Impacts of Information on Consumer Attitudes, Opinions and Choices Related to Rooftop Solar Electric Systems

Susan Buller, Pacific Gas & Electric, San Francisco, CA
Michael Sullivan, Freeman, Sullivan & Co., San Francisco, CA
Josh Bode, Freeman, Sullivan & Co., San Francisco, CA

ABSTRACT

This paper reports the results of an information experiment designed to enhance consumer awareness of and information about rooftop solar electric systems. In the experiment, representative samples of consumers were randomly assigned to three information conditions designed to provide them with different levels of information about the prevalence, appearance, practicality and cost of rooftop solar electric systems in Northern California. Measurements of beliefs, attitudes and consumers choices were observed for each of the experimental conditions. Key drivers of consumer decision making about rooftop solar electric systems are discussed.

I. Introduction

Elemental theories of consumer choice behavior posit a moderately strong relationship between beliefs, attitudes, purchase intentions and action.[1] Working from within this theoretical perspective, this study was designed to observe the impacts of enhancing consumers' awareness of and information about rooftop solar electric systems on the attitudes and opinions they have about such systems, and on their stated willingness to pay for the additional costs of such systems. To assess these impacts an information experiment was carried out with random samples of homeowners and renters in Northern California.

Participants in the study were randomly assigned to one of three information conditions. Each information condition consisted of a 3 minute video displaying various neighborhoods and landmarks in the vicinity of San Francisco, California. The visuals presented in all three videos were very similar. They contained footage of buildings, streets, traffic and landmarks. However the voiceover messages on the videos were very different. In the control video, there was no mention of rooftop solar systems at all and the theme of the video was a travelogue describing life in Larkspur California -- a suburb of San Francisco. Because solar installations are relatively common in this community, it was possible to film many installations on homes, apartments, schools and businesses. These installations were not mentioned in the narrative. In the first experimental condition, the narrative in the video was changed to point out the solar installations on the buildings in the video, and indicate their increasing prevalence in the neighborhood skylines. The narrative also included discussion of the advantages of solar systems as well as their costs. In the second experimental condition, in addition to pointing out the prevalence of solar installations, substantial additional information was provided concerning the availability of financial and other assistance for acquiring a solar system.

This paper reports the differences in the beliefs, attitudes and stated preferences observed for consumers in the different experimental conditions. It demonstrates that a short duration high intensity message can produce at least short term changes in the beliefs, attitudes and stated willingness to purchase rooftop solar systems for consumers in the Northern California market. It also describes the key drivers of

[1] For an in depth discussion of this topic see "Marketing Management; Analysis, Planning, Implementation and Control – Eighth Edition" by Philip Kotler, Prentice Hall International Editions, 1994 pp. 172-201

consumers' decision making about investment in homes with rooftop solar systems and highlights the importance of utility support for such programs in enhancing the likelihood that consumers will invest in these alternatives.

Section II, the Methodology section, contains a description of the methods and procedures used in this study. Section III describes the impacts of the information experiment on consumer attitudes and opinions about rooftop solar installations. Finally Section IV describes the factors that influence consumers' willingness-t0-pay for rooftop solar electric systems.

II. Methodology

This research contains a small scale communications experiment. The purpose of this experiment is to observe the immediate impacts of providing information about the prevalence and advantages of rooftop solar electric installations on consumer attitudes and propensity to purchase solar systems. It is designed to determine the likely impact of utility sponsored programs intended to increase the prevalence of solar installations in communities combined with public information campaigns designed to call attention to these installations while explaining the advantages of rooftop solar installations In the experiment representative samples of consumers are exposed to three short messages designed to simulate the information conditions that would result from the above described utility activities. The outcome measures of interest are the attitudes, opinions and beliefs of the consumers exposed to the different messages and their stated preferences for homes with rooftop solar installations. Differences in the beliefs, attitudes and stated preferences expressed by consumers in the different experimental conditions are observed using survey techniques.

While the choice measurements involve contingent valuation methods, the cornerstone of the impact estimates is the random assignment of survey participants to different treatment and control conditions – an experimental design. In other words, when it came to estimating impacts, the primary goal of the survey and analysis was not to estimate consumer's willingness to pay for solar, but to estimate via experimental methods the change in consumer's attitudes, beliefs and propensity to choose a solar home as a result of being exposed to an experimental stimulus.

By using such an experimental design, the change in propensity to choose solar can be directly attributed to the visual stimuli and the information contained in the treatment conditions. Because the regression methods used to estimate willingness to pay explain the variation in responses, combining them with such an experimental design allows the analysis to reduce the noise and better isolate the signal – i.e., the impact estimate.[2] In addition, given a sufficiently large sample, regression methods can decompose or explain how the impact of the treatment varies as a result of customer characteristics. Doing so enables better targeting of customers who are likely to be most responsive to the proposed program. It also provides an alternative for calibrating the impacts from the experiment to PG&E territory. The remainder of this section discusses the sample design, experimental stimuli, survey instrument design and data collection procedures.

Sample and Experimental Design

The selection of the sample and the administration of the survey were provided by Knowledge Networks, a consumer information research company that has established the first online research panel

[2] For more detailed discussion on analyzing experiments with regression methods, please see Chapter 18, "Estimating Average Treatment Effects," of *Econometric Analysis of Cross Section and Panel Data* by Jeffrey Woolridge. Stock and Watson's Introduction *to Econometrics* also provides an excellent discussion in Chapter 11, "Experiments and Quasi-Experiments."

based on probability sampling that covers both the online and offline populations in the U.S. The panel members are randomly recruited by telephone and households are provided with access to the internet and hardware if needed. Unlike other internet research that covers only individuals with internet access, Knowledge Networks surveys are based on a sampling frame that includes both listed and unlisted phone numbers, and is not limited to current internet users or computer owners. Panelists are selected by chance to join the panel; volunteers are not able to join.

