Environmentally - Active Consumers' Preference for Zero-Emission Vehicles: Public Sector and Marketing Implications

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Abstract

Certainly one of the most important public sector issues facing policy makers and marketers is that dealing with the marketing of zero-emission vehicles (ZEVs). A *public policy- desirable* and sometime mandated product, uncertain technology, and unknown demand in the market place continue to pose enormous public sector marketing questions in this area. The present study utilises diffusion theory to extend previous clean fuel vehicle research through an in-depth and very comprehensive investigation of environmentally active consumers' response to various public policy incentives, promotions and endorsements aimed at facilitating ZEV purchases, along with these consumers' knowledge and preference for ZEV configurations at a level of specificity not previously studied. Results show that enormous public policy problems exist in terms of the trade-offs that even environmentally active consumers are willing to make for a cleaner environment, though the provision of *combinations* of public sector incentives does influence share of preference. Implications and directions for public policy and for marketing action are given.

Key Words: Consumer Preference, Zero-emission, Diffusion

Introduction

The present study investigated perhaps one of the most important and far-reaching issues of the environmental studies area ever to touch the social marketing and public sector arena—that dealing with potential consumer reaction to and purchase of proposed zero-emission (electric) vehicles {{Author's note: at present, *totally* electric vehicles represent the only *potentially* viable zero-emission technology. Throughout this article the abbreviation ZEV is used to characterise totally electric vehicles. Conversely, clean fuel vehicles (CFVs) use technologies other than electric, or in combination with electric technology, and emit emissions—although these are lower than for conventional gasoline powered vehicles.}}.

This area of study is a particularly important one for marketing and the public sector for a number of reasons. These include the enormous environmental trade-offs and debates that accompany the issue, the public sector mandates surrounding product development, the dependency on anticipated consumer demand for vehicles not yet produced, the unknown effects on consumers of various components of the marketing mix—for example, of public sector promotions and incentives such as subsidised pricing, loans, tax cuts, rebates on energy bills or special express lanes-- aimed at fostering consumer purchase, and a relative dearth of consumer research which can be shared in a public setting and evaluated to help answer these questions.

The aim of the current study was to identify factors that would drive the preference--adoption process of Zero emission (ZEV) vehicles among *environmentally active* consumers. While early consumer research has only begun to investigate the potential market environment for clean fuel vehicles (CFVs)—(see for example Bunch, Bradley, Golob, Kitamura, and Occhiuzzo, 1993;Calfee 1985; Segal 1995; and Ewing and Sarigollu 2000), such studies, perhaps fuelled by the desire for larger market sales targeted by governmental mandates and production requirements of large automakers, have examined the desire for these products from a *general population*, and a "forecasting the larger market" perspective, and also appear not to reflect a theoretical orientation. For example, Ewing and Sarigollu's (2000) clean-fuel vehicle study in Montreal used a random sample of 1500 passenger car drivers, finding that general consumer interest and regulation were insufficient to create a market for clean fuel vehicles.

Yet there is a vast amount of diffusion theoretical literature that would suggest this sampling frame may be non-optimal at these early stages of knowledge. Given the fact that clean fuel vehicles, and particularly ZEV's represent a considerable innovation, it may potentially be much more appropriate and empirically interesting to examine the attitudes of those most predisposed to such innovation, and who, as innovators and particularly, opinion leaders, are more likely to aid the spread of adoption through expertise, example, word of mouth and so forth (Rogers, 1983), and to do so in some depth. As the issues surrounding ZEV adoption have a huge potential impact on consumers and public sector agencies alike, this is a key area for further and *better-targeted* research.

This paper contributes to further knowledge by examining consumer preference and market potential for ZEVs from this diffusion theory and marketing orientation perspective. The relevant research literature from these perspectives and that concerning adoption of technology and environmentally friendly products (including ZEVs) are first discussed, followed by the study methodology, key findings and marketing implications.

Background and Literature

Marketing scholars and practitioners have long examined the application of marketing to public sector issues (Kotler 1987; Kotler and Roberto, 1990) and have studied the marketing and public policy interface in a variety of areas. Of particular concern to the present investigation are studies that have examined the impact of consumers' environmental awareness and activity as it relates to product purchasing (e.g. Balderjahn 1988; Burnett, Bacon and Hutton, 1993;Henion 1976;Schwepker and Cornwell, 1991) and the tremendous challenge of renewable energy and "green" product strategies (e.g. Ewing and Sarigollu, 2000;Stisser1994; Suchwald and Agrawal 1993; Troy, 1993).

