NO  NO  YES
   3b. If an EV cost 10% more?

   YES  NO  NO  YES
   3c. What is the highest premium you would pay for an EV in terms of percent more per mile driven? ___________%  

   What percentage less would an EV have to cost for you to make the substitution? ___________%