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Residential solar hot water: Determinants of demand in New Hampshire

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RESIDENTIAL SOLAR HOT WATER

Determinants of Demand in New Hampshire

BY

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THESIS

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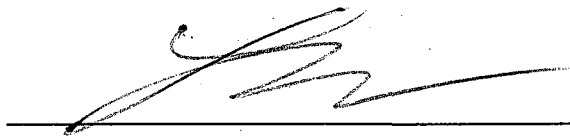

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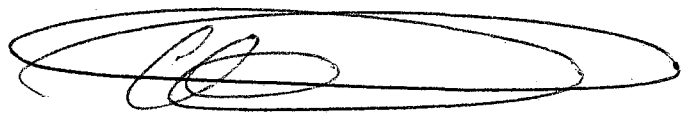

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ABSTRACT

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Determinants of Demand in New Hampshire

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As New Hampshire pursues public policy goals embedded in the Renewable Portfolio Standard, the Regional Greenhouse Gas Initiative, the Climate Action Plan, and other legislation and documentation, many advocates and policy makers are looking for reductions in fossil fuel use in the residential sector. This paper analyzes the results of a survey of New Hampshire residents undertaken in the autumn of 2009 regarding attitudes toward energy policy, and willingness to invest in renewable energy. Regarding residential solar hot water, the survey finds that the price at which half of New Hampshire homeowners would consider purchasing such a system is $5536. Seriousness of commitment is also tested, showing significant barriers to follow-through. These barriers and potential means of overcoming them are examined, based on concepts from economics and related fields. The paper concludes with recommendations for further research.

INTRODUCTION

The economic restructuring that occurred as a result of the Second World War has had significant impact on the natural world. In some respects, the impact (or potential impact) has been broadly acknowledged, and policy has been changed to reduce some of the negative effects of various forms of pollution and extraction and overharvesting of natural resources. In the opinion of many academics and environmentalists however, the policy changes that have been made – from the regulation of pesticides, to sweeping federal protections codified in legislation such as the Endangered Species Act, the Clean Air and Clean Water Acts – have been insufficient to sustain a healthy natural environment. Since the early 1970s, the proponents of 'limits to growth' have been intellectually battling with pro-growth policy makers and corporate leaders who believe that rational economic and market-based solutions will serve to overcome any shortage of natural resources.

A decade into the new millennium, the deleterious cumulative effect of humanity's impact on life-sustaining natural systems has entered the social consciousness in the West, most notably related to the threat posed by increasing levels of carbon in our atmosphere, which is a byproduct of the burning of fossil fuels for the generation of electricity and heat. Perhaps more significantly, the increasing difficulty, risk, and expense of obtaining those fossil fuels for the western economic engine have caused alarm even among those who remain unconcerned about the risks associated with the increasing concentration of greenhouse gases. In short, the realization that we

ought to do something about how and where we obtain our energy has moved into popular consciousness, particularly in Western Europe and to a lesser extent, in North America.

How this somewhat vague and general concern translates into the decision making of homeowners in one northeastern state is the subject of this study. Examined and analyzed are the attitudes, opinions, and behavior of households in New Hampshire relating to energy-consuming household practices, and how policy makers might help to accelerate the adoption of energy efficiency and renewable energy practices and behaviors.

In Chapter 1, the relevant statistics from the federal Department of Energy, the New Hampshire Office of Energy and Planning, the New Hampshire Public Utilities Commission and other sources are presented in order to provide a context for energy use in New Hampshire, particularly in the residential sector. This data provides the rationale for why residential energy is of interest to policy makers and those engaged in the promotion of energy efficiency and renewable energy in the State. In short, New Hampshire has relatively high energy prices, low energy consumption, and moderate renewable energy resources. In order to reduce fossil fuel energy consumption overall, it is important to focus on residential usage in both the electricity and thermal sectors, since these comprise a sizeable portion of overall energy use given relatively modest commercial, industrial, and transportation consumption. As yet, renewable energy technologies have attained very little market share in the state's residential sector.

Chapter 2 presents and analyzes the results of a scientific survey undertaken in the fall of 2009, which investigates current attitudes and behaviors of consumers in New Hampshire relating to energy use, and their stated willingness to change those

behaviors. Specifically examined is respondent willingness-to-pay for alternative means of heating household hot water from readily available solar thermal technologies. Presuming the survey is a representative sample, the study shows that the half the single family homeowners in New Hampshire would express willingness to install a solar hot water system if the price were $5536 and the annual savings were $550. In addition, 77% of this same population think that electricity customers should be able to choose renewable sources for their electricity, and 60% state that they would actually elect to get their electricity from a renewable energy source were that option available.

Also investigated are stated motivations and barriers for making changes, as well as the institutions or individuals the public feels confident turning to for reliable information about energy and energy generating technologies. Three quarters of those sampled indicated a preference for finding information online, while nonprofit organizations were the next most popular source of reliable information about renewable energy. Chapter 2 also examines what level of responsibility residents believe various actors have in solving current energy challenges. Results show that New Hampshire residents expect regulated utilities, and oil and gas companies to take a lead role in increasing the utilization of renewable energy, with homeowners and residents significantly less responsible for this transformation.

Following analysis of the survey, a broad analysis of economic and sociological approaches is undertaken in Chapter 3. This review is intended to help policy makers and renewable energy proponents gain insight into how innovations are effectively disseminated throughout society, as well as to distinguish between consumer attitudes and intention and actual behavior in the marketplace. Barriers to market transformation are addressed, and areas for related research are discussed. Finally, a series of

recommendations for increasing the adoption of renewable energy and energy efficiency by New Hampshire residents are made based on both economic and sociological research. These include reducing or removing transaction costs to the consumer, increasing consistency and reliability of rebates and other incentives, and engaging consumers themselves in both the identification of problems related to energy provisioning as well as possible mechanisms for addressing these problems.

CHAPTER I

RESIDENTIAL ENERGY USE IN NEW HAMPSHIRE

Background on New Hampshire's Energy Profile

Located in northern New England, New Hampshire ranks 45 out of the 50 states and the District of Columbia in terms its overall energy use per capita (US Energy Information Administration (US EIA), Table R1). New Hampshire residents use just 71% of the energy of the average American. With no native sources of fossil fuels, most of the energy used in the state for electricity generation, heating, and transportation needs is imported, which leads to high average energy costs and a financial incentive on the part of consumers to conserve. While New Hampshire's electricity generators export about half their power to energy-hungry neighbors, retail electricity prices remain among the highest in the nation. Fortunately, New Hampshire also has significant untapped capacity to generate more electricity, particularly from wind; but also from hydropower and wood (NH Office of Energy and Planning – NH Energy Facts). The potential for electricity generation from solar photovoltaics (pv) is also strong in New Hampshire, and is considered an important component of distributed generation.

Because of the relative lack of industry in the state, much of the state's energy consumption relates to the heating and cooling of buildings. While nationally, it is estimated that 40% of fossil fuel consumption is related to buildings, New Hampshire's

figures are much higher, approaching 60%, according to the New Hampshire based nonprofit energy consulting firm, The Jordan Institute. The residential sector alone is responsible for approximately 40% of the total electricity consumed in the state according to the State Electricity Profile published by the Energy Information Administration (EIA) at the U.S. Department of Energy (DOE).

