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Market Potential of Electric and Natural-Gas Vehicles

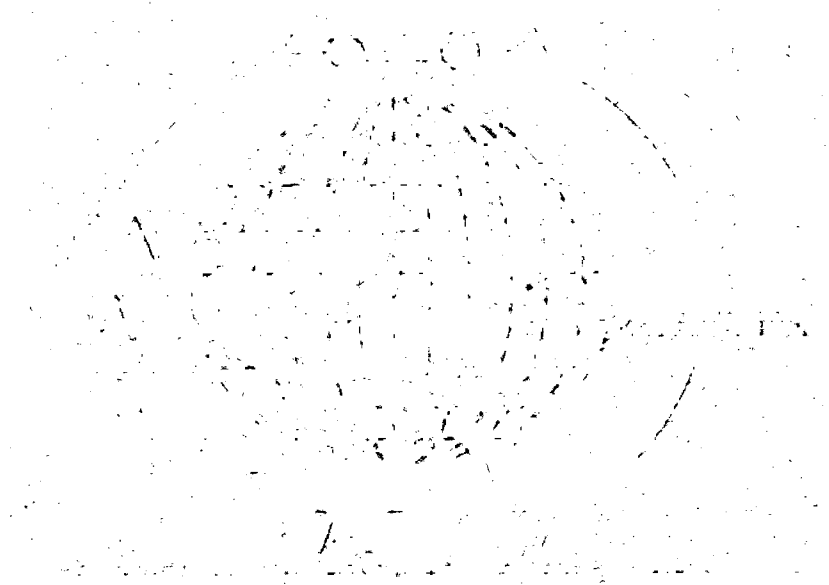**Permalink**

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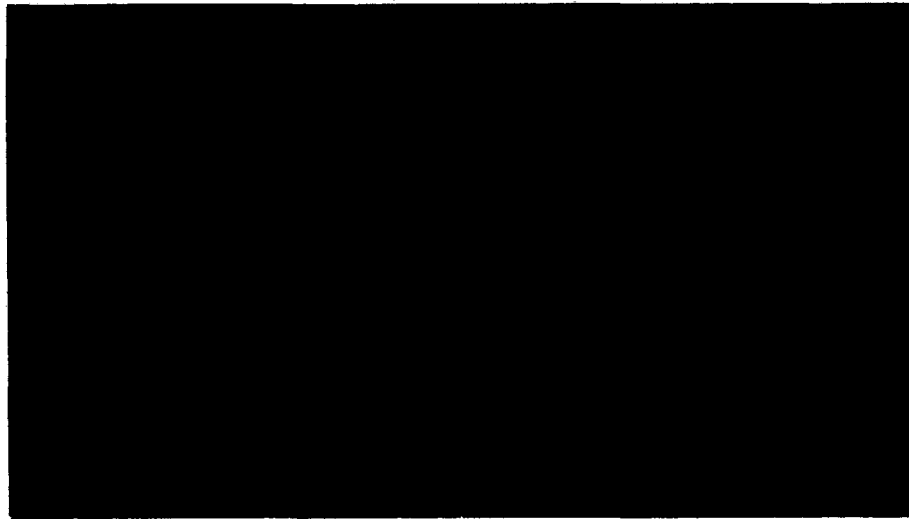
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DISCLAIMER

MARKET POTENTIAL OF ELECTRIC
AND NATURAL GAS VEHICLES

Final Report for Year One

Thomas Turrentine

Daniel Sperling

Kenneth Kurani

Acknowledgements

We would like to thank the many people and organizations who provided assistance, particularly for the test drive clinic at the Rose Bowl. The City of Pasadena generously donated the use of the Rose Bowl parking lots for five day of the test drive and the use of barriers and cones for the test drive. Don Drachand and Juan Osborn of the California Air Resources Board worked with us in locating appropriate electric vehicles for the clinic and paid for their shipment to the Rose Bowl site from the eastern U.S. We would like to thank James Worden of Solectria and Doug Covv and Rovert Adams of Solar Car Corporation for their participation, and Jeff Horn of the Southern California Gas Company which provided the CNG Buick LeSabre. We also thank Jon Leonard and Cindy Sullivan at the South Coast Air Quality Management District which provided three vehicles for the clinic. Thanks also to Don Siglar of the Los Angeles Department of Water and Power which supplied a hybrid-electric vehicle for demonstration.

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1.0 Executive Summary

Alternative Fueled Vehicles (AFVs) are being promoted and legislated into the market place in California for the purpose of reducing urban air pollution. While legislation requires producers to supply these vehicles, it is not yet certain how consumers will respond.

Market research for AFVs has gone through two phases; this project constitutes the beginning of a third phase. The first phase of AFV market studies, conducted in the 1970s, consisted of enthusiastic predictions of widespread AFV penetration in response to soaring fuel costs and fuel shortages. The predictions were based on optimism about technological developments and had minimal data on consumer responses.

With the drop of gasoline prices in the 1980s, optimism faded and AFVs market research entered a second phase, focusing upon the effects of the limitations of EVs and other alternatives on consumer choices. Compared to earlier studies, these studies have predicted relatively low penetration of AFVs and, where focus groups or stated preference studies were used, consumers did not seem enthused.

These second phase studies provided market estimations for AFVs which appear technically sophisticated but in reality have little empirical validity, are theoretically misinformed and lack any normative vision of how we might improve the situation. They use data from gasoline vehicle purchases or from opinions of consumers with no experience with AFVs. For analysis these studies used models which contain inappropriate assumptions about consumer decision processes and failed to consider the dynamic influence of information on consumer decisions in a new market. In general, second phase studies did not model the interactive competition of different AFVs, the role of a growing "green" market, and did not deal adequately with the influence of radical attribute changes, such as the effect of reduced driving range of electric vehicles (EVs) on consumer behavior or the convenience of home refueling and recharging.

ITS-Davis Project

This project by the Institute of Transportation Studies at UC Davis (ITS-Davis) is the benchmark for the third phase of research in AFVs in which analysis is based upon more substantive data, such as test drives of AFV products, more robust models of consumer decision making, and studies of experienced users of CNG and electric vehicles in New Zealand, Canada, the U.S. and Germany (we are collaborating with German researchers on a large field test in Baden Wuerttemberg, Germany in which private citizens in 13 cities will be testing EVs for a two year period). This long term, multi-faceted approach is designed to produce detailed information about potential market segments, and the best strategies to advance the AFVs market in California.

This ITS-Davis project comprises three stages of activities. This report is an interim report (work in progress) of the first year of activities. In this first year we have simulated market contexts to observe consumer decision making and to evaluate primary constraints on consumer choices. The second and third years of activities are survey projects which rely upon the first year for insight; a credible survey instrument will be developed in year two and implemented in year 3 for testing our hypotheses across the

entire California population. We will identify policy instruments that would be most effective at increasing sales of vehicles and fuels, and will estimate AFV market penetration under different conditions and in response to various policy initiatives. We are focusing on electric and natural gas vehicles (including hybrid configurations), but are including methanol as well.

This three-year project includes ten linked research activities: 1) development of a theoretical framework of consumer choice behavior; 2) test drive and interviews at the Rose Bowl in June 1991 and 11 follow-up focus groups in the following week; 4) constraints analysis of potential EV owners; 5) survey of refueling and other behavior of current EV owners in California; 6) survey of owners of CNG home refueling units in Ontario, Canada; 7) surveys and interviews in New Zealand to learn from that country's 1980s experiment with CNG; 8) use of gaming techniques (PIREG) in interviews of households to determine their decision processes for purchasing and using limited range vehicles; 9) mail surveys to extrapolate findings from previous activities to the entire California population; and 10) permanent panel studies of households to study behavior and attitude changes over time.

The information and data collection components of the first four activities have been completed and preliminary results of those efforts are presented in this summary and attached reports. Activities 5-8 have been initiated and will be completed in mid 1992. The mail surveys and panel studies are proposed for year 3 of this project. [Activities 4-7 are funded from non-CIEE sources but are included as part of this overall project on EV and CNG market potential.]

Theoretical Framework

We first developed a theoretical framework for study of the AFVs market. This framework analyzes the AFVs market as two sets of diffusion processes, one process in which innovators influence the "utility" preferences of other buyers and a second process in which moral choosers influence the other buyers to choose lesser polluting vehicles. To study consumer decisions, we divide vehicle attributes into three categories of consumer evaluations: search attributes which can be readily evaluated by inspecting and driving a vehicle; experience attributes which cannot be evaluated fully prior to purchase and therefore require distinct evaluation strategies; and finally social choice attributes which require moral commitment or cooperative political decision making.

Current EV Market Studies by Others

Many confidential studies are now being conducted by market research companies for auto, oil, and utility companies. These studies use conventional focus group and stated-preference survey techniques; they generally predict very low EV market penetrations. One of the few companies to make their findings public, Ford Motor Company, forecasts that EV market penetration will be 1% (they defined an EV in their surveys as having an advantage of being 100% emission free, but having disadvantages of a top speed of 75 mph, 50% less space, reduced range, and costing $3000 extra).

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Constraints Analysis

To test the results of these market research companies and to provide a focus for our Rose Bowl test-drive clinic, we used a very different approach to identify the early market for EVs. We screened the population using data from national government surveys to identify those that meet minimum infrastructure, vehicle ownership and travel needs criteria for purchasing vehicles during the early years of an EV market. The full report on this activity, "Home recharging and household electric vehicle market: a near term constraints analysis" is available from ITS-Davis. This constraints analysis was conducted using national data; it will be applied to California and specific regions if interest and funding exist. This analysis is important because it defines the initial target population; econometric, survey research and focus group studies that fail to target this population will distort estimates of likely initial market penetration and consumer responses to incentives and other initiatives. This analysis is relevant only to the early market.

The specific criteria used in that analysis to define the initial target market are the following:

1) own their own dwelling, since neither renters or landlords are likely to invest in the needed recharging facilities;
2) garage or carport for secure overnight charging;
3) two or more vehicles per household;
4) at least one person in the household drives less than 70 miles round-trip to work.

Nationally, 28% of the households meet these four criteria. We tested the sensitivity of the results to changes in the criteria. If this estimate is adjusted to take into account income constraints (greater than $50,000 per year income for new car buyers) and sales of only one EV per household, the 28% estimate shrinks to a maximum (initial) market estimate of 13%. If user preferences such as willingness to accept less driving range, higher cost, less power, and less luggage space are applied to the 13% penetration, then the likely market penetration drops to a very low level, approaching Ford's 1%. Thus, it is plausible that market penetration of 1% or so is likely if one were to market electric vehicles now under present conditions.

But these low estimates are relevant only for the first few years of EV sales, assuming little or no change in technology, public attitudes, and institutional support. Initially people will be reluctant to consider a vehicle that not only has attributes that are inferior to those of their current gasoline car, but costs more as well. Indeed, most people still think of an EV as being a glorified golf cart. For instance, at the Rose Bowl test-drive clinic, we found that the great majority of drivers were surprised by the high quality and performance of the EV they drove (a converted Geo Metro and Ford Fiesta); 61% said their opinion of EVs increased after the test drive, versus only 16% who said their opinion worsened.

The 1%-level estimates are likely to become quickly obsolete for another reason: electric vehicles have strong positive features that are generally ignored by conventional focus groups and surveys and perhaps by initial consumers. These positive attributes -- less maintenance, ability to recharge at home without going to a fuel station, much longer engine life, and less engine noise, and less pollution -- are ignored or slighted because at this time neither consumers nor researchers are able to determine their importance in vehicle purchase and use decisions.

Over time, four phenomena are likely to emerge that will increase the attractiveness and market penetration of EVs and other AFVs: 1) consumers will learn more about the vehicles from the media and, more importantly, from friends, relatives and professional acquaintances; 2) EV technology will improve and costs will drop; 3) vehicle users will become sensitized to the fact that they rarely drive more than 60 miles in any one day, well within the range of future EVs; and 4) many users will discard the notion that every vehicle needs to be able to serve every driving purpose, and may accept the new practice of renting long-range vehicles for longer trips.

If we begin to think of AFVs as familiar and acceptable vehicle options that are endorsed and rewarded by government as the socially approved option, then their acceptability greatly expands.

Rose Bowl Test Drive

The major activity in this project during year 1 was the Rose Bowl test drive. It represents an initial effort to extend market research sophistication beyond stated preference surveys and focus groups of uninformed users of gasoline vehicles.

This was the first public test-drive of AFVs. A total of 236 likely early buyers (selected in accordance with our constraints analysis with household income over $50,000) drove three types of AFVs: an electric vehicle (EV), a methanol vehicle and a compressed natural gas (CNG) vehicle. Each participant completed a three part questionnaire to test their responses. In addition, eleven focus group discussions were conducted after the test drive to aid in the interpretation of the test drive results.

The following text is an interpretation of the Rose Bowl responses. In addition, we have provided several appendices which include a description of the cars used in the test, a description of the participants, the questionnaire and selected frequencies and cross-tabulations which proved important in the analysis and interpretation.

Respondent's opinions of the AFVs used in the Pasadena drive-test improved after driving; respondent's valuation of the search attributes, those attributes that can be judged by driving and inspecting a vehicle, exceeded pre-test expectations for all three AFVs, indicating that surveys which don't use test drives may underestimate the market. Participants with (claimed) mechanical expertise demonstrated the most improved opinions. After the drive test, a significant percentage of participants decided that AFVs were practical to replace gasoline vehicles.

After the test drive participants were asked which of the three AFVs -- methanol, CNG and EV -- they would be willing to purchase, if the vehicles were available in the body type and style they desired. They were offered a first and second choice, and responded as follows:

	1st Choice	2nd Choice
CNG	23%	43%
Methanol	40%	30%
EV	37%	27%

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Those who selected the EV were more likely to be small-car owners, have higher numbers of cars in their household, see their choice as a moral issue, and view fuel and maintenance savings as more important than the range issue. In focus groups and initial PIREG interviews (research activity #7), we found that households with predictable driving patterns view home recharging as positive rather than negative. Participants aged 45-54 years, in part because of their more routine travel patterns, appear to be the most likely initial group to purchase EVs. We also found in informal interviews that commitment to one's community will positively influence EV purchase.

Those who chose methanol were overwhelmingly large car owners and over 55 years old, with fewer cars in the household. They viewed their choice as an economic decision, not an environmental choice. They were attracted to the flexible fuel aspect of the methanol fueled cars. These drivers had strong negative opinions of EVs, and viewed limited range, lower freeway speeds and battery replacement costs as untenable.

CNG vehicles were the least well known of the options prior to the test drive, and even after the test drive, participants were unsure of CNG features. We could not find any significant attributes of CNG choosers, and their responses in the survey were not always consistent with their vehicle choices. CNG was an overwhelming second choice, a compromise between the EV and methanol vehicle.

<u>Hypotheses and Questions for Years 2 and 3</u>

The impact of limited range and recharging time on car purchases is a difficult research problem. We have designed and tested an innovative interview technique we call PIREG (Purchase Intentions and Range Estimation Game) for exploring a household's decision processes for purchasing and using limited range vehicles. We will carry out those interviews during year 2.

During the initial stages of market penetration, the willingness of consumers to experiment depends upon the strength and stability of signals consumers receive about the commitment of industry and government to EVs and other AFVs. Our market survey in 1992-93, along with the PIREG study, will offer further insight into the likely response of different population groups to electric and other alternative fuel vehicles.

The market for CNG is currently conditioned by uncertainty about supply and refueling procedures. Our initial findings, combined with previous research by ourselves and others, suggest that CNG could capture a portion of the full and midsize market if a green consumer market develops for vehicles (which, of course, depends in large part upon government and industry initiatives and support). Since EVs are aimed at the small car market, EV and CNG sales may be largely complementary. Beliefs among consumers about the positive effect of CNG on engine life may create a loyal market for CNG.

Our initial findings suggest that sales of methanol vehicles and fuels will hinge upon convincing evidence that engines can withstand the corrosive effects of methanol fuel and that vehicle and fuel prices will be less than those of gasoline (after subsidies and incentives are factored in).

2.0 Background

2.1 Problem

Alternative fueled vehicles are being promoted in California, especially Southern California, as a solution to air quality problems. The Federal Government has recently signed the Clean Air Act which encourages the development of AFVs, including the sale of AFVs in California, but California has moved more decisively, mandating the sales of zero emissions vehicles (ZEVs) and adopting much more stringent vehicle emission standards. While rules require producers to supply alternative fuel vehicles, it is not yet certain how consumers will respond.

2.2 Previous Research on Consumer Demand for AFVs

There have been numerous studies of the potential demand for electric vehicles in the U.S., and a few studies of the demand for other fuels and fuel systems. The 1976 Electric and Hybrid Vehicle Research, Development and Demonstration Act spawned a number of studies. The first studies were wishful thinking about the future of electric vehicles while the second wave of studies used econometric and conjoint techniques to predict potential markets for EVs. Multi-attribute econometric and conjoint modeling are statistical techniques for estimating the potential market of products. Each assumes that consumers make choices by comparing the component attributes of each competing product in a choice set. Utility values can be assigned to various attributes of products by decomposing the purchase price of product choices. A researcher can then recombine attributes to form new product choices and estimate their market potential in the same choice set.

The challenge faced by econometricians and conjoint researchers was that the value of some attributes of EVs, such as limited range, long recharge time, and home recharging could not be estimated from data on gasoline vehicle purchases. Beginning with the nearly universal assumption that any household likely to purchase an EV with limited range would have to also have a gasoline vehicle, several solutions were offered.

Train (1) used gasoline purchase data and assigned attribute values which approximated those of EVs, hybrid EVs and hydrogen vehicles. He estimated the disutility of limited range by including the cost of renting a vehicle for trips exceeding the range of an electric. Other variables were considered for their relevance to EVs such as vehicle weight (because of heavy batteries), operating costs per mile, initial auto cost, and number of seats (most EV projects were for two seaters at that time). After establishing values for these attributes from current auto markets, Train estimated the likely market penetration for several types of EVs in different years: a Ni-Zn battery vehicle with 50 mile range in 1980, a hybrid with unlimited range in 1985, a high temperature battery in 1990 with 100 and 150 mile ranges, an aluminum-air battery in 2000 with unlimited range, and a hydrogen vehicle in 2000 with unlimited range.

Train projected very modest market penetration for EVs: 3.11% in the optimistic case and 2.25% in the pessimistic case by the year 2000 for all limited range vehicles. For unlimited range EVs the estimates were better: 6.3% for hybrids, 5.9% for aluminum-air and 0.62% for hydrogen. Train cites two other studies using similar approaches, one by Stanford Research Institute (SRI) (2), of 2.4% (3.4 million out of 140 million total vehicles in US) and one by Mathtech (2) which projected higher market penetration estimates of between 7.8% and 8.8% of all passenger vehicles in 2000. As Train notes,

the problem in this approach is that weight is probably not an important attribute. Better methods were needed to estimate the value of range and other attributes.

In contrast to the former studies which use data from gasoline markets, several studies have used hypothetical choice data. In a 1978 study for DOE, Morton et al (4) conducted a panel study of 170 households in nine temperate climate cities (electric vehicles were considered unsuitable for cold climates). Participants were selected from multi-vehicle households having a small car. Focus groups were presented with hypothetical vehicle choices for subcompact electric and hybrid vehicles. Each choice was described based upon purchase price, yearly fuel cost, acceleration, size, top speed, degree of pollution (an attempt to determine value of clean fuels), range, noise and maintenance costs. In addition to some EV and hybrid packages, special warranties and tax credits were added. Participants ranked a set of 16 choices. The results were decomposed for attribute value and estimates for each average value calculated using conjoint analysis. In a parallel study, Beggs et al (5) recalculated the values based upon a logit model (using the first vehicle choice only).

The most conclusive results, states Beggs et al (5:2-15), was the conjoint estimation of disutility for range. The results suggested that the average participant attached a disutility of $4000 (at 1977 car prices) to a vehicle with a range of 50 miles compared to a vehicle of 200 miles range. One can only accept this figure, and the market projections it develops, if the context of decision produces valid responses. The context, however, was a focus group setting using a set of cards with short attribute lists -- not a credible setting for obtaining measurements of the complexities of buying a car. Markets for new products and environmental benefits add further complexity because emissions benefits, range and body style cannot be combined in a linear model. Electric vehicles, for example, will probably be a distinct market segment because of their minimal emissions and limited range.

There is evidence of a growing green market for clean vehicles and fuels. Garrison, Calfee and Bruck (6) develop a similar experiment to the DOE study in which a sample of 51 volunteer participants from a church in Berkeley selected a vehicle from a list of five attributes. The researchers reported an irrational bias for electric vehicles in the choices; members picked EVs because of the perceived environmental benefits even though EVs could not meet their stated needs for a vehicle. Garrison et al explain this bias as primarily fears of the disruption of gasoline supplies. He may have missed the real bias; the members of the study were part of a social body, a church in which the environmental benefits of an electric vehicle may have encouraged a tacit agreement towards the moral selection of an EV.

Kurani (7) notes that some individuals in New Zealand in the 1980s converted their vehicles to CNG use for patriotic reasons: to assist the state in achieving energy autonomy (1991). In surveys of California and New York drivers, Sperling et al (8) found that consumers stated they were willing to pay a premium for a clean fuel.

There have been several recent focus group studies of demand for AFVs (8,9), such as the recent focus groups by Ford Motor Company, but without the benefits of product testing, they offer little added information on responses to attributes. In addition, there have recent stated preference surveys by Ford and others (10) to estimate market size and shares for AFVs. These also depend upon uninformed consumers. The participants are often consumers whose only knowledge of the products is what they are being told by the focus group moderator.

While the statistical techniques in previous studies have often been quite sophisticated, what is missing (except for revealed behavior in other countries), is more realistic product testing experiments, adequate theory to inform study design, and a deeper understanding of the potential historical processes affecting consumer tastes.

3.0 Objectives

Our objective is to improve the understanding of how consumers will respond in a cultural and historical context to the introduction of AFVs and to the technical attributes of AFVs, and thus to develop a credible survey instrument which can measure the current market for AFVs and suggest policy strategies to advance the market for AFVs.

4.0 Approach

4.1 Year One

To achieve those objectives, we designed a set of research activities to give us a complete look at the potential of AFVs. Year 1 research activities simulate market contexts to observe consumer decision making, and evaluate primary constraints on consumer choices. Year 2 and 3 projects are surveys which rely upon the first year for insight; we will develop and implement a credible survey instrument for testing our hypotheses across the entire California population. We will identify policy instruments that would be most effective at increasing sales of vehicles and fuels, and will estimate their market penetration under different conditions and in response to various policy initiatives. We are focusing on electric and natural gas vehicles (including hybrid configurations), but are including methanol as well.

