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Session 1A: Vehicle Development

Session 1B: Flywheel/Ultracapacitor

Session 1C: Market Research

SEGMENTATION AND SIZE OF THE MARKET FOR BATTERY POWERED AND HYBRID ELECTRIC VEHICLES IN CALIFORNIA: A Diary Based Survey Of New Car Buyers In California

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Abstract

We report findings from a recent survey of California households who buy new cars. This study is designed to predict and explore the potential market for alternative fueled vehicles with special emphasis on electric vehicles (EVs). Based on preliminary results from the first 175 returned surveys, we find a much larger market for EVs than have many previous surveys. This finding is attributed to the sophisticated survey design based upon two years of preliminary research into understanding EV market barriers. The most important of these barriers is consumers' lack of understanding of the impact of limited range and home recharging on their lifestyles. If our final results are borne out by the initial findings presented here, then enough new car-buying households in California would choose to buy EVs to meet the 1998 ZEV sales mandates. We expect 450 completed returns and will update and expand our results at the time of the conference in December 1994.

Research Design

The most important shortcoming of previous studies of the electric vehicle market is their failure to address fundamental information issues -- consumers are well informed about gasoline vehicles but poorly informed about electric propulsion vehicles (Turrentine and Sperling 1992). This study was designed to educate consumers about both the design features of electrics and the effects of a daily range budget and home recharging on their lifestyle. Previous research by the authors demonstrated that two variables shaped consumers' evaluation of range and recharging. The first is *critical destination*, a location which the prospective primary driver of an electric must feel is well within the daily range of their vehicle; the second is the *routine activity space* of the prospective

household, which shapes the value of home recharging. These two variables have not been incorporated in previous studies of the electric vehicle market, but did emerge in our previous detailed behavioral analysis of a household's joint utility evaluation of electric vehicles (Kurani, Turrentine and Sperling 1994). Households who buy electrics will be "hybrid" households, having two very different types of vehicles for distinct purposes. Some households already do this, buying special vacation vehicles and special commute vehicles.

Another difficulty of EV market studies has been that the prices at which electric vehicles will be sold in 1998-2003 is extremely uncertain. In order to focus on driving range and recharging, we designed choice situations in which all vehicle's prices were roughly comparable. Thus respondents had little incentive to choose between vehicles based upon price alone. With the exception of optional equipment and replacement costs of batteries, the base prices of all vehicles in this study are equivalent. The prices of gasoline and reformulated gasoline vehicles presented in the study are based upon 1992 prices of gasoline vehicles in each class and category. The base price of electric, hybrid, and compressed gas vehicles are higher, but tax credits and other incentives such as those contained in the National Energy Policy Act are offered which offset the higher purchase price of electrics, thus equalizing the base prices of electric, natural gas, and gasoline vehicles.

Households were recruited by phone, sent a survey packet, and the packets returned via mail. This survey was divided into four parts, and was designed to be completed over several days to encourage critical evaluation of the options.

1. Part One: Initial survey of household vehicle holdings, purchase intentions for next vehicle, demographics, environmental attitudes.

2. Part Two: Three day travel diary for two primary household vehicles, and a survey of the travel and refueling patterns of the two primary drivers.

3. Part Three: Information video and reprinted articles from major media which explain and demonstrate distinct refueling and recharging routines, emissions as well as other new features of compressed natural gas, battery powered electric, hybrid electric and neighborhood electric vehicles.

4. Part Four: Household is presented two choice situations for their next vehicle purchase. The first is a choice between a gasoline and an electric vehicle. The second includes six vehicle types: reformulated gasoline, compressed natural gas, hybrid electric, two types of battery electrics, and a neighborhood electric vehicle. Each vehicle type is described in detail, offered in a range of body styles, offered in economy, standard and luxury versions, and offered with distinct option sets and a price list. Participants record their choice and answer a few questions about their choice.

Description of Sample

The new car buyers sampled in this study represent about one third of the annual car sales in California -- between 250- and 300,000 annually.[1] We selected households found in previous research to be the best candidates for electric vehicle purchase. Selection criteria were that households: own two or more vehicles; buy new vehicles; own one 1989 or newer vehicle and one 1986 or newer vehicle; and at least one of the vehicles is not a full sized sedan, van, sport utility vehicle or pick-up. The ages of recruited participants was matched to age distributions in the California auto market.