Table 1. New Hampshire Population, Economy and Energy Costs, 2007 (OEP *Energy Facts, 2005 and 2007*)

Type of Data	2007 Value	US Rank 2007	2005 Value	US Rank 2005
Population (millions)	1.31	41	1.3	41
NH Total Net Energy Consumption, TBtu	315.8	46	335.4	45
Gross Domestic Product (GDP) (unadjusted, billions $)	$49.6	40	$54.1	41
Energy Expenditures (unadjusted, billions $)	$5.3	43	$4.6	42
Energy Expenditures/Person (unadjusted)	$4,065	30	$3,516	29
Average Price/Million Btu (unadjusted)	$23.25	5	$18.68	8
Thousand Btu Consumed/Dollar GDP (2000 chained $)	6.3	44		
Average Energy Consumption/Person, TBtu	239.5	47	257.4	45
Energy Expenditure as % of GDP	9.20%	30	8.5%	N/A

Housing Characteristics

New Hampshire has a more modern housing stock than all the rest of the New England states, with more than 40% of residential structures built since 1980, according to the US Census' 2006-08 American Community Survey. The energy code in force in New Hampshire is also more up to date than those of neighboring states, though it is

important to note that enforcement of this code is relatively lax. New Hampshire also has the third highest rate of second home ownership in the country at 10.3%, trailing only Vermont and Maine (US Census, Characteristics of New Housing). Given the seasonality of many second homes, whose owners come for winter skiing or summer swimming, but live elsewhere at other times of the year, one would expect average energy usage to be lower than it is in other states, thereby bringing down the average energy use per housing unit.

Also impacting energy consumption in the residential sector is the average size of homes. While modern building practices, stricter energy codes, and appliance efficiencies can reduce energy use per square foot, the average size of newly built single-family homes has increased by two-thirds in the Northeast in the past three decades, growing from an average of 1,595 square feet in 1973 to 2,651 square feet in 2008, according to the US Census. This increased size largely offsets the increased efficiency per square foot.

According to the U.S. Census, New Hampshire's population in 2007 was 1.31 million, or 177% greater than the population in 1970, while overall residential energy consumption increased at a slower pace, from 64.7 Tbtu in 1970 to 92.2 Tbtu in 2007, only a 142% rise. A disproportionate increase in energy consumption resulted not from the residential sector, but from the commercial and transportation sectors as shown in Table 2.

Table 2. NH Energy Use by Sector and Over Time Compared to Population

(US EIA State Energy Data 2007)

NH	1970	2007	% change
Population	**0.74 million ppl**	**1.31 million ppl**	**77.0%**
Residential	64.7 trillion Btu	92.2 trillion Btu	42.5%
Commercial	15.4 trillion Btu	70.4 trillion Btu	357.1%
Industrial	56.4 trillion Btu	44.6 trillion Btu	-20.9%
Transportation	50.7 trillion Btu	107.1 trillion Btu	111.2%
Total Energy	**187.2 trillion Btu**	**314.3 trillion Btu**	**167.9%**

EIA's 2005 Residential Energy Consumption Survey for the New England region, the results of which are reproduced and displayed in Table 3, show the various fuels used for heating hot water for domestic consumption in the New England region. Natural gas is used by nearly half the households in the region, while the remaining half is split between electricity and fuel oil. Other fuels, including propane, account for less than 5% of the total.

Fuel oil is both more expensive to use, and more energy intensive - requiring more Btus than other fuels to deliver the same amount of hot water. Carbon emissions from fuel oil are also dramatically higher than other fuel types used for heating hot water. The disproportionately high numbers from fuel oil are largely due to the inefficiencies inherent in the systems used to heat and store the hot water.

The figures from DOE's survey show site-use Btus, or those that the consumer uses at their home, and does not account for the energy used at the generating source. In the case of electricity, there is significant additional energy used or lost to heat and other byproducts of combustion, at the power plant, and in the transfer of the electricity to the home. To derive total source Btus, the EPA utilizes a factor of 3.34 multipled by

the number of site Btus (US EPA Energy Star performance ratings methodology). The results for source Btus for electricity and other fuels are displayed in the bottom row of Table 3 based on EPA's conversion factors, and are not part of the EIA report.

Table 3. Water heating fuel use in New England

	Total	Electric -ity	Natural gas	Fuel oil	LPG	other
Fuel used for DHW in New England (millions of homes, % of total)	5.3 100%	1.4 26%	2.3 43%	1.4 26%	0.2 4%	Q <1%
Total Annual Expenditures (in millions of $)	$1,950	$480 25%	$690 35%	$660 34%	$120 6%	
Total Consumption (in trillion Btus, end use)	110	10	50	50	10	
Average Consumption (in million Btus, site use)	21.5	8.7	21.9	31.9	26.1	
Average Consumption (in million Btus, source use)		29.1	22.9	32.2	26.4	

While more than half of homes in New Hampshire currently rely on fuel oil for space heating and hot water (OEP NH Energy Facts 2007), newly constructed single-family homes in the northeast are more frequently turning to alternatives to this fuel. From a high of 34% in 1990, the percentage of newly built single-family homes relying on heating oil as the primary source of fuel dropped to 13% in 2008, with natural gas being used as the primary substitute (U.S. Census, Characteristics of New Housing).

On the other hand, the same source documents other trends in the new housing market that could lead to an increase in demand for energy by new homes. In the relatively moderate climate of the northeast, fully 75% of these newly built single-family

homes included central air conditioning in 2008, up from up from just 50% in 1990. In addition, accommodations for three or more cars were included in 13% of these homes, a phenomenon not even recorded in 1990. The median size of northeastern single-family homes rose 18% from 1990 to 2008 to a high of 2,312 square feet. This rise mirrored the increase in homes with four or more bedrooms, from 30% in 1990 to 39% in 2008 (U.S. Census, Characteristics of New Housing, 2008). When *all* homes in the northeast are analyzed for the period 2005-2008 by the American Community Survey, it is estimated that only 20% of single family homes contain 4 or more bedrooms. Interestingly, these larger single family homes do not appear to be actually housing more people. With an average household size of 2.72 in 2006-08, owner-occupied single family homes held a comparable number of people in the 1990 census, which found an average of 2.75 people per owner-occupied single-family home.

Multi-family housing starts tell a different story, with the average size of units decreasing, and the number of units per building increasing over time (U.S. Census, Characteristics of New Housing, 2008). While multi-family housing is not the subject of this study, this sector provides many opportunities for energy efficiency that deserve greater attention, particularly in rural areas where multifamily housing has traditionally been eschewed.

Another potential area for additional study is modular housing, which currently accounts for 10% of all new single-family homes in the northeast and provides opportunities for both cost and energy savings not afforded by site-built construction (U.S. Census, Characteristics of New Housing, 2008). While modular housing is more popular in the northeast than in other parts of the country, heat pumps (both geo-exchange and air source) have barely penetrated the northeast but are very popular in

other parts of the country. Fully 34% of newly built single family homes in the country utilize a heat pump, while just 8% of homes in the northeast are so equipped. Heat pumps are most effective in warmer climates where the heating load is relatively low and cooling load is high. This does not explain the discrepancy entirely however, as heat pump use in newly built homes in the northeast has dropped from a high of 18% in 1985 (U.S. Census, Characteristics of New Housing, 2008). Given that the technology has changed and improved dramatically since that time, heat pumps may be an underutilized source of relatively efficient heat as well as air conditioning.