This project includes ten linked research activities: 1) development of a theoretical framework of consumer choice behavior; 2) test drive and interviews at the Rose Bowl in June 1991: post test-drive focus groups in June 1991; 4) constraints analysis of potential EV owners; 5) survey of refueling and other behavior of current EV owners in California; 6) survey of owners of CNG home refueling units in Ontario, Canada; 7) surveys and interviews in New Zealand to learn from that country's 1980s experiment with CNG; 8) use of gaming techniques (PIREG) in interviews of households to determine their decision processes for purchasing and using limited range vehicles; 9) mail surveys to extrapolate findings from previous activities to the entire California population; and 10) permanent panel studies in which individual and households will be monitored and periodically interviewed over time.

The information and data collection components of the first four activities have been completed and preliminary results of those efforts are presented in this summary and attached reports. Activities 5-8 have been initiated and will be completed in mid 1992. The mail surveys and panel studies are proposed for years 2 and 3 of this project. Activities 4-7 (constraints analysis, surveys of current EV owners and current CNG home refuelers, and studies of New Zealand CNG users) are funded from non-CIEE sources but are treated as part of this overall project.

4.1-1 Theoretical Framework for the AFVs Market

A comprehensive theory of the AFVs market was developed in a paper entitled "Theories of New Product and Social Choice Processes: the Case of Alternative Fuels" (11). We surveyed consumer theory from economics, marketing, psychology and sociology to synthesize an approach which consider the following aspects of the AFVs market.

- -New product choice and learning processes
- -Greater product diversity and consumer decision strategies
- -Social choice and the "the green car"

We developed a comprehensive conceptual framework for the AFVs market which accounts for each of these aspects. That framework conceives of the market as a development process which begins among new product innovators and moral choosers. The market moves towards a mature market situation in which the utility of new attributes and the political momentum of particular AFVs are accessible to a wider market of economically rational consumers.

Consumers must consider three types of attributes when confronted with a choice of alternative fueled vehicles. Search attributes are characteristics of AFVs which can be evaluated prior to purchase; for example engine noise and vehicle size. Experience attributes are characteristics of AFVs which can be evaluated only after purchase, for example the constraint of reduced range and maintenance costs. The uncertainty of these attributes forces most buyers to depend upon innovators for demonstrating the utility of such features. Social-choice attributes are characteristics of AFVs which can only be judged by evaluating the growth and development of a market; for example whether the refueling structure for CNG will continue to grow or that EVs will indeed impact air quality. The uncertainty of social choice attributes forces most buyers to depend upon information and signals from motivated buyers, suppliers and government to determine which AFVs (if any) are preferable.

The market is segmented over time according to the ability and motivation of innovators and moral choosers. As the uncertainty in the market diminishes and the utility of products is established, other segments of buyers are drawn into comparative shopping among AFV products. This process can be represented by the ven diagram on the following page.

Implementing this research plan requires an examination of the abilities and resources of consumers to experiment and make a moral choice to purchase an AFV. Such an examination would require research under quasi-experimental conditions in which consumers were responding to real stimuli rather than abstract conditions.

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figure 1

Development Of The Alternative Fueled Vehicles Market

Innovators

diffusion process

Household Utility Market

Green Market

social choice
process

1990   2000   2010
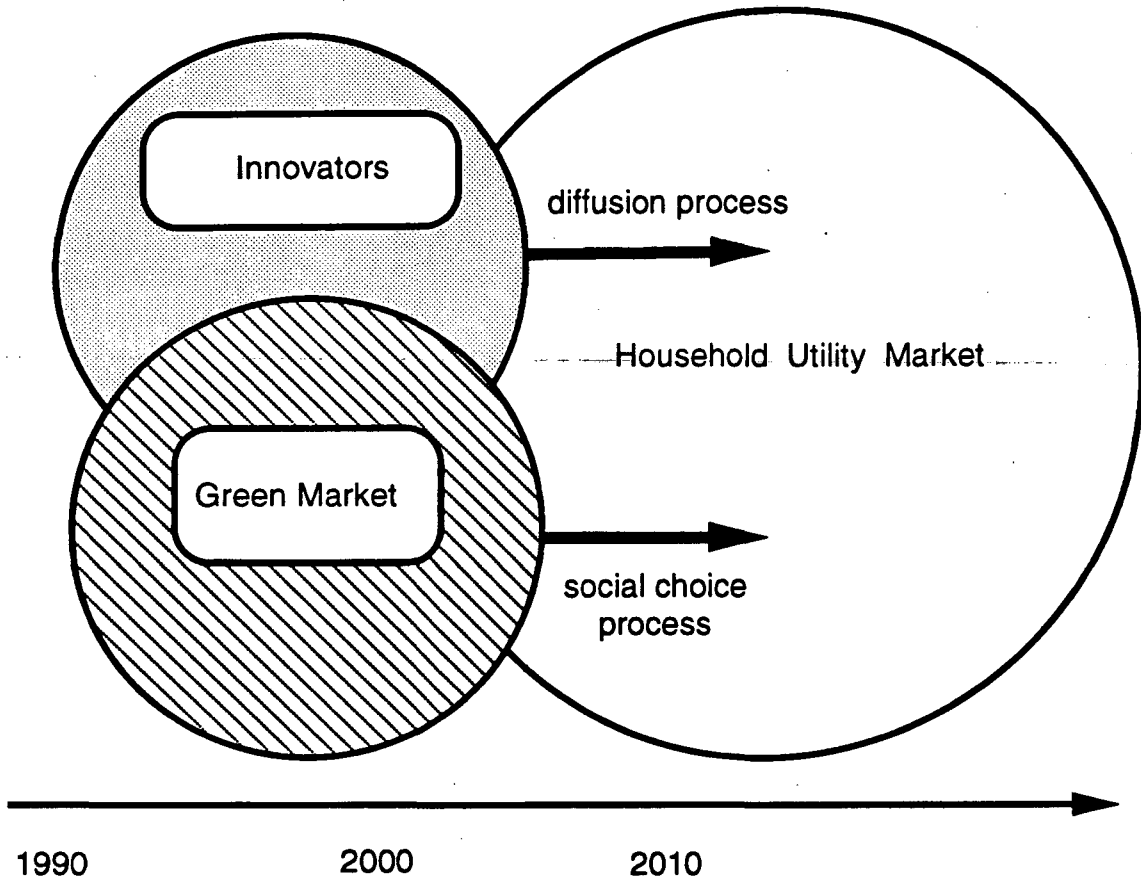
4.1-2 The Alternative Fueled Vehicle Test-Drive Clinic

Goals

The goal of the Rose Bowl test drive was to observe a set of car buyers from several hypothetical early market segments respond to actual drive tests. We wanted to compare their opinions of vehicles before and after the test: their response to <u>search attributes</u> of vehicles (such as acceleration, sound, size, starting, and visual inspection of engine. In addition, the test-drive stimulates consumer consideration of <u>experience attributes</u>, for example range limitations, fuel costs, maintenance and home recharging and <u>social choice attributes</u>, for example government and industry commitment.

Limitations of method

This test-drive was not intended as a survey instrument and does not measure the potential market. The recruitment and research logistics for such an experiment preclude scientific sampling. The test-drive is designed to assist in the development and interpretation of survey studies which will follow. Our assumptions about consumer decision processes for search, experience and social choice attributes must be validated before a credible survey tool is designed. However, the sample size of the test drive is sufficient for correlations in the study sample.

The participants

Two hundred thirty-six persons from the Pasadena area completed the auto test drive study. The sample was weighted towards consumers who we believe may be early buyers based upon our theory of the market. 193 persons were recruited from the Pasadena area by random dialing. The primary criteria for selection was that households earn $50,000 (a cutoff for new car sales suggested by the marketing research company which conducted the recruitment) and have at least two cars. We hypothesize at least initially that EVs and indeed other AFVs will work best in multi-car households. In addition, this sample was enriched by further screening to include short range commuters (less than 40 miles round trip), home owners and retired persons. These 193 random-dial participants were paid $50 to participate. An additional 43 volunteers participated, evenly split between auto mechanics from the Automotive Service Council Foothill Chapter and members of local environmental organizations. This enriched sample offered the best opportunity to observe the behavior and statements of consumers who were likely to purchase AFVs early in the market. See appendix A for further description of sample.

The Test Drive

Two hundred and thirty six citizens from the Pasadena area drove three types of AFVs at the Rose Bowl parking area during June 12-16, 1991. The City of Pasadena loaned the use of the Rose Bowl for the test period.

Six vehicles were loaned to the University of California at Davis for the test clinic. Southern California Gas Company loaned a dual-fueled compressed natural gas and gasoline Buick LeSabre. South Coast Air Quality Management District loaned a dual fueled Plymouth Reliant, and flexible fueled methanol Ford Taurus and Chevy Lumina. Two electric vehicles were made available by their manufacturers: a converted Geo

Metro by Solectria Force and a Ford Festiva converted by Solar Corporation Festiva. Both electric vehicles had solar panels. The cost of transporting and making the EVs available was borne by the California Air Resources Board. In addition, LADWP provided a hybrid electric mini-van for display. See appendix B for further description of the vehicles.

The vehicles used in the test drive do not represent all the potential of each vehicle's technology. Technology is rapidly changing; manufacturers are expecting to offer dedicated CNG vehicles soon and EVs are undergoing rapid development. However, the vehicles used in the test were selected as the best vehicles available for product testing. For the purposes of this test, they represent the general features of each technology type for the next few years.

Test drives are normally conducted with a closely matched set of body types and manufacturers, but to construct such an experiment would diminish the realism and narrow the observation of potential market segments for AFVs. Also, because the vehicles were on loan, we were unable to remove manufacturer markings, nor to repaint or modify them in other respects to remove visual influences. In addition, we were able to use only domestic chassis; no foreign made vehicles were used.

Although the vehicles represent a range of vehicle types and manufacturers, they approximate the early market for AFVs. Compressed gas is usually designed in mid to full size vehicles, methanol in mid and full size, electric in sub-compacts and vans.

The Questionnaire

A 15 page questionnaire was administered in three parts. The first part was self-administered questions completed at the test clinic just prior to the test drive. This part was designed to test prior awareness and preferences. The second part was open ended questions about attributes administered by an interviewer while the participant inspected and drove each type of vehicle. The order of driving was randomized.

Participants were questioned about the similarity of the vehicle to their own car, their response to the look of the engine and other distinct features of the technology, instrumentation, starting, acceleration, driving characteristics, weight, handling, and refueling.

The final part was administered after the test drive. It consisted of questions which compared the three types of vehicles and asked about refueling, costs, impact of incentives, and the role of uncertainty, emissions and other contextual variables on the decision to purchase an AFV. See appendix C for a copy of the questionnaire.

Test-Drive

Participants drove one each of the electric, CNG and methanol vehicles on a one mile test drive within the confines of the Rose Bowl parking area (we avoided public streets for insurance reasons). This limited participants from testing the vehicles on freeways and grades and limited speeds to 45 miles an hour. We were limited to this format by liability concerns.

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4.1-3 The Post-Drive Focus Groups

Goal

The goal of the focus groups was to explore in greater depth the response of participants to the test drive, AFVs and the political context of AFVs. The focus groups provide richer detail and a wider variety of responses than the structured questionnaires and allowed exploration of topics such as range which were difficult to incorporate into the questionnaire. Most importantly, the focus groups are a social setting, thereby allowing the exploration of the social-political dimensions of the AFVs market.

The participants

Seventy-five participants from the Rose Bowl test drive participated in eleven focus group discussions the week following the Rose Bowl test drive. Participants were recruited (with no compensation) from the 236 test drivers at the Rose Bowl. The degree of volunteerism was surprising -- more than half the participants volunteered, although many did not arrive at the scheduled focus group discussions. Two of the 11 groups were designed as specialized groups: one group was exclusively "clean air enthusiasts" and one was auto mechanics.

The discussion format

Participants were asked to recount their experience with each vehicle at the clinic. They were asked a series of questions about range of EVs in which they stated their range needs. They were then asked to simulate trading miles of range for dollars, fuel savings, or other benefits such as tax credits. Finally, consumers were asked to discuss the "green" market issue and their willingness to purchase partially on the basis of air quality and fuel dependence issues. The focus groups were conducted by Tom Turrentine and Kenneth Kurani.

4.1-4 EV ownership constraints analysis

An initial draft report for this sub-study, "Home Recharging and the Household Electric Vehicle Market: A Constraints Analysis," by Kevin Nesbitt, Kenneth Kurani and Mark DeLuchi, has been completed and is available from ITS-Davis.

In this analysis, we screened the population using data from national government surveys to identify those that meet minimum infrastructure, vehicle ownership and travel needs criteria for purchasing vehicles during the early years of an EV market. We tested the sensitivity of the results to changes in the criteria. This analysis is important because it defines the initial target population; econometric, survey research and focus group studies that fail to target this population will distort estimates of likely initial market penetration and response to incentives and other initiatives. This analysis is relevant only to the early market.

The results reported here are for the U.S. In year 2, the analysis will be conducted for California and perhaps selected regions if funding and interest exists.

4.2 Years Two and Three

4.2-1 Purchase Intentions and Range Estimation Game (PIREG)

AFVs have several "experience attributes". Most notable are the limited range of EVs, and to some extent CNG, the home recharging capabilities of EVs, the home refueling capabilities of CNG, and the fuel costs and maintenance characteristics of each. Especially during the early phases of the market, consumers will not have sufficient experience with these attributes to estimate their utility. We needed a research method to probe the underlying decision processes through which consumers will estimate their range needs and estimate the number of miles such a household is likely to substitute if they purchase an EV, and whether such a household will replace an ICEV with an EV or add an EV to the household fleet.

Working with Martin Lee-Gosselin of Laval University in Quebec Canada, we have adapted CUPIG gaming techniques to understand how consumers might estimate their range needs when considering an EV purchase and to estimate how many miles of gasoline vehicle use such a household is likely to substitute with EV miles.

Households keep detailed diaries of driving for one week. This diary is transcribed to a large graphics board which represents all driving the household did for a week. Households are then interviewed with the graphics board used as a stimulus for probes about EV purchases and possible uses. The real events of the diary board forces participants to consider their decisions carefully against the details of the previous weeks driving, thereby exposing underlying decision processes, and drawing family members into discussions of utility considerations.

The design portion of this phase has been completed. A pilot sample of three households was interviewed and a gaming technique developed which draws out the decision making of households. Households first select an EV then are asked to maximize the use of that EV under varying economic and social conditions. In subsequent rounds, the household is forced to ration their use of gasoline so that they must convert trips to EV use. The test is particularly informative about the minimum safety buffer of EV charge for each household member, the relation of a household's activity sphere to minimum residual charge, and response to EV utility in emergency considerations.

In year two, we will further refine the interview format and will conduct the household interviews. The interview format will be refined to focus upon the purchase decision, using households which have recently purchased a compact vehicle or mini-van. We will develop a graphics board with detailed information about how the household made a purchase decision and will then interview the household, conducting purchase games by adding appropriate EV and CNG vehicle packages to the choice set they had considered.

4.2-2 EV owner survey

A phone survey of 200 current EV owners in California to analyze drive patterns, recharging habits, and innovator characteristics was begun in year 1. The names and addresses were purchased from the California Department of Motor Vehicles. Almost half the interviews have been completed. No results are yet available.

4.2-3. CNG home refueling study

Another phone survey of 100 owners of CNG home refueling units in Ontario, Canada will be conducted in the first half of year 2. The objective of that sub-study is to use revealed behavior to improve our understanding of refueling habits, driving patterns, choice processes, and innovator characteristics.

4.2-4. New Zealand CNG Study

A researcher from ITS-Davis (Ken Kurani) went to New Zealand for 4 months. He worked with local representatives from industry and government to conduct a survey of CNG, LPG, and gasoline vehicle owners. He also collected the best available data on the CNG experience and interviewed many leaders in industry and government, as well as mechanics, automobile dealers, CNG station workers, and other informed individuals. This study provides many valuable insights into consumer behavior and the market penetration process of AFVs; it provides revealed preference data on CNG purchases, insights regarding refueling limitations, responsiveness of individuals to social messages and various incentives, and better insights into the information search process of individuals. Initial results will be available in early 1992.

4.2-5 Market Survey

In year two we will design a survey instrument and in year three we will use that questionnaire to conduct a survey with scientific sampling to estimate market shares for several AFV scenarios. The survey will incorporate the knowledge of consumer decision strategies gained in year one. Question formats will have been validated.

4.2-6 Panel Study

In year three we will initiate a panel study of several hundred Los Angeles citizens to track the development of the market. New funding will be used to establish this as a permanent ongoing panel study. The purpose of this panel study is to monitor and evaluate changes in behavior and attitudes over time. The value of this approach is that behavior and attitudes of specific individuals are being studied, thereby readily controlling for the many different variables that otherwise must be carefully measured and analyzed in static cross-sectional studies. Panel studies also provide a better understanding of life-cycle phenomena in explaining behavior and attitudes (something very critical to our study since purchase behavior apparently will be highly sensitive to family situations).

5.0 **Results**

5.1 Near-Term Constraints Analysis of EV Market

Nationally, 28% of the households meet the following four criteria:

1) own their own dwelling, since neither renters or landlords are likely to invest in the needed recharging facilities;
2) garage or carport for secure overnight charging;
3) two or more vehicles per household;
4) at least one person in the household drives less than 70 miles round-trip to work.

Predictions of EV penetration using conventional focus group and stated-preference survey techniques are around 1%. That is the widely disseminated result of a (unpublished) 1991 Ford Motor Company study which uses opinion surveys and focus groups. Ford defined an EV as having an advantage of being 100% emission free, but having disadvantages of a top speed of 75 mph, 50% less space, reduced range, and costing $3000 extra. Our constraints study, if adjusted for income and sales of only one EV per household, would produce a maximum (initial) market estimate of 13%. If user preferences such as willingness to accept less driving range, higher cost, less power, and less luggage space are applied to the 13% penetration, then the likely market penetration drops to a very low level, approaching Ford's 1%. Estimates of around 1% are probably reliable if one were to market electric vehicles now.

But these low estimates are relevant only for the first few years of EV sales, and only if government and industry play a passive role in marketing and supporting the vehicles. Nonetheless, this near-term market constraints analysis is useful because it defines the initial target population; econometric, survey research and focus group studies that fail to target this population will distort estimates of likely initial market penetration and response to incentives and other initiatives.

It must be understood, however, that during the initial stages of market penetration, the willingness of consumers to experiment depends upon the strength and stability of signals consumers receive about the commitment of industry and government to EVs and other AFVs. Our market survey in 1992-93, along with the PIREG study, will offer further insight into the likely response of different population groups to electric and other alternative fuel vehicles.

5.2 A. General Responses to the Test Drive

In the following section we discuss the response of participants in the Rose Bowl test. This discussion is primarily text, with some simple tables from the results of the questionnaire. More detail charts and graphs of selected frequencies and cross-tabulations are provided in Appendix D.

5.2-1 Pre-test drive awareness of AFVs.

In the portion of the questionnaire conducted prior to the test drive, we asked a number of questions about participants prior knowledge and opinions about AFVs. Ninety-eight percent of participants stated that they were aware of AFVs before coming to the drive test. We then asked which types of AFVs they knew about. The following is a list of vehicles in decreasing order of familiarity.

> 223 (96%) were aware of electric vehicles
> 194 (83%) were aware of methanol
> 168 (72%) were aware of propane
> 127 (54%) were aware of CNG
> 115 (49%) were aware of ethanol
> 60 (25%) were aware of hydrogen
> 59 (25%) were aware of hybrid electrics

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The responses indicate a relatively high level of prior awareness, especially with respect to hydrogen and hybrid electric vehicles, which have received the least media attention. In focus groups, we learned that several persons had heard of hydrogen vehicles through contact with employees and research articles from the Jet Propulsion Laboratories in Pasadena. In addition, the sample contained auto mechanics and environmentalists, who have a higher degree of awareness of AFVs. The high awareness of AFVs in the survey is also due to the inevitable bias in recruitment, in which those persons most interested in cars are more likely to participate. Despite this high level of awareness, it was clear in focus groups that some persons had confused methanol with ethanol, and propane with CNG.

In a subsequent question, we asked for the sources of their knowledge (with multiple answers allowed):

> 207 persons had heard of AFVs through the news
> 106 through friends
> 87 through magazines
> 64 through car shows and public displays
> 62 through environmental magazines and media
> 46 through other media

It is clear that the news media is the most effective means to inform the public, and probably indirectly, from a friend via the news. However, as we note below, the opinions of participants prior to driving vehicles was more skeptical than warranted by the vehicles being used. The media may be to blame for a skeptical attitude.

5.2-2 Belief in AFVs as a solution to air pollution

We wanted to a know how strongly participants believe that AFVs are a needed and inevitable step to curbing air pollution. Participants were asked to choose how strongly they felt that AFVs are the "key" to solving air pollution in Southern California.

> 34% strongly agree
> 41% agreed
> 20% not sure
> 3% disagree
> 2% strongly disagree

We discovered in focus groups that most participants had learned through the news that cars are the main air quality problem in Southern California. A number said it was obvious that cars were the main problem. A smaller group were not opposed to AFVs but also thought industrial sources were as significant. Several participants said that AFVs were not a credible plan while "smoking" diesels were still on the road; many participants nodded their approval to this point.

A few focus group participants were opposed to AFVs. Several thought late model gasoline cars were sufficiently clean to improve air quality; they argued that the focus should be on removing older cars from the road. Two exaggerated beliefs were brought up to debunk the need for AFVs. A couple of participants said AFVs were not necessary because 90% of air pollution was due to 10% of the old cars. Another participant claimed that smog was a natural condition of the L.A. area, therefore nothing could be

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done.

In a related question, later in the post-drive part of the questionnaire, participants were asked to choose one of several personal actions that they were most willing to undertake to help air quality. AFVs were the most frequent selection.

purchase AFV	57.4 %
car-pooling	17.1 %
mass transit	15.7 %
cycle or walk	6.5 %
other	3.2 %

Despite these strong indicators of belief in the importance of AFVs, in another related question participants were asked to choose between three incentives for AFVs they thought would be effective. While 56.8% selected a generous tax credit as the best incentive, 42% selected "conclusive evidence that AFVs will rid Los Angeles of air pollution", suggesting that doubt remains that AFVs will ultimately solve the problem.

5.2-3 How Practical are AFVs?

We asked participants before and after the clinic about whether they felt AFVs were not yet practical to replace gasoline vehicles.