Knowledge Networks initially selects households using random digit dialing (RDD) sampling methodology. Once a household is contacted by phone and household members are recruited to the panel, panel members are sent surveys over the Internet using e-mail (instead of by phone or mail). This permits surveys to be fielded quickly and economically, and also facilitates longitudinal research. Knowledge Networks' panel recruitment methodology uses the quality standards established by selected RDD surveys conducted for the Federal Government (such as the CDC-sponsored National Immunization Survey).

The critical feature of the experimental design is that all survey respondents were assigned randomly to one of three different experimental groups. Two of the groups were exposed to an experimental stimulus (a video recording) that involved repeated exposure to solar power imagery and information, while the third group constituted a control group that was exposed to neutral (non-solar related) imagery and information. All three groups were presented with an identical series of questions both before and after being exposed to the experimental stimulus.

Survey Instrument Design

Consumers experience relatively large transaction costs in retrofitting a solar system to an existing dwelling. They have to determine whether their home is amenable to solar a installation, find a reliable solar provider, investigate and decide on a number of design alternatives, secure the funding and work through the details with local building officials and the utility. These costs cannot realistically be overcome with stimuli that can be presented in a 3 minute video. The purpose of the experiment reported in this paper was to observe the impact of information on purchase intentions – net of these transaction costs. So the choice that consumers were given was presented as a simple one in which the solar system was already present and rolled into the price of the home they were considering for purchase or rent. This situation reveals the choice the consumer says they would make in the absence of most of the major transaction costs that are present in the market now. This approach to measurement is very useful in that it allows for the observation of significant variation in consumers' expressed willingness to pay for rooftop solar installations.

The choices presented to respondents were customized for each respondent to take account of whether they owned or rented their dwelling and the amounts of their mortgage or monthly rent. Because of this, the rent/own question was presented early in the survey. A series of questions were then presented to assess the degree to which the respondent can be considered an "early adopter" of new technology. This was followed by a set of questions that assessed their initial knowledge of solar power systems and whether or not the respondent had taken any actions to investigate or install solar water heating or solar panels. All customers were asked the same set of introductory questions.

The survey respondents were then presented with visual stimuli and information in the form a video, which varied depending on their randomly selected assignment to either the control group or one of two treatment groups. All three videos were approximately three minutes in length, and they were all shot primarily in the same "typical" Northern California community (Larkspur).

The video shown to the 279 respondents in the control group was similar to a tourism promotion video for the City of Larkspur. It presented scenes from downtown Larkspur and various neighborhoods in the area and featured a narrator describing the many pleasant attributes of living in or visiting that area. The

general theme was that the City of Larkspur is an enjoyable place to live and is conveniently located in close proximity to the many attractions of the greater San Francisco Bay Area without the hassles of a big city.

The video that the 287 respondents in the first treatment group saw was similar to the video shown to the control group, but instead of extolling all of the benefits of living in Larkspur, its major theme was that solar photovoltaic panels are becoming an increasingly common feature of many Northern California towns – even if they don't necessarily stand out visually. This video showed scenes of the many residential, commercial and community buildings in the area that have solar panels installed on them, frequently zooming in on the panels themselves to draw attention to the fact that they often blend into their surroundings. The narrator in this video also provided some commentary about solar power's attributes (including the fact that solar power systems can operate in foggy areas) and briefly noted the existence of financing options and government subsidies that can help defray the cost of installing solar panel systems.

Finally, the video that was shown to the 295 participants in the second treatment group started off much like the first solar video, with scenes of solar panel installations throughout downtown Larkspur. However, in this video the narrator quickly shifted gears and began to describe in some detail the logistics involved in purchasing and installing a solar system on one's own home. The narrator described how homeowners work with solar installation contractors, apply for local permits, apply for state and federal subsidies, take advantage of long-term financing options – all while showing footage of local solar installations. This video also included discussion of how when the homeowner's solar panel system is installed, they receive a new electric meter from PG&E that allows them to export power back to the grid and have that power credited to their account – helping them recoup their initial installation costs. The narrator concluded this video with a statement that PG&E had reviewed solar power technology and gave it its endorsement as a "safe, reliable, and clean energy source for California homeowners."

After viewing one of the three short videos, survey participants were asked a series of questions about their opinions of solar technology – asking, for example, how they would rate solar power in terms of its safety, effectiveness, cost, and environmental friendliness. These questions were specifically designed to observe the impact of the solar videos on participants' opinions of solar power.

Next the participants completed the choice exercise. In the choice exercise the respondents saw choices individually tailored to them based on their answer to the earlier rent/own and monthly payment questions. In the choice experiment, consumers were asked to assume that they had to move from their current dwelling and that in finding a new home they had identified two homes that were identical in all but one respect – whether or not the home had a rooftop solar electric installation. The non-solar home was assigned a monthly payment of exactly the same as the monthly payment (mortgage or rent) that the participant indicated they currently pay, while the solar home was assigned a monthly payment $95 greater than that amount. The "adder" of $95 was chosen for the solar home because it was approximately the value of the additional monthly payment on a 30-year mortgage of an incremental $15,000 at a 6.5% interest rate. It was estimated that a moderate size residential solar panel installation would cost about $15,000 to install, after state and federal subsidies are taken into account.