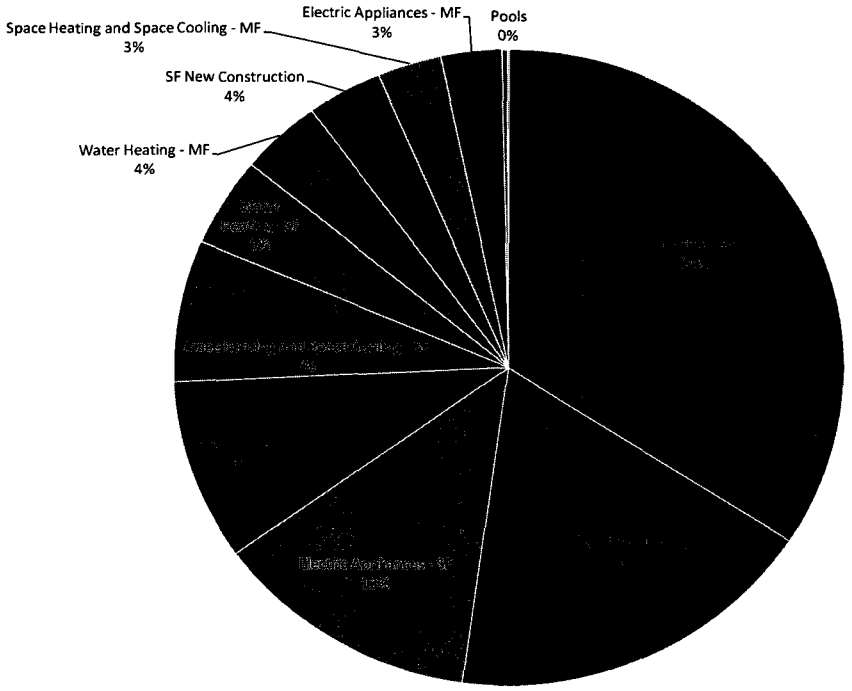
An ambitious goal for the residential sector was recently proposed by Thomas Dietz and other researchers in a study prepared for the National Academy of Sciences which concluded that fully 20% of household emissions in the United States could be eliminated over the next ten years through a combination of energy efficiency measures and behavioral change brought about through proven intervention measures and social marketing (Dietz).

A recent energy efficiency potential study undertaken by GDS Associates for the NH Public Utilities Commission found that in New Hampshire, if all cost-effective[1] measures to reduce the use of electricity in the residential sector were undertaken, 10% of the total electricity savings would be related to the heating of water, as shown in the upper left of Figure 1. This pie chart shows other additional energy efficiency potential in

[1] The definition of 'cost-effective' used by GDS for this study is based on a methodology developed by the NH Energy Efficiency Working Group in 1999, with modifications from a 2008 PUC CORE energy efficiency filing, which raised the bar on what was considered cost-effective. While many technical potential studies of this nature base their analysis on Maximum Achievable Cost-Effective potential, the GDS study developed and utilized an even stricter category they call the Potentially Obtainable scenario, which they describe as "taking customer behavior into consideration (including consideration of priorities and price)" (GDS, p. 4). The measures considered 'cost-effective' according to this very strict definition may therefore underestimate actual potential for cost effective market-based changes in energy consumption in New Hampshire.

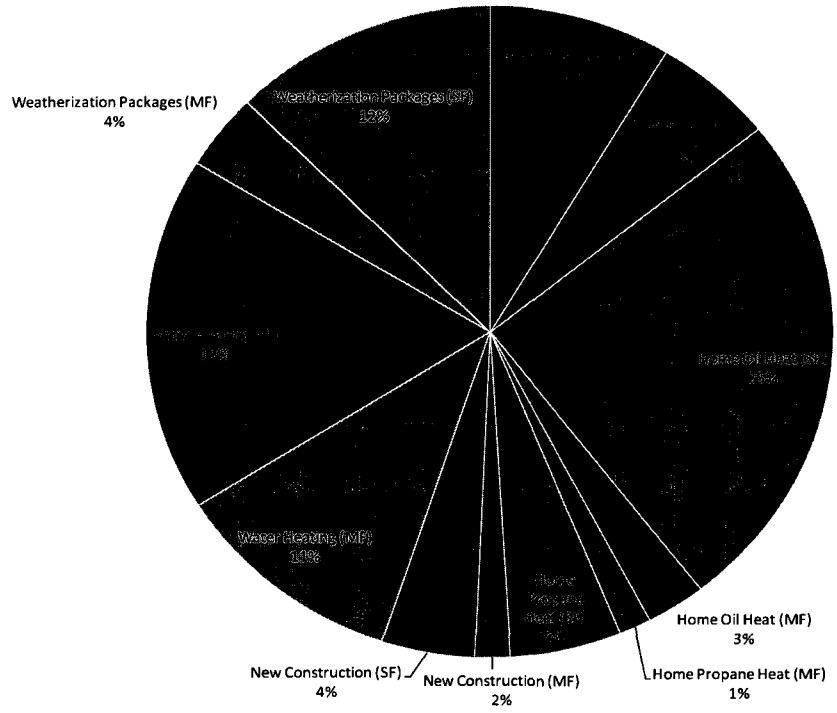
the residential sector, based on what cost-effective measures researchers think could be undertaken given currently available technology.

Figure 1. Cost-Effective Energy Efficiency Potential in NH Residential Sector, Electric (GDS, p. 11)



The potential for energy savings related to heating water by means other than electricity is even greater, comprising 29% of all identified cost-effective energy efficiency opportunities, as shown in the wedges on the left of Figure 2. There is tremendous opportunity for the residential sector, and homeowners specifically, to cost-effectively reduce their energy use and energy costs. Notwithstanding the optimism expressed by Dietz and colleagues, there remain significant barriers to making this happen.

Figure 2. Cost-Effective Energy Efficiency Potential in NH Residential Sector, Non-Electric (GDS, p. 12)



Energy Supply Side

Since discovering oil in Pennsylvania in 1849, the United States has depleted its own easily accessible natural reserves of oil to the point where as of 2007, 58% of the country's oil is imported (Crane, page 6). The situation for natural gas imports is somewhat more positive, with a smaller percentage ranging from 12% to 17% of natural gas imported between 1995 and 2008, according to EIA (US EIA, U.S. natural gas imports and exports, 2008). This increasing dependence on other countries and regions for energy – the driver of our economy - is of concern to security analysts and energy planners, even when global climate change and other environmental impacts are not considered.

A study commissioned by ISO New England[2] at the behest of the New England States Committee on Electricity identified the potential for 12,000 MW of wind energy in New England. The development of at least some of this energy is seen as a high priority in order to meet the goals of the renewable portfolio standards (RPS) of states in the northeast region (New England Governors' Renewable Energy Blueprint). New Hampshire's RPS mandates that the state meet just shy of 24% of its electricity needs from new and existing renewable sources by 2025, which will most likely be accomplished through expansion of existing renewable energy markets.

As shown in Table 4 based on information gleaned from the Database of State Incentives for Renewables and Energy Efficiency (DSIRE), states neighboring New Hampshire have similarly ambitious RPS goals, with Massachusetts requiring its electricity providers to increase their use of renewables by 1% each year, meeting 15% of consumer demand with renewable sources by 2020 (and continuing to increase thereafter). Vermont's RPS has a two-step goal of 20% of all electricity sales met by renewables by 2017, and 25% by 2025. Maine has the strictest RPS in the country, but is already largely meeting its renewable requirements through existing hydroelectric projects. Legislation in that state passed in 2007 requires a 10% increase in new renewable energy by 2017 (DSIRE).

[2] Independent Service Operators, or ISOs, were set up around the country by the Federal Electricity Regulatory Commission (FERC) to oversee deregulation of electricity markets. ISO New England was established in 1997.

