

**Automobile Buyer Decisions about
Fuel Economy and Fuel Efficiency**

**Final Report
to
United States Department of Energy
and
Energy Foundation**

Kenneth S. Kurani
knkurani@ucdavis.edu

Thomas S. Turrentine
tturrentine@ucdavis.edu

Institute of Transportation Studies
University of California
One Shields Avenue
Davis CA 95616

ITS-RR-04-31

Report submitted in fulfillment of requirements to the following contracts:

Oak Ridge National Laboratory: 4000022472
Energy Foundation: G-0309-07006

Wednesday, September 1, 2004

ACKNOWLEDGEMENT

Our thanks to the U.S. Department of Energy for the funding that provided the initial start to this project, and specifically to David Greene at Oak Ridge National Laboratory for intellectual impetus. Our thanks also to the Energy Foundation for the requisite financial support to expand the scope of this research to what is hopefully a truly illustrative sample.

Thanks to our respondent households for opening their homes to us for an evening to talk about their cars and trucks. Thanks to Martin Lee-Gosselin of Laval Université for his insights and assistance during the early phases of developing our interview protocol. Thanks also to Thomas Barron, Reid Heffner, and Brett Williams—graduate students in the Transportation Technology and Policy Graduate Group at the University of California, Davis—for assistance in recruiting and conducting interviews.

Of course, everything we say in here is our fault.

TABLE OF CONTENTS

<i>Acknowledgement</i>	<i>i</i>
<i>Abstract</i>	<i>1</i>
<i>Whither Consumer Rationality and Fuel Economy?</i>	<i>3</i>
<i>Historical Background</i>	<i>4</i>
What have economists said so far about fuel economy?	<i>8</i>
Promoting better MPG choices: can consumers be economically rational?	<i>9</i>
What are consumers thinking?	<i>13</i>
<i>Research design</i>	<i>14</i>
Primary sampling attributes	<i>14</i>
Illustrative sampling	<i>15</i>
Four step interview	<i>15</i>
<i>Findings</i>	<i>17</i>
Part One: An archeology of the role of fuel economy in household vehicle purchases—a barren dig?	<i>17</i>
Part Two: The most recent vehicle purchase—the current role of fuel economy	<i>18</i>
Part Three: Using the priority evaluator table to re-examine the current purchase or design the next vehicle	<i>19</i>
Part Four: Fuel efficiency and fuel economy—what are they and what information do people have about them?	<i>21</i>
Willingness to pay for higher fuel economy	<i>22</i>
Basis for willingness to pay responses	<i>23</i>
How long will people wait for fuel cost savings to payback a purchase premium?	<i>25</i>
The building blocks of rational decisions	<i>27</i>
Household knowledge and behaviors around fuel economy	<i>27</i>
Knowledge of fuel expenditures	<i>27</i>
<i>Decision styles</i>	<i>28</i>
Hybrid owner interviews	<i>29</i>
Knowledge	<i>30</i>
Commitment to a making a difference	<i>30</i>
Adoption	<i>31</i>
Post-purchase and communication	<i>31</i>
<i>Conclusions</i>	<i>31</i>
<i>Hypotheses</i>	<i>31</i>
<i>References</i>	<i>33</i>

ABSTRACT

Much prior research into consumer automotive and fuel purchase behaviors and fuel economy has been shaped by the normative assumptions of economics. Among these assumptions are that consumers should pay attention to costs of fuel and that they are aware of their options to save on fuel over long periods of time, i.e., the life of a vehicle or at least their period of ownership. For example, researchers have analyzed in some depth consumer choices for more fuel economical vehicles in the 1980s and more recently consumer choices in Europe for more expensive diesel vehicles with lower fuel costs than their gasoline competitors. Some of this research investigates whether automobile buyers have varying future values for money invested today in higher fuel economy, i.e., consumers' discount rates. More recently, in the context of the political battle over new CAFE standards, both automobile manufacturers and energy researchers have asked consumers questions about their willingness to pay more for higher fuel economy and consumers' payback periods for these investments. Both payback periods and net present value calculations require good knowledge of one's own vehicle and annual fuel expenses, forecasts of future prices, and a sophisticated series of calculations. The new arena of debate and research on consumer response to better fuel economy technology is CO₂ reduction strategies generally, and regulations to reduce CO₂ emissions from transportation in California specifically.

The research we report here is designed to help researchers and policy makers to ground future work in the reality of how consumers think and behave relative to fuel economy and efficiency, both on a daily basis and when they purchase motor vehicles. We recruited what we call an "illustrative" sample; fifty-seven households from ten "lifestyle sectors"—for example hybrid vehicle buyers, financial analysts, and off-road vehicle enthusiasts—that we guessed might have differing information and habits around the issue of fuel economy. We conducted a semi-structured, 2-hour interview, which included these four parts: household vehicle histories, purchase narratives, prospecting of future choices, and knowledge and daily behavior around fuel use and purchases.

Our strongest finding was that for the most part, our households do not pay much attention to fuel cost over time or in their household budgets, unless they are severely constrained economically. Consumers do pay attention to the price of a tank of fuel and the unit price of fuel on the given day they buy fuel. But this "knowledge" is ephemeral; it is rapidly forgotten over the next few days. Fuel consumption instrumentation on most vehicles is limited and drivers seldom pay attention; the exception is hybrid vehicles and their drivers.

One effect of limited knowledge is that when consumers buy a vehicle, they do not have the basic building blocks of knowledge to make an economically rational decision. When offered a choice to pay more for better fuel economy, most households were unable to estimate potential savings, particularly over periods of time greater than one month. In the absence of such calculations, many households were overly optimistic about potential fuel savings, wanting and thinking they could recover an investment of several thousand dollars in a couple of years.

Of importance to regulators, we find that good fuel economy is widely considered an attribute of cheap cars; many of our households expressed greater regard for *fuel efficiency*, a term free from

a cheap image and more closely associated to ideas of resource conservation, advanced engineering, and high technology and quality.

In the last part of the report we identify five styles of decision making relative to fuel economy, including a more detailed discussion of the decision-making in a small sample of eight hybrid vehicle buyers.

In closing, and as this is the first stage in a longer research project, we offer some preliminary conclusions and two hypotheses to steer more quantitative research. Our findings suggest that current strategies of drawing attention to annual fuel cost savings could disappoint buyers, and instead education efforts might focus on fuel efficiency and technical advances. Our interviewees ignore fuel economy for additional reasons; it is only one feature of an expensive, complex good which has many implications for lifestyle and image goals. Our research suggests that consumers might value fuel economy more highly if it were more like shiny paint or a bold body style—an attribute with some emotional punch.

WHITHER CONSUMER RATIONALITY AND FUEL ECONOMY?

We examine the role of automotive fuel economy in household vehicle purchase and use decisions. We are motivated by the continuing stalemate in the U.S. Congress regarding automotive fuel economy standards, new legislation in California to regulate greenhouse gas emissions from motor vehicles, and recent increases in the price of gasoline.

Recent studies have claimed that buyers of new cars and trucks will, on average, want to be paid back any purchase price premium for higher fuel economy technology within three years (Greene, (2002) provides an example). The very existence of a survey question about simple payback periods assumes a level of economic rationality on the part of consumers; simple payback does not discount future costs and benefits. In a more complex approach, consumers might be expected to apply an implicit inter-temporal discount rate. In this case a consumer must evaluate the time value of the stream of future savings. (Nor should we overlook in either case the fact that the consumer must be able to assess a specific divisible vehicle purchase price premium to apply to higher fuel economy in the first place.) For any positive interest rate, discounting the stream of future savings results in a longer time period over which the consumer must wait to be paid back than in the case of a simple payback period.

Within the economics literature, various analyses in the 1980s concluded that, at least implicitly, consumers use interest rates ranging from four to 40 percent to discount energy savings associated with automobile purchases (Train, 1985; Greene, 1983). In Calfee's (1985) analysis of hypothetical choices of electric vehicles he calculated implicit discount rates for future fuel cost savings ranging from essentially zero to 92 percent.

These wide ranges of values for automobiles mirror results from studies of home energy use. Studies in the 1980s and 1990s found that consumers were relatively risk-averse (Sanstad and Howarth 1995). Their inference was that some consumers had discount rates as high as 70 percent for some energy-intensive appliances such as air conditioners. Risk-aversion in this case translates into consumers who prefer to pay less now for a more energy consuming product, rather than risk not getting back an initial up-front "investment" in a less energy consuming product. Such aversion is consistent with steeply discounted future savings.

Much more recently, Verboven (1999) examines the case of diesel and gasoline vehicle purchases in Europe—diesel vehicles get better fuel economy than gasoline vehicles but cost a bit more to buy. He believes that in Europe, diesels have reached technical parity with gasoline vehicles, that uncertainty has been removed in the fuel market, and that consumers have good information about their engine options. European policy makers have in recent years used taxes to make diesel vehicles more attractive. Lower taxes and technical parity between gasoline and diesel engines (in the context of European emissions regulations) has resulted in increasing sales of diesels. In the first half of 2002, nearly 2 out of 5 new light-duty vehicles sold in Europe had a diesel engine. Verboven finds a range of more reasonable implicit discount rates in his aggregate data, closer to real interest rates. But Verboven *infers* these discount rates; he does not directly observe them in consumer decision-making.

The inference of discount rates assumes the respondents are acting in an economically rational way. If they are not, what else might people in these studies be telling us? The idea that consumers actually use discounted net present values, or even non-discounted, simple payback periods, is widely contested outside of economics. Consumer researchers, particularly those looking at energy-using appliances, have argued that such interest calculations are beyond most consumers' decision capabilities (Stern, 1992), cultural models (Kempton, 1995), and raw abilities to calculate (Chater et al, 2003). Household energy researchers have examined this issue with respect to purchases of more energy-efficient refrigerators, air conditioners, heaters, and lighting, as well as improved building and window insulation. Campaigns to encourage households to invest in these spurred studies of private cost payback periods. It appears that consumers want their money back in a short period compared to the probable life of most of these investments (see for example, Kempton and Booster 1995). Moreover, that research also shows that consumers overestimate both their energy use and their potential savings.

Much recent psychological and sociological theorizing focuses on the use of heuristics, or cognitive shortcuts. Reich (2000) reviews the work of German social theorist Gerd Gigerenzer, saying "...human beings are simply required 'to make reasonable, adaptive inferences about the social and physical world given limited time and knowledge.' As long as the survival of the species is statistically likely, rules for decision and action may well be grounded on simplifying and biased assumptions and lead to incoherent results—in short, these rules may be heuristical algorithms instead of determinable algorithms...."

Olshavsky and Granbois (1979) critiqued research into consumer decision making. They contended, "In view of the tremendous interest in consumer purchasing behavior it is surprising, to say the least, that there have been so few studies of prepurchase processes that involve actual consumers in actual settings using methodologies that permit observation of behaviors contrary to those predicted by models of choices and decision processes...."

Our research is intentionally designed to be theoretically agnostic. Our interest is to listen to households' stories about buying and using their cars and trucks; to listen for, not infer, the content of those stories. Our design is sensitive to Olshavsky and Granbois's critique precisely because we make no predictions; there is no contrary behavior. Our goal is to neither prove, nor disprove, the presence of economic rationality, but to report whether we find it or not. If consumers are behaving rationally, then we have empirical data to inform the ongoing policy debates. If consumers are not behaving rationally, then we provide empirical data to support new grounded theory.

HISTORICAL BACKGROUND

The purchase of a car or truck is a moment of heightened consumer sensibility about goals and self-identities. For most buyers, automobiles are a major purchase shaped by both immediate and future lifestyle desires such as career choice, family size, recreation activities, and pecuniary goals. To cater to those desires, there is a vast automotive market of different sizes, designs, powertrains, brands, interior fabrics, technologies, optional amenities, and colors. In the US today the new automobile market has over 1,000 combinations of makes and models available in a single year, not to mention the used vehicle market. Navigating this marketplace can be daunting; it is complex and risky, flooded by advertisements—currently a \$14 billion per year

industry itself—automotive and consumer magazines, notoriously aggressive sales people, and a burgeoning array of websites with sales options, vehicle reviews, and consumer advice. Fuel economy is just one variable in this complex market.