An important example of the latter research area is seen in public sector concerns about transportation's known adverse impact on environmental air quality (and renewable energy sources) that has led the United States, Canada, the European Commission and other governmental bodies to pass regulations to limit green house gas emissions occurring through vehicle transport. For example, the European Commission required benzene levels to be cut by 70 per cent and carbon monoxide to be reduced by one-third by 2005,and US Federal emission standards to be phased in between 2004 and 2009 require passenger cars, sport utility vehicles and light-duty trucks to be 75 to 95 per cent cleaner.

Given these efforts, major automakers in the USA, Japan, and Europe have been investing tens of billions of dollars annually in vast amounts of consumer, product, and infrastructure research and development to develop cleaner vehicles-- and particularly ZEV's (Ewing and Sarigollu 2000), and coalitions of government, large automakers, and battery manufacturers are engaging in battery research, and so on. Additionally all but minor electric utility companies have been actively engaged in their own research and planning activities in terms of dealing with potential demand on load, effects of recharging for electrically powered vehicles, and so on, again at huge economic costs. Many city planners also continue to be engaged in vast amounts of speculation, plan development and so on, in an effort to deal with the potential questions of CFV costs and requirements for construction, parking, transportation planning, and the like, adding up to an economic, public policy, and legislative issue of enormous scale.

Public sector policy makers, recognising that larger ZEV sales volumes will result in both substantial air quality benefits and reductions in demands on non-renewable energy sources, have attempted to facilitate the development of the ZEV market through a number of methods aimed at both (1) industry and public sector fleet buyers (including financing industry subsidies, or partnerships, purchase subsidies, loans, mandating purchases, and the like), as well as (2) the consumer market (through price subsidies for CFVs, taxes on gasoline, provision of express lanes, special parking and other benefits for CFVs purchasers). However, critics of these efforts point to the emissions effects, administrative burdens and increased economic outlay associated with these public policy efforts (Mills, 1994).

As Ewing and Sarigollu (2000,p.107) note, academic research on consumer preferences for CFVs has been extremely sparse (c.f. Beggs, Cardell and Hausman1981; Bunch et. al 1993;Calfree 1985;Segal 1995;Urban, Weinberg and Hauser 1996), and thus it is not known whether governments could play a vital role in swaying consumer preferences with the above, or similar measures.

The current study, which examines the preferences of environmentally active opinion leaders addresses both of the issues identified by Ewing and Sarigollu (2000), and extends previous research in a number of ways. First, it utilises the diffusion theoretical approach in helping to conceptualise the marketing issues (e.g. the nature of ZEVs as an innovation), and to help define the consumer population of interest. As is explained more fully below, diffusion theory and the nature of ZEVs as an innovation and technological advancement suggest that studying the preferences of environmentally active opinion leaders, rather than a more general population as have previous studies, may be beneficial. Second, the study's methodology, involving a consumer discrete choice experiment, utilises a more comprehensive range of product attributes, public policy factors (e.g. incentives, endorsements, etc.), attitudinal measures and the like than that featured in previous research. Additionally, as part of the earlier, more qualitative stages of the research, the method utilised is novel in employing "hybrid" focus groups utilising both more traditional interview techniques combined with a trade-off procedure done via individual laptop computers, allowing essentially instantaneous probing and feedback of consumer preferences and decision-making for greater in-depth analysis and understanding of consumer thought processes in this area. Each of these issues is discussed more fully below.

Diffusion Theory and the Adoption Process

The diffusion theoretical approach was felt to be particularly relevant for the current investigation. Rogers' (1983) seminal work defined an innovation as any idea, process or object perceived as new by an individual or other unit of adoption. In particular a favourable attitude towards an innovation is a function of the innovation's perceived relative advantage, compatibility with potential user needs, and complexity (ease of use).

Characteristics of Innovations

The innovation potentially provides a new mechanism of problem solving facilitation. Rogers' (1983) theory proposes that an individual first forms an attitude toward the innovation leading to an adoption or rejection decision. A favourable attitude toward the innovation is more likely if the innovation is perceived to have a relative advantage over an existing system, is compatible with the needs, values and experiences of the potential adopter, and is easy to understand and use. The salience of these innovation characteristics has been demonstrated in numerous studies related to adoption of technologically innovative products**.** Relevant advantage, the degree to which an innovation is perceived as being better than its predecessors, has been shown, for example, to be an important positive characteristic leading to adoption (e.g. Premkumar et al.1994;

Thong and Yap 1995, Teo, et al. 1997, Thong 1999). Compatibility has also been shown to be a significant positive factor affecting adoption in a variety of studies (c.f. Cooper and Zmud, 1990). Adoption of an innovation is less likely, however, if the innovation is perceived to be difficult to use or complex (Tornatzky and Klein, 1982, Cooper and Zmud, 1990, Thong 1999) and is also affected by the perceived costs versus benefits of the innovation (e.g. Mills 1994). There are many dimensions of cost, including the costs of acquiring, tooling up costs, costs related to the experience curve (learning to use the innovation), opportunity costs of acquiring the wrong innovation, and social and psychological costs--to name a few.