Before

      4.8% strongly agreed that AFVs were not yet practical
      28.8% agreed not yet practical
      38.4% were not sure
      22.3% disagree that afvs were not yet practical
    5.7% strongly disagreed

After

      5.7% strongly agreed that AFVs were not yet practical
      23.7% agreed that AFVs were not yet practical
      10.8% were not sure
      43.1% disagreed
      17.1 strongly disagreed

The bulk of those "not sure" shifted their opinion to "disagreed that AFVs not yet practical". A cross tabulation of these two distributions shows a significant shift toward a more favorable opinion of AFVs. Focus groups reveal that many participants had thought AFVs were still prototypes. In addition, most focus group participants had expected the three types to perform worse than they did. Some typical statements include.

"I was surprised that the compressed gas car had that much power; I mean it was a big car and it was fast."

"I expected the EV to be like a golf cart, but it was like a regular car. It wasn't fast but it

did fine."

"I expected the EV to be futuristic, shaped like an egg and made of fiberglass, but it was a normal car. That was good news."

"It (the methanol vehicle) was just like a normal car. It worked great."

The opinion of mechanically inclined participants improved more than the average participant. Thirty-one percent of the participants claimed to have some auto-mechanic skills. The relationship between mechanical ability and belief in the practicality of AFVs was significant. Mechanically inclined individuals were more likely to shift their opinion after the drive and disagree that AFVs were not yet practical.

	Mechanics	
	Before drive	After drive
Strongly agreed that AFVs not practical	4	2
Agreed that AFVs not practical	18	11
Not sure	25	12
Disagreed that AFVs not practical	20	30
Strongly disagreed that AFVs not practical	4	15

The shifting of opinion was not concentrated on one vehicle type. Participants stated overwhelmingly that their opinions of each vehicle type improved after the drive.

Opinion after drive	EV	CNG	Methanol
much better	20%	16%	24%
better	41%	38%	36%
no change	23%	34%	33%
worse	13%	10%	6%
much worse	3%	0.4%	0.4%

Apparently, opinions of AFVs, prior to the test, especially EVs, were worse than was warranted. The popular press may be in part responsible, seeing as the news media is the primary source of information about AFVs. This prior skepticism may apply more to mechanically inclined who might read more than others about vehicles. The explanation for the initial skepticism of mechanically inclined individuals may be that auto magazines regularly write critical reviews of EVs.

5.2-4 Purchase intentions before and after the clinic.

Before the test drive, participants were asked to say which of all the AFVs they would be interested in purchasing. Following are the frequencies for 218 responses.

EVs	118 (54%)
methanol	26 (12%)
hybrid EV	25 (11%)
propane	15 (7%)
CNG	13 (6%)
hydrogen	11 (5%)
ethanol	10 (5%)

Those who wanted an EV (n=118) were asked why. Their reasons are (multiple answers allowed):

the best technology to solve pollution	61%
will end oil dependence	42%
the technology they know best	39%
the most feasible technology	24%
the most economic choice	11%

After driving, many respondents defected from EV to one of the other vehicles. The great majority of these defectors owned large cars and were not willing to accept EVs because of their size (and associated attributes).

In general, those who preferred EVs and methanol vehicles were more rational and consistent in attitudes and hypothetical preferences than were CNG choosers. For example, when asked whether battery replacement costs would be a major barrier, methanol choosers, as expected, tended to say yes while EV choosers would say no. Likewise, EV choosers said a 50% lower cost per mile more than compensated for the range reduction, while methanol choosers said no.

CNG choosers emerge as more of a mystery. CNG choosers were not consistent about their responses to CNG attributes; one could not predict CNG choice from responses to questions about home refueling, choosing a "green" car or even fears about the fuel storage systems. For instance, some respondents spoke of being terrified about carrying CNG "bombs" in their trunk, and yet still stated a preference for CNG over the other options. Also, CNG was oddly the overwhelming second choice. Apparently, CNG became the second choice for the EV and methanol choosers, seen as a compromise fuel by each for opposite reasons. This confusing and mixed response by CNG choosers suggests that CNG is the least understood of the three fuels.

5.2-5 Decision Processes and Response to the Three Choices

The focus groups provided some evidence of distinct decision processes affecting AFV purchases: decisions that we classify as economically rational, morally rational, socially rational and innovative. These decision processes are illustrated by these statements

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from articulate focus group participants.

Economic-rational

"They have to make it worth my while; I'm not going to pay more for less."

Moral-rational

"I want a clean vehicle; I'm essentially looking for reasons to purchase an electric Vehicle."

Social-rational

"I would do it if I saw others were doing it."

Moderator: "How would you know others were doing it?"

Response: "I want to see a campaign, something decisive, so I knew we were all doing it together."

Innovative

"I always buy the latest thing -- I bought a Mustang, a Mazda and even a diesel."

In general, economically-rational choosers focussed upon least expensive option for the preferred set of attributes, while morally-rational choosers would seek those options with better environmental attributes and perhaps other attributes such as reliance on domestic fuels. Socially-rational purchasers look for the main political-consumption trend as the source of social benefits, and innovators try out new products to learn about the benefits.

These decision processes produce contrasting results for consumers; the car with the greatest personal utility may not fit their moral choice or the choice they think will be successful. The decisions resulting from the interaction of these decision processes is unstable; a shifting context can weight one decision process over others. Breakthrough technologies will encourage innovation while environmental crises will encourage moral choices.

5.3 Search Attributes

5.3-1 Car type\size and household fleets

Car type and size is a primary search attribute. The vehicle characteristics for the primary cars of our participants is as follows:

60 full sized
53 sub-compacts and compacts
32 import mid-sized
25 trucks, 4x4s
15 vans
12 muscle cars
11 sports cars
7 domestic mid-sized

215 Total

More than any other search attribute, car size immediately affected the responses of participants. In the questionnaire we asked individuals how closely the car they were testing resembled their own car.

Those who claimed to have a vehicle with a very similar body type to that of the EV responded more positively to many aspects of the EVs than the rest of the participants. This group was much more inclined to respond that reduced maintenance costs of 50% for EVs would more than offset the loss in range. In contrast, those with cars similar to the methanol vehicles in the test were more likely than other participants to think savings in EV maintenance would not offset the range loss. Small car owners were also more motivated by tax credits for AFV buyers.

While the most obvious interpretation of these results would be that compact car owners are more constrained by income than large owners, there are other factors at work. Most of the participants in the study have enough income for larger cars. In focus groups, those with small cars discussed the handling and parking ease of small cars. Compared to large car owners, subcompact and compact owners are not afraid of driving small cars on freeways and are less interested in acceleration. Owners of full-sized cars were more likely to have stated that AFVs are not yet practical.

Household vehicle holdings

The more cars owned by a household and the lower the driver-to-car ratio of a household, the more favorable its attitude towards EVs. This is consistent with common beliefs that EVs will work best in households which have at least one gasoline vehicle. Our sample had the following car counts per household:

2 cars - 107 households
3 cars - 59   "
4+ cars - 40   "

Of these, 57 households had 0.25 to 0.75 vehicles per drivers, 152 had 0.75 to 1.0 vehicles, and 21 had more than 1.0.

An unexpected finding is that those with trucks and 4x4s were more likely than others to choose EVs. We are investigating the hypothesis that households with specialty vehicles are more favorable to limited use vehicles. The motivation for affluent households to purchase small cars may be similar to that of truck and 4x4 owners, who have preferences for many types of vehicles and seek to diversify household fleets.

In keeping with that hypothesis, we found that households with more than two vehicles were most likely to respond affirmatively to the possibility of adding an EV to their household fleet (rather than replacing an existing vehicle). Truck and 4x4 owners were more likely to respond affirmatively as well.

5.3-2 Performance, Steering, Braking

The test drive is a limited test of these attributes because drivers did not take the vehicles on freeways or on grades. Given this limitation, most participants responded that the acceleration of all three vehicles was fine.

In the focus groups there were several members who were emphatic that the acceleration of the EVs was grossly inadequate. In focus group discussions those who own vehicles with high horsepower engines value residual horsepower for fun and consider it a means of survival on freeways. To this group, the performance of the EVs was unacceptable, perhaps dangerous.

Nevertheless, many persons who drove the Solectria Force were favorably impressed with its acceleration:

57 were impressed by the Solectria acceleration
29 thought acceleration was normal
25 thought acceleration was poor

In addition, some members of the focus groups who own luxury sedans from Europe and Japan considered their vehicle's braking and handling superior to the domestically-produced vehicles in the test drive. This group would not consider AFVs unless they were higher quality.

Some focus group participants thought the EVs did not steer properly because of the weight of the batteries. There were numerous complaints about the braking system in the Solectria, which had regenerative braking applied whenever the acceleration pedal was not depressed. The vehicle lacked a sense of coasting.

5.3-3 Engine Sound

The responses of participants to engine sounds was mixed. One of the EVs, the Solectria Force, had a high pitched mechanical whine attributable to its direct drive mechanism (which apparently can be readily fixed). Ninety-three out of 106 persons who drove the Solectria found this sound offensive.

Everyone liked that the EVs were silent at rest, although the silence confused many about the running state of the engine when pulling away from a stop. At higher speeds, many persons did not like the higher pitched sounds of the engine compared to the lower rumblings of the internal combustion engines. However, equal numbers said that they preferred the EV noise at high speed to the ICE noise at high speed.

5.3-4 Visual Attributes of Motors, CNG Tanks, Batteries, Solar Panels

CNG Tanks

Many participants commented about the bomb-like appearance of the CNG tanks and many thought the valve was in danger of shearing in an accident. However, subsequent analysis of choices indicate that such concerns had no statistical effect on likelihood of choice between methanol and CNG vehicles.

EV Batteries

Several persons commented that the battery pack in the Solar Car Festiva was in a dangerous location, just behind the driver and accessible from inside. Several participants in focus groups had seen or heard of exploding batteries and some had heard that batteries could give off hydrogen.

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EV Motor

Most of those who saw the Solectria Force motor were surprised and pleased by the simplicity and uncrowded look of the motor compartment. Many connected the simplicity with ease of maintenance and lower costs.

The solar panels were interesting to most participants. Most were disappointed by the low efficiency of the panels for adding range to the vehicle (one mile for each hour of sun), but when the charge collected in one day was equated with the charge needed for the air conditioning in the Solectria Force, the utility of solar panels was viewed as sensible. Most members of the focus groups consider air conditioning essential in Los Angeles and would not buy a car without it.

5.4 Experience Attributes

5.4-1 Range

The most significant experience attribute of the electric and compressed gas vehicles is reduced range. For electric vehicles, the range is further complicated by the long recharge time. In previous survey and focus group research consumers have been asked to estimate what range they wanted or price penalties were estimated from conjoint attribute tests. Without having used a reduced range vehicle, consumers have a difficult time estimating what their needs would be and tend to offer high estimates against this uncertainty. In real market situations, most consumers depend upon innovators to experiment with new attributes and provide information and decision making strategies.

Our drive test provided a glimpse of EV use but gave participants little opportunity to experiment with range. When asked in focus groups what range they required for a second vehicle in the household, participants estimated ranges from as low as 80 miles to as high as 300 miles. When asked how they arrived at their figures, three patterns of calculations seemed to dominate. One common pattern was to simply request the same range as that of current gasoline vehicle. This strategy minimizes reflection and planning. The second pattern was for those considering substituting an EV for a car which was used exclusively for a routine commute. The range is a combination of the daily commute and a residual "safety" buffer of approximately the same amount as the commute. The final pattern was for those who considered having a special car in the household for local driving only. For this range, the owner must reflect upon the maximum range by adding together a set of their most common journeys plus an added safety buffer for extra trips or getting lost.

We further asked if any of these persons was willing to trade away miles of range for a reduction in costs to see how firm was their estimated mileage. Many were willing to trade away a small percentage (5-15%) for a 50% reduction in gasoline costs.

In the PIREG interviews, more exacting specifications and strategies developed. In gaming interviews of three pilot households, using real travel data for reflection, we found individuals calculating the basic desired range of vehicles by adding the expected maximum daily mileage for the person in the household with the most predictable driving pattern, to a safety range equal to an expected emergency range needed if away from home in the EV. As this study develops, we expect to predict what ranges

will be demanded in a more mature market.

From discussing range with consumers who have varying amounts of information about their range needs, it is evident that initial unreflective estimates are usually higher, that as the consumer examines their own use patterns they accept lower ranges. Further support of this tentative finding is provided by the ongoing study of current EV owners in California (97 interviews have been completed so far), in which we find that once a limited range vehicle is in use, the range needs are not considered a problem (this undoubtedly will be more true with the initial early adopter group). In fact, for these drivers, because the EV is cheaper to operate, the more salient problem is maximizing the use of the EV for short journeys. Some EV owners consider their EV the main car.

However, numerous participants in the focus groups stated that they were unwilling to accept any limitations on range. Their unwillingness was based upon two possible constraints: 1) that the maximum daily mileage for all household cars exceeded even optimistic estimates of EV range; and 2) their job or lifestyle demanded open-ended range on all trips away from home. Those who were most willing to consider reduced ranges are consumers who have either a high degree of routine in their commute or who have simple or well-planned driving schedules.

Both the drive test and PIREG interviews, as well as our constraints study, suggest that few households would be eliminated from the market because of actual (vs perceived) daily range requirements. In the test drive, we could find no relationship between respondents' estimated commute range and their attitude toward the desirability of EVs. The predictability of household travel behavior appears to be more important than vehicle range in predicting acceptability and desirability of EVs (and CNGVs), according to evidence from focus groups, the PIREG study, the EV owner's study, and CNG owner studies. Limited range requires more planning, greater coordination among household members, and stronger routines. Some households appear to be more amenable to greater planning and routinization, especially when there are financial savings and conveniences.

The details and patterns of variation in how households calculate range will emerge as the PIREG interviews are completed. We plan to include an analysis of the purchase decision for vehicles of various ranges, by inserting EVs with various ranges and prices into the choice set of those households who have made a recent purchase of compact cars. This will allow us to test the validity of the above range calculations. We will also be able to estimate from the trip diaries, the trip mileage and destinations for simulated EV trips.

5.4-2 Recharging and Refueling

Recharging and refueling were difficult attributes to probe in the drive test and focus groups as well. Participants who spend most of their evenings at home had no trouble in imagining the vehicle charging at night, but those who have busy evenings thought recharging requirements were preposterous.

Those participating in the pilot PIREG interviews for estimating range needs recognized right away that nighttime charging did not interfere with any activities; in each of the households there were additional vehicles available for evening driving and residual charges on the EVs allowed for most evening driving done by households. However,

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these households were offered extensive information about their personal driving schedule which demonstrated the number of hours a vehicle was available for recharging. This observation from the PIREG interviews suggests again the important role of information in increasing the acceptability of AFVs.

In the drive test, long recharge time or CNG home refueling was most acceptable, even preferable, to households or members of households with a high degree of routine and a willingness to plan. Home refueling or recharging was perceived by these types of households as an efficient and attractive option rather than as a constraint. Those who did not like home refueling explained that their driving habits varied too much and/or they do not wish to hook and unhook the refueling apparatus.

5.4-3 Maintenance

Many focus group participants worried that methanol vehicles would deteriorate because of what they had heard in the press about the corrosive nature of the fuel. Others expected CNG vehicles to have less maintenance than gasoline because friends and acquaintances who own propane-fueled vehicles had clean engines, clean oil, and long engine life; there is a strong association between propane and CNG.

The initial inspection of EVs convinced some participants that the motor was so simple there would be little to repair. Others were worried about the maintenance and cost of batteries. Many had expected a much higher cost to replace batteries than the cost of the lead acid batteries used in the test vehicles. When asked to reflect upon maintenance costs of EVs, many thought about electric appliances such as their refrigerator and commented that there was little that could go wrong.

It is difficult to project from these studies to what extent consumers will actually consider the life-cycle costs of EVs against gasoline vehicles, and to what extent they will focus on initial costs and periodic battery replacement. The polarized responses of methanol choosers and EV choosers regarding life-cycle costs -- weighing the lower maintenance and fuel costs of EVs against the higher initial battery costs -- indicates that an attitude may have been formed in the test drive, and subsequent responses were rationalizations for an earlier choice. Lower operating and maintenance costs for EVs could be an attractive attribute for those already interested in EV purchase, but it remains unclear what role this factor will play in EV purchases.

5.5 Social-Choice Attributes

5.5-1 Vehicle Emissions

The role of emissions has not previously played a role in consumer vehicle decisions, but the introduction of vehicles to the market whose primary attributes are connected to emissions may politicize vehicle choice. In this way, EVs pose a critical dynamic for the development of the AFVs market. While questions remain about the increased emissions created by power plants in other parts of the country as a result of EVs, the emissions benefits of EVs in Los Angeles are more clear; EVs mean zero-emissions vehicles, both in Air Resources Board definitions and in the minds of most consumers in our studies. While other AFVs have mixed emission profiles, electric vehicles are perceived by most as a clean vehicle.

Because of this zero-emissions issue, EVs draw a line in the sand for consumers; they

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create an unambiguous public statement about personal environmental politics. It is uncertain whether automobiles will become an arena for political statement, due to the high costs, but the historical conditions are ripe. While there has been a decline in voting in the United States, a private political activity, public political activities such as consumption choices and protest appear to be increasing. Many of these protests are linked to health and environmental quality, two conditions which increasingly are viewed as basic rights of individuals. Against the background of basic rights of individuals, zero-emission cars could make car buying a political activity; in Los Angeles it could be a litmus test of community spirit.

For a small contingent, car buying is already political. In a study of current electric vehicle owners in California, most of whom are hobbyists who have built their own EV, every individual we interviewed became involved with EVs because of emissions and fuel dependency. In Los Angeles, several well known celebrities have purchased electrics and are using their public persona to promote EVs.

Green Market Segments

In the test drive, we could find no relation between those who belong to environmental organizations and their choices for particular vehicles (anecdotal evidence from the focus groups suggests that this apparent anomaly is due to the fact that activist members of environmental groups have erratic and extended trips). Yet a strong relationship emerged between the idea of moral choosing and choosing electric vehicles.

Participants were asked what would motivate them to purchase an AFV. Their answers were:

would purchase AFV because it's right thing to do	28%
would purchase if others purchase	21%
would purchase if government insured transition	22%
would purchase once majority owned one	10%
would purchase only when economical	13%
multiple answers to above	6%
	100%

Many of those who answered that they would purchase an AFV because it was the right thing to do, were much more likely to choose EVs than methanol than were the rest of the participants. In addition, those who answered "would purchase only when economical" were less likely than the rest of participants to choose CNG and methanol.

Much of the discussion in focus groups centered on how responsible individuals were for making changes. In each group, the participants arrived at a consensus that it was inevitable that something had to be done, that individuals would have to change behavior and make sacrifices.

But many participants said there could be no personal responsibility as long as they saw worse violators than themselves on the road, such as diesel trucks and old gas guzzlers, and as long as they saw smoking refineries. Getting the "super emitters" off the road was a prerequisite for most for accepting personal responsibility. It was a matter of what was fair. Many respondents brought up the issue of emissions from

power plants offsetting the gains from EVs.

An unanticipated factor in the green market, which emerged in less formal interviews at the drive test and other research locations was that AFV purchase would be affected heavily by commitment of residents to the local areas affected heavily by smog. Those individuals planning to leave southern California felt less committed to AFV purchases and other acts of personal responsibility; these people will not be part of a "green" market. A family expressed this decision factor as, "We have lived in Los Angeles for two generations, all of our family is here, but our jobs allow us to move to Seattle. My lungs and my wife's are probably already damaged, but we want to protect our children. We would buy an EV if we stay, but I think we are leaving."

5.5-2 Fuel Dependence

The issue of dependence upon foreign oil entered the conversation in focus groups more often than we had anticipated. The gulf war was still recent in the minds of many participants and several participants were concerned that fuel dependence was at the core of national economic problems. However, the problem was not as clearly inevitable in the minds of most participants as was the air quality problems.

Again EVs were seen as the primary solution. Most participants were uncertain about the domestic availability of natural gas. A surprising number of participants were knowledgeable about methanol production and believed it would not solve fuel dependence without subsidies. However, an equal number of participants thought methanol was made from biomass and therefore a renewable energy source that could contribute to our independence. More work needs to be done to determine the impact of fuel dependency perceptions on vehicle choice.

6.0 **Conclusions**

The test-drive clinic was designed to probe a market in which a few years from now several types of AFVs are being sold. We discovered that the majority of participants were convinced that AFVs are the solution to air quality problems in Los Angeles. In our initial report on the theory of AFV purchases, we hypothesize that once a majority of the population is convinced of the inevitability of a problem and know the solution, cooperative decisions and moral choice can become a part of the decision process. If they believe they have arrived at a historical juncture in which government and industry are committed to the solutions, consumers with adequate resources and knowledge will invest in what they believe is the future.

One of our tasks has been to identify early market segments for AFVs. In the section below, we summarize and synthesize the findings from above about who will be the first buyers of AFVs, and offer some conclusions and new hypotheses.

6.1 Electric Vehicles

The target market, according to our constraints study, is home owners, with a protected recharge area, with at least two cars and no commutes over 80 miles for at least one of the two cars. In addition, for the Pasadena test drive, we selected households with annual incomes over $50,000, a typical cutoff for new car buying.

In our drive test, we found that a large percentage of this public perceives electric vehicles as a key solution to air pollution. We also found that the same persons in the test who believe purchasing an AFV is a matter of moral choice, also choose EVs. This idealistic group tended to be younger, while older participants expressed practical concerns.

However, we also found that participants between the age of 45 and 54 were the most likely to choose EVs. Since older people are generally less idealistic than younger people, and EVs will be most attractive to moral choosers, this finding seems counter-intuitive. This contradiction is explained by the fact that other factors appear to play a more important role. EVs are relatively attractive to this group because of their high household incomes, own multiple cars (including at least one subcompact), have low driver-to-car ratios, and are interested in fuel savings, life-cycle costs, and tax credits.

We also have evidence that this group may have more predictable driving habits, which make recharging and limited range vehicles more attractive. In addition, they may be more committed to long term residence in their present community.

One possible explanation of the contradiction between moral choice and mid-age as a predictor of EV purchase may be subtleties in expression between age groups. Mid-age participants may be relatively less willing to make idealistic statements and more oriented to "voting with their pocketbook."

The target market for green consumers and lifestyles then is multiple car households, with predictable travel behavior, and long range commitment to local air-quality improvements. There is a heavy concentration of these green consumers in the 45-54 age category, probably because of income, home ownership, and diversified car ownership.

However, the potential market drops for individuals over 55 years as they reduce vehicle holdings, lose disposable income, and lose their commitment to the local community (and local air quality) as they contemplate moving to a smaller house, retirement community, or less polluted area.

The Market Share of EVs

This research is not designed to predict the percentage of EV sales. We believe it is premature to attempt such predictions. However, this test does allow some comment on previous attempts.