Table 4. Regional Comparison of Energy Policy (DSIRE and US DOE states with renewable portfolio standards)

	Population 2009 estimate	electric choice commercial/ residential	Public EE/RE finance options for residents	Renewable Porfolio Standard (electricity)
Massachusetts	6.6 million	yes/yes	No	15% by 2020 increasing by 1% each year thereafter
Vermont	0.6 million	No	PACE	Non-binding goal of 20% by 2017
Maine	1.3 million	In process	PACE (in progress)	40% by 2017, (including 10% new sources by 2017)
New Hampshire	1.3 million	Yes/In process	PACE (in progress)	23.8% by 2025

As a result of multiple considerations, regional initiatives, and ambitious state legislators eager to protect the state's environmental and economic future, the State of New Hampshire has seen a flurry of legislative and administrative activity and regulation in the past several years that goes well beyond RPS, relating to both energy efficiency and renewable energy generation. These include:

- The Regional Greenhouse Gas Initiative (RGGI) commits the state to participating in a regional carbon cap and trade system for major electricity producers with nine other northeastern states. RGGI went into effect January 1, 2009 and generated more than $17 million for energy efficiency and conservation in the state in its first year alone (NH PUC).
- New Hampshire's RGGI legislation mandated the creation of the Energy Efficiency and Sustainable Energy (EESE) Board, to guide the Public Utilities Commission as it manages the funds generated as a result of RGGI, and recommend policy and legislation to the state legislature on issues relating to

energy. This board is comprised of leaders from the public and private sectors, meets monthly, and attracts a wide array of stakeholders to each of its meetings.

- HB 1628, which amended RSA 651B, provides an incentive of up to $6,000 (or 50% of cost) to home owners who install qualified renewable energy systems (e.g., solar and wind). These incentives are paid for out of the Renewable Energy Fund, which is funded by payments from the electric utilities under the terms of the state's Renewable Portfolio Standard.
- Building Codes for Energy Efficiency, the New Hampshire Code Review Board adopted the most up to date International Energy Efficiency Code, IECC-2009, which went into effect April 1, 2010. New Hampshire has also committed to achieving 90% compliance with the code by 2017 as a condition of receiving American Recovery and Reinvestment Act funds.
- The Energy and Climate Collaborative continues the work of the Climate Change Policy Task Force, which was established by Governor John Lynch in 2008 to complete a comprehensive Climate Action Plan. This ambitious plan, published in March 2009, proposes a set of 67 specific actions to be undertaken by a variety of public and private actors to reduce greenhouse gas emissions in the state. If taken, these actions are expected to result in an 80% reduction of greenhouse gas emissions in the state over 1990 levels by 2050.
- Property Assessed Clean Energy (PACE) legislation in the form of HB 1554 made its way through the NH legislature in 2010, and will authorize municipalities to lend money to residents for energy improvements and pay the funds back through a special property tax assessment. This framework has passed in many states across the country and is viewed as a means of overcoming a primary

barrier to homeowner investment in energy efficiency and renewable energy – high upfront cost.

Solar Domestic Hot Water

Current market penetration of solar domestic hot water (SDHW) in New Hampshire is difficult to estimate. There is no regulation of this market, and installers range from do-it-yourself homeowners to licensed plumbers, to specialized solar retailers. The Energy Information Administration (EIA) at the Department of Energy undertakes periodic surveys of residential energy use. The most recent data available is from their 2005 survey of 4,381 households from throughout the country, and shows statistically unreliable results regarding the solar domestic hot water usage in the New England region (US EIA, 2005 Residential Energy Consumption Survey). GDS' Energy Efficiency Potential Study estimated a 1% solar hot water usage for the state (GDS, Appendix E). Finally, the survey analyzed here included four respondents who indicated that they had solar panels for hot water or electricity, out of a total of 567 respondents.

Solar domestic hot water systems have been installed by homeowners and small businesses in the Plymouth area in part due to outreach by the nonprofit organization Plymouth Area Renewable Energy Initiative (PAREI), which provides a supportive and friendly neighbor-to-neighbor approach to adopting renewable energy. Also furthering the adoption of solar hot water are incentive programs such as that offered by the NH Electric Coop, which offered a rebate of $1,500 per solar hot water system installed (this rebate program was oversubscribed). New incentive programs for residential solar hot water installations became available in May of 2010, paid for by the Renewable Energy Fund, which is administered by the Public Utilities Commission. The NH Office of Energy

and Planning is supplementing these funds with federal appliance rebate program monies. Private companies are also realizing success in New Hampshire in recent years, such including the USA Solar Stores, which has independent franchises in six communities throughout the state as of spring 2010. Many other electric and plumbing contractors have the capacity to install solar hot water (or other renewable energy technologies), but are not focused on promotion, relying instead on homeowners or business owners to request such systems. These small businesses have benefited from the recent state and federal credits and rebates for solar hot water, yet quality and consistency remain issues.

The cost of installing SDHW is variable and depends on many factors, including the orientation of the roof of the home, the size of the system to be installed, trees and other obstructions that could reduce the effectiveness of the system, the cost of labor to install, and other factors related to the home itself. The magnitude of savings resulting from these systems is also highly variable and can differ from home to home depending on the volume of hot water that is utilized, the fuel it is displacing (i.e., electric, oil, natural gas), and the efficiency of the hot water system it replaces. In practice, this confusing and unfamiliar array of variables presents a high transaction cost to the consumer, which is perhaps one of the greatest barriers to adoption; Chapter 3 investigates this burden further. For the purposes of the survey, this 'figuring it out' process was simplified, and respondents were presented with two cost variables – initial installation cost, and annual cost savings – and asked to answer 'yes' or 'no' to whether they would adopt SDHW based on those factors.

In its study of energy efficiency potential in New Hampshire undertaken for the Public Utilities Commission in 2009, GDS Associates estimated an installation cost of

$7,500 for domestic solar hot water (GDS, Appendix E). This is the high end of the installation cost suggested in the hypothetical contingent valuation question for this survey, with the supposition that costs would be subsidized by state and federal incentives.

Overall, solar hot water is *not* seen as a cost-effective energy efficiency measure by the Additional Opportunities for Energy Efficiency study authors, due to the high cost of installation and the availability of energy saving alternatives such as point-of-use water heating systems. However, for the purposes of this study of residential attitudes to household energy use, solar hot water is analyzed because it is a renewable energy technology that is commercially available, relatively inexpensive, and easy-to-understand.

CHAPTER II

ATTITUDES AND BEHAVIORS OF NEW HAMPSHIRE RESIDENTS REGARDING HOUSEHOLD ENERGY USE AND PRACTICES

In this chapter, I will examine the attitudes and behaviors of respondents to a variety of energy-related issues, including support for renewable-energy electricity choice[3], utilization of energy-conserving and energy-intensive consumer products and practices, public policy regarding increasing the use of renewables, and the willingness to pay for and use renewable energy technology in the home.

Survey Background and General Description

From September 25 – November 25, 2009, a web-based survey was undertaken by 567 New Hampshire households participating in a Zoomerang consumer panel. Zoomerang uses incentives in the form of points toward product purchases to attract and retain survey panel participants. Established in 1999, Zoomerang is one of the oldest web-based survey service companies and is widely used by marketers and researchers of consumer trends. Potential respondents were invited to participate in the survey and

[3] The option of selecting a green power provider for your electricity is called by different names in different states, including 'Green Power Choice', 'Clean Energy Option' and other similar names. For the purposes of this paper, I will refer to these programs generically as "electric choice" programs.

were directed to a site designed by UNH researchers. Permission was obtained by the Institutional Review Board at the University of New Hampshire prior to undertaking an initial test survey in the spring of 2008 (See Appendix A). The populations of interest for this survey were a) all New Hampshire households, and, for the contingent valuation questions, b) New Hampshire single-family homeowners.

As with almost all survey sampling techniques, the sample is not perfectly representative. The use of mail and telephone interviews was considered, and a web-based survey was ultimately determined to be the best, most cost-effective delivery method. With the exception of gender, the sample demographics were comparable to those obtained in telephone-based surveys conducted by the UNH Survey Center, and to recent census data for the state.

