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**VEHICLE ATTRIBUTES CONSTRAINING
PRESENT ELECTRIC CAR APPLICABILITY
IN THE FLEET MARKET**

JOSEPH R. WAGNER

December 1979

DEPARTMENT OF ENERGY AND ENVIRONMENT

**BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973**



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ECONOMIC ANALYSIS DIVISION

**NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
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ABSTRACT

One strategy for reducing petroleum imports is to use electric cars in place of conventional vehicles. This paper examines obstacles which electric cars are likely to encounter in attempting to penetrate a key segment of the passenger car market, namely, the fleet market. A fleet is here defined as a group of cars operated by a corporation or a government agency. The primary data source is a questionnaire that was distributed to fleet operators by the Bobit Publishing Company in the summer of 1977. Six sectors of the fleet market were sampled: police, state and local government, utilities, taxi, rental, and business. The questionnaire was specifically designed to uncover factors limiting market penetration of unconventional vehicles, although no attempt was made to determine price elasticities. Emphasis is on vehicle attributes that are readily quantifiable and relatively projectable, including seating capacity, range, battery recharging characteristics, availability of power options, and ability to use interstate highways.

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INTRODUCTION

Since the oil embargo of 1973-74, numerous proposals have been put forward to reduce petroleum consumption in the United States. Passenger cars have been the target of many of these proposals because they are the largest single user of petroleum, accounting for about 28 percent of all petroleum consumed in the United States.¹ One proposal for reducing oil consumption is to replace present cars with cars propelled by electric storage batteries. The success of this strategy requires (1) the use of electricity produced from nonpetroleum fuels to charge the electric car storage batteries, and (2) capture of a significant share of the automobile market by electric cars. The purpose of this paper is to examine certain physical characteristics of the electric car (EC) which may limit its ability to penetrate a key segment of the market, namely, the fleet market.

A fleet is here defined as a group of passenger cars operated by a corporation or by a government agency. In considering the EC, the fleet market is important for several reasons. It is a large market, typically accounting for 12 percent of new car sales^{2,3} (Table 1). Also, it is likely to differ from the household market in its reaction to changes in vehicle prices, fuel prices, and other variables affecting the desirability of switching from conventional cars to ECs. Most corporations, unlike households, can deduct vehicle costs from their taxable income; therefore, a given cost increase has a smaller impact on their after-tax income. Also, corporations often pass a portion of cost increases on to customers via higher prices. Although these influences are mitigated by competitive pressures, corporations still approach vehicle selection with a perspective different from that of households.

Table 1
United States Passenger Car Registrations and
Retail Sales, Total Versus Fleets With 10 or More Cars

Calendar Year	Thousands of registrations		Fleet share of registrations, %	Thousands of domestic & imported retail sales		Fleet share of sales, %
	Total	Fleet		Total	Fleet	
1978	117147	6876	5.9	11312	1516	13.4
1977	113696	6517	5.7	11185	1344	12.0
1973	101985	5744	5.6	11439	1291	11.3
1970	89244	5041	5.6	8405	1009	12.0

Perhaps the most important reason for examining the fleet market is because of its value as an EC test market. The U.S. Department of Energy is currently making extensive use of fleets as a proving ground for electric vehicles.⁴ Fleets provide a good test market because of a number of fleet operator characteristics:

1. Managerial and fiscal resources which permit acceptance of some of the risk associated with testing new technology.
2. Bulk buying practices, which enable a fledgling EC manufacturer to concentrate on a limited product line and a small number of customers.
3. Conscientious maintenance and record keeping.
4. The ability to assign certain vehicles to less demanding tasks.
5. Rapid mileage accumulation and high product visibility.

RESEARCH TARGETS

The market share of a specific vehicle is determined by a large number of vehicle attributes that help define trade-off parameters considered by purchasers when choosing among alternative vehicles. A system of trade-off parameters adapted from the literature is presented in Table 2.⁵ Shown with each parameter are a number of vehicle attributes of interest to fleet operators.

It is possible to perform a study in which fleet operators specify their relative preferences for various vehicle attributes. Such studies have been made on households, using focus group discussions and conjoint measurement analysis.⁶ The research described in this paper has not yet reached this level of development. The findings are limited to information that could be collected by a first-pass mailed survey of fleet operators. The research plan was to start with simple techniques and to incorporate more complex and comprehensive ones as more is learned about the fleet market.