Numerous studies project EV sales in the range of 1% or less of the market, based on opinion surveys and focus groups. Our constraint studies, after entering income constraints and assuming only one EV per household would show a potential market around 13%. Adding consumer willingness to accept lower range, less power and long recharge times, it would seem that market penetration levels indeed might drop as low as 1%.

However, that low level would only hold for the initial market. Our drive test, focus groups and PIREG interviews indicate that as consumers receive more information their attitude improves. For example, in numerous surveys and focus groups, when consumers are asked to estimate what range they desire, routinely use their current

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gasoline vehicle's range of 300-400 miles.

After driving EVs and discussing the other characteristics, participants in the Pasadena test drive estimated lower mileage needs. In PIREG interviews, consumers see their actual use of vehicles displayed graphically and are willing to estimate even lower range needs. Many current EV owners are satisfied with EV ranges under 80 miles, and would not pay more for greater range.

Therefore, the market shares are likely to go well above 1% as incentives are offered to reward EVs for lower environmental externalities and as the public has time to adjust to the limitations of EVs and experiment with the conveniences of home recharging and lower maintenance of EVs.

Social Dynamics of the EV market

As we noted above, EVs are the only zero-emissions vehicles in the market. In terms of the politics of consumption, EVs draw a line in the sand. The more distinct and clear that line, the greater numbers of consumers will commit scarce personal resources to a high priced green consumer item. The recent solar carport, for recharging of EVs announced by Southern California Edison is the type of technology to draw the line deeper (product is described in facts sheet available from SCE). Also, clear policy signals from government will deepen the line, something akin to the "campaign" one participant in a focus group mentioned: a strong, stable commitment by industry to EVs and other environmentally attractive vehicles and fuels. The campaign should focus upon rights of humans to clean air and good health.

In accordance with our findings about market segments for EVs, political leadership for encouraging EV use should spring from local governments and agencies, not just state agencies. Because the issues are political, as much power as possible should be generated among the consumers to encourage participation; this should be bottom up development. However, all barriers to EV penetration can be pursued at every level of government.

6.2 Compressed Natural Gas Vehicles

Participants were least familiar with CNG vehicles prior to the clinic. They did not have articulated beliefs about CNG systems. As we noted in the frequency of choices, CNG was a second choice of most participants. It was perceived by many as a compromise between EVs and methanol vehicles for practicality and elimination of emissions. It offered the autonomy of home refueling but the possibility of refueling away from home as well. The full-sized vehicle used in the test drive impressed many drivers with its power. With greater information and demonstration of refueling systems, CNG vehicles could be popular with those who wish to choose a clean vehicle but demand a large vehicle.

But specific responses in the drive test among those who chose CNG were inconsistent; we were unable to find statistically significant correlations to CNG choice. We believe this is because CNG had a certain universal appeal as a compromise and because participants came with fewer expectations and opinions about CNG; it was an unknown product for most.

Since the drive test did not include refueling demonstrations, the refueling concepts for

CNG left many participants with more questions than answers about safety, ease and convenience.

The vehicles used were conversions, leaving participants to wonder how permanent was the CNG market. Dedicated vehicles with adequate trunk space and hidden tanks will correct most of the complaints of participants in the drive test.

A strong positive attribute of CNG is the belief by many consumers that the use of natural gas will result in longer life of engines. This belief seems to come less from knowledge about CNG than from simple reflection on the clarity of gas and from associating natural gas with propane. Together with lower costs, this belief discourages fuel switching in dual fuel vehicles.

At the social level of beliefs, it was unclear to most participants just how much CNG was available for transportation use. Many believed supplies were limited to a short historical supply, thus it was not an answer for fuel dependency. In addition, the emissions benefits of CNG were also unclear to participants. There needs to be greater dissemination of information about the future supplies of natural gas, the emissions of CNG vehicles, and commitment of industry and government.

CNG will compete with methanol vehicles for the large car market, and could obtain a sizable percentage of that market and the wider large car market if it is repositioned as a green car with longer engine life and home refueling potential. The greatest uncertainty for CNG development will be the role of home refueling. A large percentage of CNG owners will probably want the convenience of home refueling, but the uncertainty of how these will be marketed creates complexities for predicting market shares. As one participant noted, "I want CNG and I want home refueling, but at $2000 for the appliance, I'm not going to buy it if I can fill at the local station."

6.3 Methanol Vehicles

Many participants were familiar with methanol vehicles from the press and from seeing methanol vehicles on the road. Respondents reacted positively to almost all attributes of the flexible fueled vehicles except the emissions attributes. The discussion of methanol will be short because few parts of the questionnaire and our other studies have been directed at methanol.

Market Segments

The flexible fueled, methanol vehicle was highly preferred among large-vehicle owners and older participants in the test drive. The methanol vehicle was chosen by the largest number of persons who shifted preferences from another vehicles type (after the test drive). Of the 20 participants who switched preferences from EVs before the test drive to methanol after the test drive, all were owners of larger vehicles.

Many participants had also heard of the higher performance of methanol, although in the test drive they found it hard to detect the extra horsepower. The primary advantage of methanol in the minds of participants was the flexible fuel aspect: that one could refuel at any station whether it had methanol or not. Therefore, you wouldn't have to shop for methanol stations while out of town. In addition, many participants were concerned about the corrosive nature of alcohol fuels and felt that occasionally use of gasoline would extend the life of the engine.

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Social Development of the Methanol Market

Focus groups expressed little interest in the methanol vehicle as a solution to air pollution. The electric vehicles and CNG vehicles symbolized pollution solutions while methanol was perceived more as a transitional solution.

In focus groups many persons said they liked the EV but would choose methanol from among the three because of the flexible fuel option and performance. However, they emphasized that this decision would be purely economic and the methanol vehicle would have to be cheaper than a gasoline vehicle. Thus the social development of a methanol market is not likely to be linked to green consumerism if EVs and CNG vehicles are available as alternatives. The development of methanol will depend primarily upon the price of methanol and tax credits to offset the purchase price of methanol, since methanol does not offer home refueling or maintenance improvements.

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Description of Sample in AFV Test Drive

Total Number of Questionnaires = 236

Total Number of Paid Recruits = 193
Total Number of Volunteers = 43

72% males
28% females

Annual Household Income ($)

0-40,000	11% (volunteers could have less than $50,000 income and recruits could have lied to recruiter)
40-60,000	20.5%
60-80,000	16.6%
80-100,000	18.8%
100,000 +	32.8%

Commuting patterns

do not commute	27.3%
walk, bike, transit	4.7%
other	5.2%
commute under 20 round trip	30.6%
commute 20-40 round trip	15.9%
commute 40 + round trip	16.4%

Schooling

high school	6.1%
some college	24.8%
college degree	24.8%
post graduate	44.3%

Age

18-35	24%
36-45	20%
46-55	21%
56-65	22%
65+	13%

Number of Drivers in Household

1	9.6%
2	64.8%
3	14.2%
4 +	11.6%

Cars Used in Test Drive

Electric Vehicles

1. 1991 Solectria Force

Chassis and Body of GM Geo, two seater, curb-weight 2370 lbs.
90 mile range, top speed - 65mph, acceleration 0-30 8 sec., 30-60 19 sec., single speed, 32 hp solectria brushless motor, 3 phase 150v, 220 amp. controller, 13.9 kWh. lead acid battery, 110 volt AC charger - 8 hrs full charge, 150 W, roof mounted solar panel, 7300 btu air conditioning.

2. 1991 Solar Car Festiva

Ford Festiva Body, two seater, 60 mile range, top speed 60 mph +, roof and hood mounted solar panels (adds 10 miles to range on sunny days), four speed transmission, lead acid batteries

(other specifications not available)

Compressed Natural Gas Vehicles

1. 1989 Buick Le Sabre , 4 door sedan, 3.8 liter fuel injected V six, 160 hp, dual fuel ANGI conversion, 100 cubic feet of natural gas at 3000 lbs.

2. 1989 Plymouth Reliant, four door sedan, 4 cylinder 2.2 liter, fuel injected, dual-fuel conversion IMPCO.

Flexible Fueled Methanol Vehicles

1. 1991 Ford Taurus 3.0 liter. V 6, four door sedan, front wheel drive, fuel injected.

2. 1991 Chevrolet Lumina, four door sedan, 3.1 liter, front wheel drive , fuel injected, variable fueled methanol.

63 Occupation

Occupation	
Retired	34
Sales	17
Executive, administrative	25
Teacher	9
Management	26
Lawyers,judge	8
Therapist	3
Engineer	24
Retail	3
Writers, artists, atheletes	9
Construction	8
Health diagnosis	5
Post-secondary teacher	6
Secretary	7
Technician	7
Firefighting	4
Homemaker	8
Student	9
other	6

Test Drive Questionnaire

===

1. Last Name _____ First _____

2. Appointment day_____time_____

3. Interviewer_____

===

Part A

Before driving the vehicles here today, please answer some questions about your previous knowledge of alternative fueled vehicles.

<u>Mark all selections with an x in the parentheses provided</u>

4. Were you aware of alternative fueled vehicles before this clinic?

      1 ( ) No (skip to Part B, pg 3)   2 ( ) Yes (go to # 5)

5. If you answered yes to # 4, which alternative fueled vehicles did you know about? (mark all which apply)

      1( ) electric

      2( ) hybrid electric

      3( ) methanol

      4( ) compressed natural gas

      5( ) hydrogen

      6( ) ethanol

      7( ) propane

6. How did you know about these alternative fueled vehicles? (mark all that apply)

      1( ) the news media

      2( ) environmental organization media

      3( ) conversations with friends and acquaintances

      4( ) have seen at car shows and other public events

      5( ) magazines such as Popular Science, Road and Track

      6( ) other _____

7. According to what you know about alternative fueled vehicles, please respond to the following statements.

8. Alternative fueled vehicles are the key to solving air pollution in Southern California. (mark one)

      1( ) strongly agree   2( ) agree   3( ) not sure   4( ) disagree   5( ) strongly disagree

9. Alternative fueled vehicles are <u>not yet practical</u> to replace gasoline fueled vehicles.(mark one)

    1( ) strongly agree   2( ) agree   3( ) not sure   4( ) disagree   5( ) strongly disagree

Compared to what it costs to own and operate your gasoline fueled vehicle, <u>how much</u> do you think it will cost to own and operate an alternative fueled vehicle? (mark one)

    1( ) much less   2( ) a little less   3( ) the same   4( ) a little more   3( ) much more

10. If alternative fueled vehicles were available for purchase, and you were in the market for a new car, which of the following would you do? (mark one)

    1( ) I would not consider alternative fueled vehicles until they have been on the market for several years.

    2( ) I would consider an alternative fueled vehicle, but would investigate carefully the costs and usefulness of each vehicle type before making a commitment.

    3( ) I would purchase an alternative fueled vehicle immediately, despite the uncertainty because of the need to eliminate pollution and dependence on foreign oil.

11. If you were to purchase an alternative fueled vehicle, which of the following would you be most interested to consider? (mark one)

    1( ) electric

    2( ) hybrid electric

    3( ) methanol

    4( ) compressed natural gas

    5( ) hydrogen

    6( ) ethanol

    7( ) propane

12. Which of the following reasons makes you most interested in the vehicle type you chose in # 11? (mark all that apply)

    1( ) It is the most technically feasible of all the choices.

    2( ) It is the technology I know best.

    3( ) It will lessen our dependence on foreign oil.

    4( ) It is the best technology to reduce pollution.

    5( ) It is the most economic choice for car owners.

    6( ) I am interested to experiment with that type of technology.

    7( ) Other _____

You are finished with Part A - go on to Part B.

Part B

You will now drive three alternative fueled vehicles. The test, due to liability concerns will be remain within the boundaries of Parking Lot F. An interviewer will accompany you on our simple drive test and ask you a few questions about each vehicle.

Car Number One

13. Interviewer: Please mark vehicle.

    1( ) Solectria Force (electric)   2( ) Solar Car Festiva (electric)

    3( ) Reliant (natural gas)   4( ) Buick (natural gas)

    5( ) Lumina (methanol)   6( ) Taurus (methanol)

14. How close is this body style to your tastes and needs in vehicles?

    1( ) very different 2( ) different 3( ) similar 4( ) very similar

15. What are your first impressions of the vehicle and engine (motor)?

    Probes
    ( ) location of instruments

    _____

    _____

    ( ) visual inspection of engine (motor, batteries, cylinders)

    _____

    _____

    _____

    _____

16. How does starting and driving feel?

    Probes
    ( ) starting

    _____

    _____

    _____

    ( ) sound of engine

    _____

    _____

    _____

( ) weight

_____

_____

_____

( ) acceleration

_____

_____

_____

_____

( ) steering, braking

_____

_____

_____

17. Refueling. How does the refueling arrangement seem to you?

Probe
( ) convenience, ease of use

_____

_____

_____

( ) danger, fears

_____

_____

_____

_____

18. This car performs

    1( ) worst than I had expected   2( ) about as well as I expected 3( ) better than I expected

19. Is there else about the car which you feel deserves comment?

_____

_____

_____

_____

_____

Go on to Car # 2

Car Number Two

20. Interviewer: Please mark vehicle.

       1( ) Solectria Force (electric)   2( ) Solar Car Festiva (electric)

       3( ) Reliant (natural gas)   4( ) Buick (natural gas)

       5( ) Lumina (methanol)   6( ) Taurus (methanol)

21. How close is this body style to your tastes and needs in vehicles?

       1( ) very different 2( ) different 3( ) similar 4( ) very similar

22. What are your first impressions of the vehicle and engine (motor)?

    Probes
    ( ) location of instruments

_____

_____

_____

    ( ) visual inspection of engine (motor, batteries, cylinders)

_____

_____

_____

_____

23. How does starting and driving feel?

    Probes
    ( ) starting

_____

_____

    ( ) sound of engine

_____

_____

_____

( ) weight

_____

_____

_____

( ) acceleration

_____

_____

_____

( ) steering, braking

_____

_____

24. Refueling. How does the refueling arrangement seem to you?

Probe
( ) convenience, ease of use

_____

_____

_____

( ) danger, fears

_____

_____

_____

25. This car performs

     1( ) worst than I had expected 2( ) about as well as I expected 3( ) better than I expected

26. Is there else about the car which you feel deserves comment?

_____

_____

_____

_____

_____

Go on to car number 3

Car Number Three

27. Interviewer: Please mark vehicle.

     1( )   Solectria Force (electric)   2( )   Solar Car Festiva (electric)

     3( )   Reliant (natural gas)   4( )   Buick (natural gas)

     5( )   Lumina (methanol)   6( )   Taurus (methanol)

28. How close is this body style to your tastes and needs in vehicles?

     1( ) very different   2( ) different   3( ) similar   4( ) very similar

29. What are your first impressions of the vehicle and engine (motor)?

     Probes
     ( ) location of instruments

_____

_____

_____

     ( ) visual inspection of engine (motor, batteries, cylinders)

_____

_____

_____

30. How does starting and driving feel?

     Probes
     ( ) starting

_____

_____

     ( ) sound of engine

_____

_____

_____

( ) weight

_____

_____

( ) acceleration

_____

_____

( ) steering, braking

_____

_____

31. Refueling. How does the refueling arrangement seem to you?

Probe
( ) convenience, ease of use

_____

_____

_____

( ) danger, fears

_____

_____

_____

32. This car performs

    1( ) worst than I had expected   2( ) about as well as I expected   3( ) better than I expected

33. Is there else about the car which you feel deserves comment?

_____

_____

_____

_____

You are finished with Part B, the drive test, please return to the tent and answer questions in Part C.

Part C

We have more questions about your response to the three vehicles and the future of alternative fueled vehicles, and a few questions about your own household for statistical purposes. We also have a short facts sheet on each of the alternatives which we presented to you to provide you with further information. Please read and then complete Part C.

After the Drive: Armed with new knowledge and experience, please answer the following questions.

34. Alternative fueled vehicles are not yet practical to replace gasoline fueled vehicles.(mark one)

    1( ) strongly agree   2( ) agree   3( ) not sure   4( ) disagree   5( ) strongly disagree

35. Did your opinion of electric vehicles change after the drive?

    1( ) Much better   2( ) Better   3( ) The Same   4( ) Worse   5( ) Much Worse

36. Did your opinion of compressed natural gas vehicles change after the drive?

    1( ) Much better   2( ) Better   3( ) The Same   4( ) Worse   5( ) Much Worse

37. Did your opinion of methanol vehicles change after the drive?

    1( ) Much better   2( ) Better   3( ) The Same   4( ) Worse   5( ) Much Worse

38. If alternative fueled vehicles were available in the body type and style of your tastes, which of the three vehicles you drove would you choose to purchase?

    1( ) compressed natural gas 2( ) methanol 3( ) electric

39. What would be your second choice?

    1( ) compressed natural gas 2( ) methanol 3( ) electric

40. If you were unable to substitute an alternative fueled vehicle for one of your current vehicles, would you consider adding an alternative fueled vehicle to your current set of cars.

    1( ) yes 2( ) no

Range One of the primary disadvantages of electric and natural gas vehicles is their reduced range.

41. How often do you drive more than 30 miles from home?

    1( ) daily   2( ) weekly   3( ) monthly   4( ) less than monthly 5( ) never

42. If you have a second driver in the household, how often does the other driver drive more than thirty miles from home?

    1( ) daily   2( ) weekly   3( ) monthly   4( ) less than monthly 5( ) never

43. Do any of the cars in your household <u>consistently</u> get used less than 50 miles per day?

    1( ) yes 2( ) no (skip to 44)

44. If you have a functioning car which is consistently used less than 50 miles per day, describe that car?

    1( ) Is used for commuting to work only

    2( ) Is used for local errands only

    3( ) Is used very infrequently

    4( ) Is general purpose

    5( ) other _____

45. How old is the car in #44 1( ) one to three years   2( ) four to eight years old   3( ) nine years or older

46. The range of electric vehicles will limit most of their use to within 20 or 30 miles of home. They also require long recharge times. Which of these responses feels closest to your own feelings about this limit on range.

    1( ) It seems crazy to own a vehicle which cannot be used for more than 30 miles of range. It wouldn't work.

    2( ) Being limited to 30 miles operating radius is a severe limit, but since I would have a gasoline car as well, I can imagine adjusting to the limitations.

    3( ) The way I use my car now, I don't need such range, and recharge time would be no problem.

Fuel Costs Although range is a limitation of several alternative fueled vehicles, the operating costs, including fuel costs and maintenance are projected to be less.

47. Compressed gas vehicles have slightly less range than gasoline vehicles. Around 1\2 to 2\3 the range, forcing you to refuel more often. However, the costs of fuel may be 10-20 cents less than gasoline. Which is more important to you, range or fuel costs.

    1( ) Range 2( ) Fuel costs

48. It will take more than one gallon of methanol to take you as far as one gallon of gasoline. However, methanol provides a small but noticeable power increase. How much more than the price of gasoline will you be willing to pay for the equivalent amount of methanol?.

    1( )0   2( ) 10 cents   3( ) 20 cents   4( ) 35 cents   5( ) 50 cents

49. If the fuel bills and repair bills of an electric were less than 1/2 of a gasoline fueled vehicle, would that offset the disadvantage of its reduced range?

    1( ) would not offset 2( ) would offset 3( ) would more than offset

Recharge/ Refuel

50. Electric vehicles and natural gas vehicles can both be recharged or refueled at home over a few hours. What do you think of this possibility?

   1( ) I don't like the idea. (go to 51)

   2( ) I like the idea (skip to 52)

   3( ) I would have no where at my residence for recharging or refueling.(skip to 53)

51. If you marked 1 in the last question, answer this question.- I can't imagine how it would work because;

   1( ) It sounds dangerous

   2( ) My driving habits are so varied, I would not always be home to recharge or refuel.

   3( ) I don't want to be having to hook and unhook the recharging or refueling apparatus.

   4( ) other _____

52. If you answered 2 in the former question, answer this question. I like the idea of home refueling or recharging because:

   1( ) I won't have to go to the service station.

   2( ) I like the idea of monthly utility bills rather than paying a service station.

   3( ) It seems like it might be cheaper.

   4( ) I like the idea of having a full tank each morning.

   5( ) other _____

Batteries

53. Electric vehicles will as part of their regular maintenance need to replace the entire battery pack. The need to replace batteries:

   1( ) Is an absolute barrier to purchase

   2( ) Is a major barrier to purchase

   3( ) Makes me hesitant to purchase

   4( ) Like any other maintenance cost

54. Electric and natural gas vehicles will have smaller trunks, pickups and vans will have smaller beds due to batteries or compressed gas tanks. How significant is this loss of space?

   1( ) I need every bit of cargo space, it would be an absolute barrier to purchase

   2( ) I often use my trunk, I would be hesitant to purchase smaller.

   3( ) I seldom need my whole trunk or bed, it would be a minor issue.

   4( ) Not a problem for me

Fuel Availability In the early years of the market, methanol and natural gas may not be widely available.

55. At present there are few natural gas or methanol stations. At what levels of availability would you consider natural gas or methanol to be available enough for your purposes?

    1( ) Most stations in the USA

    2( ) 1/2 of stations in the USA

    3( ) Frequent stations on major roads

    4( ) I'd be interested as soon as the local station I use most carried natural gas or methanol

    5( ) As long as many stations in the Los Angles area had natural gas or methanol

Resale and Special Cars Since there are few electric and natural gas vehicles on the road, the uses and resale of these vehicles are not well understood.

56. What would you expect the resale value to be on these alternative fueled vehicles?

    1( ) excellent 2( ) above average 3( ) average 4( ) below average 5( ) poor   6( ) no opinion

57. If you owned an electric vehicle in addition to your gasoline vehicle, for which purposes would you use the electric. Mark as many answers as apply.

    1( ) leisure activities   2( ) business

    3( ) commuting   4( ) shopping

Choosing a "Green" Car

58. If you were buying a new car and believed that alternative fueled vehicles could improve air quality, but such alternatives cost $1000 more than the same make and model gasoline vehicle, which of the following conditions would express your level of commitment.

    1( ) I would purchase the AFV because its the right thing to do.

    2( ) I would purchase a cleaner vehicle if I knew that other people were going to do it, therefore my efforts would be effective.

    3( ) I would purchase a cleaner vehicle once I believed the government was going to insure a change.

    4( ) I would purchase once a majority of drivers have switched to an alternative.

    5( ) As long as the alternative cost more, I would not purchase.

59. If you bought an alternative fueled vehicle, would you want it clearly marked to show you had bought such a vehicle?

    1( ) yes   2( ) no

60. If you were to choose one way of affecting air quality in Southern California, would you choose

    1( ) carpooling to work

    2( ) bicycling and walking instead of driving

    3( ) purchase an alternative fueled vehicle

    4( ) use mass transit instead of my car

    5( ) other _____

Incentives

61. Which of the following would <u>most</u> influence your decision to purchase an AFV. (choose one)

    1( ) A generous tax credit

    2( ) A strong endorsement by the Sierra Club or American Lung Association

    3( ) Conclusive evidence that Alternative Fueled Vehicles will rid Los Angles of air pollution.