There is also a significant amount of research investigating the effect of environmental factors on adoption of a technological innovation, including provision of incentives to purchase, customer pressure, customer willingness to pay for innovation, and the like. For example, incentives offered by suppliers have been shown to have an effect on adoption in studies by Gatignon and Robertson (1989), and Ha (2000). Customer pressure has also been shown to be an environmental factor in adoption (Premkumar and Robert, 1999). Other studies (such as Mills, 1994) have investigated customers' willingness to pay for technological innovation, finding a "gap" often exists between customers' willingness to pay and the realities of technological service delivery costs—thus making for dilemmas in terms of (1) potential adoption of the technology by supplier organisations, as well as (2) pricing service delivery if the innovation is adopted, and (3) public policy concerns.

Finally, environmental factors in the form of a variety of regulatory issues (e.g. Mills and Harris 1982; Leverick et. al 1997), have been shown to be related to adoption of technology, and/or the ability to recognise optimally the significant gains in desired goals the innovation represents.

Characteristics of decision-makers/opinion leadership

Roger's initial work (1983) with conservative seed corn farmers has spawned a vast literature detailing characteristics of the diffusion process, those individuals characteristic of each phase of adoption, and of the important role played by early adopters and potential adopters in aiding the diffusion process. Summarising this literature is well beyond the scope of this article. However, many diffusion studies of technological innovations have shown the importance of opinion leaders and innovative decision-makers to the adoption process. (c.f. Blythe,1999; Gatignon and Robertson, 1989; Mills, 1994;Prekumar and Roberts 1999;Rugimbana and Iversen,1994). In general, previous studies have found such opinion leaders to be younger, better educated, more knowledgeable, more outward looking, or cosmopolitan than non-adopters (Kimberly, 1978; Ozanne and Churchill, 1971;Robertson and Wind, 1983;Rogers,1983).

While previous studies have focussed on a more general sample—this study extends this previous research in that it uses the findings of the diffusion literature in its focus on environmentally active opinion leaders, as well as in the characteristics of innovations identified in previous research to aid selection of attributes and issues for the conjoint and other research phases, as described below

Method

The study employed qualitative, "mixed" and fully quantitative phases. The first phase of the research involved a series of focus groups with environmentally active consumers on the ZEV topic. This first phase of the research probed respondents' knowledge about and attitudes toward ZEVs, their awareness and ratings assessment of ZEV's relative advantages, compatibility, and other characteristics of innovations in terms of technological innovation (Rogers, 1983), and knowledge of ZEV technology, as well as their general design preferences for these vehicles. The knowledge gained from these groups was felt to be important in its own right, as well as being critical in terms of guiding the next stage of the investigation, including questionnaire design, procedure, and so on.

Following the first qualitative phase, a second series of "hybrid" focus groups was conducted, which followed up and broadened the knowledge gained in the first phase, but also tested the conjoint procedure and questionnaire, attribute levels, and so on to be used in the larger, third phase quantitative study. During the second stage "hybrid" focus groups respondents went through a conjoint program (via laptop computers) that asked them to detail their product design preferences for a ZEV, and then discussed their preferences and the process, with the group.

The third stage of the research was a larger, quantitative study, in which respondents were asked to detail their knowledge of ZEVs, their own environmental preferences, and so on, in addition to completing a conjoint procedure (Louviere 1988; Hensher, et. al 1988)) which asked them to detail their design preferences (including "augmented product" public policy incentives, endorsement, promotions and the like) for ZEVs, based on both the earlier two stages of the research (in which items, attributes, levels and procedure were refined) as well as actual manufacturer specifications for anticipated ZEVs. Target consumers were screened and qualified in high-traffic mall locations in Northern and Southern California and via pre-recruiting in eight different areas of the state.

For all phases of the research respondents had to meet the following sample qualifications:

All participants had household incomes of $50,000 or more and owned two or more late model vehicles

In addition, qualified participants had to score highly on concern for the environment both globally, and personally. They indicated high agreement to scaled items such as

"I am very concerned about air and water pollution and the depletion of the earth's resources."

"I regularly spend extra money on products that claim to be environmentally safe."

Qualified participants also had to score highly on a battery that rated environmental opinion leadership.

The diffusion theoretical research discussed previously suggested sample participants who were (1) economically able to buy a new car, (2) high in environmental awareness and action, and (3) high in environmental opinion leadership. California, as the bellwether state in environmental reform and the leader in passing ZEV legislation, was chosen for the sample area, with an equal split between Northern and Southern California to reflected possible differences in attitude and to reflect actual difference in driving requirements and vehicle usage.