Web-based surveys remain somewhat controversial in the field of social science research given the difficulty of quantifying selection bias and non-observational error, yet they are increasingly widely used as more traditional forms of sampling, namely telephone and in person, face their own challenges (Couper). A special issue of Public Opinion Quarterly from 2008 is dedicated to the discussion of web-based surveys. Contributors to this issue identify both potential benefits and challenges for researchers to consider when undertaking and analyzing the results of web-based surveys. One article in this issue concludes that there are small but statistically significant differences in response between frequent internet-using panelists who completed a web-based survey and respondents from the same panel with little or no internet use who were administered an identical mail-based survey (Rookey, Hanway and Dillman).

Responses from the NH Energy and Housing survey were received from 567 individuals representing as many households. Of those who began the survey, 557

(98.2%) completed it, which is a very high rate, particularly given that the survey was both long and potentially challenging. Individual respondents were between the ages of 18 to 88, and were from communities throughout the state, representing both rural and urban areas. Of the total sample, 416 respondents describe themselves as owning their own home. According to the 2006-2008 American Community Survey undertaken by the U.S. Census the rate of homeownership in New Hampshire was 72.9% compared to 73.8% of respondents in this survey. One of the primary motivations for the survey was to test willingness to pay for solar hot water, and for this portion of the survey, only the responses of single-family homeowners were analyzed, given that these respondents have greater legal authority to modify their homes than renters, condominium or mobile home owners, most of whom are restricted by community rules.

The sample is disproportionately female, with 73% respondents in the sample identifying as women. Of the homeowners, a similar percentage, 72% were women. Interestingly, a Pew Research Center study from 2008 shows that women have a greater role than men in the decision making around household budget and home improvements. While 46% of couples make such decisions together, fully 30% of the couples surveyed defer to the woman, while only 19% of households defer to the man. Women are engaged in fully 76% of household decisions, therefore, either as one member of a couple, or on their own (Morin and Cohn). Understanding the motivations of women in the sample can help researchers to understand the motivations in the larger population surrounding the adoption of new technologies.

Research shows that web-based surveys tend to attract more highly educated respondents, however with the wide-spread adoption of computers and access to the internet, this bias is less significant today than it used to be. The American Community

Survey 3-year estimate for the period 2006-08 indicates that 90.5% of the population of New Hampshire over the age of 25 has attained at least a high school diploma, compared to 98.2% of the survey respondents. The Census estimates that 32.6% of New Hampshire residents over 25 have attained a bachelor's degree, while 34.6% of survey respondents indicate they have graduated from college.

Of primary interest to the researchers is the willingness among New Hampshire residents in general, and homeowners in particular, to adopt renewable energy technologies, and to identify the barriers to such adoption. Policy makers, advocates, private -sector providers of energy and energy technology, and decision makers must make assumptions regarding who would be most likely to adopt renewable energy technologies, and at what cost, largely without benefit of supporting information from the consumer base. The survey and this analysis is therefore intended to provide a more solid basis on which to design programs, subsidies, and emerging technology marketing. A summary of the results of the entire survey are contained in Appendix A of this paper.

Electric Choice

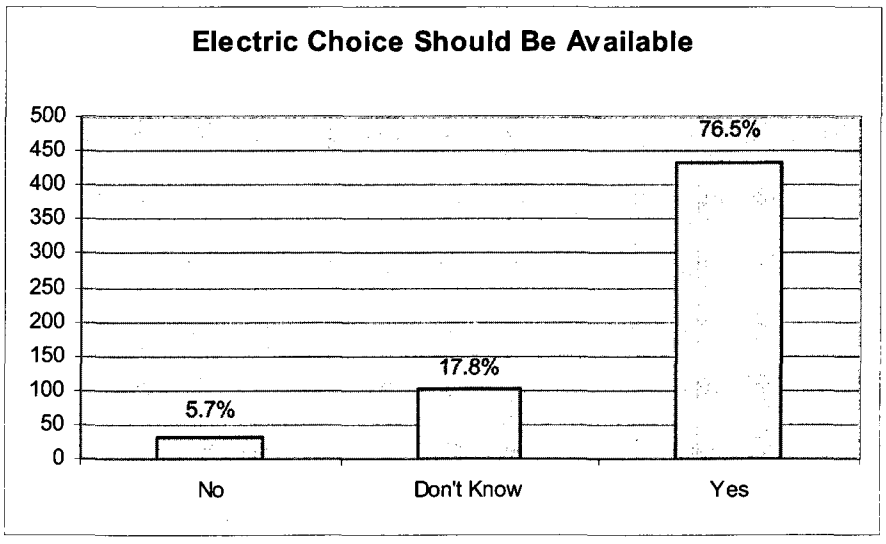
The New Hampshire legislature recently passed legislation requiring the state's four electric utilities provide their residential consumers information regarding the environmental attributes of the electricity that is provided to them. The Public Utilities Commission is also beginning to mandate that the regulated utilities give their customers the option of receiving their energy from a certified renewable energy supplier. The state's largest electric utility, Public Service Company of New Hampshire, began offering this option to consumers in the spring of 2010. In the past, it has been assumed that the

number of residential customers that would opt in would be too small to make it economically feasible for an energy provider to provide.

The interest on the part of the New Hampshire utility customers to the idea of electric choice has not been tested recently, but both surveys and actual implementation that has occurred in other states can shed light on the attractiveness of such choice to consumers. Typically, socially desirable response bias has led to overestimates of the interest in renewable energy choice, as respondents, faced with no actual responsibility to follow through, answer the "right" way based on their own interpretation or what they believe the surveyor wants. Complicating interpretation of electric choice programs that have actually been implemented are the fact that incentives and rebates often accompany initial roll out, which change price signals (Paulos, pps. 46-56).

With these caveats in mind, the results of the survey of New Hampshire residents shows very strong support for residential electric choice. Two questions related to electric choice were asked of respondents:

Figure 3. Results of Electric Choice Availability Question



1. "Do you think electricity customers in NH should be given the choice of where their personal household electricity comes from (in other words, traditional sources or renewable)?" and,
2. "Would you choose to get your electricity from renewable sources?"

The results of the first question for the entire survey group, including renters, are displayed in Figure 3. An analysis of several criteria including gender, respondent education, household income, age, housing ownership status, and political persuasion show strong support for a electric choice among all groups.

Table 5. Support for Electric Choice by Political Persuasion

should electric choice be an option?	**very conservative**	**conservative**	**neither liberal nor conservative**	**liberal**	**very liberal**	**Total**
No	4	7	12	8	1	**32**
	11%	5%	5%	8%	4%	6%
Don't Know	8	27	47	15	2	**99**
	22%	19%	18%	15%	8%	18%
Yes	24	108	199	78	21	**430**
	67%	76%	77%	77%	88%	77%
Total	**36**	**142**	**258**	**101**	**24**	**561**

Pearson χ^2 (8) = 6.5728 Pr = 0.583

The χ^2 results when the respondents are broken down by political identity, as displayed in Table 5, show that there is no statistically significant difference among the groups. However, comparing the 8% of very liberal respondents who 'don't know' to the 22% of very conservative respondents who 'don't know' makes one wonder whether a

larger sample would show statistically significant differences between these two politically disparate groups.

Gender *does* have a statistically significant impact on respondent position on electric choice, as displayed in Table 6, with women favoring it more and being less sure about their opinions than men. The probability of such a result being repeated in a sample of this size, should the views of men and women on this question actually be the same, are less than one in one thousand (P=0.007).