62. Which of these strategies should the State of California follow to encourage the purchase of environmentally friendly automobiles.

    1( ) Offer tax credits which would offset the added costs of owning an alternative fueled vehicle.

    2( ) Tax vehicles and fuels according to how much they pollute.

    3( ) Do nothing.

Demographic Information

63. Occupation _____ Industry _____

64. Do you have a special interest or ability in auto mechanics.

    1( ) yes   2( ) no

65. How often do you recycle products such as bottles, cans or newspaper

    1( ) never 2( ) every few months 3( ) monthly 4( ) weekly

66. List the year, make, model, years owned and mileage of each vehicle in your household.

	year	make	model	years owned	mileage
1( )_					
2( )_					
3( )_					
4( )_					
5( )_					

67. Do you plan to purchase a vehicle

     1( ) In the next six months

     2( ) In the next year

     3( ) In the next two years

     4( ) In the next five years

     5( ) never

68. It will be   1( ) used   2( ) new

69. How often do you purchase a <u>new</u> car?

     1( ) 1-2 years   2( ) 3-5 years   3( ) 5-10 years   4( ) seldom 5( ) never

70. How many drivers in your household _____

71. How many persons other than yourself are there in your household

     _____ under six years   _____ 6-15 years

     _____ 16-24 years old   _____ 25-64 years old

     _____ older than 65

72. What year were you born? 19 _____ _____

73. How far is your drive to work? (mark one)

     1( ) I do not commute, am retired or work at home.

     2( ) I walk, bike or ride transit to work

     3( ) other _____

     4( ) A commute under twenty miles round trip.

     5( ) A commute under forty miles round trip.

     6( ) A commute over forty miles round trip.

74. Do you support or belong to Sierra Club, Coalition for Clean Air or other environmental organizations?

     1( ) yes   2( ) no

75. 1( ) male   2( ) female

76. Housing

     1( ) own home   2( ) own condominium   3( ) rent home   4( ) rent apt or condominium

77. Schooling (mark grade completed)

    1. elementary 1 2 3 4 5 6 7 8

    2. high school 9 10 11 12

    3. college 13 14 15 16 17 18+

78. For statistical purposes only, what is you annual, pre-tax household income? (mark one)

    1( ) 0-25,000   2( )25-40,000   3( )40-60,000

    4( )60-80,000   5( )80-100,000   6( )100,000 +

79. Is there anything you would like to add.

Selected frequencies and cross-tabulations of questionnaire responses

5 Aware of this fuel type

electric vehicles	223
methanol vehicles	194
propane vehicles	168
CNG vehicles	127
ethanol vehicles	115
hydrogen vehicles	60
hybrid electrics	59
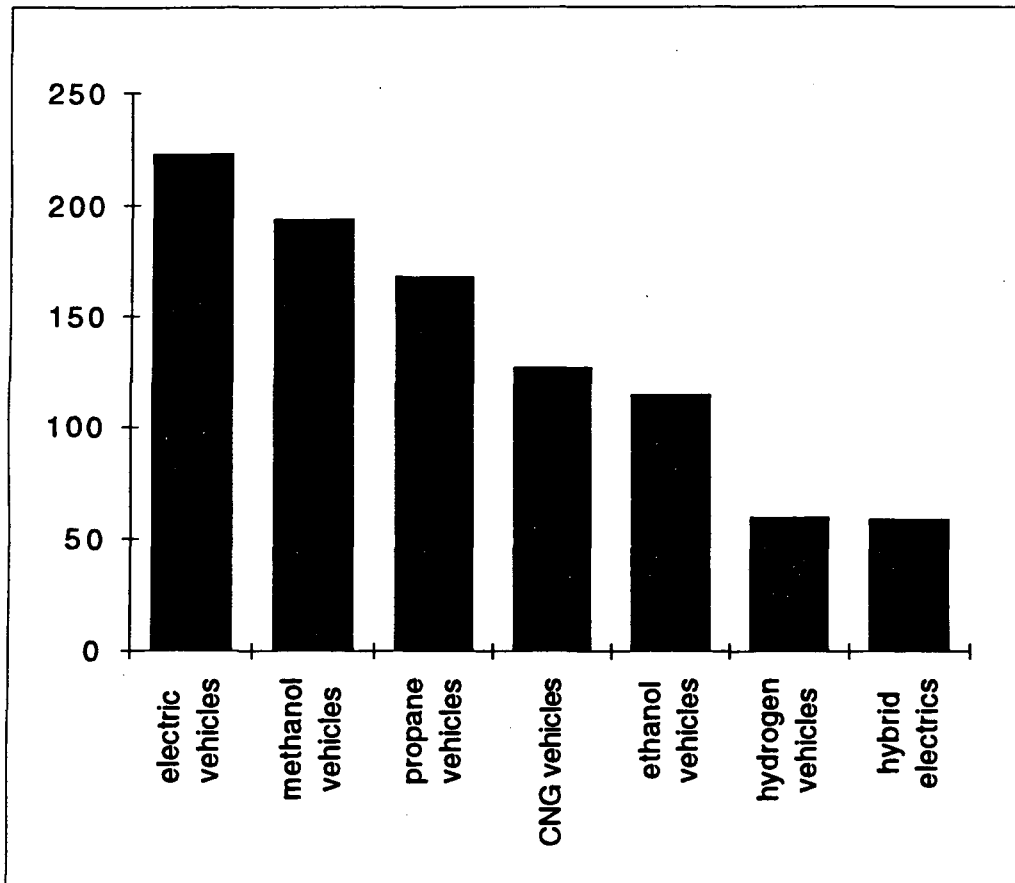
8 AFVs are the key to solving air pollution in Southern California

Strongly agree	80
Agree	94
Not Sure	46
Disagree	7
Strongly Disagree	4
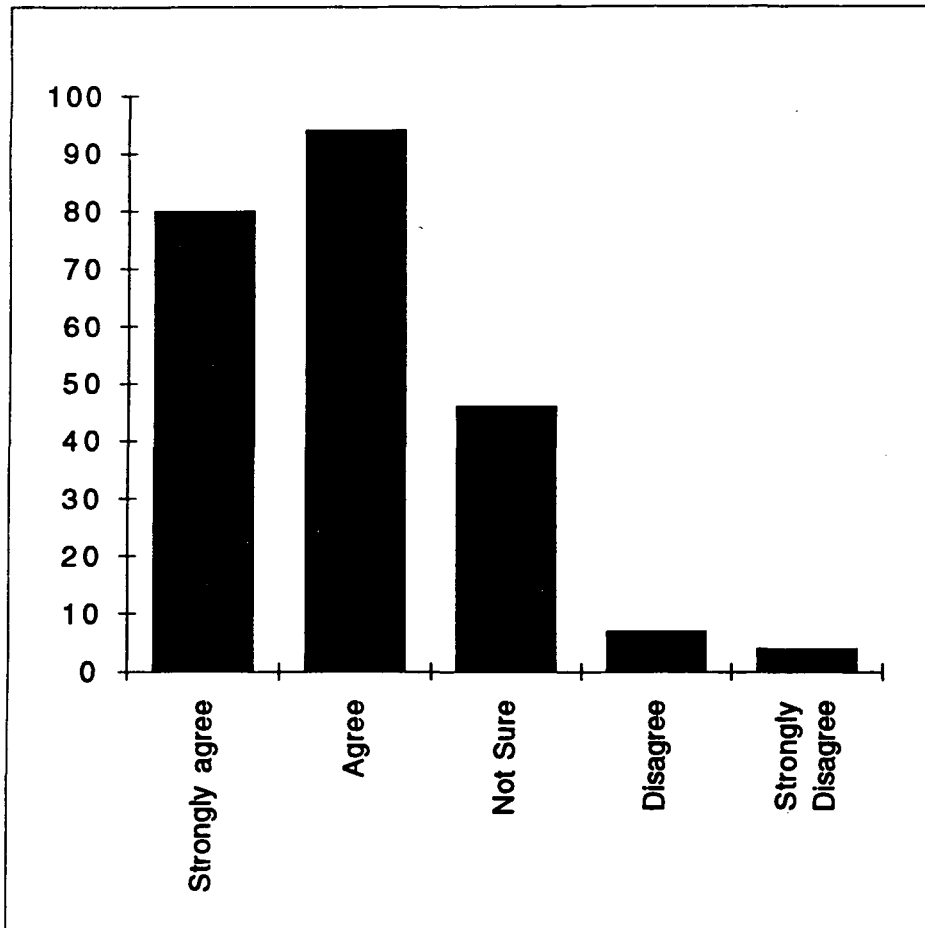
11 If you could purchase, which would you choose?

electric	118
methanol	26
hybrid electric	25
propane	15
CNG	13
hydrogen	11
ethanol	10
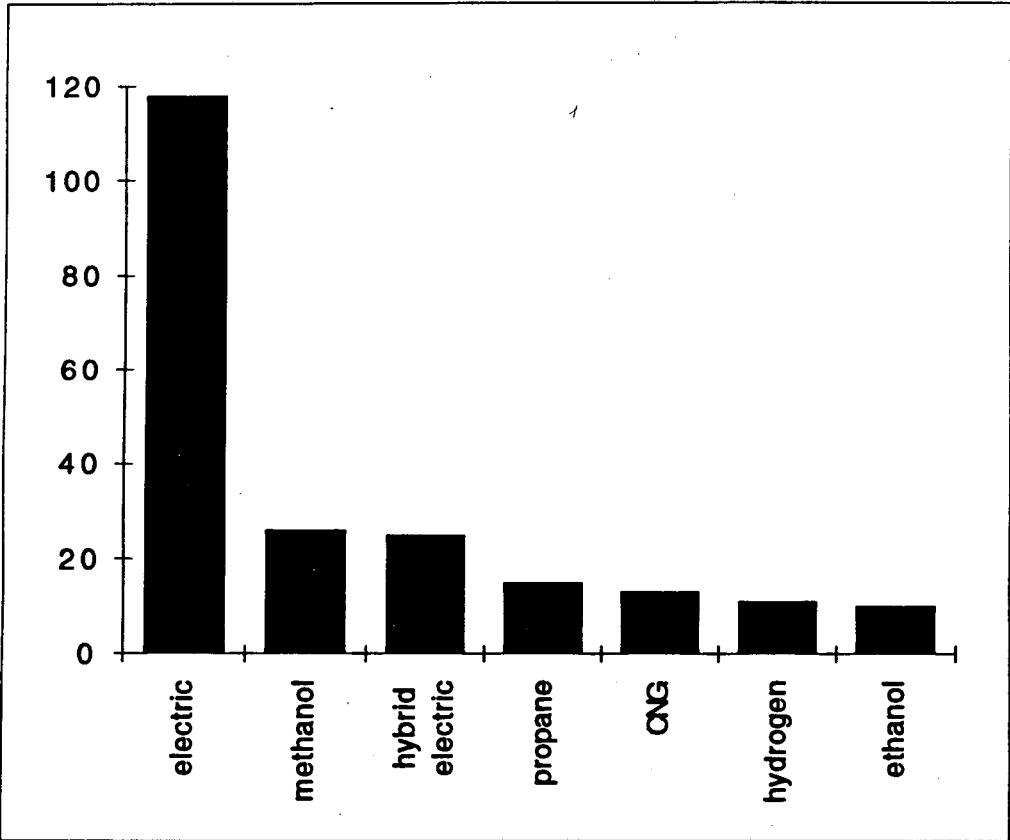
9 and 34 Alternative fueled vehicles are not yet practical to
replace gasoline

	before	after
Strongly agree	11	12
Agree	66	55
Not sure	88	25
Disagree	51	100
Strongly disagree	13	40
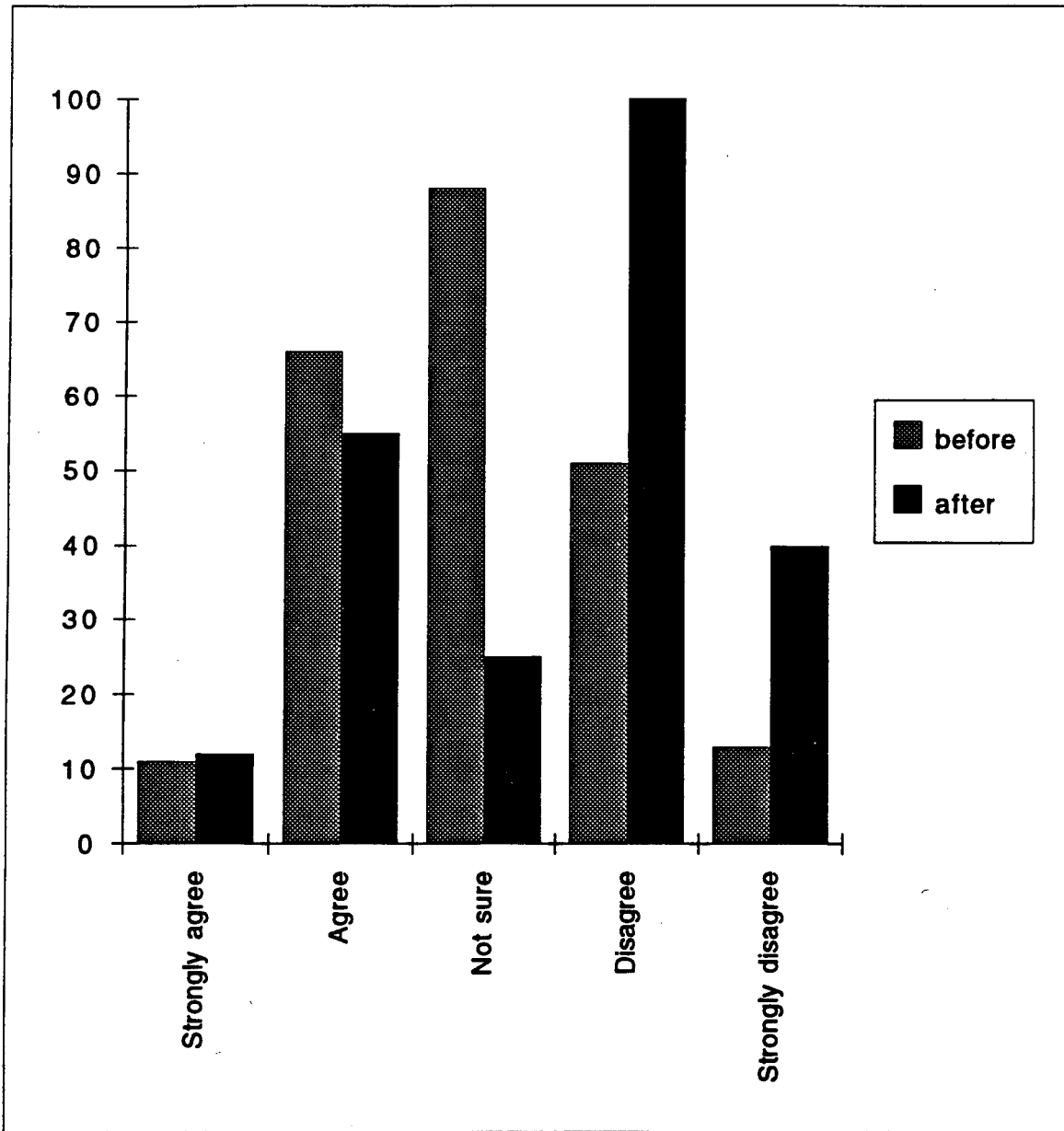
35 Did your opinion of EVs change after driving?

Much better	47
Better	96
No change	55
Worse	31
Much worse	6
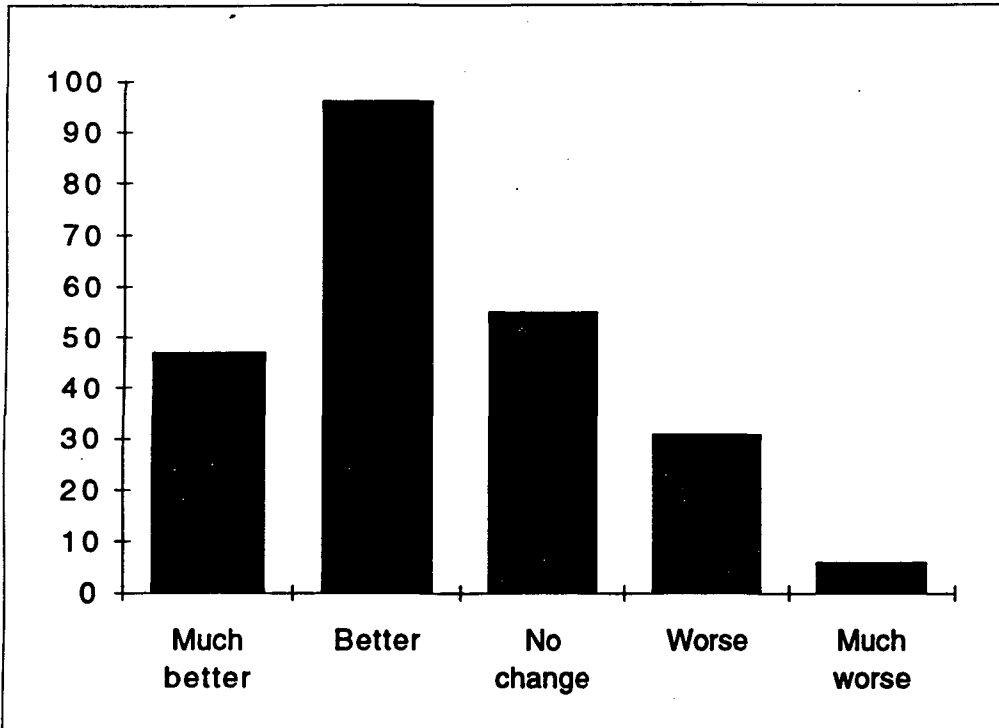
36 Did your opinion change of CNG after the drive test?

Much better	38
Better	90
No change	80
Worse	24
Much worse	1
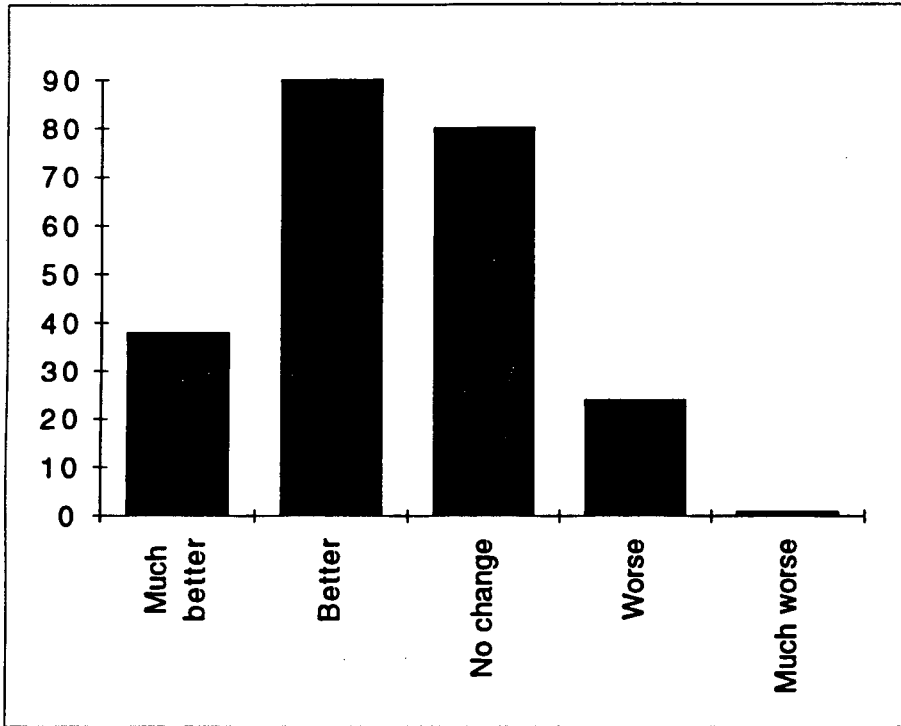
37 Did your opinion change of methanol after driving

Much better	56
Better	85
No change	78
Worse	13
Much worse	1
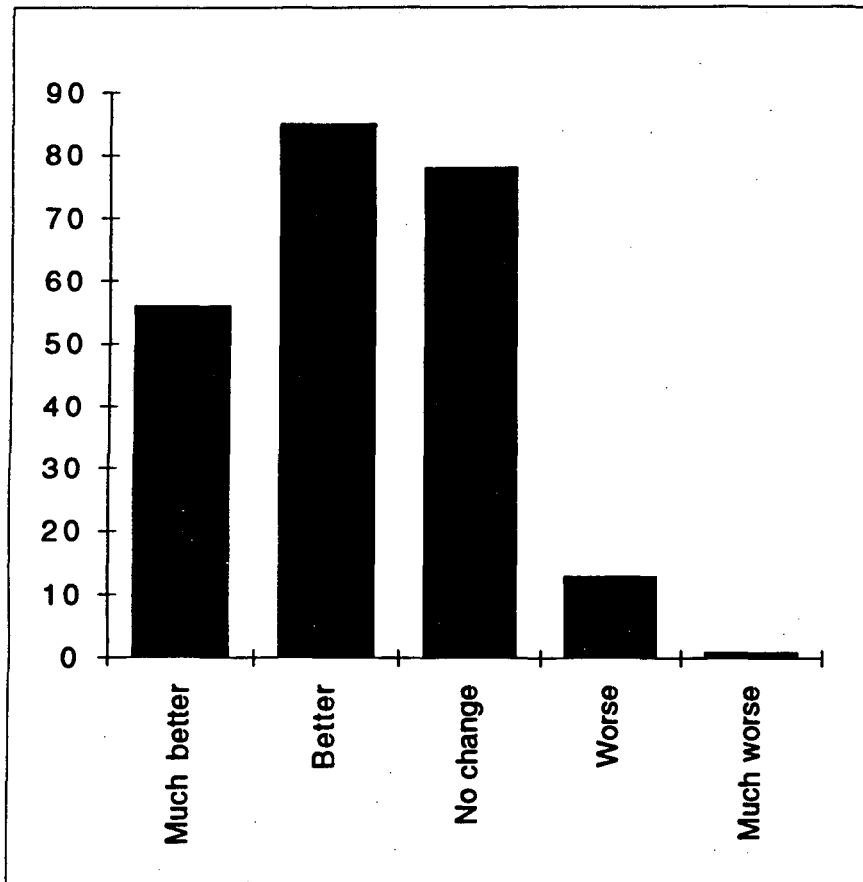
38,39 Post-test drive vehicle choice

	1st Choice	2nd Choice
CNG	23%	43%
Methanol	40%	30%
EV	37%	27%

1st Choice

37.00% 23.00% 40.00%

■ CNG
□ Methanol
▨ EV

2nd Choice

27.00% 43.00% 30.00%

■ CNG
□ Methanol
▨ EV
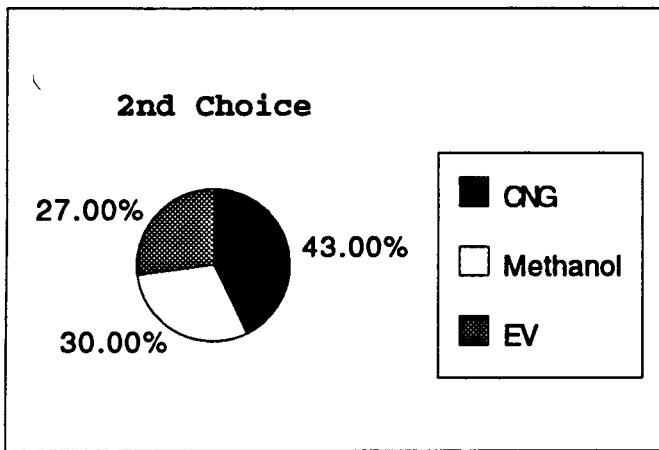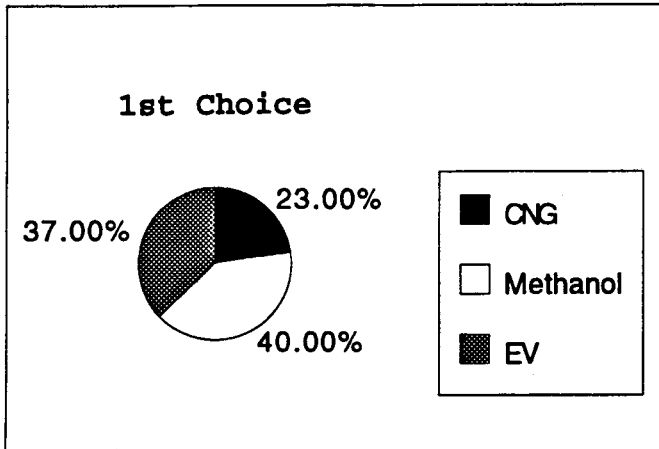
40 Would you consider adding an AFV to your household fleet
if you couldn't substitute?