Attitude Measurement

All attitudinal items used in the study, either for sample qualification above or later preference analysis, were adapted from previous environmental and diffusion research studies (e.g. Ewing and Sarigollu 2000, Mills 1994), and were five point Likert scales. In addition to the vehicle choice preference procedure, the questionnaire utilised items to assess attitudes towards the environment, technology, ZEV technological aspects, and other measures, with Phases 1 and 2 of the study serving to further refine and develop the instrument, after its initial development and pre-testing.

Attribute Development and Levels

The attributes used in Phase 2 and 3 of the study were initially suggested from a number of sources, including previous CFV research (e.g. Bunch et al. 1993;Calfree 1985;Ewing and Sarigollu 2000, Urban, Weinberg and Hauser 1996), and the diffusion literature (e.g. Rogers, 1983). Previous CFV research studies have investigated only a very limited number of attributes such as (1) purchase price, (2) cruising range, (3) refuelling time and so on. The diffusion literature, and particularly those elements of an innovation that affect its adoption discussed previously—relative advantage, consistency with the needs of the adopter (a measure of its compatibility), its ease of understanding and use (measures of its complexity), suggested and helped categorise many other ZEV attributes for research in this study. For example, relative advantage suggested attributes such as emissions levels, various public sector incentives for purchase, and so on. Compatibility suggested additional attributes over the limited number of attributes in previous studies such as operating costs, seating capacity, cargo capacity, and a number of others. Complexity suggested additional attributes such as simplicity of operation, recharging time, location of recharge stations, and the like. Conversations by the author with government officials and with major automakers, as well as from provision of proposed ZEV attribute specification from the automakers suggested other attributes for testing. Prior to use in any stage of the study the early questionnaire and attributes and their levels were pre-tested with a small sample of automotive employees to ensure both realistic attribute levels and combinations. Subsequently these attributes were again tested and refined in the Phase 1 Consumer focus groups and Phase 2 "hybrid" focus group procedures prior to the larger Phase 3 study. This testing was illustrative, and revealed, for example, that the attribute "cargo space" was best communicated to consumers through using "number of grocery bags" to define attribute levels. Likewise consumers contributed to description of other attributes and levels—for example the vehicle interior levels, suggesting terms like "spaceship like", and "office on wheels".

Findings from each of the three phases of the research will now be described.

Findings

Phase 1 Focus Groups:

Six groups, 3 in Southern California, 3 in Northern California (n=58) Probed consumer attitudes toward electric vehicles, knowledge of public policy directives, design issues, cost estimations etc.

Observable differences in attitudes and knowledge across the Northern and Southern California samples were small for the most part, and hence the findings from this phase of the study will, for the most part, be reported for the sample taken as a whole. Where appropriate differences in terms of potential usage, as this affected response will be noted.

In general, the Phase 1 findings showed that respondents had misconceptions and/or gaps in their knowledge about the current state of zero emission development or the technologies themselves. In particular, the focus group respondents had generally not followed electric vehicle development and had various misconceptions about the complexity, compatibility and viability of the technology. Interestingly, a surprising number of respondents knew that "electric vehicle technology had been around since the very beginnings of automobile manufacturing", although again, the study was held in California, "where people love their cars" {{Author's note: items in quotations are taken verbatim from individual comments as expressed in the focus groups}}.

The results showed that the general concept held by consumers of electric cars involves one of very small, spartan, utility-type vehicles with limited range and cruising speed. (Author's note: this is generally the type of ZEV that has been shown in auto shows and in the press).

Interestingly a number of the focus group respondents had little knowledge of the progress of public policy mandates in the ZEV area. They were not aware of the 2% sales requirement for manufacturers that was mandated in 1998, the proposed 10% requirement in 2003, or the stepped up requirements that were to occur beyond that date. This is an interesting finding given the considerable publicity that has been given to this issue in the general and speciality press. After being made aware of the history of these regulations consumer attitudes showed a bi-polar tendency, in that there was divided opinion about whether the regulations were a "good thing", and whether it was "necessary to force people to buy a non-polluting vehicle", particularly "in California, where people love their cars".

Respondents were made aware of the actual performance capabilities of proposed ZEVs from manufacturer's specifications and then asked about their attitudes about and willingness to buy such vehicles, as well as how they would utilise a ZEV if purchased. The findings showed that ZEVs will not replace the "primary" household vehicle. Rather consumer prospects might accept the concept for a "second" or "third" vehicle for errands and trips of predictable length given the performance shortcomings of the technology. Respondents were extremely concerned about "being stuck someplace because the car's batteries were low", and about the slowness of ZEVs.