The use of a mailed survey limited the study to attributes that lend themselves to a questionnaire format. For instance, it is easy to formulate a question regarding the minimum number of seats a fleet operator considers acceptable in a vehicle, but is difficult to formulate questions dealing with vehicle attributes such as gradeability (i.e., the speed that can be maintained on a hill of a given steepness), comfort, or crash avoidance. The problem is these attributes are either inherently difficult to quantify, or respondents are not conversant about them.

Although the study was limited to readily quantifiable factors, the list of attributes was still too long for a single questionnaire. Since the principal use of the data would be in making projections, the decision was to concentrate on the attributes whose future values were deemed most predictable. This eliminated cost data because future costs are subject to many unknowns, including government subsidy policies and economies of scale.*

*Data on fleet operator trade-offs between price and other vehicle attributes have become available via a second questionnaire, but the information has not yet been tabulated.

Table 2
Trade-off Parameters and Associated Vehicle
Attributes of Interest to Fleet Operators

Parameter	Vehicle Attributes
Cost	Life-cycle cost Purchase price Depreciation cost Maintenance cost Fuel cost Insurance cost
Functionality	Seating capacity Trunk capacity Range Refueling characteristics Acceleration Speed Gradeability Availability of power options Reliability Durability
Amenity	Comfort Styling Drivability Image
Safety	Crash avoidance Crashworthiness Nonoperating safety
Social cost	
Resource consumption	mpg or mi/kWh
Emissions	Ability to meet federal, state, and local regulations
Noise	

Table 3 shows the results of sorting the attributes according to the above two criteria. Grouping on the basis of ease of quantification and perceived ability to project EC attributes brought together high-priority attributes for inclusion in the first-pass questionnaire. The highest-priority attributes are identified as primary targets. The lower-priority attributes are identified as secondary or tertiary targets.

Table 3
 Targeting Vehicle Attributes on Basis of Ease of Quantification
 and Ability to Project Relative Attributes of Electric Cars

Ability to quantify preferences of fleet operators	High	Secondary targets: Purchase price Life-cycle cost Depreciation cost Maintenance cost Fuel cost Insurance cost Reliability Durability	Primary targets: Seating capacity Range Refueling characteristics Availability of power options
	Low	Tertiary targets: Safety attributes Amenity attributes	Secondary targets: Trunk capacity Acceleration Speed Gradeability Social cost attributes
		Low	High

Ability to determine
 relative advantage/disadvantage
 of EC in mid-1980s

SURVEY INSTRUMENT

A questionnaire (see Appendix) reflecting the Table 3 priorities was developed for distribution to fleet operators. Attributes identified as primary targets were treated in a way that allowed direct quantification. This direct quantification is demonstrated by the treatment of the range attribute, where respondents were asked to assign their vehicles to specific categories (e.g., 0-50 miles, etc.). Most of the attributes identified as secondary targets were quantified indirectly. For instance, respondents were not asked to specify required acceleration (e.g., seconds needed to accelerate from 0-48 km/h), speed, and gradeability, but they were asked what percent of their vehicles needed to use interstate highways. Responses to this question provide an indirect measure of needs for acceleration, speed, and gradeability because a vehicle using an interstate highway has specific requirements for these attributes.⁷

The survey was distributed by the Bobit Publishing Company in August 1977, with a partial resample in January 1978. Recipients were subscribers of Bobit's Automotive Fleet magazine, plus additional persons included to ensure coverage of certain sectors of the fleet market. The sectors were defined to be compatible with existing data available from Bobit. The sample is not a statistically designed probability sample because of the lack of a reliable fleet census containing such variables as the regional location and size distribution of all fleets. Table 4 shows response rates per sector and estimated sampling rates, computed with the aid of published Bobit data.³

SURVEY RESULTS AND USES

Complete survey results are available in a report prepared by Brookhaven National Laboratory for the U.S. Department of Energy.⁸ Table 5 shows results covering all the attributes selected as primary targets. In general there is great variability among the sectors, though they tend to fall into groups; for instance, the government and utility sectors display similarities.