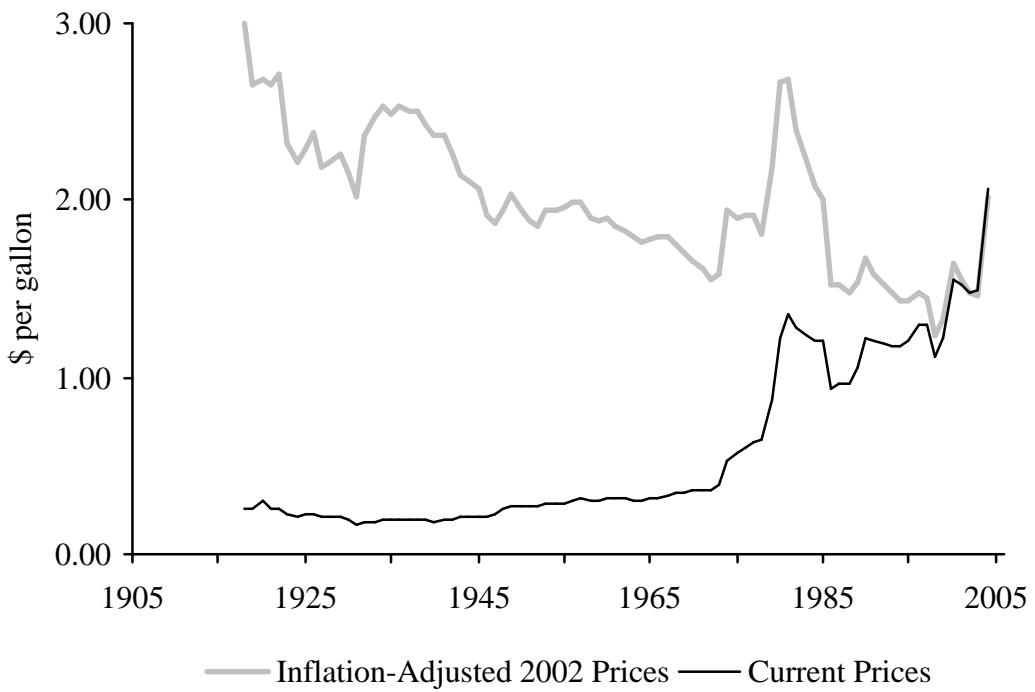
The importance of fuel economy appears to come and go in the minds of consumers as the price of gasoline—or in an opposite sense, household incomes—go up and down, or as individual drivers goes through lifestyle changes, e.g., ones that require an increase in driving. Fuel economy would seem to lend itself to rational economic consideration compared to many other aspects of vehicles. Options and amenities such as styling, color, and even air conditioning are more subject to desires than calculations; we don't ask what the payback period is for leather upholstery, a particular shade of red, or even fast 0 to 60 acceleration times. A few other vehicle attributes appear to lend themselves to economic calculations, i.e., purchase (or lease) price, finance costs, insurance, and maintenance and repair costs.

With notable exceptions, the cost of gasoline appears to have decreased in importance in consumers' vehicle purchase and use decisions over both the longer term of the 20th century and the shorter term of the past two decades as Americans became more affluent, the inflation-adjusted price of gasoline dropped, and some gains were made in new vehicle fuel economy. The long-term trends in current and constant gasoline prices are divergent; this divergence is not well understood by consumers, yet seems to be central to the role that fuel economy did, or did not, play in consumers' choices over the past several years. Data for average annual gasoline prices in the US over the 20th century are plotted in Figure 1. Data in current dollars trace the price-at-the-pump consumers would have seen in each year. The generally upward trend since the early 1970s is what consumers complain about. The data in constant-2002 dollars trace the unit price of gasoline in comparison to other goods and services. The generally downward trend over the past 100 years facilitates longer-term personal (travel) and societal (land-use) decisions toward more automobile ownership, more automobile travel, and lower density development.

With the exception of the period of high gasoline price in the 1970s and early 1980s, as well as the increases in the first months of 2004, low fuel prices encouraged (or at least did not inhibit) trends in vehicle sales over the past three decades towards larger engines, larger vehicles, increased prevalence of fuel-consuming options such as four-wheel and all-wheel drive, automatic transmissions, air conditioning. These trends are illustrated for the period 1975 to 2004 in Figure 2—a simple index of horsepower, weight, and fuel economy plotted across fuel economy and traced over time. After the imposition of CAFE standards following the oil crisis in the late 1970s and during the period of high gasoline prices in the early 1980s, automotive manufacturers made vehicles that were more fuel economical. The chart also shows that around 1982, and more dramatically in 1986, the carmakers and the market turned toward producing larger, more powerful, but not more fuel economical vehicles.

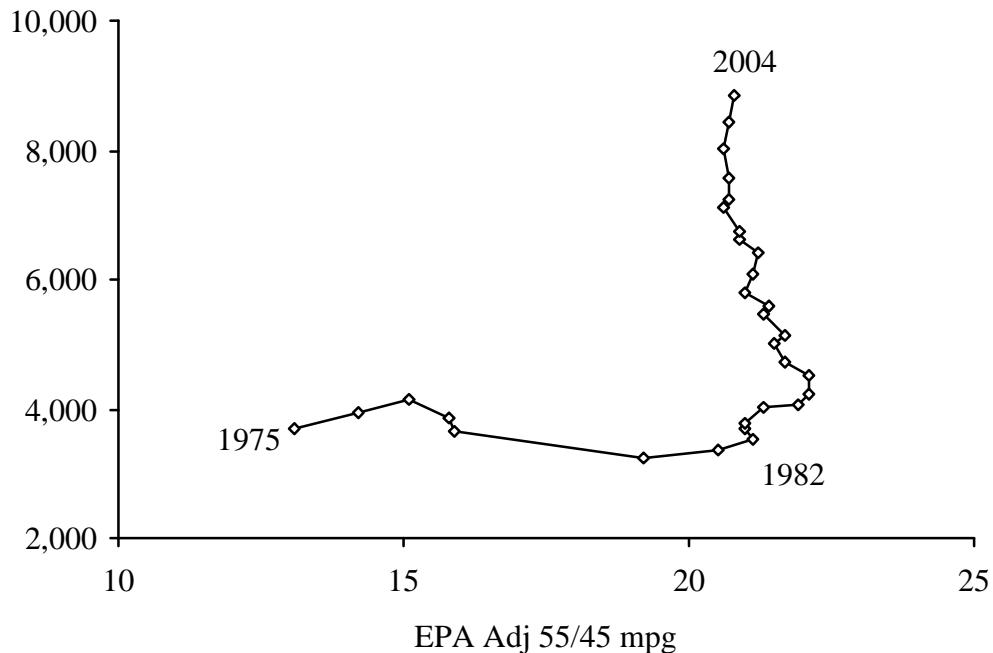
Automobile manufacturers have claimed that this pattern is purely consumer driven; that the main obstacles to further improving fuel economy is buyers' disinterest in fuel economy. In fact, manufacturers might argue that consumers value trucks and SUVs so much that such vehicles reputedly are the most profitable models for car and truck makers.

Figure 1: Current and 2002 inflation-adjusted US prices for gasoline



Source: API (2003)

Figure 2: Trends in new LDV weight, power, and fuel economy, 1975 to 2004

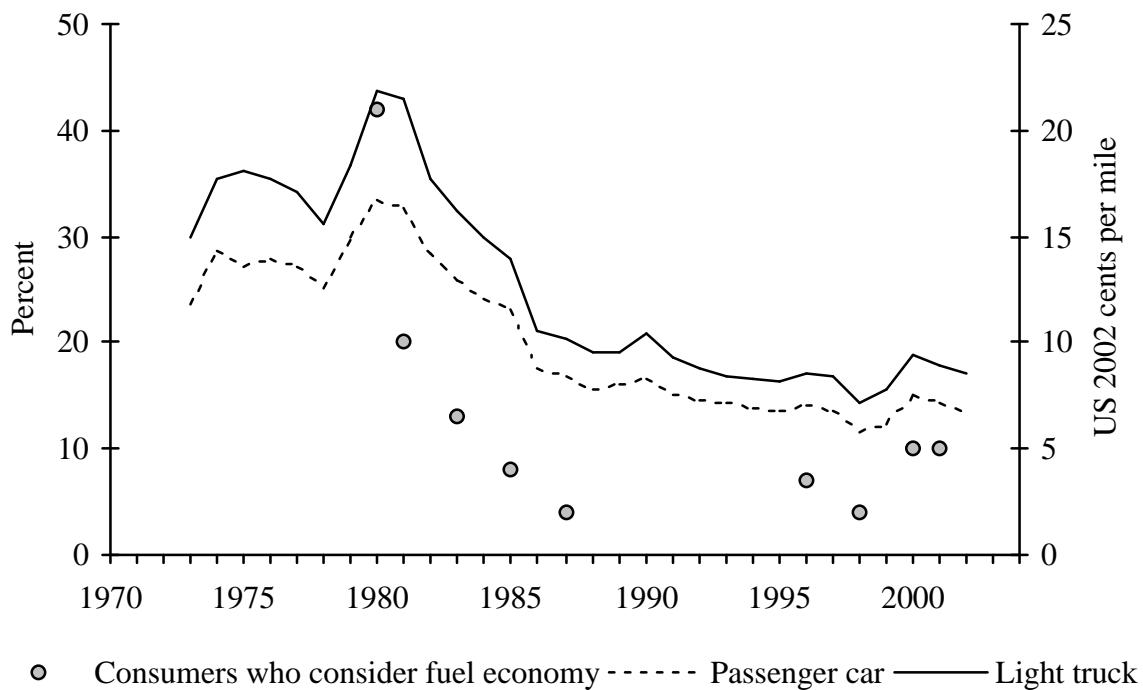


Source: USEPA (2004)

The net result of long-term trends in real gasoline prices and fuel economy is that the cost of fuel to drive one mile has declined. Data for the period 1973 to 2002 are plotted in Figure 3. 1973 is the first year in which fuel economy data are uniformly available; 2002 is the latest year for which we have data. For cars, the lowest per mile cost during this period was in 1998; it was barely over one-fourth the highest cost (in 1980). For trucks, the lowest cost was barely over one-third the highest. While per mile gasoline costs have risen slightly since 1998, the average cost of gasoline in 2002 was much lower than historical highs.

As Figure 3 also shows, consumer interest in fuel economy appears to track these trends in fuel costs per mile. A Department of Energy review of several studies by J.D. Powers and Opinion Research Consumer Insights (ORCI) shows how fuel economy was important in the early 1980s, dropped in the 1990s and has risen a bit in the last few years.

Figure 3: Percent of consumers who consider say the consider fuel economy in their vehicle purchase decisions and mean per mile gasoline costs in the US, 2002 cents per mile



Sources:

Cents per mile: API (2002), Table 6; Davis and Diegel (2003), Table 10.11.

Percent consider fuel economy: Gurikova, 2002

The relative share of the cost of automobiles that is gasoline has also declined since the 1980s. As the data in Table 1 show, between the peak per mile fuel costs in the early 1980s and 2002, the price of gasoline rose comparatively slowly. The price of gasoline grew slower than the purchase price of new and used vehicles, the price of repairs and maintenance, and the price of

insurance. In general, fuel and vehicle purchase prices grew slower than the price of the overall “market basket” of goods and services on which the consumer price index is calculated.

Table 1: Changes in the costs of vehicle ownership and operation, 1982 to 2002

Cost Category	Percent change, (1982-1984) to 2002
Gasoline	19.0
New Vehicles	39.2
Used Cars and Trucks	53.7
<i>All Items in the Consumer Price Index “market basket”</i>	80.5
Motor Vehicle Repair and Maintenance	91.2
Motor Vehicle Insurance	194.1

Source: API (2002), Figure 5.