If the participant responded that they would prefer the solar-powered home, they were then presented with the same option again but with a monthly surcharge of $190 -- twice the previous level. If the responded indicated that they would choose the non-solar home in the first question, they received the same question again but with the monthly surcharge cut in half to $47. (If they again declined the solar option, they are asked whether there is any amount they would be willing to pay for a solar system, and if not, why not.) This is a standard willingness to pay question designed to observe the interval in which the respondent would be likely to pay for the proposed system. (Cite Hanneman).

The solar home choice experiment questions were asked of survey participants twice. In the first version, participants were told that the solar panel system they could choose was inspected and endorsed by PG&E as "safe, reliable, and cost effective." In the second version of the question, respondents were told

specifically that the system had *not* been inspected or endorsed by PG&E. The purpose of this two-fold selection process was to determine the impact of the PG&E branding and endorsement of the solar system.

Data Collection

The survey was fielded from August 22, 2007 to August 28, 2007, to a random sample of 2,963 Knowledge Networks panel members living in Northern California who were eighteen years of age or older. For the purposes of the survey, Northern Californians were defined as California residents not living in the following eight counties: San Diego, Imperial, Riverside, Orange, San Bernardino, Los Angeles, Ventura, and Santa Barbara. The goal of the survey was collect a minimum of 800 qualified interviews. Ultimately, 1,234 respondents completed the survey (for a completion rate of 63%), and of those, 861 were counted as qualified respondents completed the survey. (In order to qualify the respondent had to see the video successfully.)

Knowledge Networks panel members selected to participate in the survey were sent an email message with a link to the online survey when it became active. Panel members who failed to respond to the initial email message received a follow-up email reminder, and finally a telephone call notifying them of the survey deadline. The email link took the participants directly to the first page of the survey – no login name or password was required – where they could begin filling in the survey fields and then watch the randomly assigned experimental video.

After the survey was fielded, Knowledge Networks applied post-stratification weights to adjust for non-response and non-coverage of the survey. This was implemented separately and identically for the three sub-samples that saw the three different video conditions. Demographic and geographic distributions – including gender, age, race/ethnicity, household income, and residence in metropolitan areas – from the Current Population Survey (CPS) conducted by the U.S. Census Bureau for the population of Northern Californian adults age 18 and older were used as benchmarks in this adjustment.

III. Impact of Information on Attitudes and Knowledge

Table 1 displays the impacts of the information supplied to consumers regarding the prevalence, benefits and utility support for rooftop solar systems. After viewing the information videos in each experimental condition the respondents were asked a battery of questions about their beliefs concerning rooftop solar electric systems. The questions were agree/disagree questions with answers yes, no or not sure. The statistics in the table reflect differences in the percentages of consumers in the control and experimental conditions that agreed with the statements. The table also indicates, whether the topic was discussed in the video and the direction of difference between the responses of the control group and those observed in each treatment group. The dark arrows indicate statistically significant differences between the percentages agreeing with the statement in the control and treatment conditions. The direction of the arrows indicates whether the percentage agreeing with the statement increased or decreased – left arrows indicate a decreasing percentage, the right arrows indicate an increasing percentage. The light colored arrows represent differences that are not statistically significant.

It appears that merely showing subjects images of rooftop solar systems improves their tendency to think positively about these systems. For example, the solar installations that were shown in the "Solar" experimental condition were pointed out to respondents, but there was no verbal message in these videos as to whether these systems took up a lot of space, were out of date or had limited lifespan. Nevertheless, something about the appearance of these systems increased the percentage of respondents who thought such systems didn't take up too much space, were not obsolete and did not have a limited lifespan. They say a picture is worth a thousand words, and it appears that these results testify to the truth of that axiom. These

results also suggest that increasing the prevalence of such systems in communities along with an effort to point them out will increase the percentage of consumers with favorable attitudes toward the technology.

Table 1: Impacts of Information on Beliefs About Rooftop Solar Systems

	Solar video			PG&E solar video		
STATEMENT	Direction of Impact	Change	Topic discussed?	Direction of impact	Change	Topic discussed?
Solar power is almost unlimited	→	4.6%	NO	→	5.2%	NO
Solar power is low cost energy	→	5.9%	NO	→	8.6%	NO
Solar power is very safe	→	7.9%	NO	➡	9.9%	YES
Solar power panels require a lot of space	⬅	21.0%	--	←	13.9%	NO
Solar power panels are unsightly	⬅	19.2%	YES	←	7.8%	NO
Solar power panels are expensive	←	4.5%	YES	←	1.0%	YES
Solar power systems are expensive to install	⬅	4.1%	YES	⬅	2.0%	YES
Solar power systems are expensive to maintain	←	6.5%	YES	→	-8.8%	NO
Solar power technology is out of date	⬅	12.9%	NO	←	7.3%	NO
Solar power only works in sunny areas	⬅	18.5%	YES	←	0.8%	YES
Solar power systems require the owner to have a lot of special knowledge to operate	←	11.8%	YES	⬅	13.9%	YES
Solar power systems have a limited lifespan	⬅	18.0%	NO	⬅	19.8%	NO
Solar Power is good for the environment	→	4.1%	NO	→	2.8%	YES
Solar Power will make us more energy independent	→	4.5%	NO	→	-1.7%	NO

*All significance tests via binary regression with a heckman model to control for selection bias