[1]Baseline studies of the California auto market do not include all of the household demographic criteria used in this study to select households, therefore we cannot give a more precise estimate. We have crossed referenced sales figures for California with a 1990 Newsweek Study of the auto market.

740 households were recruited by marketing firms in five metropolitan areas of California: the San Francisco Bay Area, Sacramento, Fresno, the Los Angeles Basin and San Diego. Participants were paid a 50 dollar incentive because of the time demands of the survey and to keep the study from being biased to those interested in the subject.

Findings

These findings are based upon 175 completed surveys received and analyzed by May 9, 1994. We report only preliminary findings. We expect 450 completed returns by October 1994.

Vehicle Choice in Situation One

In situation one, respondents chose between a gasoline vehicle and an electric vehicle. 48% of respondents selected a battery powered electric vehicle and 52% chose a gasoline vehicle in Situation One. The median price combined of both electric and gasoline choices was $20,396 (electric vehicles are initially priced $4000 higher but then discounted $4000 by incentives).

Electrics were offered with two driving ranges -- 80 to 100 miles or 100 to 120 miles. The longer range batteries were priced $800 higher. 57% selected the longer range battery. A special "fast charging battery", which could be recharged up to 80% of a fully discharged vehicle in 20 minutes at a special stations, was offered for an additional $900. 46% chose to purchase the fast charging option.

Both gasoline and electric vehicles were offered in a range of body styles; in economy, standard and luxury versions; and with options such as air conditioning, four wheel drive etc. However, electric vehicles were not offered in any full-sized body styles.

Below is a table with the number of household's vehicle choices by body styles. Buyers of small sedans unanimously chose battery electric vehicles over gasoline. Electricity is the preferred energy source for buyers of compact sedans and small sport utility vehicles. Only buyers of midsize sedans were more likely to prefer gasoline to electric among buyers of those body styles offered in both electric and gasoline vehicles. Twenty-four households chose large vehicles which were offered only as gasoline vehicles.

Table 1:
Choice of Gasoline or Electric Vehicle by Body Style

Body Style	Gasoline	Electric
2 seater sports car	9	8
compact pick-up	9	7
small sport utility	3	8
small sedan	0	12
compact sedan	7	17
midsize sedan	28	20
minivan	11	12
full sized sedan	6	not offered
full-sized sport utility	10	not offered
full-sized pick-up	6	not offered
full-sized van	2	not offered

Respondents were asked to state their first and a second reason for why they choose an electric or a gasoline vehicle. The most important first reason of electric vehicle choosers (38%), was the ***environmental benefits. Most economical*** was next at (24%). For the second reason of electric vehicle choosers, ***flexibility of recharging*** and ***EVs are the car of the future*** tied (18%), followed by ***environmental benefits*** (15%). Among gasoline vehicle choosers, desire for ***longer range*** was the most important first reason (45%). Among those loyal to gasoline, range was so important that it, and ***ease of refueling*** (26%) tied as the second most important reason.

Vehicle Choice In Situation Two

Situation two included six possible vehicle types. The choices made by households are in Table 2.

Table 2:
Choice of Vehicle in Situation Two.

reformed gasoline	compressed natural gas	hybrid electric	community electric	regional electric	neighborhood electric
28%	22%	12%	10%	24%	5%

Neighborhood Electric Choosers. Neighborhood electrics were described as a non-freeway vehicle with top speed of 40 miles and a range of 40 miles offered in three models -- 2, 3 and 4 seaters. The prices of NEVs were substantially lower, ranging from $5,500 to $10,000 depending on size and options. Buyers were given a $2000 ZEV credit.

A total of 8 households selected NEVs. This was unexpectedly large, but we had very little in the way of previous studies to gauge response to these types of vehicles. The number of NEV choosers could have been higher according to comments in the study by participants. Some respondents complained about the boxy styling of the only NEV presented in our information video. Four households selected a 2 seater, one household a 3 seater and 3 households a 4 seater. Half the NEV choosers had previously chosen a gasoline vehicle in Situation One.

Community Electric Choosers. The community electric was presented as a moderate priced electric vehicle, with a 60 mile range as "standard equipment" and 80 mile driving range as an $800 option. Fast charging was not offered in community electrics.

A total of 17 households chose community electrics. 64 % chose the 80 mile battery while 35% chose the 60 mile battery.