Yes   159
No   75
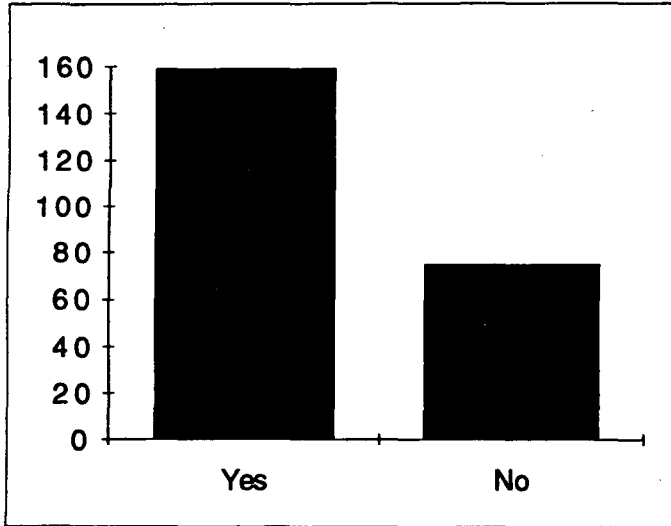
46 Evs have a range which will limit their use to around thirty
miles of home. How do you feel about that ?

Crazy- wouldn't work   46
I can imagine adjusting   157
No problem   32
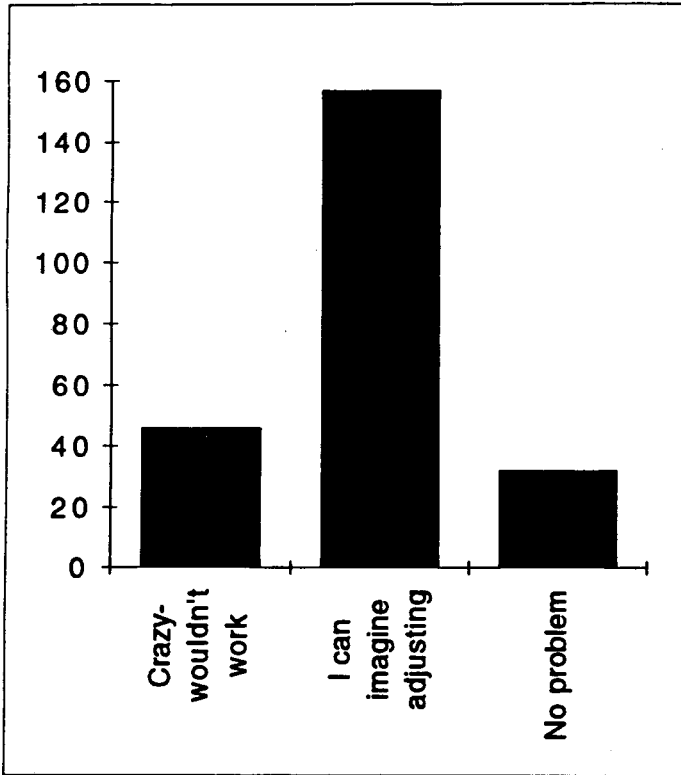
47 CNG range may be 1/2 to 2/3 of Gasoline but cost 20-30 cents
less a gallon. Which is more important to you, range or fuel cost?

Range	116
Fuel costs	116
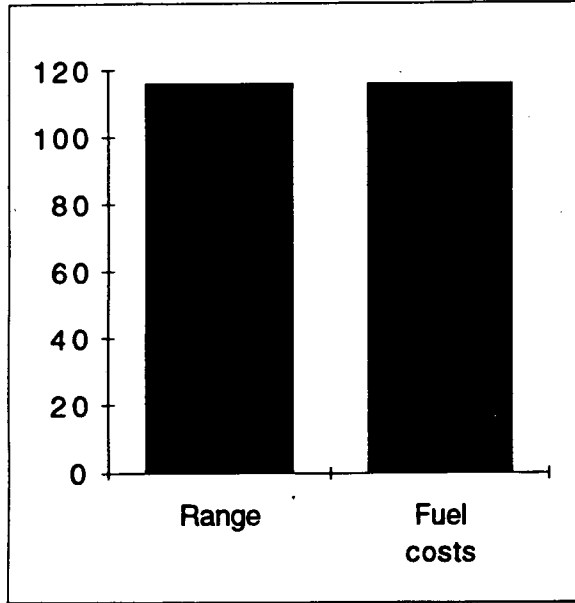
48 How much more will you pay for methanol than gasoline if more powerful.

0 cents	109
10 cents	93
20 cents	27
35 cents	3
50 cents	2
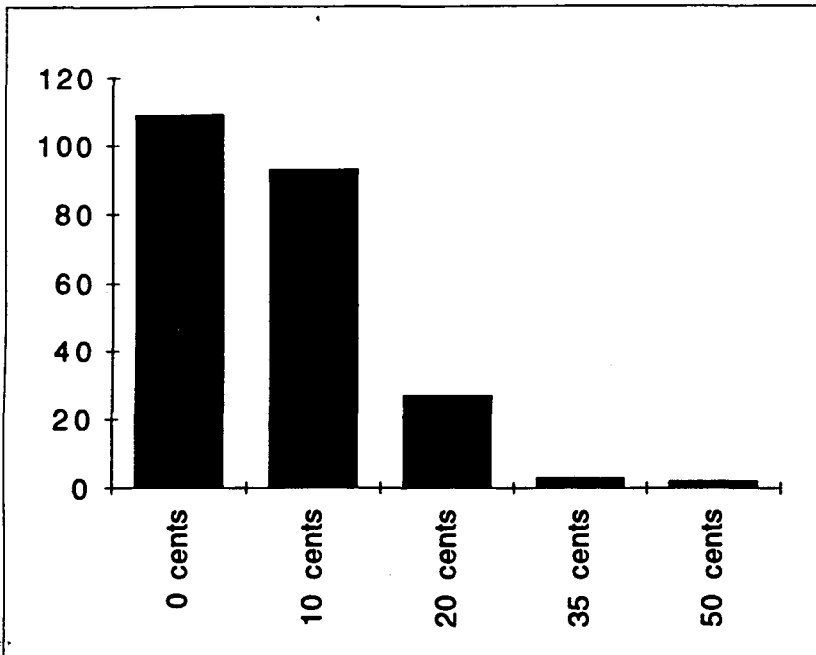
49 If fuel and repair bills of EV were 1/2 of gasoline,
would offset less range?

Would not offset	81
Would offset	113
Would more than offset	40
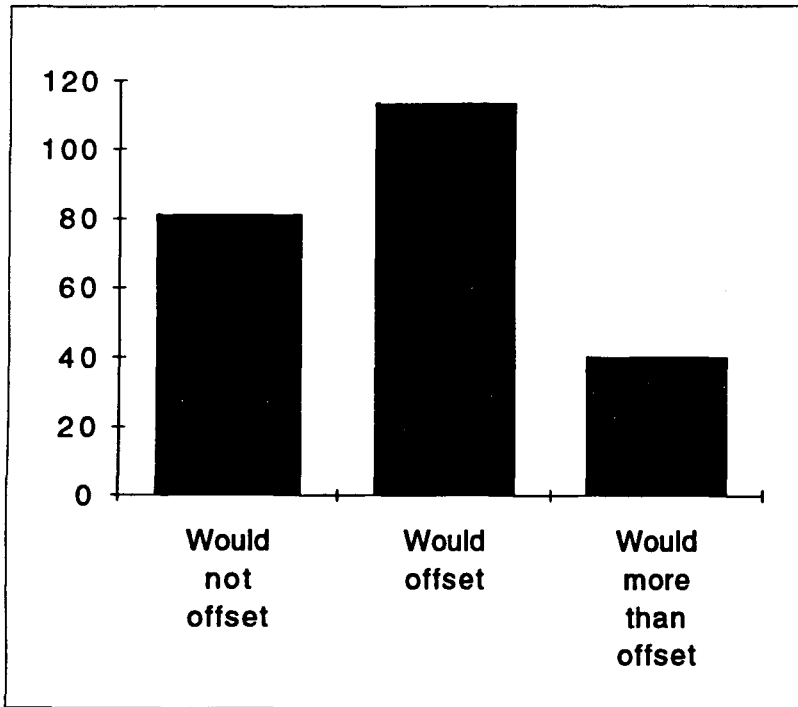
50 What do you think of home recharging?

Don't like idea (go to 51)	25
I like idea (go to 52)	197
No place at home (go to 53)	10
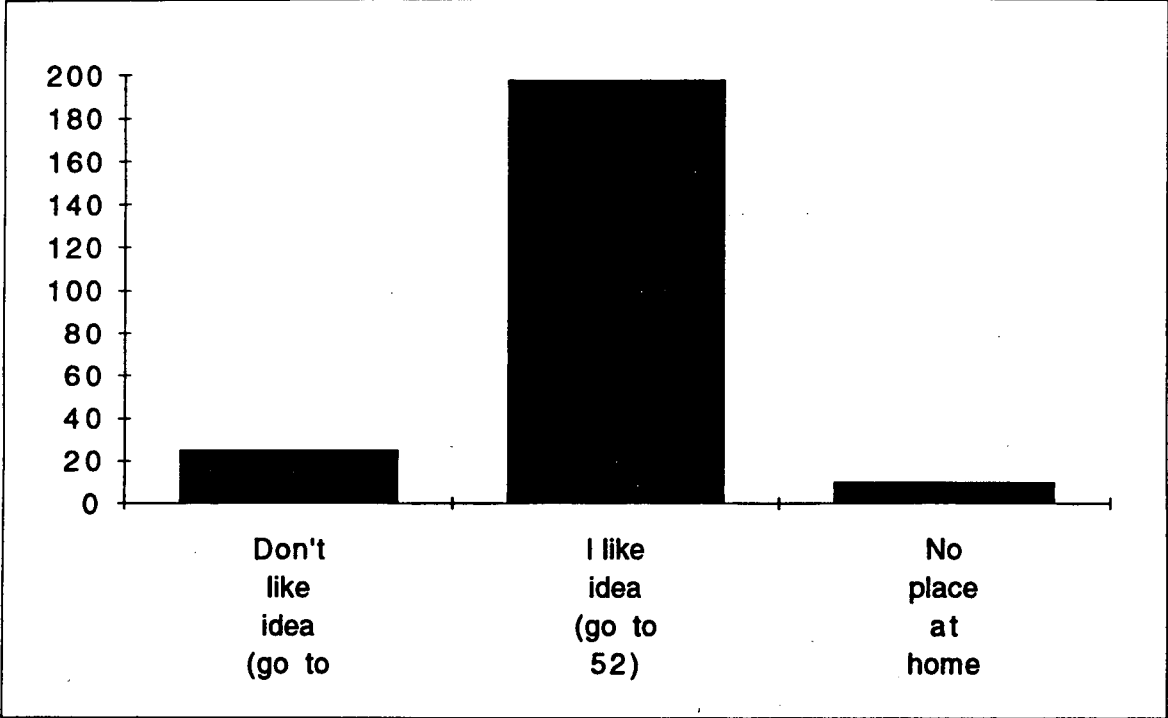
51 Why don't you like the idea of home refuel?

sound dangerous	1
I won't be home to refuel	13
I don't want to hook, unhook	10
other	6
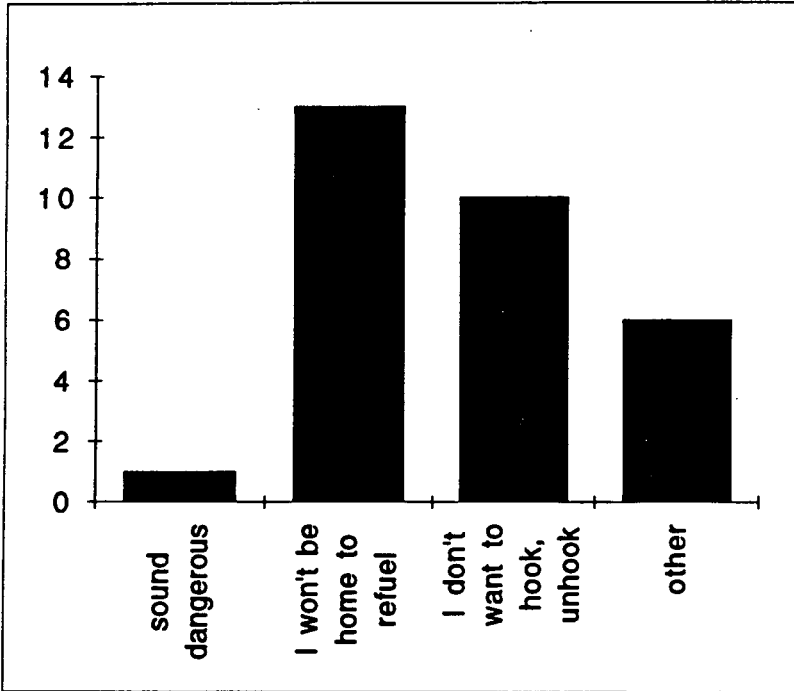
#52 I like the idea of home refueling because..

Won't need service station	54
Idea of monthly utility bill	12
Sounds cheaper	20
Full tank each morning	29
Other	6
1 and 2	5
1 and 3	7
1,4	16
1,5	1
2,3	1
2,4	2
2,5	4
3,4	4
3,5	1
4,5	1
1,2,3	5
1,2,4	9
1,2,5	
2,3,4	1
2,3,5	
2,4,5	
3,4,5	
1,3,4	3
1,4,5	1
1,3,5	
1,2,3,4	16
1,2,4,5	
1,3,4,5	
2,3,4,5	
1,2,3,4,5	

53 The need to replace batteries is:

absolute barrier	3
major barrier to purchase	36
makes me hesitant	82
like any other cost	110
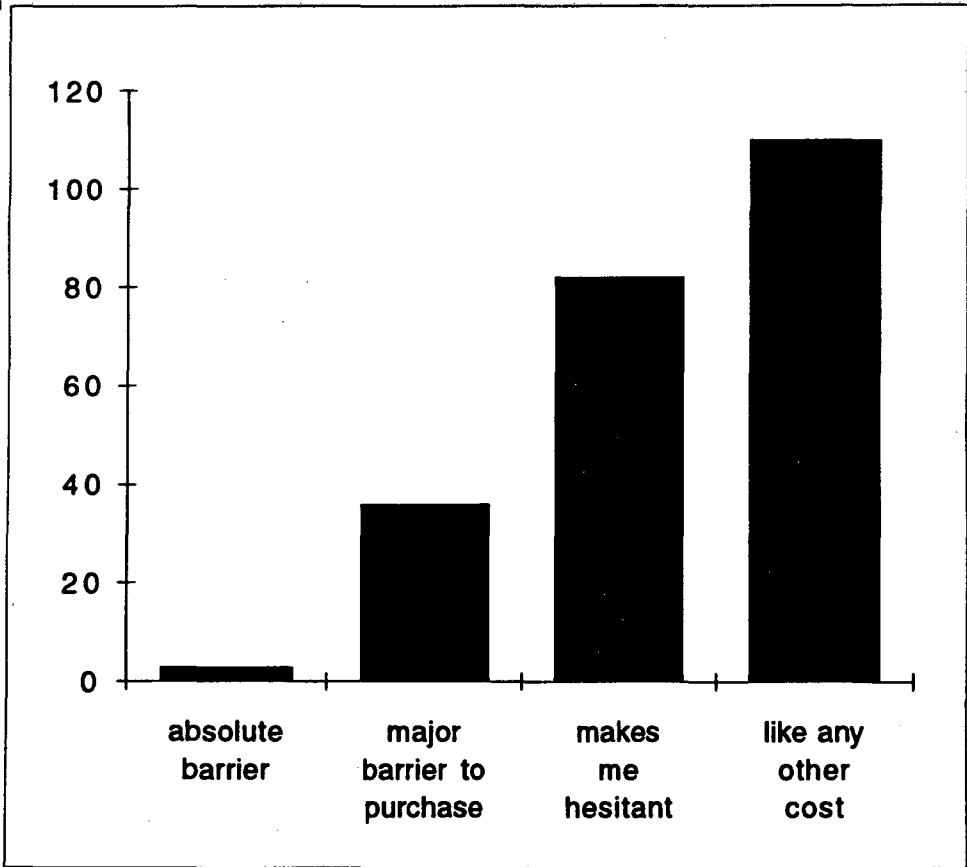
54 How significant is loss of trunk spce in CNG vehicles

Absolute barrier	14
Would be hesitant	115
Minor issue	74
No problem	27
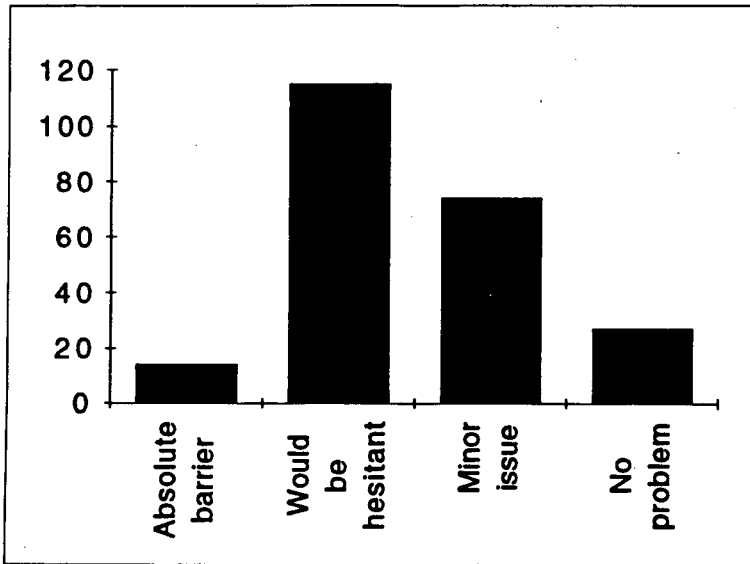
55 At what levels of availability would you consider CNG
 or methanol sufficiant for you?