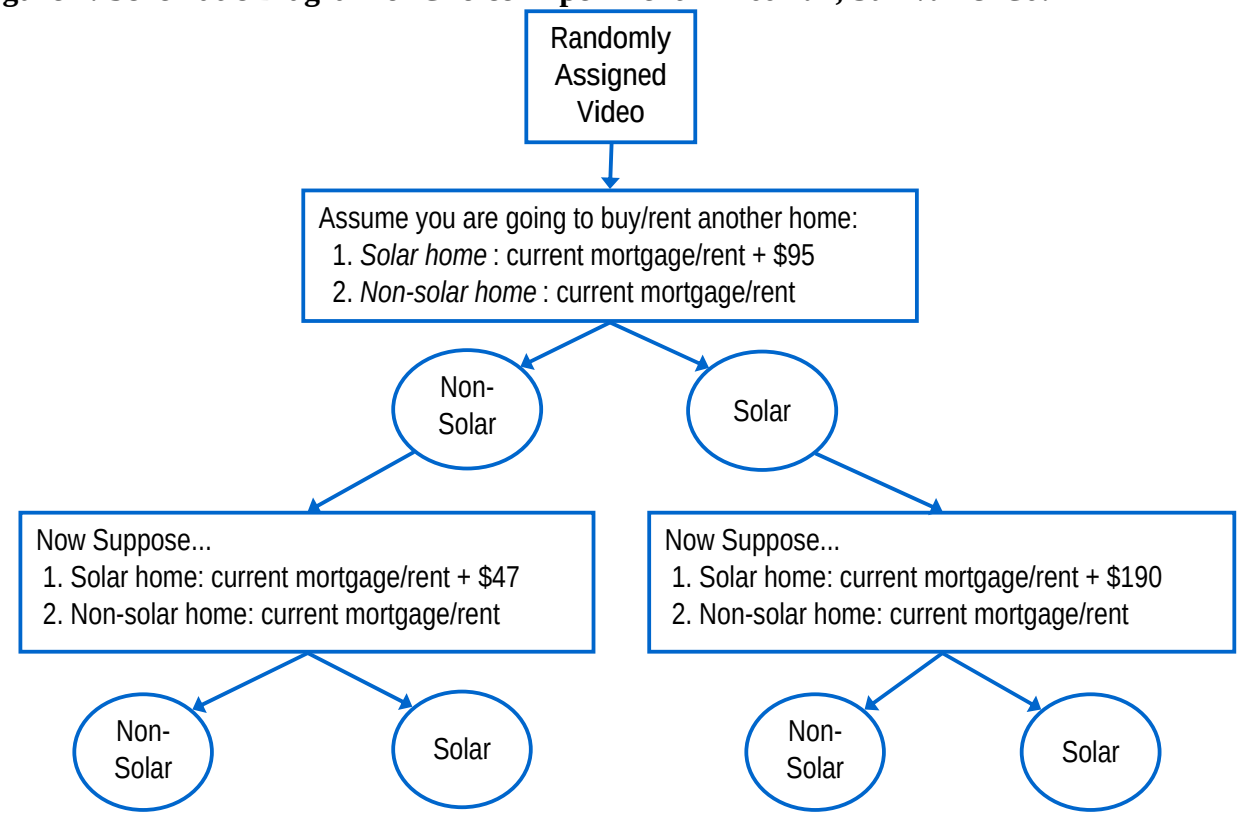
It also appears that providing verbal messages along with the images also can change customer beliefs. For example, an important theme in the Solar" video was that rooftop solar systems could be well integrated with the lines of buildings so that these systems were not unsightly. The video explicitly pointed out numerous instances of buildings where it was almost impossible to notice these systems in the context of the roofline and other features of the building. This message reduced the fraction of parties who said that rooftop solar systems were unsightly by almost 20 percentage points – from 33% in the control group down to about 14% in the group exposed to the solar treatment. In the "PG&E Solar" video which did not emphasize the appearance of these systems, the fraction who believed these systems were unsightly decreased, but not to a statistically significant degree.

IV. Key Drivers of Consumer Decision Making

The choice exercises in the study were designed to estimate the amount consumers would be willing to pay in addition to their current mortgage or rent for a rooftop solar system capable of meeting most of their electric energy needs. Figure 1 below displays the design of the choice exercise. This is a standard choice experiment design called a double bounded discrete choice experiment. It is used to observe the interval in which the increase in the price consumers would be willing to pay to obtain a given choice outcome is found. For example, consumers who select the solar home at a $95 monthly increase in mortgage but choose the conventional home when the price is raised to $190 are willing to pay somewhere between $95 per month and $190 per month more for a home with a rooftop solar installation. Alternatively, parties who are unwilling to pay an additional $95 per month for a rooftop solar installation but are willing to pay an additional $47 are willing to pay somewhere between $47 and $95 additional each month. By examining the pattern of choices made by consumers in the experiment it is possible to find the intervals in which all the parties in the experiment are found.

Using the distribution of choices made by consumers exposed to such an experiment it is possible to estimate the overall demand curve for homes with rooftop solar electric systems at the time of the experiment. That is, it is possible to estimate the percentage of the market that reports they will pay a given additional amount for a home with a rooftop solar electric system. Remember, this is the amount consumers said they would be willing to pay on a monthly basis for such a system already installed on a home they are purchasing or renting. There are virtually no transaction costs involved. Moreover, since consumers do not have to live with this decision in an economic sense their response probably overstates their likelihood of actually selecting the rooftop solar alternative – to an unknown extent. Despite these obvious limitations the analysis of the choices made by these consumers can be very instructive as to the relative importance of the

Figure 1: Schematic Diagram of Choice Experiment – *Freeman, Sullivan & Co*.



various factors that influence their choices. That is, while the amounts consumers are willing to pay may be overstated (to an unknown degree) the statistical relationships between what they say they are willing to pay and other variables are not likely to be biased.