Table 6. Support for Electric Choice by Gender

should electric choice should be an option?	**Female**	**Male**	**Total**
No	16 4%	16 11%	**32** 6%
Don't Know	78 19%	23 15%	**101** 18%
Yes	322 77%	111 74%	**433** 77%
Total	**416**	**150**	**566**

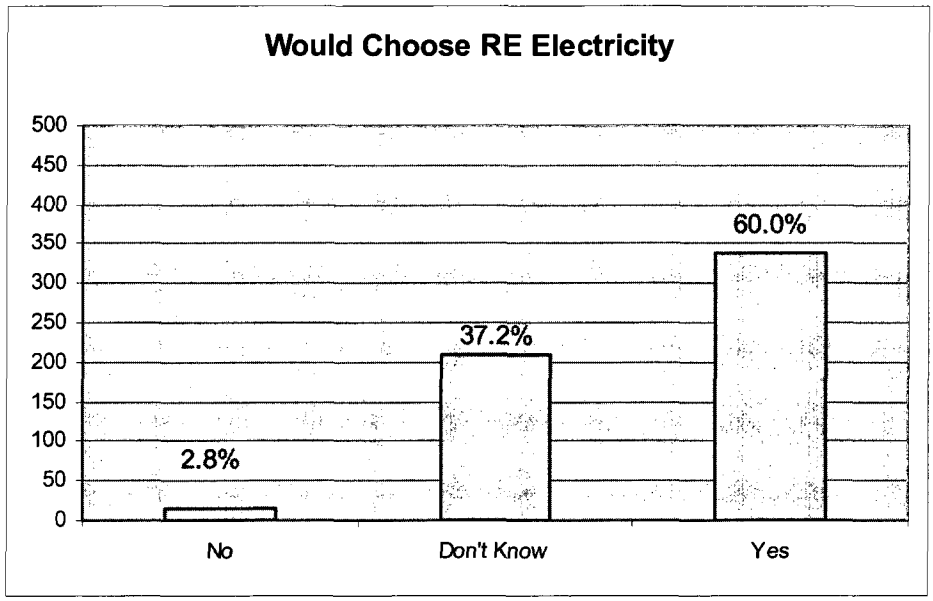
Pearson χ^2 (2) = 9.9595 Pr = 0.007

Another demographic factor, education, does not show a statistically significant impact on the question of electric choice, though education will be shown to have a statistically significant impact on the question of solar hot water, discussed later in this chapter.

The next question in the survey asked, were electric choice an option, would respondents actually opt to get their own household electricity from a renewable source. In the actual marketplace, such a decision would be complicated by factors including

how much such an option would cost, whether cost was locked in and for how long, whether the power received would be distinguishable from one's current electric service, etc. Therefore, one would expect a greater degree of uncertainty among respondents regarding what their own choice actually would be, as opposed to their position on a choice simply being offered. This is indeed the case, with more than one-third of the respondents indicating 'Don't Know' when asked the question, as shown in Figure 4.

Figure 4. Percent That Would Choose Renewable-Source Electricity



For this second question, statistically significant differences can be shown based on various factors. Analysis shows that, with 90% confidence, women are more likely to answer that they would choose to get their electricity from renewable sources than men. It also shows that, with 98% confidence, those between the ages of 25 and 45 are disproportionately likely to answer that they would choose to get their electricity from

renewable sources, while those between the ages of 45-65 are disproportionately likely to answer that they don't know.

Political persuasion is a statistically significant variable (at the 99th percentile), albeit difficult to interpret, with the very conservative having the most definitive answers; this certainty among conservatives increases the proportion that answered both yes *and* no to the question. Finally, respondent household income plays a statistically significant role (90% confidence). Those households making less than $65,000 per year are disproportionately more likely to answer that they would choose to get their electricity from renewable sources. Other respondent attributes tested showed no statistically significant impact from respondent education, housing ownership status, or whether the respondent lived in one of the state's 10 most populous communities.

Renewable Energy Policy

As described in Chapter 1, New Hampshire has passed a number of laws regarding renewable energy, including the Renewable Portfolio Standard, which mandates that the state's electric utilities provide an increasing percentage of electricity from renewable energy sources, or make an alternative compliance payment that will be used to increase small scale renewable energy generation. This policy, which became law in mid-2007, brought the state in line with most other states in the country. As of early 2010, 37 states, including New Hampshire, had similar standards on the books, and the federal government is currently debating the merits of a national standard.

In order to gauge the support for such state policy among the population, researchers asked respondents the following question: "New Hampshire has recently passed legislation mandating that an increasing percentage of our energy come from

renewable energy sources such as wind, solar (sun), landfills, and water. Please rate your level of opposition to or support for this policy." The results for the entire sample show that 72% either "somewhat support" or "strongly support" such a policy.

An analysis of the results based on the same independent variables used with the electric choice questions shows more pronounced and statistically significant differences regarding the public policy question. As can be seen from Table 7, women support renewable energy policy more consistently than men, with a χ^2 approaching 0.

Table 7. Support for Renewable Energy Policy in New Hampshire by Gender

	Women	Men	Total
Totally oppose	4 1.0%	10 6.8%	14 2.5%
Somewhat oppose	7 1.7%	8 5.4%	15 2.7%
Neither oppose nor support	92 23.3%	34 23.1%	126 22.5%
Somewhat support	125 30.3%	44 29.9%	169 30.2%
Strongly support	184 44.7%	51 34.7%	235 42.0%
Total	**412**	**147**	**559**

Pearson χ^2 (4) = 22.9666 Pr = 0.000

When political persuasion is examined, those who identify as 'very conservative' are found to be disproportionately opposed to renewable energy mandates, with 20% answering "totally oppose" and just 57% answering either "somewhat support" or "strongly support". On the other end of the political spectrum, those who identify as 'very liberal' support the policy either strongly or somewhat strongly by a margin of 20:1. These results are displayed in Table 8.

Table 8. Support for Renewable Energy Policy in New Hampshire by Political Persuasion

	Very Liberal	Liberal	Neither	Conservative	Very Conservative	Total
Totally Oppose	1 4%	1 1%	3 1%	5 4%	4 11%	**14** **3%**
Somewhat Oppose	0 0%	2 2%	4 2%	7 5%	2 6%	**15** **3%**
Neither Opopse nor Support	2 8%	20 20%	61 24%	30 21%	12 34%	**125** **23%**
Somewhat Support	5 21%	24 24%	73 29%	53 38%	12 34%	**167** **30%**
Totally Support	16 67%	54 53%	113 44%	45 32%	5 14%	**233** **42%**
Total	**24**	**101**	**254**	**140**	**35**	**554**

Pearson χ^2 (16) = 47.2913 Pr = 0.000

Other independent variables – age of respondent, housing ownership, household income, and presence of children in the home – showed no statistically significant relationship to support for renewable energy standards. Respondent education shows no significant difference, though the greater the level of education the more likely the respondent is to have formed a definite opinion, and the less likely they are to respond "neither oppose nor support".

Responsibility for Increasing Renewable Energy

Immediately following the questions regarding New Hampshire renewable energy policy, respondents were asked to rate the level of responsibility they believe each of eight societal actors has to increase the use of renewable energy. The order in which the actors were displayed in the survey was randomized in order to minimize bias toward those listed first. The researchers were interested in the answers to this question in

order to determine a) the support for public policy versus market forces as a means of increasing the use of renewable energy, and b) the level of responsibility homeowners feel they themselves have for generating renewable energy at home.

Respondents were allowed to pick the same level of responsibility for more than one type of actor, as survey designers felt respondents would find it difficult to accurately rank responsibility. The results are presented in Table 9. Each group (i.e., "homeowners", "all residents", "state government", etc.) was found to have at least "some" responsibility by over 90% of the respondents. It is more interesting, however, and telling, to look at the percentage that assigned either "moderate" or "total" responsibility to each group. The far right column of Table 9 combines the results of these two options, and the table is organized in order of greatest responsibility to least.