On average, depreciation of vehicles in the U.S. rose from 27 percent of the cost of owning and operating a vehicle in 1985 to 47 percent in 1999. In 1985, gasoline and oil were 23 percent of annual motor vehicle costs, and were the second biggest category of costs after depreciation. The cost of gasoline and oil dropped to 10 percent of annual costs in 1999, and ranked fourth behind depreciation, insurance, and financing (Davis and Diegel, 2003). Against this backdrop, marginal changes in fuel economy make less difference to the cost of owning and operating a motor vehicle.

What have economists said so far about fuel economy?

We have characterized economics as an attempt to operationalize a specific set of assumptions about consumption (and production) decisions within mathematical models, and to conduct experiments within those models (Kurani and Turrentine, 2000, p. 13.) Compared to other social sciences, economists share a far more singular core set of assumptions about human behavior. The cornerstone of economic thought is that firms, individuals, and households act individually in their own interest and make rational decisions when making choices. Consumers are assumed to have stable, rankable preferences for goods or features of goods, and perfect information about all their options. Choices are constrained by budgets and consumer research is often framed around prices—how much will people pay for what amount of which products or features?

In reviewing the literature we see how the underlying reality of past vehicle options and fuel prices can shape expert analysis. That past reality is reflected by the most common description we have heard and read of vehicles that get good fuel economy, that such vehicles are small. This perceived diminutiveness often extends to performance, comfort, and safety. We hear this description in our household interviews as well as the expert literature. This perception leads to an expectation that vehicles with higher fuel economy ought to cost less to buy and operate than vehicles with lower fuel economy.

Until quite recently, with the advent of hybrid electric vehicles, consumers have not faced the prospect of paying more for a vehicle with higher fuel economy. Experts have not had data to analyze on such revealed choices, except in such cases as we discuss below in which differences in fuel economy are accompanied by differences of fuel or propulsion technology. The effects on expert analyses include the following: choice of problems to analyze—and importantly, the very incidence of any studies at all; assumptions that shape what are—or are not—"surprising" findings; and, inferences drawn from econometric models.

Related to vehicle and fuel purchase and use decisions economists have studied, for examples, household response to higher gasoline prices (see for example Kayser, 2000; Pitts, Willenborg, and Sherrell, 1981; Puller, and Greening, 1999), aggregate economic impacts of inaccurate EPA mileage estimates including impacts on consumer surplus (see for example Sennauer, Kinsey, and Roe, 1984), and competing effects such as fuel cost savings versus safety (see for example Yun, 2002).

Regarding the incidence of analysis, long periods of quiescence in gasoline prices such as most of the period from the mid-1980s to the late-1990s have not attracted the attention of analysts. Even some very recent studies are re-analyses of data from the period of most concentrated historical change in gasoline prices and vehicle fuel economy—the early 1970s to early 1980s. Kayser (2000) use data from the 1981 Panel Study of Income Dynamics because "data from 1981 are the most recent data for one year in which gasoline prices were changing rather substantially." While the data may allow for observation of consumer behavior under substantial changes in gasoline prices, it does invalidate some of Kayser's inferences if we are looking forward rather than backward. Specifically, Kayser concludes, "It appears that higher income allows households to purchase newer cars that will on average be more fuel-efficient because cars in 1981 are subject to the corporate fuel efficiency standards." Clearly the context has changed since 1981. New vehicles are not likely to be more fuel economical: CAFE standards have not been made more stringent and new "cars" are now as likely to be less economical trucks. The question now is, will higher income households drive fleet average fuel economy up or down in an era when new vehicles may be either more economical, e.g., hybrids, or less economical, e.g., trucks and truck-based vehicles?

The impact on Pitts, Willenborg, and Sherrell's (1981) analysis of the practical means through which consumers could obtain a vehicle with higher fuel economy during the time period of their analysis (1973 to 1979) is revealed in their statement that, "The consumer may be required to make major changes in lifestyle by driving less or *by exchanging comfort, safety, or other satisfactions for smaller car fuel efficiency.*" [Emphasis added.] They continue in this theme when explaining attitudinal variables they include in their analysis, "The comfortable-life variable was included in this study because, intuitively, many actions to downsize [household's] automobile inventories would require purchasing smaller vehicles, and experiencing a corresponding increase in physical discomfort." Again, their assumptions, inferences, and conclusions may soon be anachronisms.

Promoting better MPG choices: can consumers be economically rational?

Thus far, the federal government, automobile makers, and even environmental organizations have discussed fuel economy decisions primarily on the grounds of rational economic choices, debating whether consumers are willing to pay more for vehicles with higher fuel economy, and

if so over what period of time consumers will want their investment returned. Automobile manufacturers have argued, based on their view of market trends, that in general consumers are not interested in higher fuel economy. The manufacturers have testified before the National Academies of Science that the average vehicle buyer will want the increased costs of improved fuel economy back in three years. This is less than the average term of a new vehicle loan and probably not enough time to pay back more than a few hundred dollars given current US gasoline prices and the historically available differences in fuel economy between otherwise similar vehicles. Furthermore, automobile makers have argued that recent California legislation to control greenhouse gas emissions from motor vehicles will increase the cost of vehicles, forcing consumers to postpone new purchases, and retain old technology longer, thereby slowing the turnover vehicles in the California fleet and impeding the deployment of new efficiency technology in the market.

Proponents of higher fuel economy argue that if only consumers knew better their potential savings they would value fuel economy more highly, especially if they could be encouraged to think about the saving over the life of the vehicle.

While the low cost of fuel eased one constraint on buying larger, more powerful vehicles, it has been problematic for environmental goals, the safety of people in smaller vehicles, and national security. Because of security and environmental concerns, some groups in government and some non-governmental organizations are again pushing to raise fuel economy standards and also to educate and encourage automobile buyers about fuel economy. The latter efforts include exhortations to pay more attention to fuel economy, instructions to buyers about the fuel economy of vehicles, and aids to calculate potential fuel cost savings from more fuel economical vehicles. The federal government has used CAFE standards over the years to regulate fuel economy. Other efforts include the federally mandated fuel economy window stickers—that offer both test values for miles per gallon and estimated average annual fuel costs—and government and industry websites that compare fuel economy between vehicles. California is embarking on an effort to control greenhouse gas emissions from automobiles; the automotive industry opposes such efforts on the basis they are *de facto* fuel economy standards.

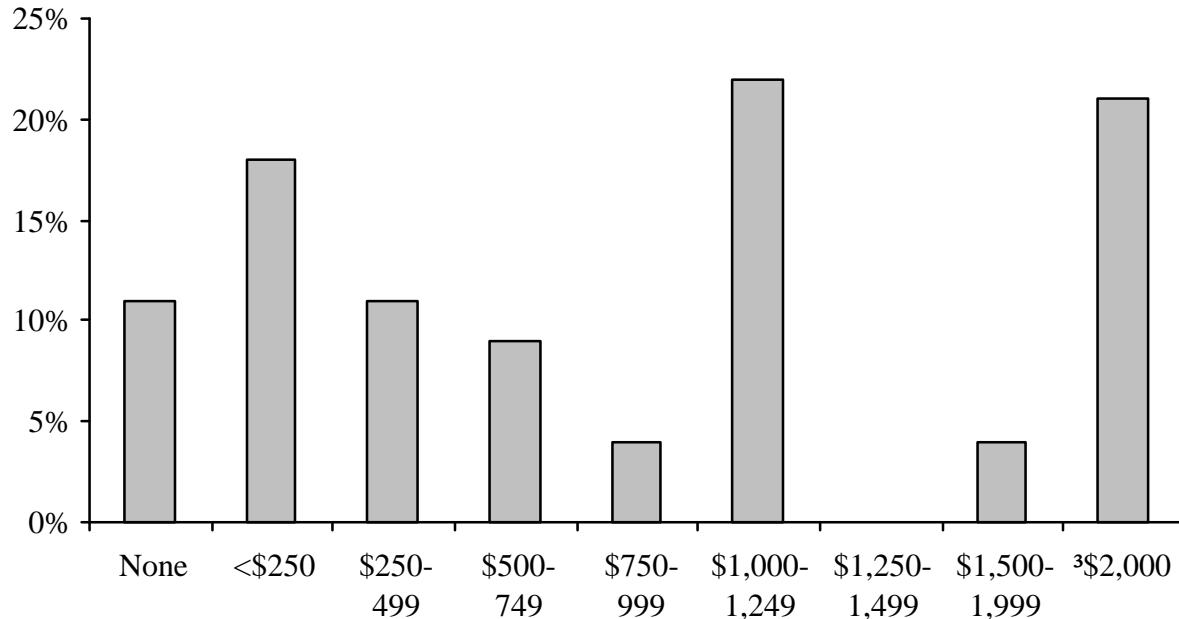
The question behind all this activity is will consumers pay more for better fuel economy technology? How much more? \$500? \$1,000? \$2,000? If consumers are rational, the amount they should be willing to pay will depend on the net benefit to them of higher fuel economy. To answer this, consumers must balance a higher upfront cost against a future stream of fuel cost savings. Assuming there is some point in the future where payback is achieved, households will then have to decide if they are willing to wait that long. In a simple case, households will conduct a simple payback calculation—assigning no particular penalty to having to wait; more complexly, they will discount that future stream of savings. Economists call these two approaches *simple payback period* and *net present value* respectively.

In fact, consumer willingness to pay for fuel economy improvements is a long-standing debate relative to CAFE and other regulatory efforts. In a 2001 presentation to the National Academies of Sciences, Mark Thibault from GM presented the following view from a GM study conducted by Maritz in 2000:

- Fuel economy is a secondary concern in all segments except low priced vehicles (13.9% of market) and the hybrid automobile segment (0.1% of market)
- Styling, price, quality, functionality and safety are significantly more important in purchase decisions
- In general, the higher the price of the vehicle, the less important is fuel economy
- Willingness to pay for fuel economy is low
- Consumers will not make tradeoffs for better mpg unless fuel prices increase significantly or consumers fear a supply disruption.

The federal government has commissioned its own research on this issue. The results of a survey in May 2004 for the National Renewable Energy Laboratory show that some automobile buyers would be willing to pay \$1,000 to 2,000 more for a vehicle that provides \$400 of fuel cost savings per year. These data are plotted in Figure 4 below. These are sensible amounts (separate from the issue of whether they are rational amounts) if answers are driven by how long households typically hold on to vehicles. However, more than one-of-four respondents to the survey show either a very high implicit interest rate or an apparently irrational disinterest in fuel savings, declining to wait at all or for less than one year. Or, are they telling us something about ingrained assumptions they hold about “economy” cars? For example, that they had better be a financial payoff for driving a small, cheap car?

Figure 4: Willingness to pay for a vehicle that save \$400 per year in fuel costs



Source: Phil Patterson, USDOE, personal communication; June 4, 2004.