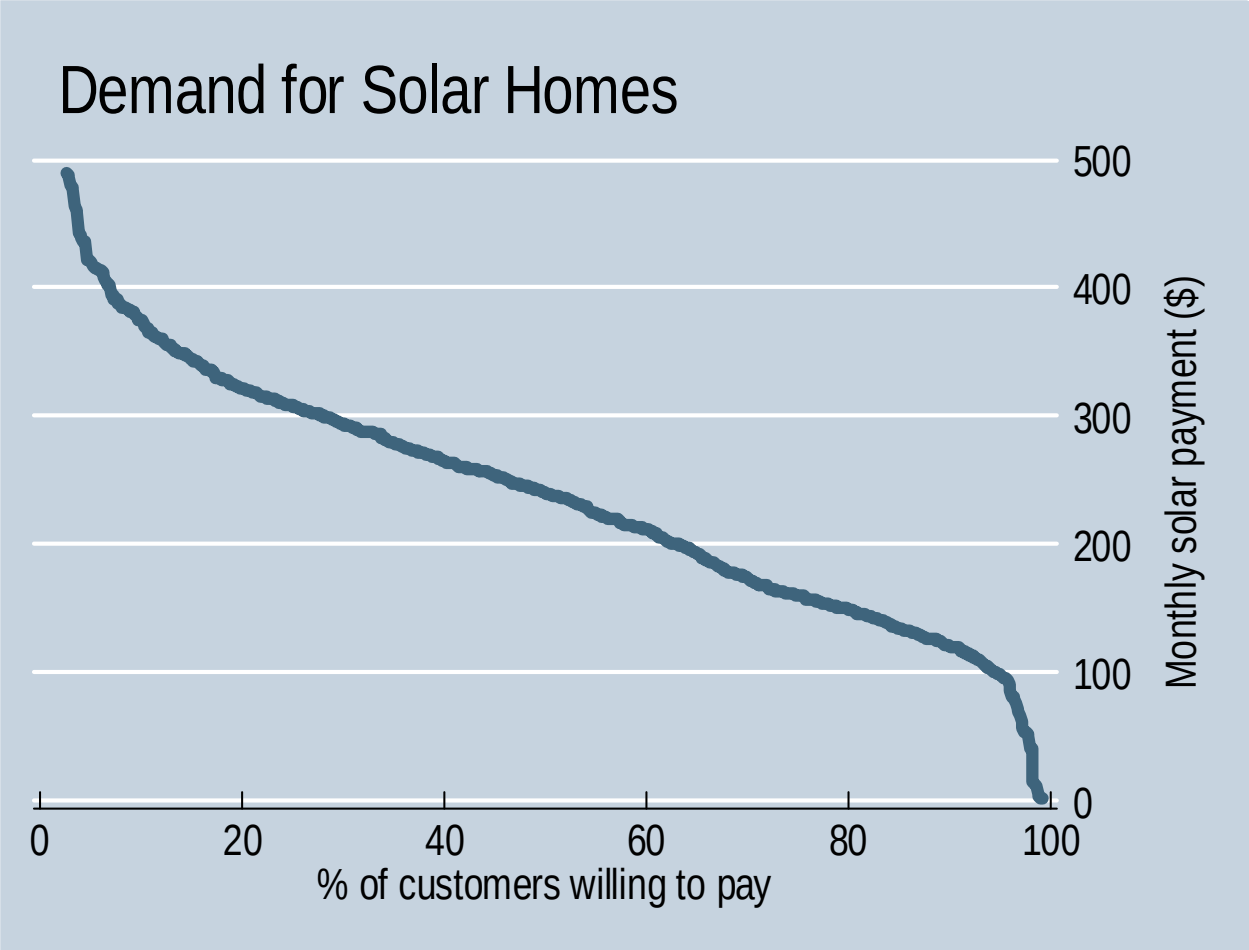
Figure 2 displays the "demand" curve for rooftop solar electric homes.[3] The curve shows the percentage of consumers that said they would be willing to pay a given additional amount (in monthly mortgage or rent) for a home with a rooftop solar electric system. The demand curve indicates that more than 90% of consumers would select the home with the rooftop solar electric system if the monthly increase in the mortgage or rent was below $100.[4] This result is quite remarkable in light of the fact that the estimated monthly cost of amortizing the installation of a rooftop solar electric system is about $90 per

[3] Obviously, demand here is being measured by stated preferences rather than by revealed preferences – hence the quotation marks.

[4] Excluding parties with base mortgages or rent less than $250 per month.

month over 20 years at 6.5% interest. The figure also shows that roughly 60% of consumers said they would pay more than $200 more per month for a solar home; and 25% would pay more than $300 per month for such a home. These results seem reasonable in light of the fact that solar electricity production would offset a very substantial fraction of household electric bills and electricity bills in the warm climate zones of Northern California can range into the hundreds of dollars.

Figure 2: Demand for Homes with Rooftop Solar Electric Systems



This research was completed in the summer of 2007 before the full extent of the housing market collapse became apparent in early 2008. It is likely that consumer willingness to pay these amounts has been tempered somewhat by recent events. How much consumer enthusiasm has been dampened by recent events is anyone's guess at this point. Nevertheless, the fact that consumers were willing to pay substantially more on a monthly basis for homes with rooftop solar electric systems will probably remain true; and when economic conditions return to normal, it is reasonable to expect that this latent demand for such systems will continue.