The results range from a high of 79% of respondents assigning either moderate or total responsibility to regulated utility companies, to a low of 55% assigning the same level of responsibility to "all residents". Homeownership increases responsibility of individuals in respondents' minds only slightly, and not in a way that can be shown to be statistically different from the responsibility held by all residents.

Because different respondents will have different definitions of "some", "moderate" and "total", it would be a mistake to read too much into these statistics, but they do give a general sense of where the public feels responsibility for increasing the use of renewable energy lies. Residents do not see themselves as primarily responsible for increasing the use of renewables, but rather see energy providers themselves, as well as state and federal government, as the most responsible parties.

Table 9. Level of Responsibility Assigned

	no responsibility	very little responsibility	some responsibility	moderate responsibility	total responsibility	NA	Some or more	moderate or more
regulated utility companies	7	11	88	274	170	13	532	444
	1%	2%	16%	49%	30%	2%	94%	**79%**
oil and gas companies	10	19	101	249	170	14	520	419
	2%	3%	18%	44%	30%	2%	92%	**74%**
state government	9	12	121	264	144	12	529	408
	2%	2%	22%	47%	26%	2%	94%	**73%**
federal government	14	22	116	229	167	13	512	396
	2%	4%	21%	41%	30%	2%	91%	**71%**
town and local government	12	19	135	271	109	14	515	380
	2%	3%	24%	48%	19%	2%	92%	**67%**
businesses	5	25	148	274	95	12	517	369
	1%	4%	26%	49%	17%	2%	92%	**66%**
homeowners	12	28	189	235	86	14	510	321
	2%	5%	34%	42%	15%	2%	90%	**57%**
all residents	12	29	198	231	81	13	510	312
	2%	5%	35%	41%	14%	2%	90%	**55%**

Given that 'regulated utility companies' are regulated by the state, and that state government is also seen as a highly responsible party in generating renewable energy, it seems safe to conclude that the public is comfortable with state government acting to ensure increases in the use of renewables. One caveat: because this question regarding responsibility appeared immediately following a question about the state's recent law mandating a greater use of renewable energy, it is likely that respondents were more comfortable assigning responsibility for such policy to the state because that is clearly a role the state has assumed.

Level of Concern Regarding Various Household Issues

Early in the survey, after an introduction that focused on the researchers' interest in energy use, but before any other direct questions regarding energy attitudes or

behaviors, respondents were asked "Please rate your level of concern, if any, with each of the following issues as they affect you and your family." The results are presented in Table 10. It was deemed likely by survey designers that respondents' level of concern with various issues could help predict the likelihood of supporting renewable energy, and this hypothesis was tested with mixed results.

Table 10. Respondent Concern for Various Household Costs and Issues

	not at all concerned	a little concerned	somewhat concerned	moderately concerned	very concerned	Somewhat or more	mod or more
The cost of health care	24	31	85	136	289	510	425
	4%	5%	15%	24%	51%	90%	**75%**
The cost of heating your home	31	45	92	153	244	489	397
	5%	8%	16%	27%	43%	87%	**70%**
The cost of gasoline	15	47	130	175	199	504	374
	3%	8%	23%	31%	35%	89%	**66%**
The cost of food	21	56	140	185	163	488	348
	4%	10%	25%	33%	29%	86%	**62%**
The amount of energy you use	32	66	173	167	129	469	296
	6%	12%	31%	29%	23%	83%	**52%**
The resale value of your home	120	51	127	121	146	394	267
	21%	9%	22%	21%	26%	70%	**47%**
Your job security	169	82	100	82	131	313	213
	30%	15%	18%	15%	23%	55%	**38%**

Solar Domestic Hot Water

Because of the complexity and dynamic character of the residential renewable energy market, researchers chose to focus on the willingness of respondents to adopt a relatively cost-effective and accessible technology at one's home, namely the solar-heated domestic hot water system (SDHW).

One of the goals of the surveyors in asking questions regarding willingness to pay for SDHW was to estimate at what price 50% of the population would be induced to invest in domestic solar hot water. To do this, the entire sample was broken into ten subsets based on a random variable (the last digit of the respondent's phone number). The size of these sub-samples ranged from 34 to 41 respondents for those who identified as single-family homeowners. Respondents in each of the ten subsamples were then asked to answer 'yes' or 'no' to whether they would purchase SDHW based on a specific combination of five installation costs ($1000, $1250, $2500, $5000, and $7500) and two annual cost savings ($400 and $700).

Those who answered 'yes' to installing SDHW were then asked to gauge the likelihood of their actually purchasing such a system on a scale from 1-7, and also to pick all relevant reasons among 10 offered motivating them to purchase SDHW (an optional "other" field was also provided). Similarly, those who answered 'no' to purchasing SDHW were asked to pick all relevant reasons among 12 offered as to why they would *not* purchase SDHW; as with those answering in the affirmative, respondents were allowed to provide their own reason for answering 'no'.

Another follow-up question was asked of those answering in the affirmative to purchasing SDHW: "If you were interested in finding out more about installing alternative energy options at your home, where do you think you would start first?" Ten possibilities were offered in addition to the option of writing in their own answer. The results of this series of questions shed important light on the moods and motivations of homeowners in New Hampshire regarding the adoption of renewable energy technologies at their residences.

Looking at the dependent variable 'solar answer' which represents respondents' yes or no answer to the question of whether they would adopt SDHW, we find that of the 369 single-family homeowners surveyed, 130 (35%) answered 'no' they would not adopt and 239 (65%) said 'yes', they would adopt regardless of the value of any of the independent variables, including upfront cost. As with the question regarding the electric choice, and respondents' position on whether they would personally opt to get their electricity from a renewable energy provider, the question regarding adoption of SDHW is likely inflated due to respondent social bias or what is also referred to as the 'halo effect'. There is a psychological impulse to appear to be in favor of what seems to be beneficial social policy, which causes respondents to answer 'yes' on a survey where an actual decision or behavior made privately, may be different.

Looking at the results to the follow-up question in Table 11 asking respondents how likely they would be to actually follow-through helps cut through the halo effect to some degree. Only the extremes of 1 and 7 were labeled in the survey, with 1 indicating "I would look, but I could not buy" and 7 indicating "I would absolutely buy". Only 97 respondents, or 26% of the homeowners surveyed, answer at a level 5 or greater, compared to 65% who answered 'yes' to the original 'would you or wouldn't you purchase' question. These results reflect a high degree of uncertainty on the part of respondents, suggesting that they do not have enough information to commit more fully to such a purchase. On the other hand, the high percent answering 'yes' to the initial question suggests a high level of general support for the concept of adopting solar domestic hot water.

Table 11. Solar Domestic Hot Water Commitment

Answer	Freq	Percent
Would Look, But Could Not Buy	11	4.6%
2	18	7.5%
3	42	17.6%
4	71	29.7%
5	57	23.8%
6	25	10.5%
Would Absolutely Buy	15	6.3%
Total	**239**	**100.0%**

The Contingent Valuation Method

Contingent valuation methods have typically been used for public goods that by their nature are not for sale on the open market. By contrast, consumers' willingness to pay for products and services actually available in the marketplace can typically be determined by studies of actual sales. Having first been utilized as a means of placing a monetary value on environmental resources whose existence benefits a large population, contingent valuation is now being used to assess value in a variety of fields of study, including health care, arts and culture, and recreational management.

In this study, researchers are extending contingent valuation to an emerging market: residential renewable energy technology in New Hampshire. The marketplace for renewable energy technology is currently encumbered by extraordinary transaction costs for the consumer, including perceived lack of availability of the technology, lack of knowledge about or understanding of the technology, and tax credits and rebates that attempt to expand the market until economies of scale bring the cost down. Contingent valuation can serve to reduce the noise surrounding homeowners' willingness to adopt renewable energy technologies in the home.