The focus group respondents valued the freedom, performance, and convenience of their current gasoline powered automobiles, and were not generally willing to trade-off these factors to buy an electric (ZEV) vehicle. They felt that "the government should provide tax subsidies and other incentives to motivate purchase." As one respondent's verbatim put it "they should pay us to buy those dogs".

However, the respondents are in conflict regarding "freedom" and a healthy environment. The focus group respondents felt air pollution is a serious problem and recognise that ZEVs are a part of the solution. Yet interestingly they seemed to be occupied with the restrictions of these vehicles rather than the opportunities.

Cost perceptions for ZEVs were bi-model. Some of the focus group respondents perceived ZEVs as inexpensive, while others felt electric vehicles will sell for the same as their conventional counterparts. The focus group respondents did not have the idea that electric vehicles will sell for <u>more</u> than their current vehicle, although this is surely to be the case {{Author's note: auto manufacturers estimate that a typical proposed electric vehicle would sell new for between $40,000 and $50,000 for a basic model in today's prices}}.

From Diffusion theory (Rogers, 1983) an important aspect of consumer perception of the technology (and the innovation) is the operational costs associated with electric vehicles. The focus group respondents expected operations cost to be lower than for gasoline vehicles, given what they felt to be a "simpler technology" with "less moving parts". Importantly, the majority of prospects were not aware of the need for expensive battery replacements and other maintenance requirements. Technologically, the ecological impact of battery disposal concerned a minority of people, where others were concerned about the potential explosions occurring as a result of a traffic accident. About 40% of the sample respondents expressed some other concern about the safety aspects of electric vehicles, some of this due to the cars "being slower than molasses in January" and "potentially being run over on the freeway", whereas others felt the absolute quietness of the vehicles would represent a safety hazard because "people can't hear you coming".

The vast majority of the (environmentally active-opinion leader) focus group respondents appeared to want an electric vehicle just like their current gasoline-powered automobile. As in much new product research the respondents appeared to have difficulty going beyond current product features and specifications. As one respondent put it "give us a car just like we have now, same cost, same performance, only make it electric".

The Phase 1 results showed that design preferences were not universal. Some respondents preferred a ZEV that is indistinguishable from conventional vehicles; others wanted a unique design. Those who expressed a preference for a unique design "wanted others to know that I was doing my part to help the Earth"; these tended to be respondents who had expressed the highest levels of environmental awareness and of personal environmental consumption. The respondents expressed the following as key reasons for wanting an EV; "for clean air, non-polluting, saving the earth, preserving the environment, low cost to operate, and dependence on electricity not foreign oil".

Overall, the Phase 1 research results suggested that even environmentally active opinion leading consumers had little desire for ZEVs as these products are currently feasible. From a diffusion theory standpoint, the limitations of the technology in terms of complexity and compatibility as expressed in vehicle performance, ease of use, and the needs for recharging (e.g. compatibility) and so on, coupled with the high vehicle cost outweighed the relative advantages they associated with ZEVs.

Phase 2 "Hybrid" Focus Groups

Six groups, 3 in Southern California, 3 in Northern California (n=55) Probed consumer attitudes toward electric vehicles, knowledge of public policy directives, design issues, cost estimations etc., building on Phase 1 results. Also served to test the conjoint procedure aimed at testing consumer tradeoffs vis a vis ZEVs.

Phase 2 built upon Phase 1, with the Phase 2 focus groups proceeding in the following way: First the respondents were led through a focus group procedure which in many ways duplicated that of Phase 1, although additional questions were asked and probed. Then respondents were led to individual laptop computers where they completed a trade-off analysis aimed at discovering respondent preferences for various combinations of product attributes. Following this the group reconvened and the respondents were asked about the choices they had made and the reasons for these. This novel methodological approach allowed near "real time" in-depth probing of the trade-off decisions that consumers were making about proposed ZEV vehicle configurations, including the "augmented product" incentives, endorsements and so on.

As the qualitative findings for Phase 2 were very similar to the findings of Phase 1, they will not be discussed here, except to note that, following the trade-off analysis, many respondents indicated that they were surprised by the importance they had given to attributes which were not environmentally friendly (especially air conditioning, for example). The complete trade-off procedure used in this phase is described in Phase 3.

Phase 3 Quantitative Study:

Given that the previous qualitative Phases of the study had shown that even environmentally active consumers had little desire for ZEVs as they were currently feasible technologically, the objective of Phase 3 of the research was to ascertain, with a larger sample and a quantitative methodology, the tradeoffs that consumers *would* make with respect to product attributes (including, for example, public sector incentives, endorsements and so on), and their preferences for vehicle configuration, in order that the most optimum results in terms of product design and policy effects might be achieved.