It is possible to describe the relationship between the amounts that consumers said they would be willing to pay for rooftop solar electric installations and important household characteristics like income, magnitude of utility bill, knowledge about solar electric systems, environmental attitudes and age. This is done by a technique known as interval regression. Like ordinary multiple regression, interval regression

expresses the dependent variable (in this case, the interval within which consumers said they would be willing to pay for a solar system) as a function of a set of dependent variables (e.g., household income, respondent age, etc.). The resulting regression parameters reported in Tables 2 and 3 are not directly interpretable because the interval regression estimation equation is non-linear. However, the z and p values

Table 2: Interval Regression Results – Utility Inspected and Endorsed Systems

					95% Confidence Interval	
Variable	Coefficient	s.e.	z	p. value	Lower Bound	Upper Bound
Homeownership	0.6597	0.1686	3.91	0.000	0.3292	0.9902
Natural log of income	0.0641	0.0452	1.42	0.156	-0.0244	0.1526
Natural log of utility bill	0.2192	0.0610	3.60	0.000	0.0997	0.3387
Knowledge of solar panels or water heating	0.3431	0.1281	2.68	0.007	0.0921	0.5942
Considered purchasing solar equipment	0.0319	0.1241	0.26	0.797	-0.2113	0.2752
Purchase a hybrid vehicle	1.0253	0.2114	4.85	0.000	0.6111	1.4396
Read a solar news article within 7 days	-0.2686	0.2050	-1.31	0.190	-0.6703	0.1331
Age	-0.0103	0.0037	-2.76	0.006	-0.0176	-0.0030
Knew of federal and/or state incentives	0.1444	0.0626	2.31	0.021	0.0218	0.2671
Inverse Mills Ratio	3.0761	1.5817	1.94	0.052	-0.0240	6.1761
Constant	1.7278	0.8179	2.11	0.035	0.1247	3.3308

Table 3: Interval Regression Results – Not Inspected or Endorsed by the Utility

					95% Confidence Interval	
Variable	Coefficient	s.e.	z	p. value	Lower Bound	Upper Bound
Homeownership	-0.0939	0.1959	-0.48	0.632	-0.4779	0.2901
Natural log of income	0.2004	0.0742	2.7	0.007	0.0549	0.3460
Natural log of utility bill	0.0969	0.0676	1.43	0.152	-0.0356	0.2293
Knowledge of solar panels or water heating	0.2162	0.1594	1.36	0.175	-0.0963	0.5287
Considered purchasing solar equipment	0.5268	0.1442	3.65	0	0.2440	0.8095
Purchase a hybrid vehicle	0.9775	0.2301	4.25	0	0.5264	1.4285
Read a solar news article within 7 days	-0.3183	0.1898	-1.68	0.094	-0.6903	0.0537
Age	-0.0023	0.0053	-0.42	0.672	-0.0127	0.0082
Knew of federal and/or state incentives	0.1183	0.0792	1.49	0.135	-0.0370	0.2736
Inverse Mills Ratio	-1.1179	1.7444	-0.64	0.522	-4.5369	2.3011
Constant	1.9131	1.0629	1.8	0.072	-0.1702	3.9964

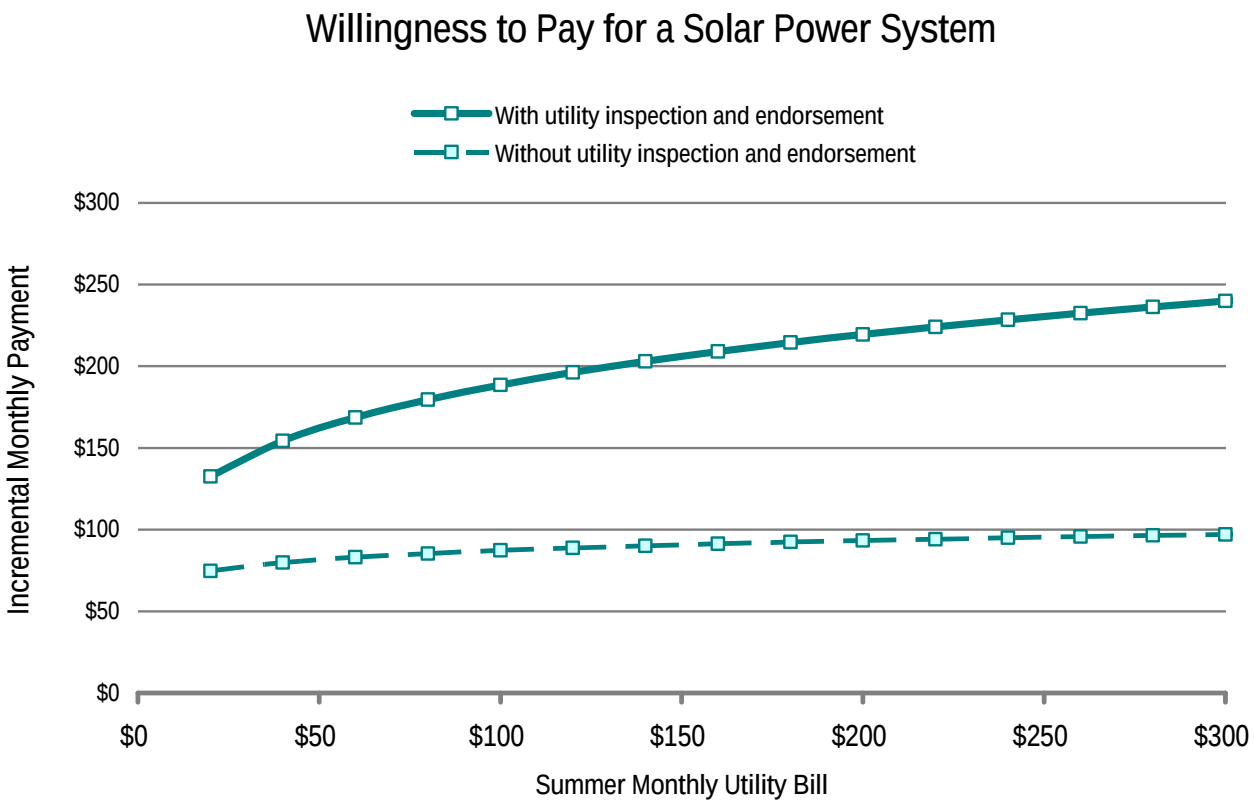
for the parameters in the equation are interpreted in the usual manner.[5] That is, it is possible to assess the statistical significance of the regression parameters by referring to these values. To observe the magnitude of the impacts of the independent variables on the dependent variable (amount willing to pay) it is possible to graph the regression results. This is done by exponentiating the interval regression functions holding all but the independent variables of interest constant at their means.