Most stations in US	35
1/2 of stations in US	32
Frequent on major roads	91
My local station	26
Many stations in LA area	48
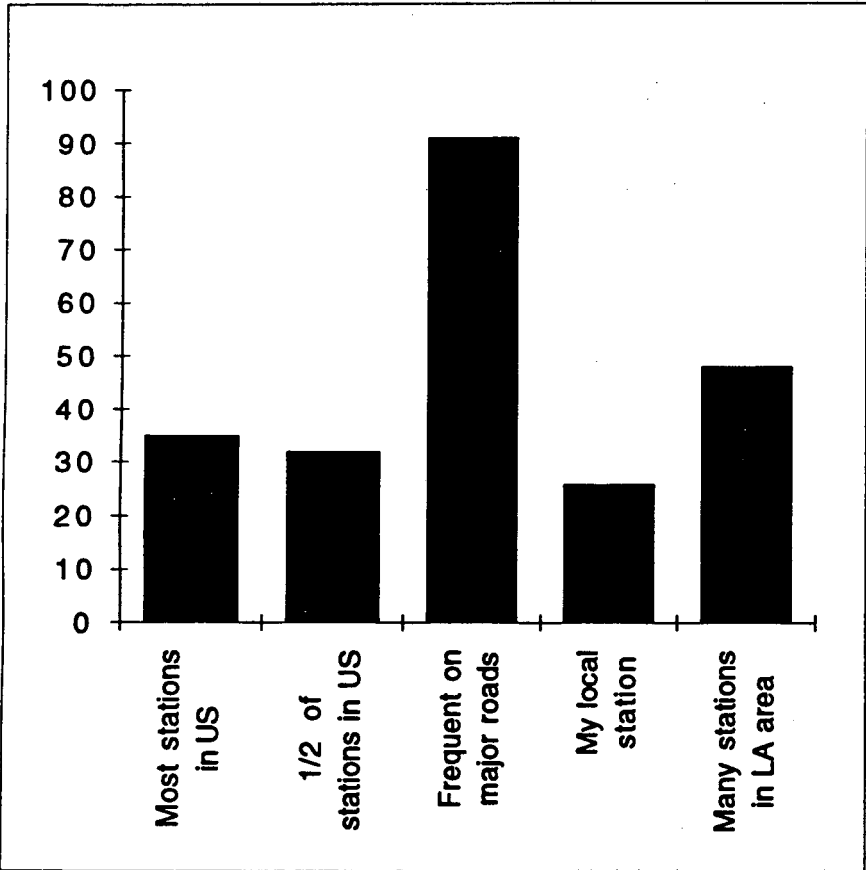
56 What would you expect of the resale value for AFVs?

excellent	5
above average	26
average	67
below average	73
poor	42
no opinion	22
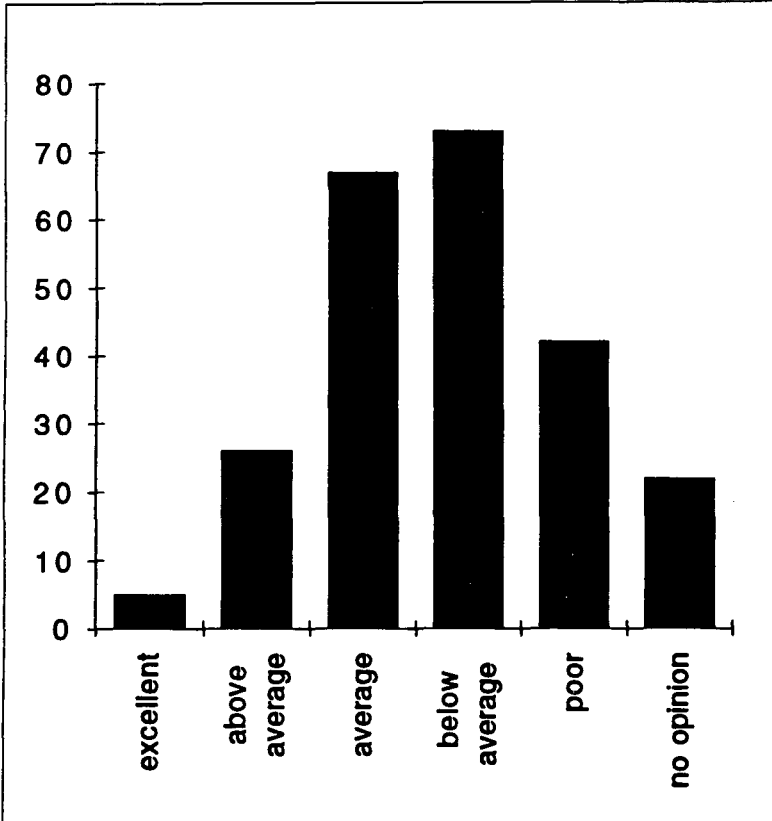
58 Would you purchase if a "green" car cost $1000 more than the same make gasoline?

Yes, right thing to do	64
If others were also buying	48
If government insured	51
If majority bought	22
No, until economical	30
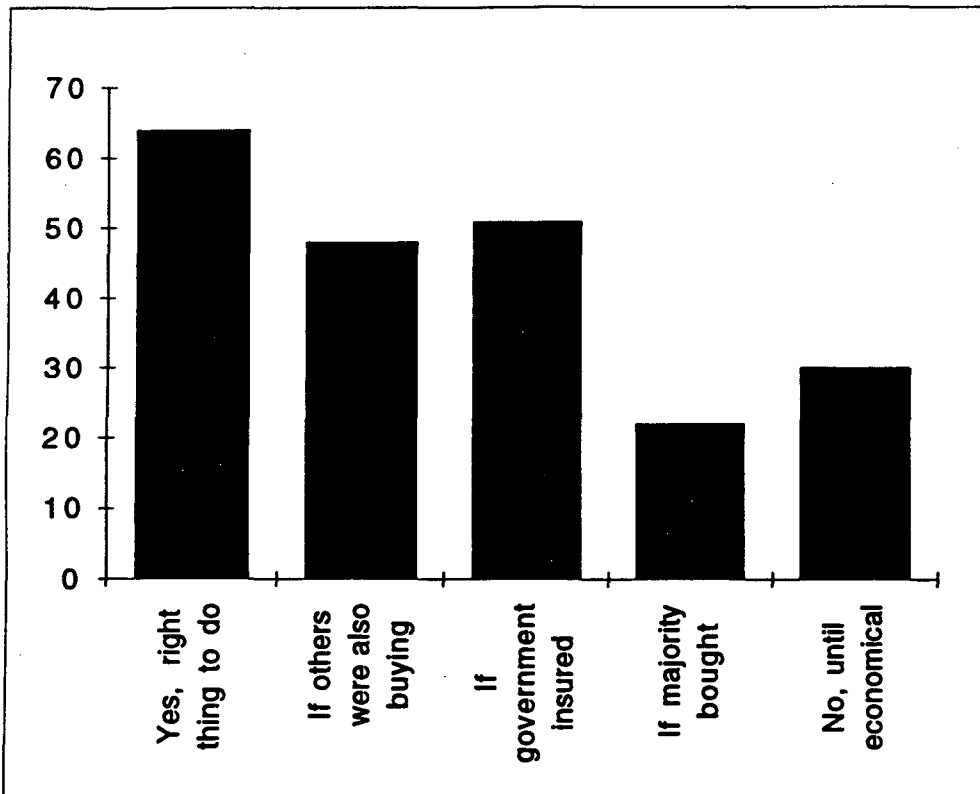
60 If you could affect air quality, what would you do?

|	
carpool to work	37
bicycling and walking more	14
purchase AFV	124
use mass transit	34
other	7
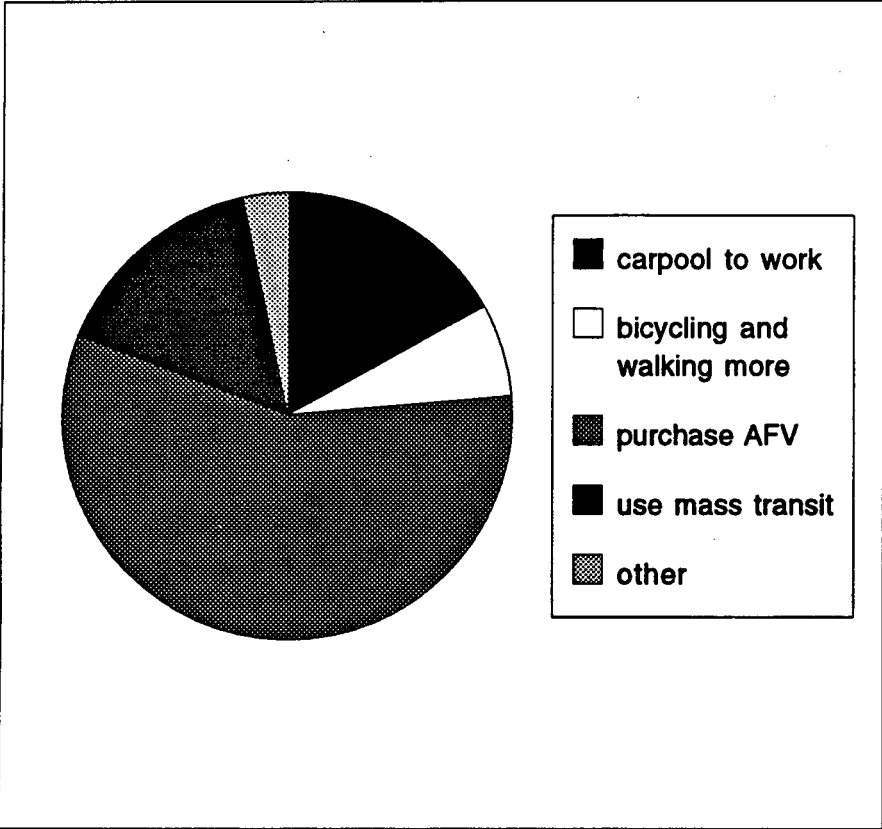
Cross tab of question number 9 - "are AFVs not yet practical"
and question number 14, "how much is your car body type
similar to the EV in this test".

	strongly agree	agree	not sure	disagree	strongly disagree
very different	8	33	41	24	3
different	0	17	21	10	2
similar	3	8	18	11	4
very similar	0	6	2	5	3
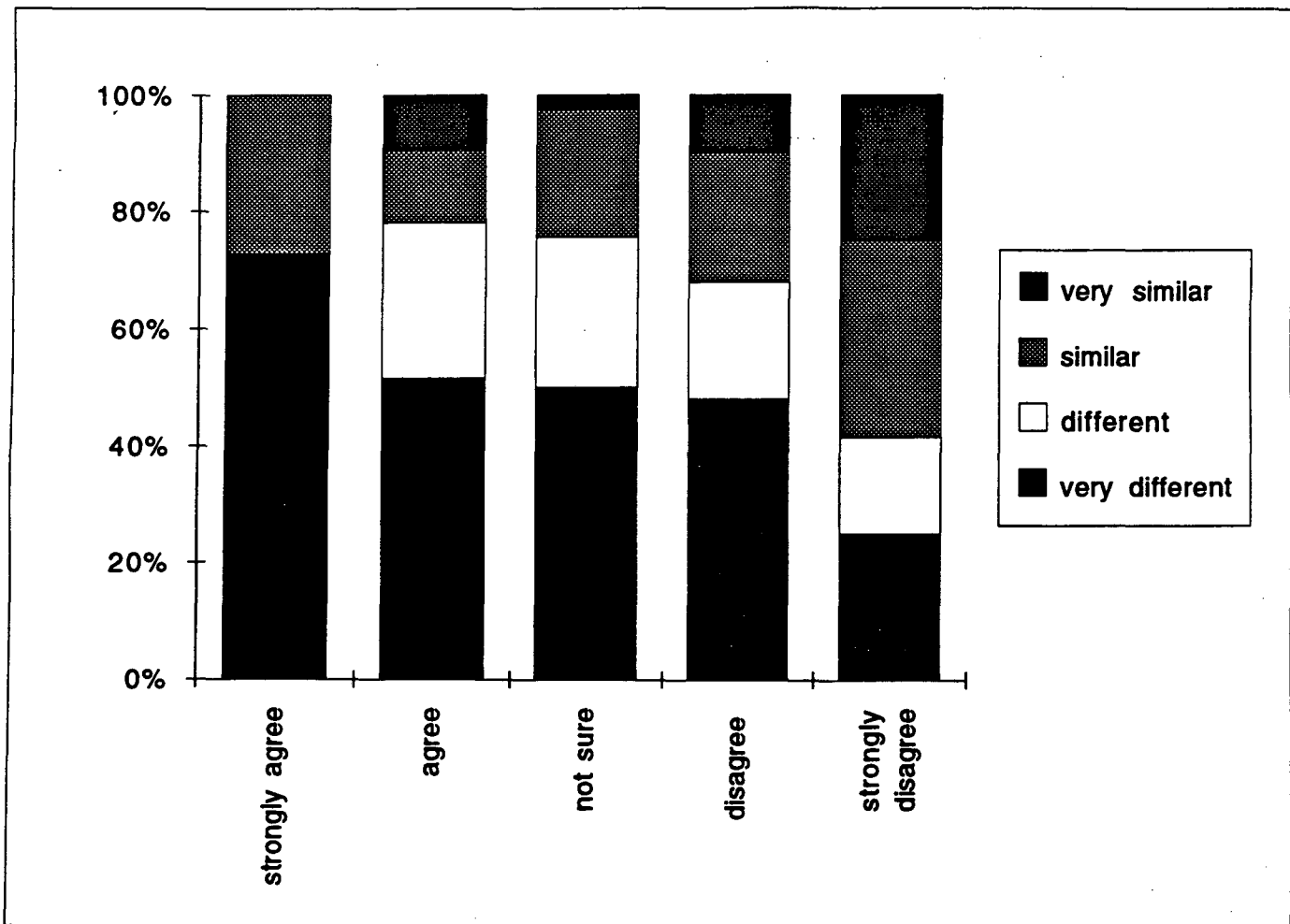
This cross tab shows how the group of participants whose personal
vehicle was similar to the test EV also were more likely to
strongly disagree that AFVs were not yet practical.
Note that question 9 was asked before the test drive.
The chi square probability for this test was .085

Question 38	CNG	Methanol	EV
very different	0	1	6
different	3	4	5
similar	7	22	31
very similar	9	18	11
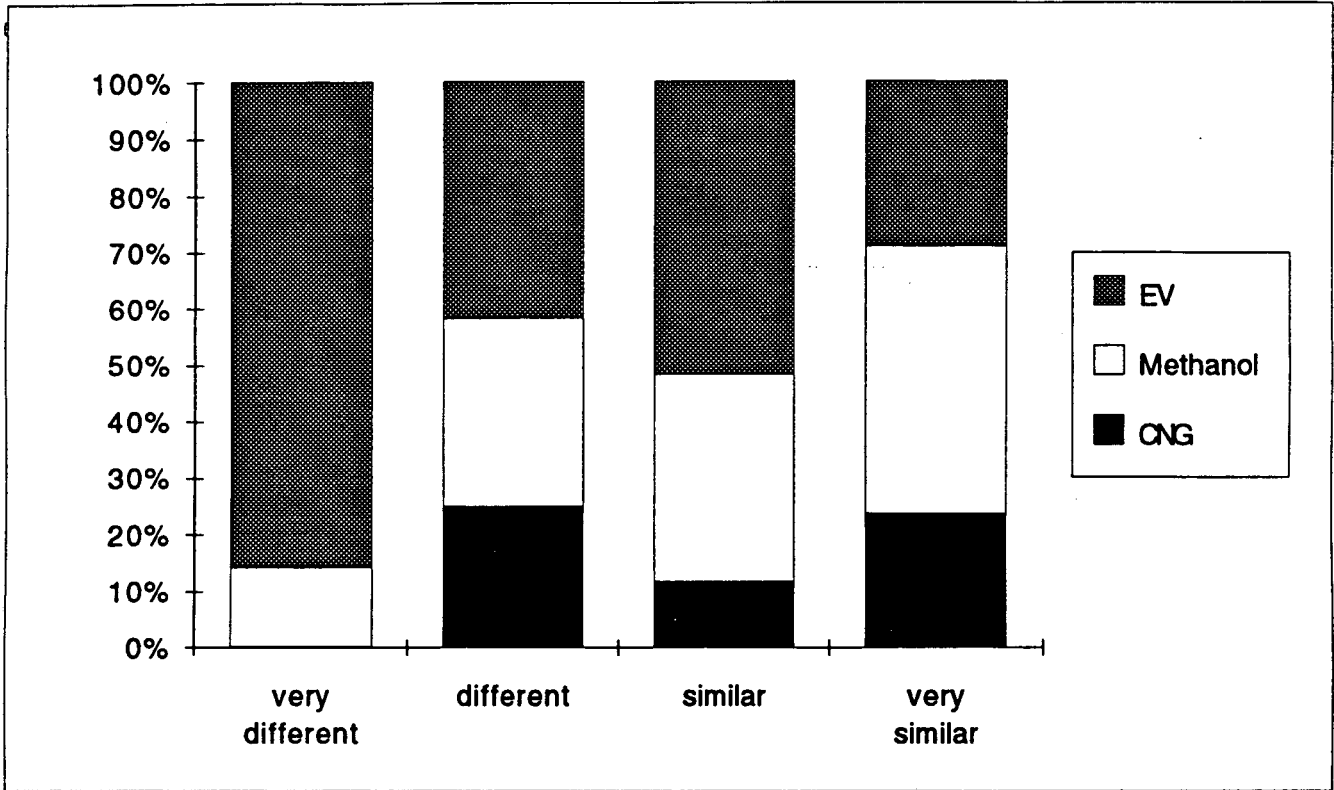
This graph shows how current body style affected defection from EV.
A sizeable group of defectors to methanol had larger cars and from previous tests
proved to be older drivers (55+) as well.

This is a cross tab of question 14, how similar is the body style of your
vehicle to that of the test drive EV with question 38, which vehicle
from the test drive would you choose first.

| Question 38	CNG	Methanol	EV
very different	25	51	35
different	11	19	22
similar	11	14	21
very similar	5	3	8
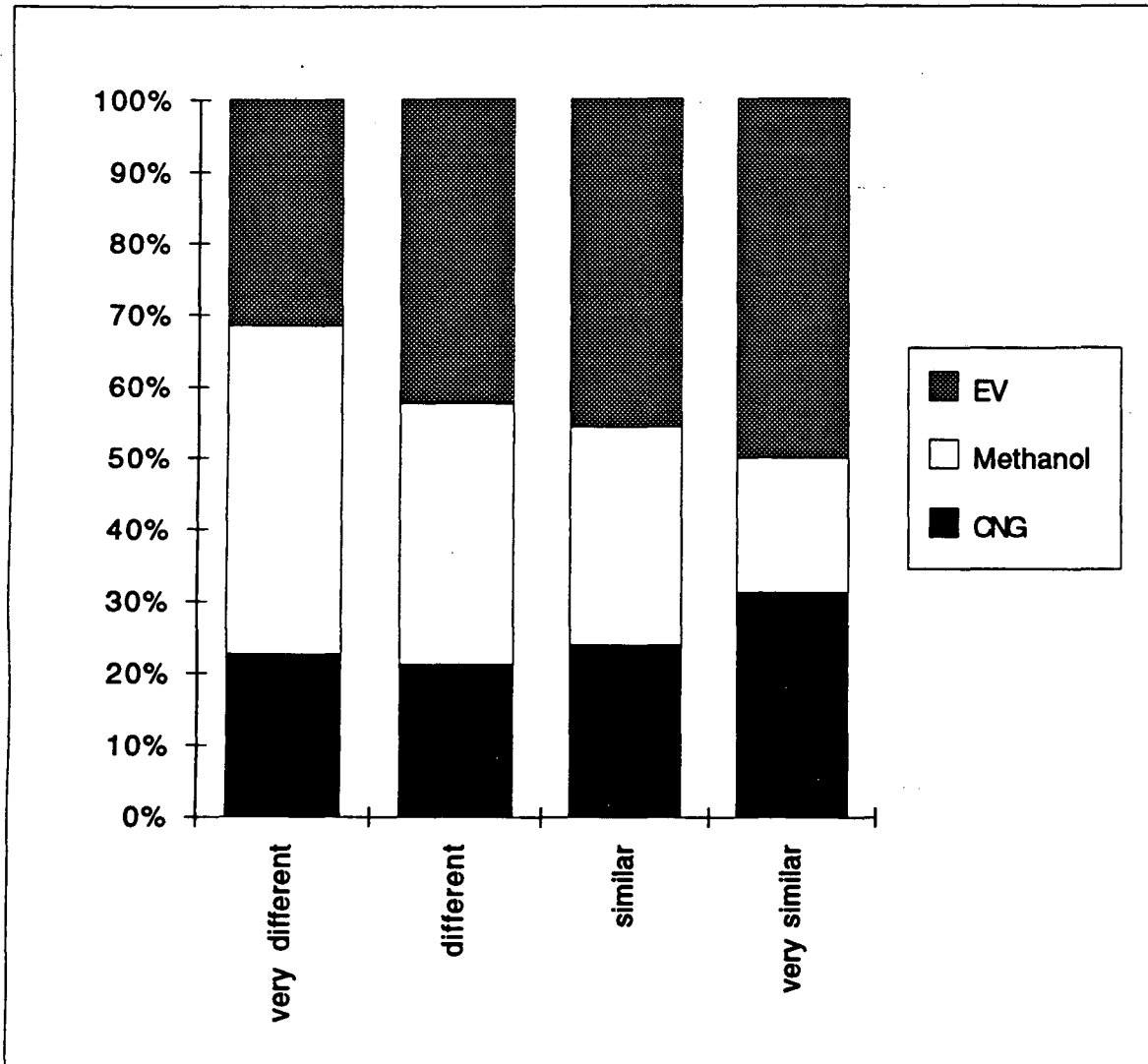
This column graph of the crosstab shows how there was a tendency
of those who now drive cars with similar body types to the EVs used in the test drive
to also choose EVs as a first choice. Those with non-EV body types
showed a stong tendency to choose methanol.
The Chi square for this cross tab was .287.

Cross tab of question 49 , "if EV fuel and maintenance costs
were 1/2 of a gasoline car would that offset the limited range" with
question 14, "how similar is the body style of the test EV to your personal vehicle.

|	would not	would	decidely
very different	43	53	14
different	16	31	5
similar	11	19	16
very similar	7	5	4
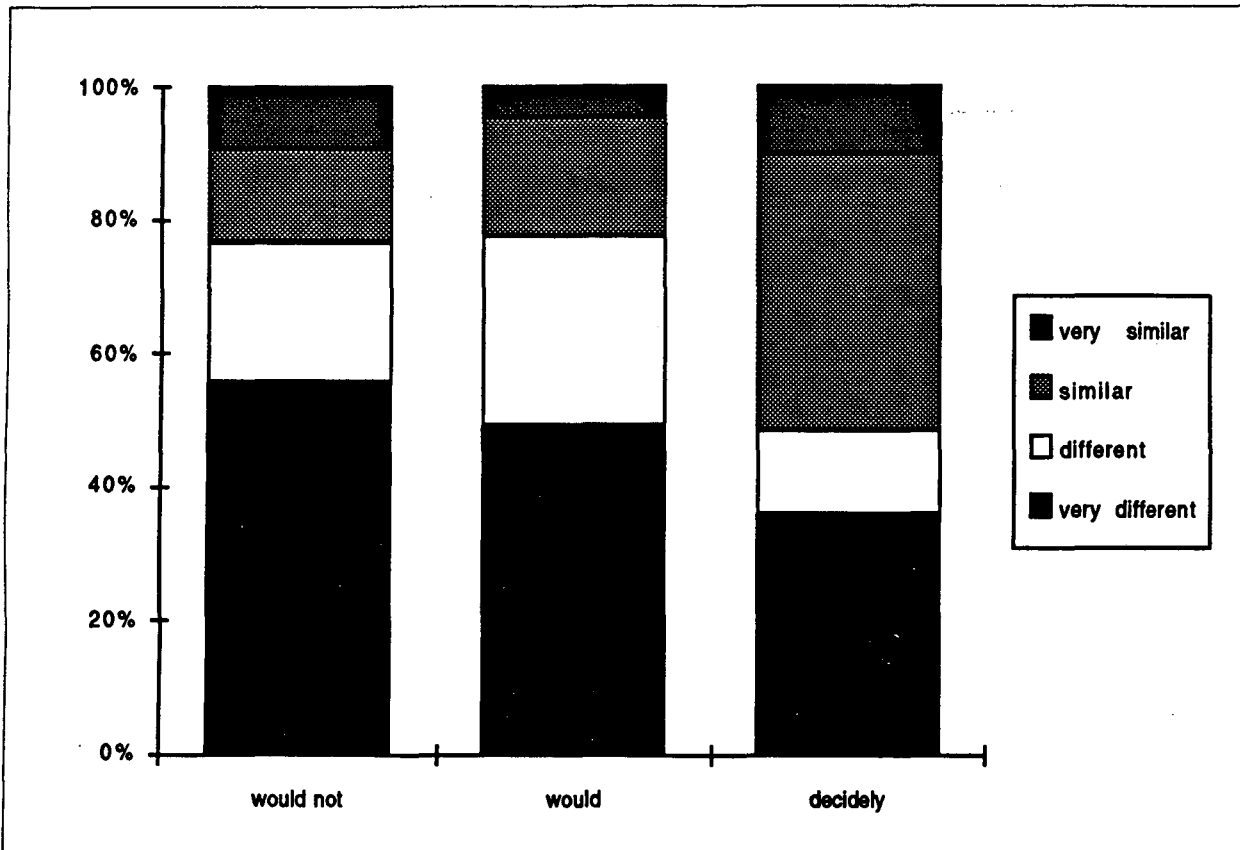
This cross tab shows that participants who owned vehicles most
similar to the EVs used in the test drive were more likely to
value fuel cost and maintenance savings as well as adjust to
limited range.