Three hundred twenty five target consumers were screened and qualified in high-traffic shopping malls and via pre-recruiting in eight different areas of Northern and Southern California. Qualified participants were college graduate males and females between 21 and 70 years old. Quota samples were established to represent Californians in this age range. As before, all participants had household incomes of $50,000 or more and owned two or more late model vehicles. In addition, all respondents were required to score highly on environmental attitudes, and action, both globally and personally, as well as environmental opinion leadership, as measured on the environmental batteries employed in Phases 1 and 2 of the research.

Phase 3 Sample Profile

Table 1 shows a profile of the Phase 3 respondents. As shown, the sample was split nearly equally between males and females, the mean age was approximately 41 years, average income was approximately $71,000, with two-thirds of the sample being married and living primarily in a single family dwelling. While personal environmental activity as well as environmental opinion leadership were requisite qualifications for study participation, one-half of the Phase 3 respondents reported contributing "very significant time and/or money to an ecological cause in the past 12 months."

Phase 3 Trade-off Analysis:

When consumers make purchase decisions they weigh their options. They compare and contrast alternatives based on the factors that are most important to them at the time. That is, customers make exchanges, concessions, compromises and sacrifices in nearly all purchase situations, but particularly in high dollar, large ticket durable purchasing like that for an automobile. ZEV purchase decisions can be thought of as possessing specific levels of defined attributes, representing actual circumstances, which a customer could achieve or want. Accordingly as a major part of Phase 3, respondents were taken through a trade-off analysis based on 18 attributes, which emerged from the previous research phases. Attributes and their levels are shown in Figure 1. As is evident from the figure, attributes included physical product features, as well as less physically tangible elements such as endorsements, and public policy items such as tax benefits associated with electric vehicle ownership.

Figure 2 shows average utility weights for the top ten listed trade-off issues. Respondents placed the highest value on long battery ranges, with two levels of battery range getting two of the top ten priorities. Lower purchase price and cost to operate were also seen to be very important. One hundred per cent reduction in toxic emissions ranked third with prospects, while safety related product features like air bags and anti-lock braking systems were also highly valued. As shown in Figure 2, acceleration comparable to one's present car (powered by an internal combustion gasoline engine) is another significant product feature.

Figures 3-20 show breakdowns of individual attribute utility values by level. Several of these are particularly revealing. For example Figure 6 shows that the sample respondents (who valued a battery range of 200 miles as the most important attribute with a utility weight of 72), only gave the rating of 54 to a range of 150 miles (eighth overall out of 65 alternatives), a weight of 32 for a 100 mile range, and a utility value of only 1(!) for a range of 50 miles; clearly sample respondents did not want to give up their driving freedom.

Respondents obviously wanted "the most for the least" as is shown in Figure 15. An $11,000 price is two and one-half times more appealing than $19,000, everything else being equal, for example, with a purchase of $7,000 the second rated attribute for the sample as a whole. Consistent with the idea that prospects want "the most for the least", it is important to note that, as shown in Figure 15, consumers would assign essentially "no utility" to a manufacturer's estimated price of over $40,000 for a new electric vehicle (the actual projected price by manufacturers for a base ZEV). While most auto customers are familiar with the notion of "sticker shock" clearly this finding suggests a very feal problem exists with respect to the anticipated price of ZEVs.

As shown in Figure 20, a 100% reduction in toxic emissions was extremely important to consumers; a 67% reduction was not very appealing to prospective ZEV buyers while a 33% reduction has essentially no utility. These findings are important in that they suggest that environmentally active consumers may well not accept the notion of "hybrid" CFVs (which combine electric and conventional power but which are not "zero-emission).

On the other hand, Figure 5 shows that respondents also wanted "creature comforts" like air conditioning (that at present contains CFC contaminants, which are harmful to the environment), while Figure 8 reveals that respondents also valued a high cruising speed. Clearly consumers' lack of consistency in this area (which also was seen and discussed with consumers in the Phase 2 study) may prove difficult to auto manufacturers and public policy makers aimed at facilitating ZEV adoption. Additionally, it is interesting to compare these findings with the fact that at present no known ZEV prototype is capable of the top cruising speeds required by consumers.

From a public sector policy standpoint the utility weights shown in Figure 13, which deal with tax and utility rate rebate incentives to ZEV purchase are revealing. Consistent with the qualitative results of Phase 1 of the research, respondents placed significant importance on certain incentives to EV purchase such as electric bill discounts. As shown, however, these incentives have much greater value when "chunked", as a combination of 10% off electric bills and a one time $1500 Federal income tax credit is given a utility weight of 50 (fairly high) and a 10% electric discount (by itself) has only one-half the utility weight of the combined option. This would seem to be a very key finding for public sector action.