By graphing the functions in Tables 2 and 3 it is possible to describe the impacts of the different demographic factors on the amount that consumers said they would be willing to pay for a rooftop solar electric system. The single most powerful determinant of the amount that consumers said they would be willing to pay for a rooftop solar electric system was whether or not the electric utility company inspected

[5] Values of p and z are conventionally used in regression analysis to evaluate the extent to which the parameter estimates in a regression function are significantly different from zero statistically. That is, they indicate whether the factor of interest is statistically associated with the dependent variable.

and endorsed the system. Figure 3 shows a comparison of the amounts consumers said they would be willing to pay in relation to their monthly electric bills, for systems that were described as expected and endorsed by the local utility and those that were described as not inspected or endorsed by the local utility. The amount consumers said they would be willing to pay for a rooftop solar electric system generally

Figure 3: Consumer Willingness to Pay for Rooftop Solar – With and Without Utility Endorsement



increased with the size of the monthly electric bill.. Consumers said they would be willing to pay substantially more for rooftop solar systems that were described as inspected and endorsed by the utility. This result was not anticipated and while we can speculate as to its cause, we really don't know what consumers were thinking that led them to express this preference. Additional research should be undertaken to understand the mechanism that is producing this result. Whatever the reason consumers have for expressing the above described preference, this finding suggests that utilities will have an extremely powerful influence on the market penetration of rooftop solar electric systems in the future.

Other important determinants of the amounts consumers say they would be willing to pay for a rooftop solar electric system include:

- Monthly Utility Bill – as expected, parties with higher monthly electric bills said they were willing to pay substantially more for rooftop solar electric systems than those with lower monthly bills.
- Home Ownership – home owners said they were willing to pay approximately 2 times more (on a monthly basis) for rooftop solar system than renters;
- Whether or not they have already purchased a hybrid electric vehicle – consumers who had already purchased a hybrid electric vehicle said they were willing to pay approximately 2.5 times more for a rooftop solar electric system than parties who had not.

- Annual household income -- households with high annual incomes said they were willing to pay more for rooftop solar electric systems than households with relatively low annual incomes;
- Respondent Age – young people said they were willing to pay much more for rooftop solar electric systems than older persons.
- Knowledge of Federal and State Incentives – parties who were aware of federal and state incentives said they were willing to pay more for rooftop solar electric systems than those who were not.

Figure 4: Impacts of Consumer Important Consumer Characteristics on Willingness to Pay