In a 1998 survey of 1,000 automobile buyers, conducted during the depth of disinterest in fuel economy shown in Figure 3, ORCI reported the following results about what would motivate

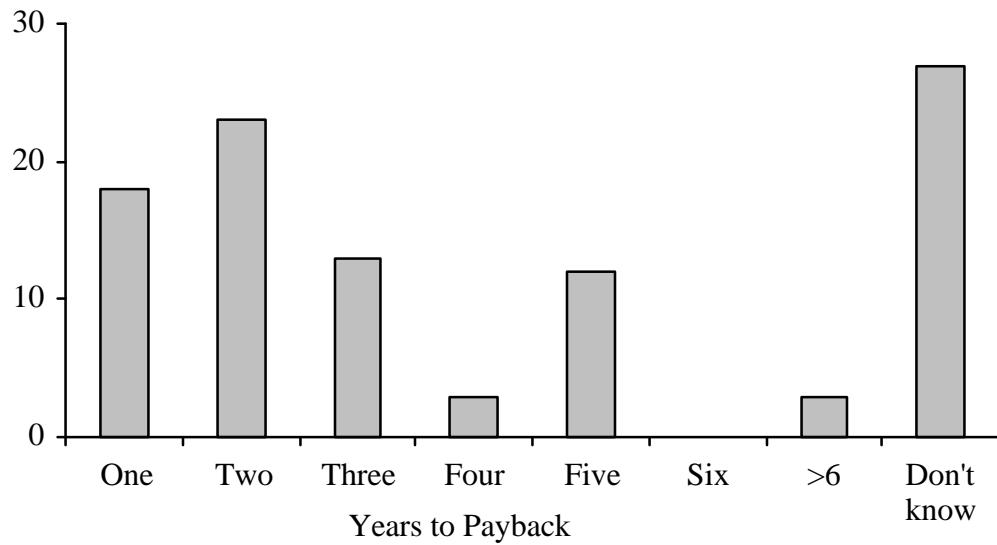
buyers to purchase a more efficient vehicle. The responses are to an open-ended question, “For your next vehicle purchase, what would motivate you to buy a more fuel efficient vehicle?”

- 428 said they would be motivated if there were cost savings (159 lower sticker price, 130 said lower costs in general, 121 said lower cost of fuel, 43 said other cost savings)
- 219 said they would be motivated by features and performance attributes (104 said less pollution and acceptable emissions, 33 said horsepower and speed, and 99 said other features/options)
- 167 simply restated the question, saying they would be motivated by the fuel efficiency/gasoline mileage
- 46 said they would be motivated by availability of the type of fuel needed
- 105 said “other”
- 74 said “not interested”
- 87 said “don’t know”

This open-ended question reveals a complicated set of responses. How do we interpret these findings in light of the low interest by consumers in fuel economy in 1998?

Results of an NREL survey conducted by ORCI in 2002 indicate that many automobile buyers would want an investment in automotive fuel economy back in one or two years, even worse than the figure of three years offered by the automobile companies. The data are plotted in Figure 5. Tellingly though, a large number of participants are unwilling to offer an answer.

Figure 5: Number of years to get back cost of improved MPG.



Source: ORCI, for National Renewable Energy Laboratory, (2002) *Higher Fuel Economy Options*, March 21.

What are consumers thinking?

We have been investigating what might be behind the answers to questions such as those shown in Figures 4 and 5, and the results are eye-opening. For example, in the household interviews (that provide the primary data for this report) in which we can probe answers in greater detail, many buyers who say they want their money back in one or two years are actually optimists, who want the latest in fuel economy-enhancing technology. They are stating their optimism about how much money they believe they will be saving, not presenting the results of a calculation. Many of our interviewees are just guessing when we ask them how fast they want their money back. Some of the more rational-sounding answers come from those who financed their vehicle, and when pressed for a payback period, respond with the term of their vehicle financing as a temporal anchor—a familiar time period, but again, not the result of any rational consideration. Among the group of people who buy cars based on monthly payments, many said that whatever savings they received from higher fuel economy should offset the increase in monthly payments for the more expensive vehicle. The other temporal anchor, offered by other respondents, was the length of time the household expects to own the vehicle.

Part of the answer to question why so many households guess or grasp for familiar anchors may seem obvious; fuel cost is not that significant and none of the households we interviewed (except lower income such as students and enlisted military personnel) treat gasoline as an expense they need to budget or control. This indifference is not that surprising. For one thing, we knew from previous research that few households would limit travel because of higher gasoline costs¹; many households say “the price of gas is a fact of life.” And we learned in this research that few car or truck buyers have thought about good fuel economy either for their most recent purchase or for purchases going back years. After all, the savings from buying a vehicle that has a few miles per gallon better economy than the next saves pennies per day for the average driver, hardly a big motivator when shopping among vehicles that cost tens of thousands of dollars. For many vehicle buyers, a used vehicle offers an easier way to save money than higher fuel economy in a new vehicle. Additionally, none of the households we interviewed knew how much they currently spend on gasoline per year, how much they pay per mile for gasoline, or even how far they drive per year. Few households do any tracking of fuel costs and so don’t know how much they are spending on gasoline. The most commonly recalled metrics of gasoline use appear to be what they typically pay per tank, the price per gallon they last paid, and in a few households who tend to put most of their gasoline on a single credit card, what they spend per month. In all fairness to these drivers, few automobiles and trucks provide detailed and accurate fuel use or cost instrumentation.

And yet, changes in the price of gasoline are hardly ignored. When the price of gasoline rises, we hear television and radio news reporters interviewing drivers at gasoline stations. Driver reactions are typically unfavorable. When we interview people, their answers regarding fuel use, gasoline costs, and miles driven are seldom congruent. Our evaluation is that most of our respondents guess they spend a lot more on gasoline than they really do. When we talk to people

¹ While household responses to rising gasoline prices were not discussed directly, in the research reported in Kurani, Turrentine, and Sperling (1994) we used rising gasoline prices as part of a gaming scenario. Faced with both a hypothetical price for gasoline of \$5 per gallon, most households we interviewed preferred to relieve a real week of their life rather than eliminate any trips.

who just bought a larger vehicle than in their past, they are often upset about the increase in the cost of a tank of gasoline, especially so if the tank of the new vehicle is also bigger. They may have paid \$25 per tank to fuel their previous vehicle and may now be paying \$50 per tank for their new vehicle. Such a change in costs, if accompanied by a rise in gasoline prices, a longer commute, or a downturn in their economic fortunes, looms large for households. But against the backdrop of the complex market, fuel economy is forgotten until it manifests at the pump.

RESEARCH DESIGN

For the most part previous research on consumers and fuel economy has assumed consumers are rational in the economic sense. The questions asked in such surveys assume consumers can answer with knowledge and certainty about willingness to pay or desired periods of payback. Our research takes a step back from those assumptions, letting automobile owners tell us in detail about the cars they have owned, just bought, and hope to buy. Only after we allow them to tell these stories in their own words do we ask about fuel economy, use, and costs in their daily life. We interviewed 57 households over a 12-month period. Though our sample for this study is small, because we discuss the entire history of automobile ownership with families, we discussed over 400 vehicles and over 125 specific vehicle transactions. Moreover, in the course of the interviews, we also discussed the vehicle purchases of friends and other family members.

Most these interviews were conducted at the home of the buyers; two were conducted at their place of business and three in local restaurants. With the exception of four of these five interviews and three student households in which their parents played a strong role, all were conducted with all household decision makers present. The home puts the participants at ease and gives researchers greater information about the household. In most households that include spouses, children, and other close partnerships, decisions about vehicles are made jointly.

Primary sampling attributes

Households chosen for this study had recently purchased a vehicle, or were in the middle of a purchase. The purchased vehicles were all types including new and used cars, trucks, minivans, vans, and SUVs. Of the households in this study who own more than one vehicle, most own both an automobile and truck-based vehicle. In addition to families and couples, there were some single person households as well as some students and other young adults who lived with roommates. The households live, generally speaking, along a 150-mile stretch of Interstate 80 in northern California, from Davis in the Central Valley, through the conurbation of the Sacramento region, to Truckee at the crest of the Sierra Nevada Mountains.

Given that we interviewed only 57 households, it is not surprising that our sample differs from the population of California households. While we would predict the sample mean number of vehicles per household would be 1.9, it is in fact 2.1. Our sample is more rural than the state population and we have too few retired persons. The most radical difference is our choice of six hybrid buyers. However, as we describe next, our goal was not to attempt a representative sample with fewer than 60 households (a fools errand), but to illustrate whether specific groups appear to have identifiable responses to motor vehicles and fuel economy, to explore the range and variety of behaviors with regard to fuel economy, and to explore differences between expert and lay populations.

Illustrative sampling

In conducting small-sample research the advantages of random sampling must be weighed against the advantages of alternate schemes. Small sample studies are generally not suitable for testing hypotheses in a population; exceptions include the case in which null hypotheses can be stated so strongly that even a small sample can reject them. One of the strengths of qualitative research is the ability to take a different look at material that is believed to be well known. In this case, we attempt to pull back the “as if” veil that hangs between inferences from data collected and analyzed within the economic paradigm and the explanations vehicle buyers and drivers offer themselves. Qualitative methods also allow follow-up to questions and direct observation of the respondents. In this way we are able to assess and record whether people understand our questions and their process of answering.

Given that we would not be constructing a representative sample for this study, we identified nine different “sectors” defined by economic and lifestyle types for which we had simple hunches about their potential choices and values. We interviewed six household from each of these sectors, plus three pilot interviews during a process of methodological development. These ten groups and a brief description of our interest in them are as follows:

1. Pilot interviews: three household used to develop interview methods
2. College and graduate student’s nearing graduation or recently graduated: limited income, well educated about environmental issues, transition point in their lives
3. Off-road vehicle users: aware of fuel economy because of their fuel consuming hobby
4. State resource agency employees: might know more about environmental and energy issues in California
5. Farmers and ranchers: business people who do financial calculations and budgets over annual cycles
6. Computer industry: probably better connected by internet with technology developments, high level of quantitative skill
7. Military households: personal connection to the social costs of oil
8. Financial jobs: high level of financial quantitative skills
9. Recreational industry: lifestyle driven, sympathetic to environmental issues
10. Hybrid vehicle buyers: already buying very fuel efficient vehicles

Four step interview

The interviews each took about two hours and were conducted in these four major steps:

1. A history of all vehicles owned by the household members, and major lifestyle and travel stages in the household (such as children and job relocations)
2. A narrative of the most recent and other important vehicle purchases.
3. A prospecting of future purchases using something called a priority evaluator table and an exploration of willingness to pay for better fuel mileage.
4. Discussion of how household accounts and manages fuel use.

In the first part of the interview, we listen carefully to households talk about past vehicles and purchases, listening for bits and pieces of past attention to fuel economy, much like an archeologist looking for artifacts in the layers of a dig. For some individuals, these histories are

quite long, going back to the 1950s and including more than 20 vehicles. On the other hand, some students had just purchased their first vehicle. We are careful not to probe about fuel economy, as we want to elicit past interest in fuel economy, not prompt interest during the interview. Here we learn about the development of individual tastes and major influences on vehicle choices such as family, friends, and co-workers. We also learn under what conditions each person or the household made vehicle choices.

In the second part of the interview, we ask about the most recent vehicle purchase in much greater detail. As with the first part histories, the intent is to listen for clues as to whether fuel economy was a consideration: we do not probe about fuel economy. While vehicle purchases are not all that frequent, in some ways households we interviewed are in a constant state of anticipating their next purchase. Drivers see many sizes, shapes, brands, and ages of vehicles every day. People are confronted several times a day with motor vehicle related advertising on television, billboards, the Internet, radio, and magazines. When the time comes for people to actually shop for a vehicle, many have given considerable thought to what sort of vehicle they want and have discussed their desires, wants, and needs with a wide set of friends, family, and acquaintances.

In the third section of the interview, we prospect the household's next vehicle purchase using a simple priority evaluator table. After establishing whether they want a truck or sedan, we offer a list of vehicle attributes: performance, number of seats, cargo capacity, safety equipment/rating, fuel economy, pollution rating, options packages, and for trucks towing capacity and four-wheel drive. Each attribute is offered in three levels. For example, the seating options for an SUV were 4, 6, or 8 seats, which cost 1, 2, or 3 points respectively. We constrain their vehicle design by limiting their total points. Once they have completed an initial "design," we reduce or increase their points. Of course this structure forces households to spend more points to get higher fuel economy—just as they are being asked to do now, but in contrast to many people's expectations.

The game allows us to listen to the household discuss what they want from their next vehicle. We of course are listening for what they say about fuel economy, both initially, and as we further constrain or further facilitate their options. In some households we use a different strategy than changing points. For some households it was clear the heads of household had very different ideas about their next vehicle. In these cases, we asked them to each design their own vehicle. In some households, there was a question as to whether the next vehicle would be an additional vehicle, a replacement for an existing vehicle, or even the household's sole vehicle. In these cases, households designed a vehicle for each situation.