Regional Electric Choosers. The regional electric vehicle was presented as a longer ranged (120 or 140 mile battery packs), higher performance, and with a longer lasting battery (50,000 miles). Additionally, fast charging was offered at $900. A total of 41 households chose regional electric vehicles. 49% chose the longer ranged battery. 56% purchased the fast charging option.

A large contingent, 17 households, chose mid-sized sedans as regional electrics. This sized vehicle (a Ford Taurus for example) stretches the potential capabilities of battery powered electrics in terms of range and size of the vehicle. The regional electrics drew off the second largest group of defectors from gasoline choosers in Situation One -- eleven households.

Compressed Natural Gas Vehicle Choosers. CNG vehicles were offered in the complete range of vehicle body styles, and with the option of a 80 or 120 miles. A home refueling appliance was offered separately under lease or sale from the gas utility. CNG choosers were offered a $1000 tax credit for a ULEV emissions standard.

Compressed gas vehicles drew off the largest set of defectors from gasoline vehicle choosers in Situation One -- 26 households. This was expected based on previous research done by ITS.

Hybrid Electric Choosers. Hybrids were also offered with two battery packs, 40 or 80 mile options, and an additional 100 miles from a 40 hp reformulated gasoline engine, for total combined ranges of either 140 or 180 miles. Hybrid choosers were offered a $1000 ULEV tax credit.

A total of 20 households chose hybrids. 65% purchased the longer range battery option.

Reformulated Gasoline. Reformulated gasoline vehicles were described as identical to today's gasoline vehicles in every way except that their emissions were improved to meet LEV standards. LEVs were not offered a tax credit. A total of 50 households chose reformulated gasoline vehicles. 18 of those choices were of vehicle body styles not available in electric or hybrids.

Transitions in Choices Between Situations One and Two

Households frequently chose entirely different kinds of vehicles in Situation Two than they had chosen in Situation One. These transitions are tabulated in Table 3. The cells marked with an * show the number of households which defected from their original fuel type choice in Situation One. When offered an expanded array of alternative fuel and electric vehicle options, 50 of 90 (56%) households defected from gasoline. Half of these defected to a variety of electric vehicles and half defected to natural gas vehicles. While we have not finished a complete analysis, we hypothesize that the defectors to natural gas very much wanted a cleaner car, but were unwilling to give up a full-size vehicle in Situation One -- that is, they would have chosen an EV in Situation One if EVs had been offered in full-size body styles. This hypothesis is based on the fact that driving range and the ability to refuel at home are common to NGVs and EVs, only body style is markedly different.

Twenty-four households defected from EVs in Situation Two -- half to NGVs and half to reformulated gasoline.

Table 3:
Choice Transitions from Situation One to Situation Two

	CHOICE 1		
CHOICE 2	Gasoline	Electric	Total
Reform. Gasoline	38	**12***	50
Natural Gas	**26***	**12***	38
Hybrid EV	**8***	12	20
Community EV	**3***	14	17
Regional EV	**11***	30	41
Neighborhood EV	**4***	4	8
Total	90	84	174

Environmental Attitudes. In Part One, prior to the travel diary, informational video or vehicle choice situations, we asked participants some brief questions about their environmental attitudes, and opinions about electric vehicles. We first asked about the importance of environmental problems relative to other social/political problems. Responses showed:

- 13 percent agreed with the statement that the environment was "the biggest crisis and challenge of our times. The solutions require immediate international effort and major changes in our economies and lifestyles";
- 56 percent agreed with the statement that the environment was "among our biggest problems. The solutions require cooperation of government and citizens. Time to reconsider our lifestyles and make changes";
- 30 percent agreed with the statement that "environmental problems exist and need some attention, but are minor compared to other problems in our world".

When offered a list of environmental problems and asked which problem was the worst; respondents showed a concern for global and local problems. ***Rain forest destruction, household waste,*** and ***zone depletion*** were all ranked as the worst environmental problem by a nearly equal number of households, followed by two. environmental concerns linked to automobiles ***(automobiles, oil spills)*** .

Table 4:
Choice of worst environmental problem from a selected list.

rain forest destruction	22 %	pesticides	6%
household waste	20%	greenhouse effect	4%
ozone depletion	18%	farmland erosion	2%
automobiles	15%	utility power plants	1%
oil spills	9%	other	6%

Initial Likeliness to Buy an EV

Also in Part One, prior to presenting any information on electric vehicles, we asked respondents how likely they were to purchase an electric vehicle given what they currently know. The answers in Table 5 indicate that our sample was not so pre-disposed toward buying EVs that this alone would explain the high percentage of EV choices in Situations One and Two.