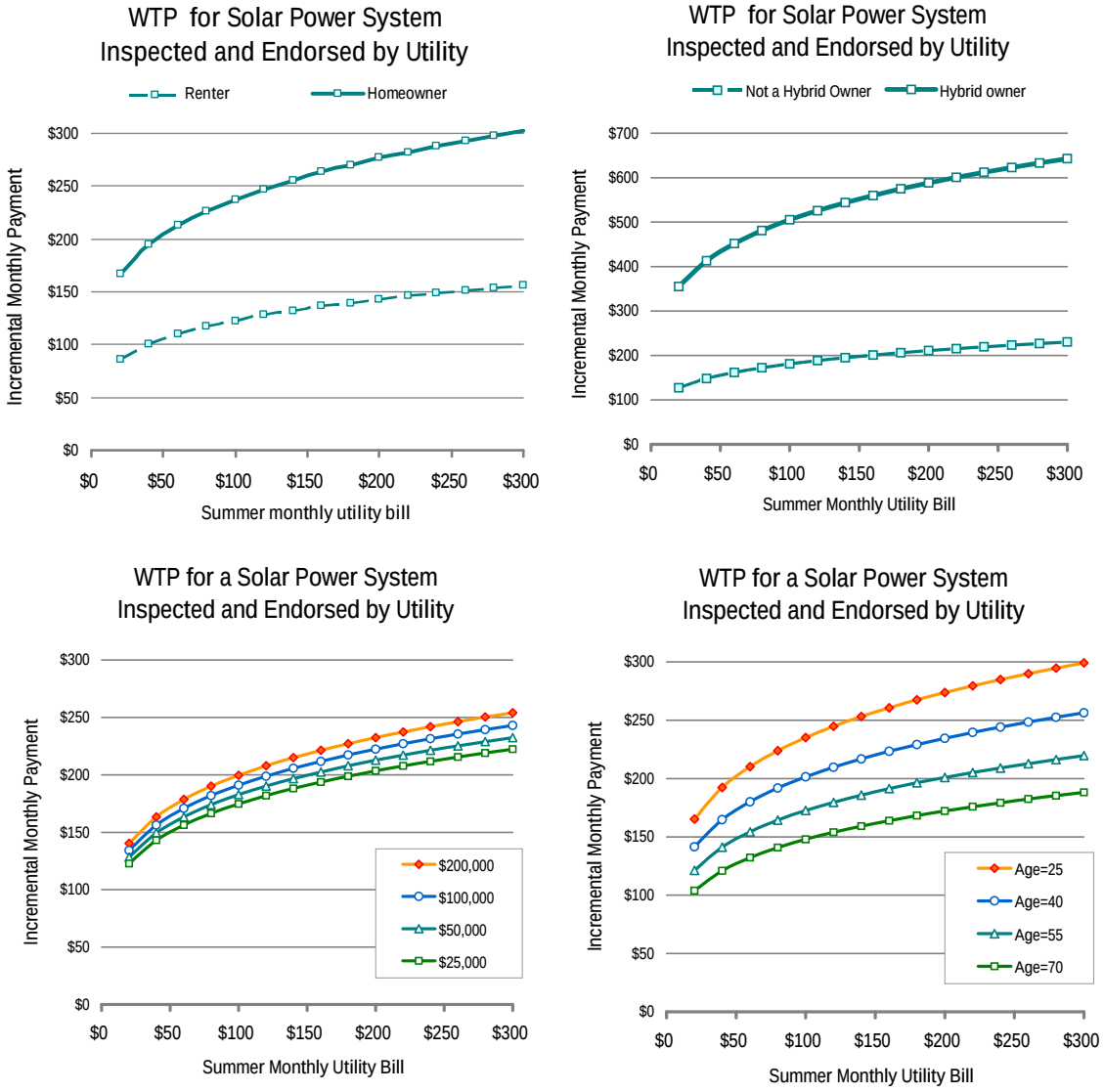


Figure 4 displays a series of graphs showing the relationship between monthly utility bill and amounts different groups of consumers said they would be willing to pay for a rooftop solar electric system. It is evident in the graph that current homeowners are willing to pay approximately twice as much in monthly mortgage payments for rooftop solar electric service than parties are willing to pay in rent.

The survey incorporated a number of measurements designed to identify "green" consumers and early adopters. It was thought these consumer characteristics would predict consumer willingness to pay for rooftop solar electric systems. It turned out that these characteristics were relatively weak predictors of

consumer willingness to pay for rooftop solar electric systems. However, consumers who reported that they had previously purchased a hybrid electric vehicle

The effect of the information conditions on the amounts consumers said they would be willing to pay for a rooftop solar electric installation was interesting and complicated. While consumers were randomly assigned to the experimental conditions, they were able to select themselves out of the study before completing the choice exercises. Parties who selected themselves out of the study before the choice exercises could be completed were disproportionately comprised of females, persons who received the control group stimulus, late adopters, persons who reported they had previously considered solar, and persons with high annual income. The above selection problem complicates the interpretation of the differences between the control and experimental conditions. Before controlling for these selection differences, the differences in willingness to pay between the control and information conditions are in the expected direction, large and statistically significant. After controlling for selection (using Heckman's technique[6] the differences are in the expected direction but smaller and not quite statistically significant (i.e., in the range of 12%[7]. Since the statistical adjustment for selection may or may not have overcorrected for selection, the findings concerning this aspect of the problem must be said to be ambiguous.

V. Conclusions

Consumer interest in rooftop solar electric power supply alternatives is much higher than the current rate of market penetration of these systems would suggest. This stated preferences study shows that a very substantial fraction of homeowners in Northern California would be willing to pay for the cost of such systems amortized over the life of their mortgage. It also shows that a substantial number of potential home buyers values rooftop solar electric systems substantially in excess of the amortized cost of these systems – that is they are willing to pay for such systems substantially in excess of their amortized cost. This bodes well for the future of rooftop solar electric systems as a value added component of housing. The challenge is to overcome the transaction costs consumers experience in retrofitting rooftop solar systems to their homes. The study also suggests that the support and sponsorship of this new technology by electric utilities strongly influences consumer interest in and willingness to pay for it. Other very important drivers are consumers' tendency to adopt energy efficient transportation technology, family income, age of household head and utility bill.

On the whole, the results of the experiment conclusively demonstrate that providing information to customers concerning the prevalence, appearance and performance of rooftop solar electric installations will change their beliefs about these systems in ways that will enhance the likelihood that they select such systems when they have the chance to do so. Of course, a number of interesting questions remain. For example, the measurements of beliefs were taken a very short time after exposure to the information conditions. It is unknown how long these changes in beliefs will persist. Nevertheless, these findings suggest that pilot information campaigns designed to carry these messages should be undertaken.

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[6] Cite Heckman

[7] A 12% increase in the amount that consumers would be willing to pay for a rooftop solar electric system is not substantively insignificant. However, given the variation in willingness to pay for these systems observed in the experiment, it is impossible to say that the result may not have occurred by chance alone. Increasing the sample size and replicating the experiment could improve the precision of the statistical measurements and clarify the magnitude of the impact of information on consumer choices.