In the fourth part of the interview we focus on issues of fuel economy and fuel efficiency. Our goals here are to test whether energy experts and the automobile-buying public share similar vocabulary, to directly observe households respond to questions about paying more for higher fuel economy and payback periods, and to see whether households track the basic "building blocks" of rational consideration of fuel economy. These building blocks are elements of the "perfect" (or at least really good) information that is assumed to be available to rational actors. This fourth section is the one section where we are as interested in individual responses as we are in whether the household discusses and negotiates amongst themselves.

FINDINGS

Because our sampling technique is illustrative rather than representative and because our data takes the form of long narratives about each household, we typically do not emphasize percentages or other quantitative summaries of the responses. The greatest strength of our data is the detailed individual narratives, not descriptions of the sample. Sample distributions more appropriately do serve as hypotheses suitable for testing in representative samples. We do intend to describe the variety and range of consumer behaviors we hear in the interviews. Moreover, during the interview process, we continued to develop and change individual sections and questions of the interview protocol and to otherwise tailor each household's interview. However, in some cases the results across the sample are so complete and compelling that we report both the strength and numbers of responses. In other cases we offer qualifiers to convey a sense of importance or prevalence. We provide anecdotal information where we think it is important to the interpretation of the interviews.

Part One: An archeology of the role of fuel economy in household vehicle purchases—a barren dig?

Perhaps the strongest finding from this part of the interview is that so few households mention fuel economy when discussing past vehicle purchases. A few households did mention specific cars that they appreciated for their good fuel economy. These vehicles were often purchased during a period when a household member had a long work commute and the household still had modest income. Also, some older households who were buying cars and trucks in the 1970s recalled buying “economy” cars at that time. Recalling the magnitude of upward dislocation of gasoline price (and also recalling actual gasoline supply disruptions at that time), we note the strength of market signals required to shift some consumers to more fuel economical vehicles—at that time.

Across all our groups, some households with adults in their 20s and early 30s recalled their parents had shifted to vehicles with higher fuel economy during the 1970s and early 1980s. Since these young adults had no direct experience as automotive consumers with high gasoline prices and gasoline shortages, the (now adult) children remained bemused by their parents’ thrifty attitude toward fuel use. In many cases though, the shift to economical Japanese cars in the 1970s continues to echo in the children’s continuing purchase of what are now perceived to be reliable, high quality Japanese cars and trucks.

As a group, college students are currently the most interested in the fuel economy of their vehicles. This is because of two reasons, sometimes at work for the same person. One, money tends to be in short supply. Two, fuel costs can be the entire cost of operating a vehicle otherwise paid for by their parents. Three of our six college students stated they had shopped for an automobile with good fuel economy. Most discussed the environmental importance of good fuel economy.

Household histories show us whether the household and their members have been consistent in their tastes over time or whether they have a history of experimentation. Some households demonstrated multi-generational patterns. In some households, sons’ desires for pickup trucks were traced back through fathers and grandfathers. On the other hand, one of our hybrid buyers,

an engineer, had purchased a Nash Metro in the 1950s. This was one purchase in a pattern of experiments with cars throughout his life.

Part Two: The most recent vehicle purchase—the current role of fuel economy

Much like the first part of the interview, fuel economy rarely surfaces when talking about the most recent vehicle purchase, except for students, enlisted military personnel, and other less affluent respondents.

Particularly in middle and upper middle-income households with children, the focus of automotive purchases may be on a vehicle that is large enough for children, friends, dogs, vacation baggage, and large shopping items—a vehicle for general household use capable of meeting most of the demands a household might ever place on a vehicle it owns. Moreover, some families with young children have a strong interest in larger vehicles based on perceptions of safety. Because we were interviewing people along the Interstate-80 corridor in the Sacramento area, many households were interested also in four-wheel and all-wheel drive for access to winter and summer recreation activities in the nearby Sierra Nevada mountains. In other households, stronger assignment of household vehicles to specific people or tasks may mean more specialized vehicles. This specialization may be based on function or image. One illustration is from a household that owns a luxury sedan for the husband (a banker) who believes the vehicle conveys an appropriate image of successfulness and a mid-size four-wheel drive SUV that is large enough to carry the children for day-to-day activities, is capable of towing a (still imaginary) boat, and support the wife's job as a realtor specializing in undeveloped mountain properties. (In her words, "I sell dirt.")

This household is an interesting case of 1) competing decision criteria resulting in distinct vehicle types in the household and 2) the most fully developed case for fuel economy affecting vehicle choice. They are not yet on the rising income trajectory they had imagined they would be. He—despite having technical financial skills that allowed him to make the most sophisticated response to the later payback questions of any respondent—clearly cares more about presenting a successful image than in saving a few dollars through higher fuel economy. He stated that he could earn more money by "presenting myself as successful than I could save driving an economy car." She on the other hand took a more pragmatic approach to solving one of the problems with their prior mid-size SUV—its low fuel economy. This predecessor SUV was their first truck and it had replaced a mid-size sedan. They had both been unpleasantly surprised at the increase in fuel cost. When it came time to replace the first SUV, she was the only person we spoke to who had visited the USDOE/USEPA consumer-oriented automotive fuel economy web site: fueleconomy.gov. Fuel economy was subordinated to other household desires and needs, but she was determined to get high fuel economy given those other desires and needs.

Despite—or perhaps because of—the pervasiveness of vehicles and advertisements, the most common influences among all our households are the opinions and vehicles of family and friends. In fact, a common first step towards buying a vehicle is a conversation with friends or family, possibly including a test-drive in the desired vehicle. Frequently, the next stop is now the Internet, to read about vehicles at a manufacturer websites, independent companies that review vehicles, or—especially if looking for used vehicles—at sites listing used vehicles. Most of the

buyers we interviewed now avoid dealerships until the last step. They narrow their choices and increase their knowledge of prices and financing in anticipation of pressure from salespeople.

In contrast to lengthy and careful information searches and negotiations, many vehicle purchases are spurred by accidents and breakdowns. Sometimes these incidents provide a reason to execute a long considered plan; other times they interrupt such plans or thrust people into situations in which they act hastily to restore their lost mobility. The latter circumstance describes one of our students—a young woman days away from her law school graduation. While shopping for a sedan, she had started to focus on the hybrid available at that time. She'd been working as an intern at an environmental law firm and hybrid vehicles had been a topic of conversation among the lawyers and staff there. She began saving money for a hybrid. However, she was involved in an accident and her insurer declared her previous car a total loss; she needed an immediate replacement. She made some quick calculations about her expected income and expenses over the next few months while she studied for the bar examination and worked to find a job. All in all, she decided she did not have quite enough money yet to buy the hybrid and so she felt she had to settle for a conventional mid-size sedan, putting off her desired car for a few more years.

Part Three: Using the priority evaluator table to re-examine the current purchase or design the next vehicle

We had two primary purposes for the third section of the interview. First, it was usually clear by this point that most households were not paying high levels of attention to fuel economy in their vehicle purchases. So this part of the interview was intended to insure that we could listen to them talk about fuel economy as one of several vehicle attributes. Two, we wanted to establish as realistic as possible a context for introducing a “1.5X” fuel economy vehicle in Part Four. This context usually took the form of the next vehicle the household imagined themselves buying, so we wanted them to spend some time designing that vehicle. In some cases, we revisited the recent vehicle purchase. Because the hybrid vehicle itself was the context for discussing fuel economy with hybrid vehicle buyers, we did on conduct PE exercises with them.

By placing fuel economy in a table with seating and cargo room, options, performance, safety, emissions, and in the case of trucks towing and four-wheel drive, we sometimes learn additional information about how and why households buy vehicles than we did in Parts One and Two. Importantly, we see how other factors in peoples' lives can change their perception of their ability to choose higher fuel economy, we observe differences within a household in the importance of fuel economy, we discover the source of some peoples fuel economy expectations, and we detect whether current (at the time of the interview) conditions such as increases in gasoline prices appear to cause fuel economy to be treated differently than in past purchases.

Household 8 illustrates how the larger economic fortunes of a household can affect the role of fuel economy in vehicle purchase. This household is in the process of completely reorganizing their lives. They recently moved from the Midwest, adopted an infant child, decided that one of them would give up working outside the home to stay home with the baby, and then moved again from Sacramento to Davis. They are in a multi-year process of sorting out, among other things, vehicle ownership—going from being a two-car household in the Midwest, to a three-car household in California, to a two- or one-car household in California. The current three car phase is due to a lease on a vehicle that has one more year to run and a somewhat impulsive purchase

of two cars (a used Prius and a new Matrix) when they had been shopping for only one (the Prius). The household appears to have a high sense of environmental responsibility tempered by the possibility of looming budget constraints.

Rather than change the number of points they had to spend in the PE table, we had them design a vehicle for each of two scenarios. If their next vehicle was one of two, (assuming they are doing well financially) then it would need minimal passenger and cargo capacity, and the household would want the highest possible fuel economy and emissions control (as well as a moderate option package). If however the next car is to be the households only car (on the assumption that they might be doing less well financially), then the vehicle would have to be able to haul all three of them plus baby supplies and art supplies including large canvases. Within the same point constraint, they spend three additional points on seating (+1 pt.) and cargo room (+2 points) and relinquish some fuel economy (-1 point), emissions control (-1 point), and options (-1 point). In this household, the possibility a period of lower income would prompt a choice of a less fuel economical vehicle because the overall cost saving strategy is to own one vehicle, not two.

Household 29 is a farming family with two adults and four children. The finances of running a small farm shape their choices about almost everything. The joke told us by the male head of household: “How do you turn a large fortune into a small fortune? Buy a farm.” So, initial cost and reliability of their vehicles count more than fuel economy. This family makes almost its entire annual income in a few weeks during summer selling specialty produce, melons, and berries directly through farmers’ markets. The farm vehicles they own don’t travel many miles, so upfront cost matters more than fuel economy. For this reason, they buy only used cars and trucks. The larger trucks for trips to farmers’ markets are rented; reliability is more important than fuel economy. Higher fuel economy might save a few dollars on a trip, but if their load of produce and fruit doesn’t arrive on time, they lose far more money. The family did choose which farm to buy based on how far out of town they were willing to live. All the children must go into town for school, and all shopping, doctor and dentist visits, etc. require travel to town. So there is some sense of limiting fuel expenses and time on the road. They are large consumers of cellular phone minutes as they attempt to coordinate schedules to minimize trips and waiting time.

In their PE exercise they are shopping for another truck capable of supporting general work around the farm and trips to farmers’ markets. Overall the truck is very “practical,” it can tow but does not have four-wheel drive; it has the lowest performance rating, highest cargo capacity; meets emissions standards but is not among the cleanest vehicles available, has a high safety rating but not the highest, and the most basic trim package. They choose the mid-level fuel economy, and stick with it while manipulating seating and options in subsequent rounds.

Household 23 demonstrates how different views of the importance of fuel economy—for a specific vehicle choice—can be in a household even when there is substantial agreement on so much else about the vehicle choice. Household 23 is a middle-age couple with four sons; two of the sons are driving age. Their PE exercise involves each of the household heads designing a replacement for the Subaru that the female head of household now uses to commute 60 miles round-trip to downtown Sacramento. They agree on everything—which vehicle they will replace next, when they will replace it, who will drive it, and the details of its design—everything except options and fuel economy. She (who will drive it everyday) chooses the highest trim level and

the lowest fuel economy. He (who handles the household budget—though he doesn't treat gasoline as a line item) chooses the lowest trim package and highest fuel economy.