What do the survey data imply for the electric car? The primary value of the data is that they can be used to estimate upper bounds on the market penetration of an EC with given physical attributes. For instance, Table 5 shows that 17 percent of the cars in the survey sample need only two seats, with the remaining cars needing three or more seats to fulfill their vehicle missions. The implication is that any EC having only two seats could obtain at best a 17 percent share of the fleet market. This would hold regardless of its other physical attributes, although it could be argued that this might not be true if the EC were to have some very great advantage over other vehicles in terms of certain

Table 4
Response Rate and Car Sampling Rate by Market Sector

Market sector	Questionnaires sent	Responses received	Response rate, %	Cars in U.S. (thousands), 1977 ^a	Cars in sample (thousands) 1977	Car sampling rate, %
Police	328	85	26	292	41	14
Government ^b	1942	94	5	642	37	6
Utility	2360	293	12	518	37	7
Taxi	752	68	9	202	2	1
Rental	1050	56	5	385	36	9
Business	6342	671	11	3067	130	4
Total	12774	1267	10	5106	284	6

^aEstimate.³

^bState and local non-police.

Table 5
Summary of Survey Data
(percent of cars)

	Police	Government ^a	Utility	Taxi	Rental	Business	All Sectors
Needs only 2 seats	3	26	29	3	11	14	17
Needs a range of:							
Less than 80 km (50 mi)	0	3	2	0	0	0	1
Less than 161 km (100 mi)	1	25	34	5	33	8	16
Less than 241 km (150 mi)	3	32	57	39	40	18	26
Without options:							
Automatic transmission	0	1	5	6	2	0	1
Power steering	0	5	30	6	9	1	6
Power brakes	0	18	33	23	10	3	9
Air conditioning	19	49	57	49	2	1	18
Available for long refueling (8 h at central location)	20	49	51	25	18	20	28
Not needing high performance (interstate highway capabilities)	9	31	25	40	5	24	21
Available for long refueling and not needing high performance	4	11	15	9	3	11	10

^aState and local non-police.

physical attributes other than seating. The 17 percent figure therefore defines an "applicability rate" for a two-seat vehicle whose physical attributes are otherwise the same as, or superior to, those of other cars. It differs from an estimate of market penetration rate in that it does not take into account the effect of vehicle cost. From the data in Table 4, a 17 percent market share is estimated to represent 870,000 cars (0.17 x 5,106,000) in the fleet sectors covered by the survey. Assuming that these vehicles spend an average of 3 years in fleet service,⁹ this corresponds to a sales volume of 290,000 cars per year.

In judging which attributes are most restrictive of EC applicability, it is helpful to examine the attributes of currently available ECs. These are shown in Table 6, along with those of a late model conventional car.¹⁰⁻¹² The Dodge Omni was chosen for comparison because it was assumed to be representative of the type of petroleum-fueled car against which ECs would compete in the mid-1980s, the earliest possible date for large-scale EC production. This is not to say that the attributes of either ECs or conventional cars will be static. On the contrary, it is reasonable to assume that the attributes of ECs will improve both in absolute terms and in comparison with those of conventional cars. The point of the present analysis is to show where improvement is most needed.

Table 6
Present Status of Electric Car Attributes and
Likely Attributes of Mid-1980s Conventional Car

	Electric			Conventional (1979 Dodge Omni)
	EC 1 (EVA Change-of-Pace)	EC 2 (SCT R-1 Electric)		
Primary targets:				
Seating capacity	4	2		4
Range (SAE J227a,C)	50km(31mi)	71km(44mi)		500km(300mi) ^a
Refuel time (80% discharge)	8h	8h		0.1h
Availability of options:				
Automatic transmission	yes	no		yes
Power steering	no	no		yes
Power brakes	no	no		yes
Air conditioning	no	no		yes
Selected secondary targets:				
Acceleration, 0-48 km/h	11s	10s		4s
Speed: Cruising	71km/h(44mph)	71km/h(44mph)		>89km/h(>55mph)
Maximum	90km/h(56mph)	97km/h(60mph)		146km/h(91mph)
Gradeability (10% grade)	24km/h(15mph)	35km/h(22mph)		89km/h(55mph) ^a

^aEstimate.

From Table 5 and 6, it appears that the applicability of EC 1 is most constrained by its range, in that one percent or less of the sample vehicles had range needs within EC 1's expressed capability of 50 km (31 mi). EC 2 is in the same situation with respect to range, but is also held in check by its lack of an automatic transmission. If these barriers were eliminated, the next obstacles to limit the applicability of the two ECs would likely be their lack of power steering and power brakes, although these factors are much less restrictive in certain market sectors. When examined singly, the least restrictive EC attributes appear to be their refueling characteristics and their inability to use interstate highways (this inability is deduced from the Table 6 data on acceleration, speed, and gradeability). This information is summarized in Table 7. Note that, aside from the possibility of a constraint arising from seating capacity, the conventional car appears to have unconstrained applicability.