Finally, Figure 16 shows the especially interesting story of the utility weights given to various levels of battery recharge time – clearly an important issue to consumers. As shown, potential EV buyers want fast battery recharges – a 3 to 4 hour recharge was twice as appealing as a 7 to 8 hour process, and a recharge time of 11 to 12 hours was not appealing. From a public policy standpoint these findings are revealing in that they have enormous implications for electric utility "load". While respondents clearly value the convenience of fast recharges, utility companies will want to spread the load factor over a number of hours or will wish to require recharging during night time hours to balance the load. It appears that with respect to this attribute the desires of consumers and the desires of public policy makers and utilities are essentially incompatible.

Phase 3 Cluster Analysis:

A cluster analysis was conducted on respondents' utility weights for segmentation purposes. Figure 21 shows the three-cluster solution that resulted from this analysis. Cluster 1 (the "Comfort Seekers") gave high utility values to creature comforts and useable space. In essence these individuals (who comprised 37% of the sample) would prefer a ZEV, which has all the creature comforts of a present day automobile. Group 2 ("Budget Speedsters") placed special relevance to fast performance and low cost issues, whereas those in Group 3 (the "Safety Greens", comprising 31% of the sample) placed extraordinary emphasis on pollution and safety factors. This later group gave high utility to 100% reduction in toxic emissions, fuel versatility (electric and solar), safety specifications that exceeded government requirements, and to endorsements by public policy makers and the media.

Figure 22 shows demographic and other breakdowns for these three groups. As shown, Group 1 (the "Comfort Seekers") was skewed slightly to Northern California, younger females, and married home owners, whereas Group 2 ("Budget Speedsters") was slightly skewed to Southern California, older males, more singles, and to multiple dwelling residents with lower overall income; Group 3 ("Safety Greens") was slightly skewed to females, with significantly higher incomes. They owned more vehicles and were more likely to have contributed a very significant amount of time and/or money to environmental causes.

Phase 3 Trade-Off Simulation Results

From a product development standpoint, once prospects' utility values are established, it is possible to see which combination of features has the highest overall value. This has important meaning for both marketers/product designers, as well as public policy makers in that it is in the interests of all to design a zero-emission product which will sell in the marketplace, especially given expressed consumer negativity for currently feasible ZEV products. Figure 23 shows a four-model configuration "Base Case" which served as an arbitrary "benchmark" for simulations and is used here for illustrative purposes {{Author's note: Uutility values for all possible combinations of attributes were calculated}}. The four "products" defined in the Base Case were chosen so as to provide some comparison for auto company management and public policy makers with similar present vehicles – representing points along a continuum suggested by the Phase 1 qualitative research and management hypotheses of spartan commuter vehicles to upscale luxury, and do not in any way represent the "best" combinations of attributes. The question to auto manufacturers and public policy makers illustrated here could be expressed as "suppose you could produce one of four different product configurations, which would receive the most preference in the market"? A benchmark "share of preference" was calculated for every possible combination.

Figure 24 shows "share of preference figures for the four products outlined in the "Base Case" as calculated for the overall sample. A "high-end mid-sized" vehicle comprised of the attributes and levels shown previously in Figure 23 would get a 53% share of preference for the four product simulation. A "small and comfortable" unit would get approximately one quarter of the buyers, while the "low-end mid-sized" unit would get twice the interest as the "small and spartan" alternative (15% to 8% respectively). However, the "Base Case" simulations showed differences across the three cluster segments, as shown in Table 2.

However, for comparison purposes a three product "low-end" simulation (removing the most preferred "high-end" alternative) was run with the results showing the majority of preference share going to the "small and comfortable" option (Figure 25). The "small and spartan" vehicle would get slightly more than twice the preference share as the "low-end mid-sized" alternative. Conversely removing the "low-end" product from our four "Base Case" configurations would yield the results in Figure 26, which indicate that, given these choices, the vast majority of consumers would prefer the "high-end mid-sized" choice, the "small and comfortable" unit would be a clear second choice, and only one in ten buyers would prefer the "small and spartan" option.