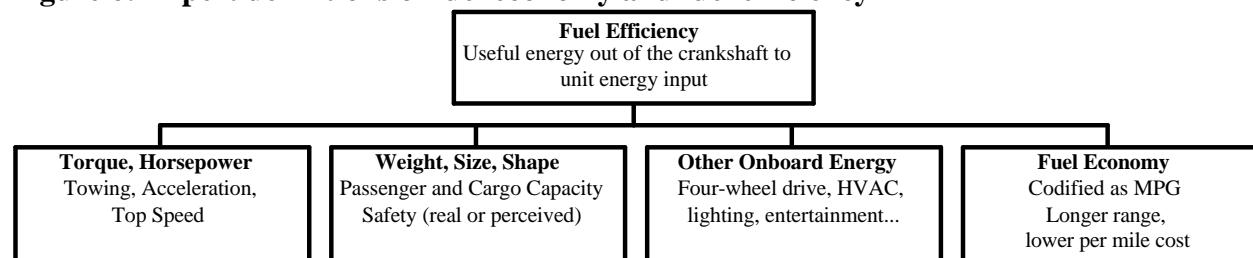
Some full-size truck buyers are interested in lower fuel costs, and look to “alternative” drivetrains. Both households 44 and 45 imagine they would next buy (another) full-size pickup truck. Both currently own gasoline powered trucks but are interested in diesel engines. Both choose the highest level of fuel economy in the (truck) PE table—24 mpg—because that is what they expect they would get from a diesel engine.

In the course of the PE exercise, no household appeared to make a strong commitment to high levels of fuel economy for a future vehicle (or a revisited version of a recently purchased vehicle) based on current increases in gasoline prices. Households who did choose high or mid-level fuel economy for their vehicles appeared to be doing so out of longer term commitments to environmental and social issues, or because high fuel costs incurred because of long commutes or other demands such as towing at some point in their personal or household histories. Still, in some high fuel use households, fuel economy was surprisingly (to us) undervalued. Some people towing or traveling long-distances seemed satisfied with low fuel economy ratings in the PE table (mirroring what they are achieving now in the real world) and choose to spend points elsewhere, even when offered more points.

Part Four: Fuel efficiency and fuel economy—what are they and what information do people have about them?

This is the part of the interview where we finally reveal our real interest in fuel economy. The first question we ask participants in this section is whether there is a difference in their minds between *fuel economy* and *fuel efficiency*. In technical writing and discussions we see and hear automobile companies, engineers, regulators, lobbyists and other experts using the terms in specific ways. These expert definitions and their relationship to each other are illustrated in Figure 6. To experts, *fuel economy* is codified in federal regulations as miles per gallon (under specified test conditions). Some experts may add a market based definition linked to the cost to drive, something like dollars per mile. This is of course mediated by fuel prices. The expert definition of *fuel efficiency* is narrowly technical—the amount of useful energy out of the crankshaft per unit energy input. The relationship between these two is therefore that fuel economy is simply one service that flows from fuel efficiency; movement of the vehicle down the road is simply one use of energy out of the crankshaft.

Figure 6: Expert definitions of fuel economy and fuel efficiency



Few of our households share the same understanding of these two basic terms. The most common “off-the-top-of my-head” response to the question of whether these two phrases mean the same thing or something different, is that they mean the same thing; both phrases are about how much gasoline the vehicle consumes. Note this is not always about how much fuel is consumed *per mile*, in many cases fuel consumption is more abstract than that, as if people are thinking in terms of some aggregate fuel use—the gasoline they use to create the dispersed, mobile, lifestyle possible through automobility.

As some people continue to talk about the question, they convince themselves that *fuel economy* is about saving money while *fuel efficiency* is about saving fuel. When we ask people to tell us what type of automobile comes to mind when we say “good fuel economy,” most think of the smallest, least expensive, most economical vehicles. In contrast, “good fuel efficiency” tends to split the respondents into those for whom there is no different image and those who say fuel efficiency evokes images of higher quality vehicles, with better engineering, maybe better manufacturing, and new technology. Those respondents with engineering backgrounds tend to give more technical definitions, but do not uniformly provide the same distinctions as automotive experts. A truck driver noted that his tractor-trailer combination was efficient, saying, “I may only get seven or eight miles per gallon, but it’s an efficient way to haul 16,000 pounds.”

The many “lay” definitions of fuel economy and fuel efficiency and their differences from expert definitions are important findings. There are likely biases and mistaken inferences from some questioning of consumers. Many lay people cannot separate the idea of good fuel economy from their worst idea of a cheap vehicle. Until the advent of hybrid vehicles, the reality of paying more for good fuel economy was not present in the market; one got good fuel economy by paying less for a vehicle, not more. If you wanted higher fuel economy, you bought a small car rather than a big car, or a car rather than a truck; you bought a four or six cylinder engine rather than a six or an eight; you did not buy additional expensive energy consuming options like air conditioning and four-wheel drive. A car with high fuel economy was an economy car.

Willingness to pay for higher fuel economy

After we developed an understanding of the priorities they hold for some vehicle attributes in priority evaluator (PE) exercise during the third part of the interview, we then ask households how much they would be willing to pay for an increase in fuel economy. The reference vehicle is the first one they designed in the PE exercise. The fuel economy increase we posit is usually a 1.5 times increase. While we occasionally choose a different multiplier than 1.5, we typically chose this number for two reasons. First, it is the maximum possible change in the PE table (and thus might be a change the household actually made in the PE exercise when we allowed them more points to spend). Second, a 1.5x change is large enough on the one hand to get the attention of people who for the most part are not paying attention to fuel economy, but on the other is within the realm of technical plausibility. Once they have answered the question of how much they would pay, we follow up by asking how they arrived at their answers.

In Table 2 we summarize the types of answers we received to this question. In eight of the early interviews we did not ask this question about willingness to pay directly, so no values were solicited. In eight interviews in which we did ask the question, the household could not or would not offer a value. Ten other households offered a wide range of values for their answer. Typically these ranges were on the order of \$2,000—“\$2,000 to \$4,000” or “\$5,000 to \$7,000”—and

conveyed obvious uncertainty. Sometimes these ranges represent disagreement between spouses who are unable to agree on an amount in the course of the interview. Among the households who offered specific dollar amounts (or ranges of less than \$1,000) values ranged from zero to \$10,000. We describe the various bases for these responses next.

Table 2: Willingness to pay for increased fuel economy

Amount willing to pay for a 1.5x improvement in the fuel economy of their design vehicle from part 3 of the interview:	Number
\$0	2
\$0<\$1K	3
\$1-2K	1
\$2-3K	5
\$3-4K	2
\$4-5K	1
\$5-6K	7
\$6-7K	1
\$7-8K	0
\$8-9K	1
\$9-10K	0
= \$10K	1
No amount offered—unable to answer	8
Broad range of answers offered	10
Question not asked by us	8
Hybrid buyers—who as a group viewed their purchase more holistically than merely one about fuel economy	7

Basis for willingness to pay responses

More than the values themselves, our qualitative approach best illustrates why people answer as they do. To illustrate the types of answers households offer, we include these notes from Household 56. They are responding to our inquiry about their willingness to pay for a 1.5X improvement in the fuel economy of their design vehicle—a full size SUV, i.e., 11 mpg improved to 17 mpg. These are two technically skilled people from our financial sector. As a matter of household decision-making they appear to negotiate a lot with each other, having done so throughout the interview. Further, prompted by a desire to buy another home, this household is in the midst of a review of all their expenses as they try to determine how much they can afford to spend. They eventually offered a specific dollar answer—\$3,000—but, their dialog illustrates that even financially technically competent people have a hard time responding to this question, in part because they have never thought about their vehicle purchases in this way.

The male head of household answered first, saying, “\$2,000...I’m so wanting a spreadsheet right now.” He laughs. The female head of household makes a joke about a colleague writing the spreadsheet program; they both laugh. Then she says, “\$4,000...it’s a gut feeling.” He continues, “I was trying to calculate it [in my head], but I didn’t carry it through very far....” She continues,

“We probably drive each car about 7,000 or 6,000 miles every year.” She then suggests they might save 1,000 gallons per year; he thinks this might be too much. He says “\$2,000 to \$4,000.” Together they say, “Call it \$3,000.” If a household in which both household heads are financial professionals has trouble providing an answer to our question, how would they respond to the same question during a phone survey, and how would we expect other households to respond?

Table 3: Basis for willingness to pay answers

Basis	Number
Guessing or clearly never really understand the question.	9
Discussion is along the lines of a payback period calculation, but make mistakes.*	8
Comparing to other vehicle options, pricing	6
Comparing to what they’ve heard about hybrids	4
Big, round “magic” number signifying importance	2
An apparently plausible payback assessment	2
Balance increased monthly payments with fuel cost savings	1
Expected duration of ownership	1
“Intelligent” guessing—asking the right questions, but clearly not repeating a prior practice	1

*The most common mistake is to overestimate that amount of fuel saved.

In nine households, our respondents admitted they were guessing or didn’t really understand the question. Six households arrived at a dollar value through a comparison to other vehicle types, the cost of options packages, and what they experienced as incremental price differences in the market for things like more powerful engines. Some (non-hybrid owners) are already familiar with the price difference of hybrids and used that as the basis for answering. These findings mean that some of our respondents were not telling us how much they were willing to pay for 1.5 times higher fuel economy, but rather were telling us what they were guessing it would cost.

In eight households, their answers followed from a discussion of time—along the lines of a payback calculation—how long they expect to own the vehicle, balancing fuel cost savings with monthly payments, etc. That is, they tried to “back into” a dollar amount by first addressing the question of how long it might take to be paid back.

A few households simply offer large round numbers, e.g., \$5,000, without much explanation as to why. We call these “magic numbers,” signals that within the social context of an interview in their home, respondents are representing that fuel economy is something that should be important.

Only two individuals offer plausible willingness to pay answers arrived at through a process that could be described as rational (rather than through simple guessing). We judge the plausibility of their answers based on their producing a consistent set of answers to this question and later questions about the time they are willing to wait to be paid back, how much they drive, and what

price they pay for gasoline. Their rationality is limited in the sense that neither based their answer on a net present value calculation, but rather on simple payback period.

We treat the hybrid buyers as having actually having paid, at least in part, for higher fuel efficiency and fuel economy and thus do not ask them precisely the same questions. Any price premium for a hybrid cannot be solely attributed to higher fuel economy. No hybrid buyer we spoke to say the choice to buy a hybrid was primarily, or even importantly, about fuel economy—in either the sense that *fuel economy* is about miles per gallon or the cost of driving. Some hybrid buyers were attracted by the new technology; others by the low emissions of criteria pollutants; and others still by a sense of “living lighter”—getting around while consuming fewer resources. One respondent said, “I looked at the whole package, and judged it was worth the price.” Further, it is clear that even assessing what is the relevant difference in fuel economy depends on detailed knowledge of the households’ vehicle holdings and transactions. Many hybrid buyers are crossing vehicle classes in order to buy the only hybrids available at the time of this research. One hybrid buyer traded in his Jaguar XJ6; another, his Toyota Camry; and another bought a Prius (a mid-size sedan) rather than a small SUV.

We estimate that at least 14 of our respondent households have at least one member who is either a professional in the financial services sector, likely had at least one collegiate level course covering the topics of payback periods and net present value calculations, or otherwise has high quantitative skills. These include our financial services sector households, our computer hardware/software households, and other households who happened to include a banker and a mathematics professor. These include the eight households in the table who discuss the problem in terms of payback (but make mistakes), the two people who offer plausible payback discussions, and the one person who was asking the right questions, but clearly had never thought about this question previously.

How long will people wait for fuel cost savings to payback a purchase premium?

Following the question about whether and how much they would be willing to pay for higher fuel economy, we asked whether they expected this purchase price premium to be paid back by fuel cost savings, and if so, how they arrived at their estimate of how long they would be willing to wait. Table 4 and the discussion below summarize the range of responses.

More than one-third of the households to whom we posed this question would not or could not offer a payback time; most of these said it was just not the way they thought about it. Six households were clearly guessing; some offered a serial string of numbers in a questioning tone suggesting they hoped we would stop them when they arrived at the correct answer. Another group, either immediately or after some discussion, settled on a time period that corresponded to the term of their vehicle loan. We call this a “temporal anchor,” a familiar time period offered in response to an obviously unfamiliar question. The other temporal anchor offered by some households was the time they expected to own the vehicle.