A more conclusive way of estimating applicability rates is to compare a particular vehicle's full set of attributes with the needs of a particular respondent. An applicability rate can thus be found for each respondent. An applicability rate for each market sector can then be found by taking a vehicle-weighted average of the rates for the individual respondents.

Table 7
Ranking of Applicability Constraints

Constraints	Maximum applicability percent when constraints applied singly	
	EC 1	EC 2
Range <80 km (<50 mi)	1	1
Manual transmission	---	1
No power steering	6	6
No power brakes	9	9
2-seat capacity	---	17
No air conditioning	18	18
Unable to use interstates	21	21
8-hour refueling	28	28

When this is done for EC 1 and EC 2, applicability rates of about one-tenth of one percent emerge. However, to date this has been done only under the pessimistic assumption that there is no correlation between the attributes needed for a particular vehicle mission. To illustrate, assume a fleet operator indicated that 10 percent of his or her cars need less than a 80 km (50 mi) range and that 20 percent need only two seats. The applicability estimates compiled to date have assumed no correlation between seating capacity needs and range needs. That is, assuming that one is evaluating an EC with a range of 80 km (50 mi) and two seats, the calculated applicability rate for the above respondent would be 2 percent ($0.1 \times 0.2 = 0.02$). The true situation may be that there is high correlation between seating capacity needs and range needs, such that all of this respondent's cars that need only 80 km (50 mi) range also need only two seats. In that case, the applicability rate for this respondent would be 10 percent ($0.1 \times 1.0 = 0.1$).

SUMMARY

If the EC is to play an important role in reducing petroleum consumption, it must obtain a significant share of the automobile market. Within the automobile market, the fleet market is an important segment because of its size, unique motivations, and attractiveness as an EC test market. A large number of vehicle attributes will ultimately determine the market penetration of ECs in the fleet market. This paper has attempted to illuminate the effect that some of the more quantifiable and projectable attributes can have on the market success of the EC.

The greatest constraints on the fleet market applicability of currently available ECs appear to be their range limitations and their lack of power options. Their least constraining attributes, among those examined, appear to be their need for lengthy recharging and their presumed inability to use interstate highways, but even these would limit ECs to a

minority share of the fleet market. Comparison of all attributes of present ECs with the needs of sampled fleet operators, albeit under pessimistic assumptions, shows estimated EC applicability rates to be negligible.

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APPENDIX: BOBIT QUESTIONNAIRE

LOCATION AND TYPE OF FLEET

The questions on this page are not intended to identify specific respondents, but rather will be used to divide respondents into general groups. All responses are considered confidential. With these things in mind, you would greatly assist us by placing a check mark next to your market sector and by recording your location and fleet type (owned or leased).

I. MARKET SECTOR:

- State Government
 - Police _____
 - Non Police _____
- Local Government
 - Police _____
 - Non Police _____
- Utility _____
- Taxi _____
- Auto Rental _____
- Business Fleet (25 vehicles or more) _____
- Business Fleet (4-24 vehicles) _____
- State: _____ City: _____

Management:
 Percent of vehicles owned = _____, leased = _____

HISTORICAL INFORMATION

In addition to knowing the composition of your fleet as it exists today, it is important for us to know how this composition has changed over the years to enable us to identify historical trends. Please indicate in the tables below (in absolute numbers) the purchases made for the fleet and the composition of the fleet for the years 1966 through 1976.