Understanding Consumer Preferences – the implications of Modifying Specific Product Features for a Given Product Configuration

Given the results of Phase 1 of the research, which showed a very distinct lack of environmentally active consumer interest in ZEVs as they are currently feasible, as well as the previously indicated results which have discussed the low utility value associated for example with price estimates for currently feasible EVs, it would seem critical for marketers and public sector policy makers to understand the implications for modifying specific product features of a *specific product configuration* to increase share of preference. Some of these modifications would be under the control of public sector policy makers (eg tax incentives, endorsements, etc.) whereas others would be more directly the purview of auto- makers. Figure 27 gives an illustrative example for the widely preferred "high-end mid-sized" option within the four product "Base Case" scenario for the sample taken as a whole. This chart illustrates what happens when each of several feature improvement changes are made to just one product configuration. As shown tax incentives combined with 10% off electric bills has the most significant single effect. However, "chunked" combinations of issues, including tax incentives, 10% off electric bills, solar and electric power and a 3 to 4 hour recharge increase the Share of Preference to 70%! Thus these results suggest public sector policy makers and marketers might optimally work together to increase the commercial viability of an available EV product in the marketplace.

Conclusions and Implications

In contrast with previous CFV research using a more general population, this study has systematically and in some depth investigated the factors that would drive the preference-adoption process of ZEVs among environmentally active consumers. The study has extended previous research through its comprehensive methodological approach, its use of diffusion theory to guide the choice of sample as well as the characteristics of ZEVS that would, as an innovation, effect their adoption by environmentally active consumers, and through its findings.

The findings from the study have yielded a number of important contributions to ZEV knowledge and to the existing literature, and suggest implications for public sector policy makers and marketers. These include the following:

1. Even environmentally active, opinion leaders were not particularly well informed about ZEV technology, and/or the progress of public policy mandates and directions in this area.

This finding would seem to be quite consistent with previous, general population based clean fuel vehicle research results (e.g. Bunch, Bradley, Golob, Kitamura, and Occhiuzzo, 1993), but in view of the nature of this study's sample, suggests government and automakers may need to try harder in their efforts to publicize the specifics of electric vehicle development. Clearly a much more targeted educational campaign to inform consumers of electric vehicle developments may be warranted.

2. From a diffusion theory perspective the results of this study of environmentally active consumers suggest that ZEVs as an innovation score well in terms of relative advantage, but do not do well on compatibility, complexity or cost dimensions. These consumers see the key relative advantages of a ZEV as fostering clean air (being non-polluting), helping to save the earth, preserving the environment, and limiting dependence on foreign oil.

The study shows, however, that even while environmentally concerned and active, and considering the relative advantages of ZEVs noted above, consumers value the freedom, performance, convenience, and low prices of their current gasoline powered automobiles, and are not generally willing to trade-off these factors to buy an electric (ZEV) vehicle. These results are generally consistent with previous CFV research on a more general sample (c.f. Ewing and Sariigollu 2000). ZEV feature deficiencies would mean that even environmentally active consumers would only consider purchasing a ZEV as a second or third vehicle—thereby limiting the overall size of the market, and the corresponding gains in air quality and in fossil-fuel savings.

The study results are also very consistent with previous research investigating the cost dimension for environmentally beneficial products (e.g. Mills 1994). Mills' (1994) study, for example, showed that even environmentally concerned consumers indicated they would not pay the price for environmental improvements mandated for new automobiles, preferring to keep their present vehicle rather than pay for the mandated improvements.

3. Key product attributes that consumers will demand from any electric vehicles include a 200 mile range, a price comparable to today's subcompact vehicles, zero-emissions, comparative acceleration to today's automobiles, and a convenient recharge time (preferably 3 to 4 hours or less).

These findings have enormous implications for auto -makers and public policy makers in that current technology does not allow an electric vehicle that meets these specifications (on any of the above attributes). That is, no manufacturer can currently produce a vehicle that meets these expectations excepting a major and unanticipated technological breakthrough. Clearly public sector policy makers and marketers face huge obstacles in terms of changing even environmentally active consumers' expectations in terms of product performance and cost.

4. The findings of all phases of the study suggest strongly (as do the specific trade-off results) that future ZEV sales –even with targeting to those most environmentally active and influential, will not likely be met without very strong and active incentives to purchase – many of these, the province of public sector policy (e.g. tax incentives, discounts off electricity bills and so on). The good news from the study results is that public sector incentives, when bundled or "chunked" together have a major impact on the share of market calculation. This is a key finding from the study and suggests that public sector agencies may do well to look at bundled incentives in combination with other agencies to facilitate EV adoption, and that government and manufacturers need to work very closely to develop incentives that may help to achieve desirable results.

Limitations and future research directions

The chief limitations of the current research concern its limited geographical focus (the state of California), and relatively small sample sizes. Both limitations suggest future research directions. Future studies might be conducted over a larger geographic basis, and employ larger sample sizes. Future ZEV research might also study additional attributes and levels than those investigated here. Researchers might also find it useful to build on the hybrid focus group methodology in Phase 2 of the research, as this study suggests that there are real benefits in being able to dissect consumer trade-off decisions on a "real-time" basis.

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