Those who gave the shortest (non-zero) payback periods, i.e., one to three years, were in many cases being optimistic rather than impatient. When we asked about how they arrived at their answer to the question of how long they would be willing to wait, it became clear these people were over-estimating how much they thought they would save on gasoline.

Table 4: Willingness to wait to be paid back by higher fuel economy

Of those who offered a specific time (years):	Number
0	2
1 to 2	2
2 to 3	2
3 to 4	2
4 to 5	1
5 to 6	5
6 to 7	0
7 to 8	1
8 to 9	0
9 to 10	0
More than 10	2

Of those who did not offer a specific time:	
No time solicited	7
No time offered by respondent	20
Guessing, widely varying times offered	6
Expected duration of vehicle loan	3
Cash flow constrained (willing/able to wait no time at all)	2
Not able to answer, don't understand	2
Not able to answer, does understand (our one forecaster)	1
Balance fuel cost savings with monthly payment	1

The two households who said they would not be willing to wait at all explained that they believed their spending was so constrained by cash flow they could not pay anything more upfront.

The three households who offered the longest payback periods all based their replies on the belief they would own their vehicles for long periods of time; in effect saying, “I want any purchase price premium to be paid back while I still own the vehicle, but I expect that to be a long time.”

The most common mistake made by our respondents is to overestimate fuel savings, and therefore overestimate the dollar value of fuel savings. In turn, inflated estimates of fuel savings are usually the result of overestimating how much fuel they consume. We discuss the quality of peoples’ knowledge of their fuel expenditures in the next section. Also, a number of households made the mistake of assuming they would be saving their entire fuel cost for a year instead of just the 50% improvement in fuel economy. Even households who offer large willingness to pay figures often think they can get back their investment in a couple of years.

The idea of a payback period for an “investment” in higher fuel economy is not part of the vehicle purchase decision-making even in the most financially sophisticated of our households.

They tend to understand the question immediately, but as one accountant responded, “Oh yea, payback calculations; I would never have thought about it that way.”

The building blocks of rational decisions

So are any of the answers to questions about willingness to pay and payback periods rational? The answer clearly is, no. The overwhelming conclusion from this section of the interviews is that most people are unable to construct reasonable estimates from their own vehicles, fuel use, and travel of how much a fuel economy improvement is worth to them in strictly private financial terms. Financial professionals perform almost as poorly as the other groups in our study. Even those respondents who do construct competent answers demonstrate that this is something they have never done before for any real vehicle purchase they have ever made. In addition to whether people understand, algorithmically, how to construct rational responses, we also asked questions about the basic building blocks of rational decision-making—the perfect, or merely really good, information consumers are assumed to have about their own costs and options for improved fuel economy.

Household knowledge and behaviors around fuel economy

In the final part of the interview, we asked households several questions to test their knowledge of their vehicles fuel economy, fuel costs, and their vehicle travel. We found that 34 of our households could tell us the MPG of their vehicles with varying degrees of certainty, while 19 could not for one or more of their vehicles. Additionally, within several households we found that one person might know the mpg of their vehicle while others in the household did not. (These questions were not asked in three households.)

Households have different ways of ascertaining their vehicles fuel economy. The “known” mpg values may be measured in use from tank to tank, recalled from the window sticker when the vehicle was purchased, or recalled from reading the owner’s manual. Seven of the 34 who know their vehicles’ fuel economy are households who own hybrid vehicles that have more obvious, precise, and visible fuel economy instrumentation. Of the 27 households who own only conventional gasoline ICEVs, several measure their fuel economy as a diagnostic tool to judge vehicle performance over time, not to track costs or fuel economy per se.

Knowledge of fuel expenditures

We asked households how they best understand their fuel expenditures, and prompted them “annually, monthly, or weekly?” Most chuckle at the idea of knowing their annual fuel cost, it is an unknown number for all but a couple households. The time periods for respondents understanding of their gasoline expenditures are summarized in Table 5.

The largest number of households, 27, either said they had no idea of their gasoline expenditures over any period of time (14) or knew only what they spent per tank of gasoline (13). Many of these households tried to develop a “monthly” estimate by calendarizing their gasoline purchases—starting with their estimate of the cost of a tank of gas and multiplying that by how their guess as to how many times they refuel per month. For example, “We buy gasoline about every two weeks, and each tank costs \$40. So we spend about \$80 per month.” As with the issue of whether people conduct payback or NPV calculations though, the simple fact that people

could guess their monthly gasoline costs is not the same as their actually doing so on an ongoing basis. These 13 households were constructing this estimate for the first time for us.

Table 5: Basis for households' knowing their gasoline expenditures

	Number
We didn't ask	10
Household didn't know and wouldn't even guess gasoline expenditures	14
Per Week	6
Per Month	9
Per Year	3
Calculate over specific trips	2
Calculate from tank to tank	13

Overall, the most common way for people to know their gasoline costs was by knowing the cost of a tank. That the cost of refueling their tank is a common measure people are able to recall is supported by data specifically about recalling their last refueling. 31 households could recall with some confidence how much they paid for that tank of gasoline. That confidence appears related to how long ago the last refueling was done. It takes only a few days for the specific amount to appear to be forgotten, and a “typical” amount substituted for it.

A few households do have credit cards dedicated to their gasoline purchases, and they seem to have a better handle on monthly costs. Still, many of these households buy gasoline for several vehicles on the same card, and thus do not have any better idea how much they spend on gasoline for any one of their vehicles.

Of the three households who appear to know their annual fuel costs, one was clearly guessing and two were undertaking broad reviews of annual household expenses at the time of their interviews. One was in the process of completing his taxes and had just figured his annual miles for purposes of claiming a business deduction. The other household was contemplating buying another home and was tracking all expenses to assess how much they could afford to pay.

It is clear that for most households, fuel expenditures are not tracked over time, rather are perceived through refueling events. That is knowledge of fuel costs appears to more commonly be episodic and ephemeral; the largest group of people can recall the price of their last tank, and last gallon, of gasoline. However they do not sum or integrate these costs over time, and we observed that the certainty with which even these numbers were offered appeared to depend on how long ago the last refueling event occurred. Refueling done in the past few days appear to provoke quicker, more confident responses than refueling done earlier.

DECISION STYLES

We offer here a summary of the different ways we heard households make decisions about fuel economy. This categorization scheme is not binding; these are not social groups with distinct cultures. Rather, these groups are clusters of traits centered on life experiences and shaped by the

constraining, or facilitating, effect of lower, or higher, income. Membership of any given household in any given category might be stable over time, but is not so fixed that non-incrementally new performance, e.g., hybrid technology, cannot shake people loose.

1. Households with limited funds, like students and enlisted military personnel, pay attention to fuel economy. They will pick at least one smaller and lower cost vehicle. Additionally, they may choose to lower vehicle costs by purchasing used vehicles. They do not track or consider *annual* fuel costs. In fact, this group uses either cash or debit cards for gasoline, and therefore has fewer records of their gasoline use. The exceptions to the latter are students who follow a father's instructions to measure their fuel economy from tank to tank. This is not for financial reasons, rather to track the performance of the vehicle for maintenance purposes.
2. A large group for whom any desire for higher fuel economy is submerged under competing desires. In particular, affluent families whose needs and desires for seating room, cargo capacity, and perceived safety overshadow fuel economy concerns. This group may have threshold values of fuel economy below which they prefer not drop ("Anything over 20mpg is okay, but I really wouldn't be comfortable with a car that got less than that.") and even shop occasionally for cheaper fuel at a place like Costco.
3. Another group of people who are most interested in luxury and performance, and therefore ignore (disdain?) fuel economy. We also include in this group owners who so strongly want towing capabilities and large SUVs that it is fair to say these desires have not merely submerged fuel economy, they have sunk it altogether.
4. A group of people, who were raised in very poor households and, whether or not they are still poor, are ambivalent about fuel economy. Their discussions alternated between a (real or felt) need to be both thrifty and a desire for extravagance. Vehicle purchase decisions are often impulsive and tend toward expensive, powerful vehicles. But these households may limit the use of such a vehicle and shop for inexpensive gasoline. These households can be interested in new technologies for the attention they garner.
5. Our hybrid vehicle owners form a distinct group. While we have seen on hybrid owner web sites discussions of fuel economy, none of the hybrid owners in our study track fuel economy over long periods of time. We emphasize that no hybrid owner we interviewed was solely or even importantly interested in saving money on gasoline. Rather they are most interested in resource conservation, reduced air pollution, new technology, and being a part of, what they perceive to be, the future. Because of their distinctive purchase and some of the results that we found surprising, we discuss this group further next.

Hybrid owner interviews

We interviewed hybrid buyers because they appeared to have paid several thousand dollars for a high-tech approach to better fuel economy. We wanted to know how they made this decision. The interview protocol for these households was different than for other households. For example, we did not prospect the purchase of a vehicle with better fuel economy using a priority evaluator table; the hybrid buyer appeared to have already done this, so we spoke directly about

that decision. Additionally we spoke with hybrid buyers about the wider meanings of their purchase, as well as what it was like to own a vehicle with this new technology

We specifically recruited five Prius owners, and additionally recruited unintentionally three Honda Hybrid Civic owners within in our other samples (one student, one rancher-farmer, and one career military family who had bought a Civic hybrid in Hawaii where it is still used).²

Knowledge

We were surprised that none of the eight hybrid owners in our study tracked fuel economy over long periods of time; nor were the hybrid owners any more likely than the other 49 households to know their annual fuel costs—*beyond what the vehicle will do for them without their intervention*. We emphasize that no hybrid owner we interviewed was solely or importantly interested in saving money on gasoline. Rather they are most interested in resource conservation, reduced air pollution, new technology, and being a part of, what they perceive to be, the future. Several were motivated by the Prius's *super ultra low emission vehicle* rating. They knew a lot more about the vehicle they were buying and the environmental issues it addressed than they did about their own fuel costs and mileage demands. It wasn't just about the right vehicle for them, rather it was also the right vehicle for society. Or perhaps, it is that the vehicle they perceive to be right for society, is the right vehicle for them.

Commitment to a making a difference

For the Prius buyers, the vehicle is a commitment to be pioneers and lessen their impact on the environment. In almost all cases, the household had to wait several months for delivery of the vehicle. This commitment included for one buyer also biking and walking more, i.e., once she had the hybrid vehicle, she looked for other ways she could save energy, including driving less. For several buyers this commitment included talking to other people about their car, setting an example, being a pioneer. Several buyers also shifted from a larger vehicle to a smaller vehicle. For one household, their Civic Hybrid was part of a larger project to reduce their environmental impacts. This household had moved to a “hobby” farm in a remote rural area, which given their job locations and other interests resulted in lots of driving. Satisfied as they are with their hybrid, they are hoping to buy another (and thus be a two hybrid car, one medium-duty truck household) to further reduce their resource use and pollution.

Not all of our buyers were that committed; two got their vehicle under different circumstances. Our student who drives a Civic Hybrid had wanted a used VW Jetta. But his father, an engineer, was impressed by the Honda hybrid technology and was paying for the vehicle. The student agreed to the hybrid because the interior of the Honda hybrid was much nicer than the Jetta.

² Hybrid sales in 2004 are approximately 4.2 percent of vehicle sales at Toyota dealers in Northern California (Matt Nauman, San Jose Mercury News, August 26, 2004). Hybrid registrations in CA for 2003 were 11,425; annual national growth rate was 88 percent (Polk, (2004) *Hybrid Vehicle Registrations up 25.8 percent in 2003*, accessed at http://www.polk.com/news/releases/2004_0422.asp). We estimate that hybrid sales for CA that year were about 5,000 vehicles. California's annual household vehicle market is about 1.2 million, which means hybrids are about 0.5 percent of annual sales in 2003. Thus, we might have expected at most one hybrid out of our 57 households, if the households had been drawn at random. We think perhaps our recruiting firm may have found two hybrid buyers (we recruited student households ourselves) and thought we would like to talk to them, which is true.