Table of Purchases

	<u>Small Cars</u>	<u>Medium Cars</u>	<u>Large Cars</u>	<u>Light Trucks</u>
1966				
1967				
1968				
1969				
1970				
1971				
1972				
1973				
1974				
1975				
1976				

Table of Fleet Composition

	<u>Small Cars</u>	<u>Medium Cars</u>	<u>Large Cars</u>	<u>Light Trucks</u>
1966				
1967				
1968				
1969				
1970				
1971				
1972				
1973				
1974				
1975				
1976				

QUESTIONNAIRE - FLEET OPERATOR

1. Rate the following criteria for your automobile purchases on a scale of 1 to 5, 5 being the most important: (circle answer)

Purchase Price	1	2	3	4	5
Resale Value (as % of original cost)	1	2	3	4	5
Maintenance Costs	1	2	3	4	5
Life-Cycle Cost	1	2	3	4	5
Reliability (day by day)	1	2	3	4	5
Running Lifetime	1	2	3	4	5
Tradition (i.e., past experience)	1	2	3	4	5
Gas Mileage	1	2	3	4	5
Other (specify) _____	1	2	3	4	5

NOTE: Please answer questions 2 through 10 in terms of each of the size categories defined in question 2.

2. How many vehicles do you have in the following categories:

Passenger Car - Small (e.g. Gremlin, Vega, Mustang II, and others weighing less than 3050 lbs.) _____

- Medium (e.g. Granada, Maverick, Aspen, Volare, Hornet, Skylark 6, Nova, Omega, Ventura, Pacer and others weighing 3050-3500 lbs.) _____

- Large (e.g. Skylark 8, Monaco, Fury, Matador, Chevelle, Century, Cutlass, LeMans, LTD II, Cougar, and others weighing more than 3500 lbs.) _____

Light Truck - Pick Up _____

- Van _____

3. Which of the following power options would you typically (more than half the time) specify for your vehicles: (circle answer)

	Small Car		Medium Car		Large Car		Light Truck	
- Automatic Transmission	Yes	No	Yes	No	Yes	No	Yes	No
- Power Steering	Yes	No	Yes	No	Yes	No	Yes	No
- Power Brakes	Yes	No	Yes	No	Yes	No	Yes	No
- Air Conditioning	Yes	No	Yes	No	Yes	No	Yes	No
- Radio	Yes	No	Yes	No	Yes	No	Yes	No
- Trailer Towing Options	Yes	No	Yes	No	Yes	No	Yes	No
- Other (specify) _____	Yes	No	Yes	No	Yes	No	Yes	No

4. Is the present availability of diesel fuel sufficient for you to consider using diesel power, if it were available as an option in the models you currently use? (circle answer)

Small Car	Yes	No
Medium Car	Yes	No
Large Car	Yes	No
Light Truck	Yes	No

5. NOTE: As of now electric vehicles have a limited cruising range, after which an eight hour recharge period is typically required. The purpose of this question is to determine on the basis driving range only, the suitability of the electric car in automobile fleets.

On any given day a vehicle selected for your fleet must be capable of driving at least: (circle answer)

Small Car	(a) 0-50 miles	(b) 50-100 miles
	(c) 100-150 miles	(d) more than 150 miles
Medium Car	(a) 0-50 miles	(b) 50-100 miles
	(c) 100-150 miles	(d) more than 150 miles
Large Car	(a) 0-50 miles	(b) 50-100 miles
	(c) 100-150 miles	(d) more than 150 miles
Light Truck	(a) 0-50 miles	(b) 50-100 miles
	(c) 100-150 miles	(d) more than 150 miles

6. What percentage of your cars sit idle for eight consecutive hours or more at a central location, during every 24 hour period (for each size category)?

Small - _____% Large - _____%

Medium - _____% Light Truck - _____%

7. What percentage of your cars, within each size category, do not need the ability to accelerate and cruise on interstate highways? (Fill in number)

Small - _____% Large - _____%
Medium - _____% Light Truck - _____%

8. What percentage of your cars have both characteristics (i.e., do not need interstate travel capabilities and sit for 8 hours or more at a central location), for each size category?

Small - _____% Large - _____%
Medium - _____% Light Truck - _____%

9. What percentage of your fleet would be adequately served with a vehicle capable of seating only two (2) passengers?

Small - _____% Large - _____%
Medium - _____% Light Truck - _____%

10. What is the minimum number of adult passengers that you would expect your vehicles to be able to carry?

Small - _____ Large - _____
Medium - _____ Light Truck - _____

11. What is the estimated number of miles driven per year by your average vehicle?

Answer - _____

12. How do you select the engine size you order for your vehicles? (e.g., always take standard equipment, always V8 engines, etc.)

13. How do you decide to dispose of a vehicle? (e.g., accumulated mileage, vehicle age, etc.) (please specify an amount) _____

14. Are your purchases or leases restricted at all by any special contractual arrangements? (circle answer) Yes No

If so, how? _____