Table 5
Likeliness to Buy and EV prior to Travel Diary and Informational Video

very unlikely	18%
unlikely	23%
not sure	37%
likely	12%
very likely	10%

Electric Vehicle Choices by Driving Range

The distribution of EV choice by range in Situation One and Two are shown in Table 6 and 7, respectively. The EV market clearly grows larger as the range capability of the vehicles increases. But a high enough percentage of respondents chose EVs of even short range to satisfy the ZEV mandates for 1998. The percent of Community EV choosers alone translates into a 2 - 3% market share of new car sales in California (using 1991 new car sales figures). If Neighborhood Electric Vehicles are counted too, then the prospects for meeting the 1998 mandates appear favorable.

Table 6:
Situation One: Vehicle Choice By Range For Electric Vehicles

Vehicle Type	Range, miles	Number of Households choosing that Range
EV with Type I batteries -- compact pickups, small sport utility vehicles, mid-size sedans and minivans	80	15
EV with Type I batteries -- 2 seat sports car, small and compact sedans	100	16
EV with Type II batteries -- compact pickups, small sport utility vehicles, mid-size sedans and minivans	100	28
EV with Type II batteries -- 2 seat sports car, small and compact sedans	120	19

Table 7:
Situation Two: Vehicle Choice By Range For All Electric Vehicles

Vehicle Type	Range, miles	Number of Households choosing Range and Type
Neighborhood EV	40	8
Community EV with Type I batteries -- all body styles	60	6
Community EV with Type II batteries -- all body styles	80	11
Regional EV with Type I batteries -- compact pickups, small sport utilities, mid-size sedans and minivans	120	13
Regional EV with Type I batteries -- 2 seat sports car, small and compact sedans	130	7
Regional EV with Type II batteries -- compact pickups, small sport utility vehicles, mid-size sedans and minivans	140	15
Hybrid EV with Type I batteries -- all body styles	140	3
Regional EV with Type II batteries -- 2 seat sports car, small and compact sedans	150	5
Hybrid EV -- with Type II batteries -- all body styles	180	17

Conclusions

These findings are preliminary, but they confirm findings in our previous work. Education of participants about electric vehicles and extended reflection on household driving patterns are necessary ingredients of EV market studies and market development. These findings indicate a larger EV market than many previous surveys. In Choice Situation One, which is designed to test attitudes about electrics, the results to date show half our sample choose EVs with driving ranges of 100 or 120 miles. In Situation Two, which is designed to simulate one probable scenario of the California auto market between 1998 and 2003, the market shares of electrics are quite large, easily satisfying the 2% mandated shares required in 1998.

One potential criticism of this study may be that we have priced EVs too low. Price is a central issue in the ZEV debate, but a variable which is highly uncertain and relatively politicized. Some auto companies claim that electric vehicles will cost much more than the $4,000 price differentials we offered respondents for EVs. While we go to much trouble to educate our participants about the technical features of EVs, it is unrealistic to attempt to calculate price elasticity at this time. It is an explicit and intentional part of our research design to eliminate the importance of prices in household choices. The study is designed primarily to test household response to limited range and household recharging.

The technical features and performance levels we offer in EVs are in many cases modest, and well within the technical feasibility of existing EV technology. For example, Community Electric Vehicles are modest vehicles in terms of range and performance; examples of such vehicles are already on the road. Yet the market share indicated for this vehicle type alone is 2-3 % of annual California sales, thus satisfying the early mandates. This figure does not include fleet sales which are expected to fill most of the mandate or any other market segments such as NEVs, Regional Electrics, or penetration into other market niches not surveyed in this study.

References

1. Turrentine T. S., D. Sperling and K. Kurani (1992). "Market potential of electric and natural gas vehicles." Research Report, Institute of Transportation Studies, University of California, Davis. UCD-ITS-RR-92-8.

2. Kurani, K.S, T. Turrentine and D. Sperling (1994). "Demand for Electric Vehicles: Exploring the Hybrid Household Concept." forthcoming in Transport Policy.

3. A copy of the survey instrument can be obtained by contacting Tom Turrentine at the address on the title page.