Another hybrid buyer had acquired her Prius used; as it turns out this hybrid owner became unhappy with her mileage, reporting her Prius got under 40 mpg, and planned to sell the vehicle.

Adoption

Some aspects of the hybrid vehicle purchase were a natural transition for some buyers. Several Prius buyers said they were already loyal to Toyota products. Their trust for Toyota reliability encouraged them to try the new technology. Several Prius buyers were influenced by friends and colleagues who owned Prius's; this allowed them to trust and even try their friend's vehicle. In comparison, some hybrid buyers were clearly experimenters. One had purchased several innovative vehicles over a fifty-year period. He is now retired but liked driving the Toyota so much he was driving more miles than usual. He had also been a pilot and like the instrumentation and cockpit like feel of the Prius.

Post-purchase and communication

In some cases, hybrid buyers were testing the vehicle after purchase. One family took a vacation with friends to Las Vegas—a destination they had never previously visited—right after purchase to see if the vehicle was big enough for four people on an extended trip. All hybrid drivers reported watching their mileage closely after purchase—facilitated by the more prominent fuel consumption display. The post-purchase phase was also the period in which they were communicating their experience to other buyers. Some of the Prius buyers are gregarious and like talking with people—acquaintances and strangers—about their vehicle.

CONCLUSIONS

So how are we to think about consumers and fuel economy? How does fuel economy figure in vehicle purchase decisions? Based on what we heard in almost every single one of our 57 households, many findings from past energy research and analysis that report consumer payback periods for new fuel economy technology in automobiles seem unrealistic. We would conclude that consumers in past studies were not answering questions about willingness to pay or payback periods in the way survey writers assumed they would. In effect, we expect that most people are caught off guard by such questions; in answering, respondents are in the process of making up an answer to a novel question, not recalling the result of a past calculation. We consistently watched consumers overestimate their fuel cost, express willingness to pay values out of line with an objective review of their potential savings and past behavior, and then offer payback periods that are out of line with their expenses.

Hypotheses

We offer two competing hypotheses.

1. Consumers engage in a type of limited economic rationality. Because of the low price of gasoline and limited fuel use instrumentation, consumers give little attention to fuel economy. In this case, if gasoline prices increase enough, consumers will develop more calculating, economically rational decision-making regarding fuel economy.
2. Automobiles are repositories of too many other high valued attributes, some which have important but non-quantifiable/non-monetized value, that few automobile buyers pay

much attention to fuel economy. Even if gasoline prices rise, buyers respond in surprising, i.e., non-economically rational, ways.

We described in the historical context the small and declining real cost of gasoline compared to other aspects of vehicle ownership and operation (as well as most other goods and services in the “market basket” used to calculate the Consumer Price Index). We reported the association by many of our respondents between high fuel economy and cheap vehicles. We noted the poor fuel use instrumentation in most vehicles. It would seem little wonder that consumers, at best, engage in a limited or bounded type of economically rational decision making, that they forgo the monitoring of gasoline costs over time, substituting a quick look at the cost of a tank of gasoline in place of longer term attention to fuel costs.

Choosing between these two hypotheses would require a broader study. But even based on our limited sample, we are prepared to go so far as to say that we can no longer afford the luxury of the assumption that so many consumers are behaving in an economically rational manner that such rationality is the sole sufficient basis for policy formulation and analysis. Even in a sample constructed such as ours, if economic rationality is that pervasive in the population, we should have found some one who articulated their automotive purchase and use decisions in a manner consistent with the assumptions of *homo economicus*. We did hear from a hybrid buyer who thinks he drives more now—but not because it is cheaper to drive. He drives more because he likes how his Prius reminds him of the cockpit of the small planes he used to fly and because he feels the SULEV emissions rating lets him drive more while polluting less. In contrast to the expectation that lowering the cost of driving will lead to increases in driving, we also heard from a hybrid owner who was prompted by the purchase of her vehicle to find more ways to use less energy, including driving less. We heard from households with high fuel demands who were attracted by non-incremental, non-marginal improvements in fuel economy and fuel efficiency such as those offered by hybrids and as offered by us in the course of their interview. They appeared to be inspired by large changes in fuel economy beyond even what those large changes might save them in gasoline. Conversely, we listened to households who consume tremendous amounts of gasoline remain blasé about large changes in fuel economy and sanguine about rising gasoline prices; not all these households appear to be operating with high incomes.

We find that car and truck drivers do not have the basic building blocks to make calculated decisions about better fuel economy, and most do not keep track of fuel cost over any significant time period, be that the life of the vehicle, their duration of ownership, annually or even monthly. Refueling does not happen on a regular schedule, so even in the context of our interviews, households can only make rough estimates of costs over time. But going back to the vehicle purchases, it is clear that even our most financially capable buyers have not purchased their cars and trucks based on the application of payback or net present value analyses to these household decisions.

We also noted in this research that consumers most often overestimate their annual fuel costs. For these people, pointing out their true annual fuel costs and the difference in their costs made possible by higher fuel economy might not be the best strategy to foster purchases of more fuel economical vehicles—if we assume higher fuel economy or fuel efficiency have only private monetary value to economically rational consumers.

We believe, at least as a viable hypothesis for further assessment, that lay populations, i.e., the vast majority of car and truck buyers, use the phrases *fuel economy* and *fuel efficiency* differently than do many automotive and energy experts. Experts tend to use a very specific definition of efficiency—the ratio of useful energy out of a system to a unit of energy into the system. Fuel economy is defined, in fact codified in federal law and regulations to be miles per gallon under specified test conditions. Thus, to experts higher fuel economy is just one of many energy-based services that could be derived from higher fuel efficiency. No layperson we interviewed articulated this entire set of definitions and relationships between economy and efficiency. The top-of-mind response of most of our respondents is that fuel economy and fuel efficiency are the same thing—a measure of how much fuel a vehicle uses. As they continue to talk about it, some of our respondents conclude that fuel economy is about saving money (based on the association between the word “economy” and money) while fuel efficiency is about saving fuel. Others take efficiency to be a measure of quality, how well the vehicle works. Based in part on consumers more positive images of the term *fuel efficiency*, it might be strategic for those interested in promoting good fuel economy to shift their terminology and focus to good fuel efficiency.

We can't say whether consumers will be more calculating if the price of gasoline rises considerably over the next few years. Consumer may still rely on the heuristics of pump and tank prices. We do observe that vestiges of the last great dislocation in gasoline prices during the 1970s and early 1980s do survive—but as faint echoes of remembered behavior. Further, we have seen no analysis of that time period that separates fuel price effects from fuel supply effects. (See Kurani and Turrentine, 2004 for a more general review of past research on consumers and fuel economy.) In addition to rapidly rising gasoline prices, consumers at that time had to contend with actual supply disruptions and governmental attempts at rationing through even/odd day gasoline sales.

Whatever the apportionment of cause to price or supply, our older respondents could talk about changes to their vehicle purchasing during that decade. Younger respondents may recall what their parents did. Some households did experiment with small, frugal, and quite often Japanese “econo-boxes.” The echoes to this day include many older people who became lifelong Toyota and Honda buyers, and younger adults who know these former economy car brands only as reliable, affordable, well-made, high quality—if not always exciting—automobiles.

We tentatively conclude that we heard five distinct kinds of stories about fuel economy and fuel efficiency—once we prompted such conversations. Our classification scheme is based on personal histories and household incomes. As such, we expect there to be some stability of membership in category. However, events outside the person and household impinge and both personal history and household income are subject to change from within.

REFERENCES

- American Petroleum Institute (2002) How Much We Pay for Gasoline? The Cost of Motor Gasoline to Consumers, October 2002 Review. Washington, DC: API.

- American Petroleum Institute (2003) Basic Petroleum Data Book, Washington , D.C.; US Dept. of Labor, Bureau of Labor Statistics; and US Energy Information Administration
- Chater, N., Oaksford, M., Nakisa R., and Redington, M. "Fast, frugal and rational: How social norms explain behavior", *Organizational Behavior and Human Decision Processes*, 90 (2003) 63-86.
- Davis, S. C. and S. W. Diegel (2003) *Transportation Energy Data Book, Edition 23*. Oak Ridge, TN: Oak Ridge National Laboratory, Center for Transportation Analysis. Available at: www.cta.ornl.gov/data
- Greene, D.L. (1983) "A Note on Implicit Consumer Discounting of Automobile Fuel Economy: Reviewing the Available Evidence." *Transportation Research* 17B:6 pp. 491-9.
- Greene, D. (2002) "Is this Market Efficient? Implications for Fuel Economy Policy." Presentation to SAE Government/Industry Meetings; Washington, DC. May 14.
- Gurikova, T. (2002) *Transportation Energy Survey Data Book 1.1*. Oak Ridge National Laboratory; Oak Ridge, TN.
- Kayser, H.A. (2000) "Gasoline Demand and Car Choice: Estimating Gasoline Demand using Household Information." *Energy Economics*, v. 22, pp. 331-48.
- Kurani, K.S. and T.S. Turrentine (2004) Analysis of Consumer Response to Automobile Regulation and Technological Change in Support of California Climate Change Rulemaking. Report to the California Air Resources Board and California Environmental Protection Agency. Contract 02-310, Project No. 008545.
- Kurani, K.S, T. Turrentine and D. Sperling (1994). "Demand for Electric Vehicles in Hybrid Households: An Exploratory Analysis." *Transport Policy*. 1:4, 244-56. October.
- Kurani, K.S. and T.S. Turrentine (2002) *Marketing Clean and Efficient Vehicles: A Review of Social Marketing and Social Science Approaches*. Research Report UCD-ITS-RR-02-01, Davis, CA: Institute of Transportation Studies, University of California.
- Olshavsky, R.W. and D.H. Granbois (1979). "Consumer Decision Making—Fact or fiction?" *Journal of Consumer Research*. 6:2, pp. 93-100.
- Pitts, R.E., J.F. Willenborg, and D.L. Sherrell (1981) "Consumer Adaptation to Gasoline Price Increases." *The Journal of Consumer Research*. v.8, n.3, pp. 322-30.
- Puller, S.L. and L.A. Greening (1999) "Household Adjustment to Gasoline Price Change: An Analysis using 9 Years of US Survey Data." *Energy Economics*, v. 21, pp. 37-52.
- Reich, W. (2000) Heuristics as Plausible Models of Rationality? *Acta Sociologica*
- Sanstad, A. and Howarth, R. (1995) "Consumer Rationality and Energy Efficiency." *Proceedings of the ACEEE 1994 Summer Study On Energy Efficiency in Buildings*.
- Senauer, B. J. Kinsey, and T. Roe (1984) "The Cost of Inaccurate Consumer Information: The Case of the EPA Mileage Figures." *The Journal of Consumer Affairs*. v.18, n.2, pp. 193-212.
- Steiner, E. (2003) *Consumer Views on Transportation and Energy*. Draft. Washington, DC: USDOE Office of Energy Efficiency and Renewable Energy.

- Stern, P.C. (1992) "What Psychology Knows about Energy Conservation." *American Psychologist* 47:10 pp. 1224-32.
- Verboven, F. "Implicit Interest Rates in Consumer Durables Purchasing Decisions: Evidence from Automobiles" Research Report. Center for Economic Research: University of Antwerp, March 1999.
- U.S. Environmental Protection Agency (2004) *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*. Ann Arbor, MI: Office of Transportation and Air Quality, Report EPA420-R-04-001. April. Available at:
<http://www.epa.gov/otaq/fetrends.htm>
- Yun, J.M. (2002) "Offsetting Behavior Effects of the Corporate Average Fuel Economy Standards." *Economic Inquiry*, v.40, n.2, pp. 260-7