The chi square for this test was .008

This table is a crosstab of question # 58, which asks participants about what historical circumstances they would consider purchasing an AFV which cost 1000 dollars more than an other wise equivalent conventional gasoline fueled car, with question # 38, their choice of cars after drive test.

38

	CNG	Methanol	EV
right thing to do	13	14	37
if other were doing it	16	19	13
if government insured	9	24	18
once majority switched	3	15	4
not until economical	5	14	11
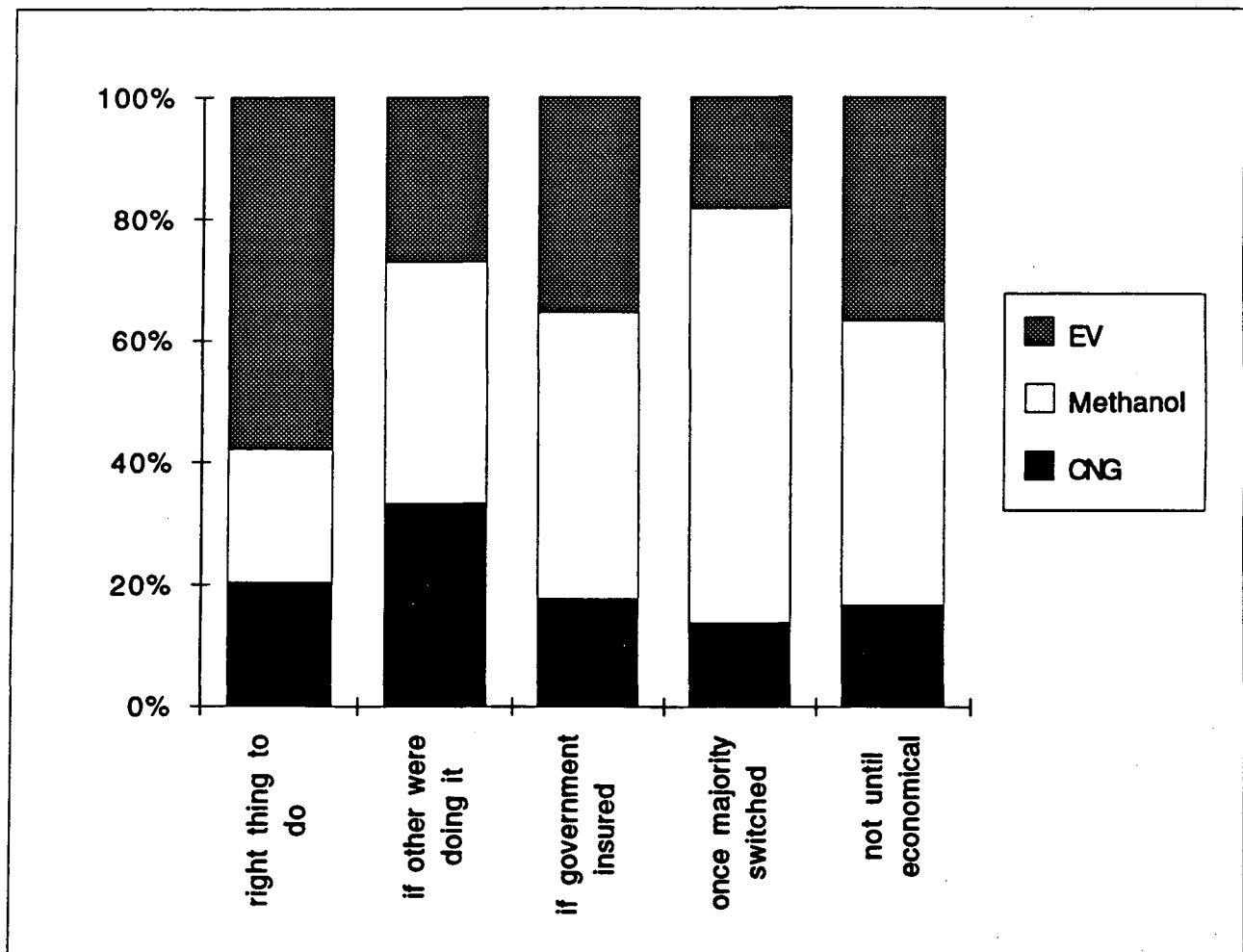
This percentage chart show a tendency of EV choosers to indicate moral reasons would guide choice while more methanol choosers said economics would guide their decision. The chi square for this crosstabb was .008.

This is a cross tab of age by question # 38, which of the test vehicles would be your first choice.

| Age	CNG	Methanol	EV
0-34	16	18	23
35-44	13	14	18
45-54	6	16	25
55-64	10	28	16
65+	8	17	7
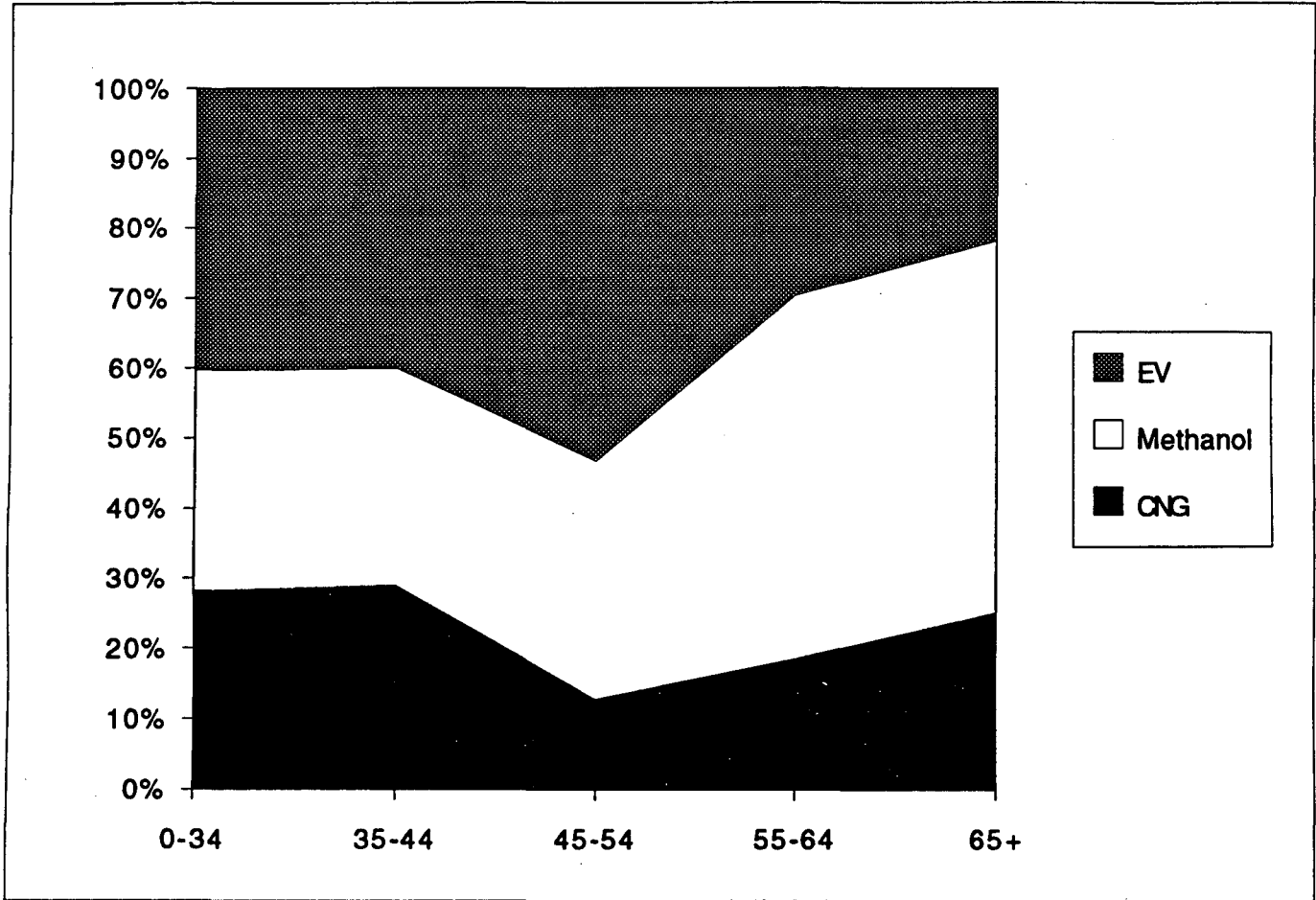
This column graph of the crosstab shows how age group 45-54 shows a
strong tendency to choose EVs and a tendency not to choose CNG.
Also there is a tendency for those over 54 to choose methanol and reject EVs.

The CHI square for this was .044

The following is a cross tab of the pre-test car choices of 157 persons who prior to the test
drive said they were aware of all three types of vehicles used in the test, compared with
their post-drive choices in question 38.

AFV buy prior to drive

|	prior CNG choice	prior Methanol	prior EV choice
EV choice after	4	3	53
CNG choice after	7	5	20
methanol choice after	15	5	45
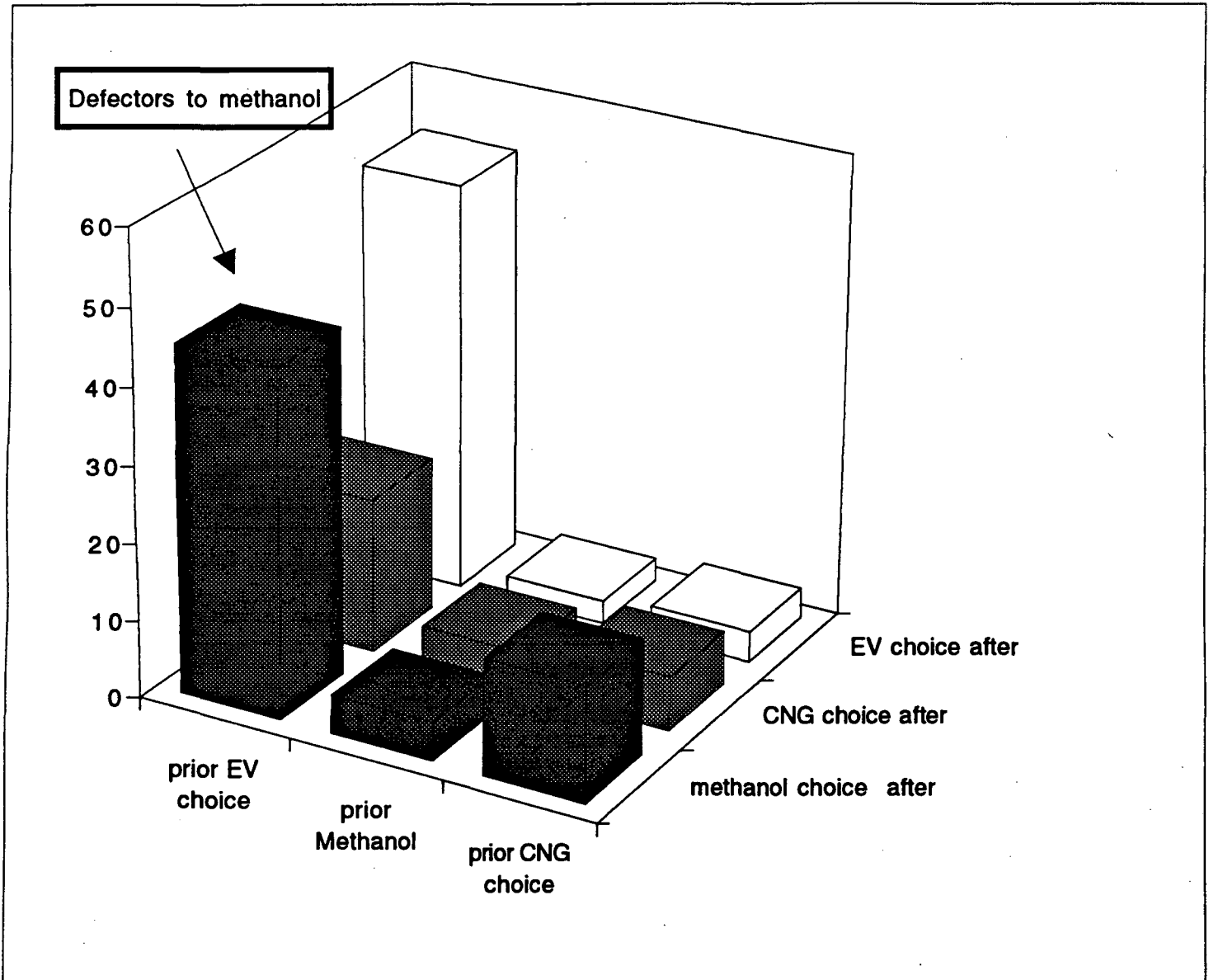
This graph shows the large number of defectors from EV choice prior to
methanol after. We attribute this defection primarily to prefered
body size and type.

This is a cross tab of the 118 persons who choose EVs prior to the test drive., their answers
to question 14, how similar is your cars body style to that of the methanol test
car by the post drive choice in #38.

Before the drive test we asked participants what kind of AFV they would prefer,
and 50% of the participants chose EVs. A large number of those eventually
defected to another vehicle type after the drive. Below is a table of age by defection rate.

|	0-34	35-44	45-54	55-64	65+
Loyal	14	11	17	8	3
Defector	17	12	8	20	8
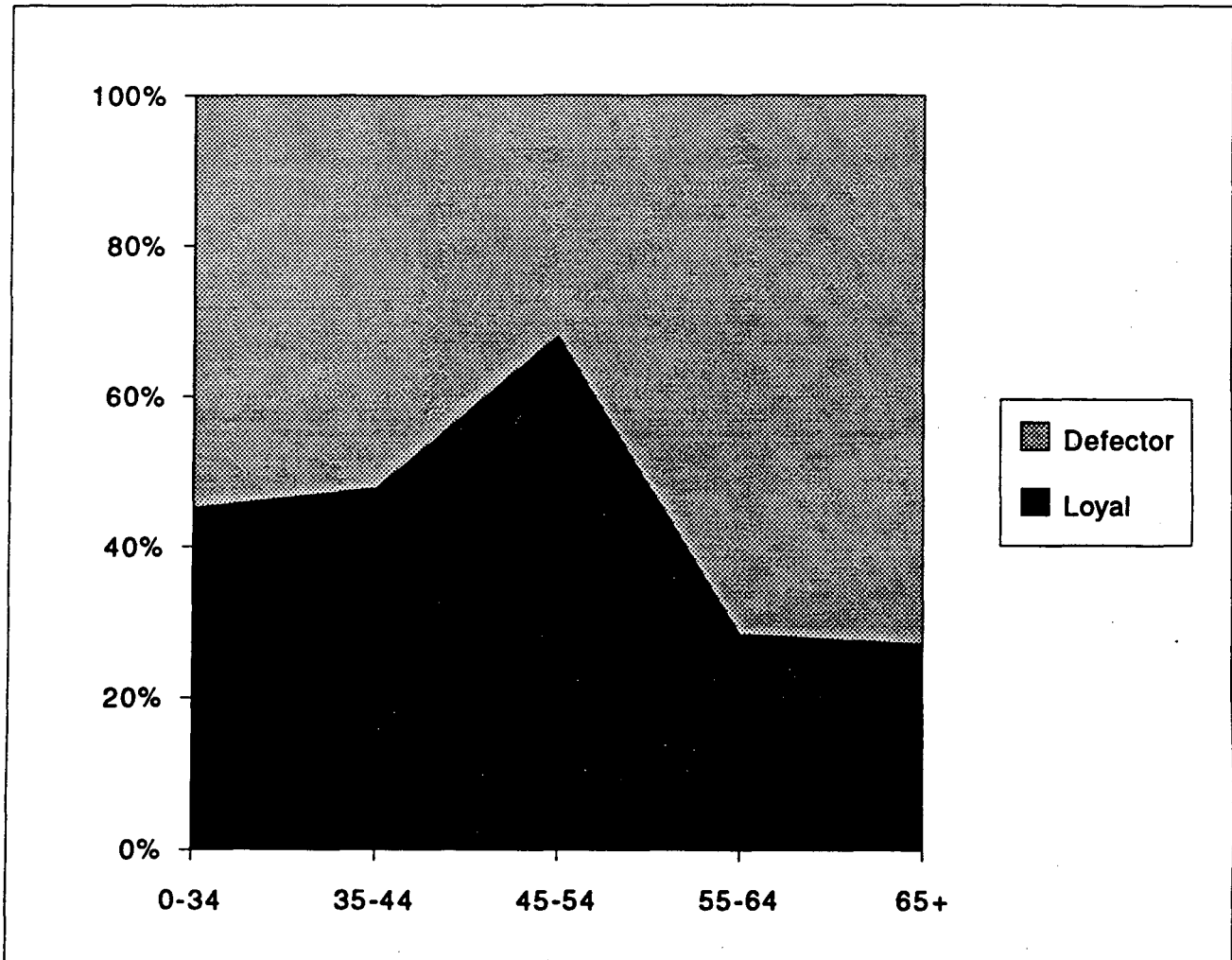
This graph of loyalty and age shows a strong tendency of older drivers to
defect to another fuel choice after the testdrive. While those in 45-54
group show strong loyalty to the EV. The Chi Square was .01

Later test show that loyalty was related equally to age and preferred car type.

This is a cross tab of age by response to question 58,
under what sort of historical circumstances would you purchase an
AFV if it was 1000 dollars more than a gasoline vehicle.

Age	0-34	35-44	45-54	55-64	65+
right thing to do	16	16	14	15	3
if other were doing it	11	7	8	13	9
if government insured (	10	11	7	13	10
once majority switched	6	1	5	6	4
not until economical	7	4	11	6	2
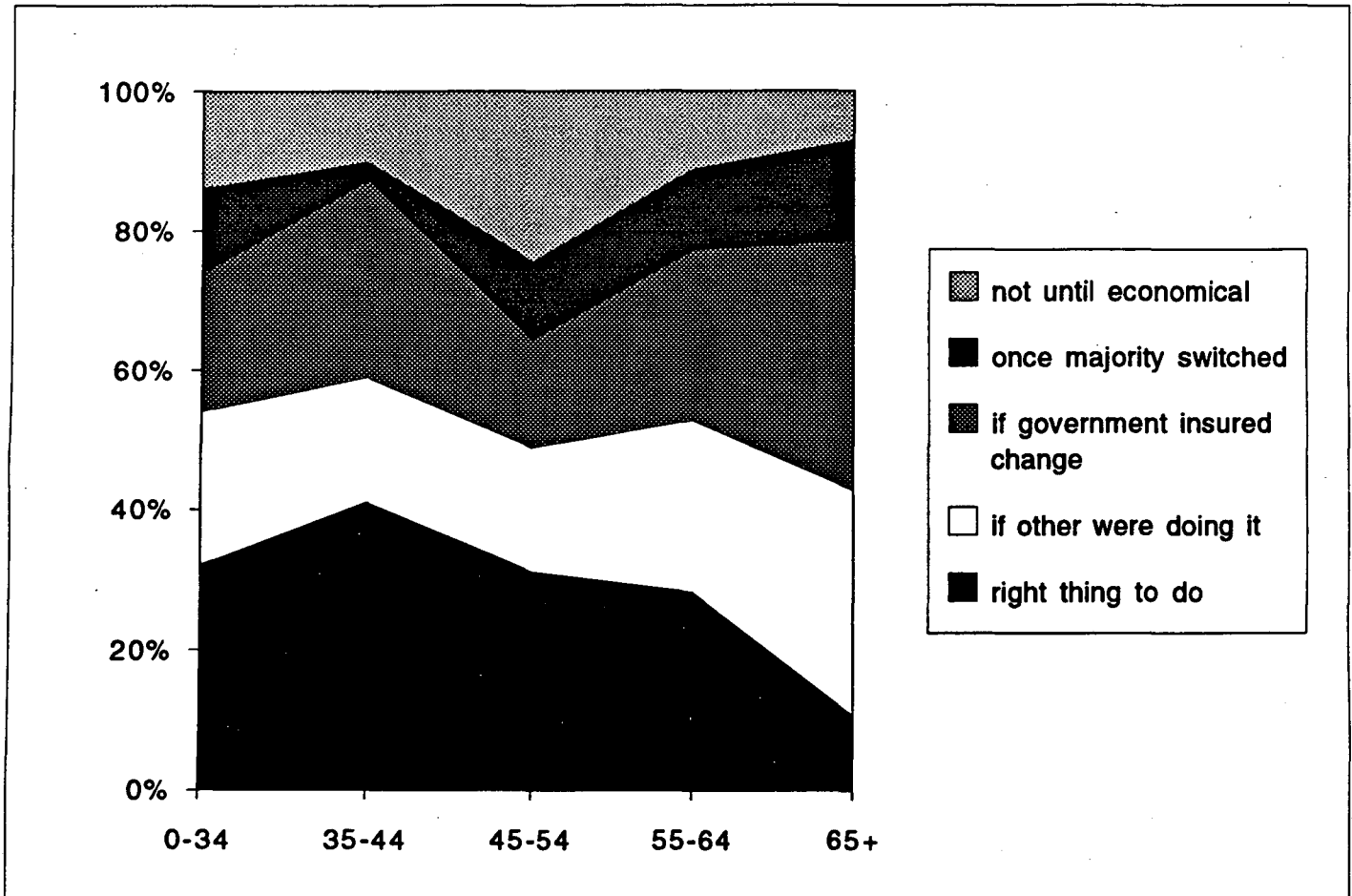
This chart shows an apparent anomaly, that the age group 45-54 show
a trend towards viewing a decision as purely economic, but is also the age group
most interested and loyal to EVs. Further analysis found that the age and choice
relationship proved stronger than the economics only opinion. We conclude that
this group wishes to sound less idealistic than it really is.