As with surveys measuring willingness to pay in hypothetical markets for public goods, this survey measures willingness to pay in a hypothetically simplified market. The results should help public policy makers to identify what price consumers are willing to pay for an entry-level renewable energy technology, and therefore adjust rebates and credits accordingly.

Researchers looked at those homeowners who answered 'yes' to the initial question about purchasing such a system based on a simple combination of up-front cost and annual savings. As described above, one of ten price combinations was offered to each of ten sub-samples. The results are displayed in Table 12.

Table 12. Results of the Contingent Valuation Question regarding SDHW

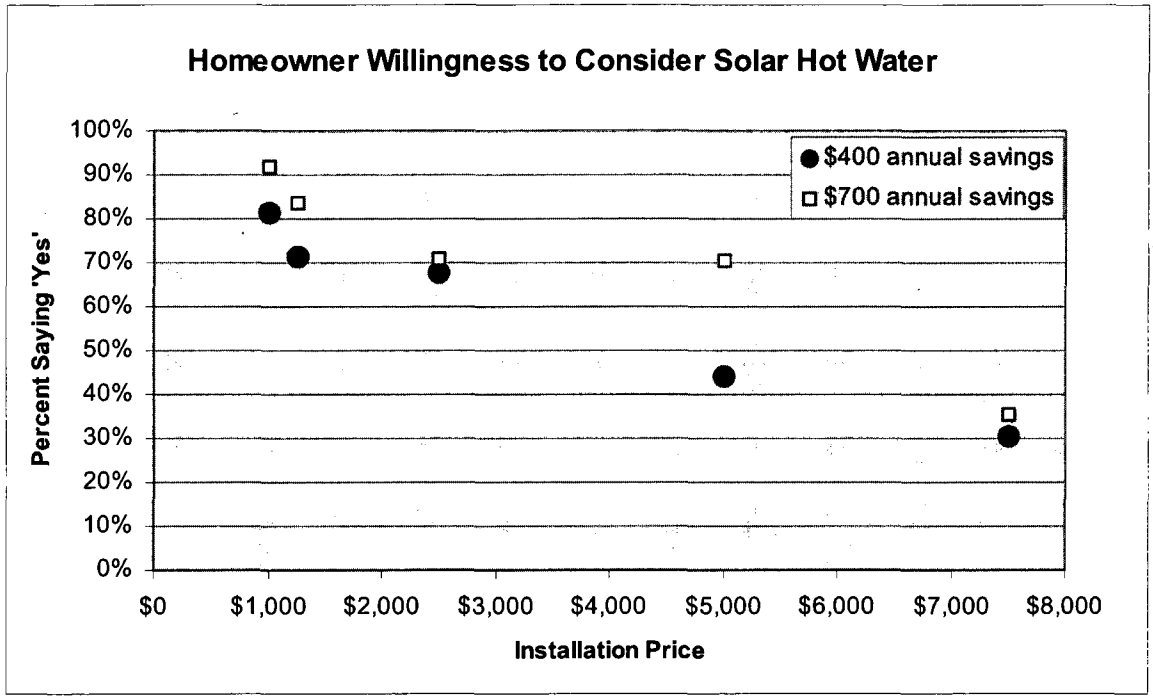
Annual Savings	$400					
Upfront cost	$1,000	$1,250	$2,500	$5,000	$7,500	**total**
No	7	10	12	23	25	**77**
	18%	29%	32%	56%	69%	41%
Yes	31	25	25	18	11	**110**
	82%	71%	68%	44%	31%	59%
Total	**38**	**35**	**37**	**41**	**36**	**187**

Annual Savings	$700					
Upfront cost	$1,000	$1,250	$2,500	$5,000	$7,500	**Total**
No	3	6	12	10	22	**53**
	8%	16%	29%	29%	65%	29%
Yes	33	31	29	24	12	**129**
	92%	84%	71%	71%	35%	71%
Total	**36**	**37**	**41**	**34**	**34**	**182**

Of note here is the fact that the percentage of respondents answering 'yes' to purchasing SDHW was greater at the $700 annual savings than it was at the $400 annual savings. The percentage of respondents saying 'yes' differed when the annual

savings was different and upfront installation costs were the same. This information is presented graphically in Figure 3.

Figure 3. Support for Solar Domestic Hot Water by Annual Savings



Statistical Analysis of Independent Variables

Given that the characteristics of each of the ten sub-samples are not equivalent however, these statistics only tell us so much. In order to help predict the likelihood of a New Hampshire homeowner saying 'yes' to the question of willingness to adopt DSHW, we need to look at various independent variables and smooth out the variations in the subgroups. To do that, researchers used a binomial logit to estimate the probability of any given individual answering 'yes' to the question of whether they would adopt SDHW, and how strongly they were committed to that answer. The most important of the

independent variables is the upfront cost of installation, but others variables from the survey can help improve the odds of correctly estimating an individual's answer and their commitment to actually installing SDHW.

Demographics, Household Characteristics, Practices, and Concerns

In designing the survey, researchers were sensitive to the need to gain information regarding demographic characteristics that could serve as independent variables, while keeping respondents from being overwhelmed by too many questions. Researchers sought to determine which of various household behaviors, choices, or concerns could help to predict whether or not a respondent was more or less likely to opt for SDHW. Data analysis does shed some light on these issues, with Table 13 showing the results of an ordered logistic regression test in which these variables are analyzed. Note that statistical significance in indicated by the column labeled 'P>|z|', referring to the probability that the independent variable has no correlation or impact on the dependent variable (i.e., a yes or no answer). A high absolute z score / low P>|z| value means there is greater likelihood of a correlation and that the results are not simply random or accidental.

Table 13 contains 20 independent variables that were tested in the survey. The vast majority do not meet the test for statistical significance, and were dropped in the next round of testing. Listed in order of decreasing significance, the variables can help shed some light on those concerns, practices, and even motivators associated with willingness to consider solar hot water. The odds ratio provides the modeled change in odds of a 'yes' answer with every 1-unit increase in the value of the independent

variable. For dummy variables, this equates to the odds of a yes answer when the variable is positive.

Table 13. Logistic Regression Results for Concerns and Practices

Logistic regression — Number of obs = 341; LR chi2(47) = 133.01; Prob > chi2 = 0.0000; Log likelihood = -155.27574; Pseudo R2 = 0.2999

Yes to SDHW	Odds Ratio	Std. Err.	z	P>|z|	95% Confidence Interval	
Upfront cost	0.645591	0.0434901	-6.5	0	0.56574	0.736713
Annual savings	1.326382	0.136315	2.75	0.006	1.084398	1.622364
Years of education	1.244821	0.0950369	2.87	0.004	1.071818	1.445748
Support RE Policy	1.756553	0.3523729	2.81	0.005	1.185513	2.602654
Decades in home	0.698249	0.1087657	-2.31	0.021	0.51454	0.947548
# children in home	0.581624	0.1641864	-1.92	0.055	0.33447	1.011411
like_economy	0.281316	0.2177358	-1.64	0.101	0.061713	1.282378
concern_gas	0.741571	0.1462382	-1.52	0.129	0.503843	1.091465
Hhd_repair~m	1.469126	0.374207	1.51	0.131	0.891756	2.420315
Hhd_CFL	1.68482	0.6043489	1.45	0.146	0.834114	3.403153
like_no_tax	1.645178	0.6136332	1.33	0.182	0.791998	3.417446
home_age	1.004637	0.0035194	1.32	0.187	0.997763	1.011559
# ppl in home	1.302286	0.2751253	1.25	0.211	0.860753	1.970308
Hhd_spend_5k	1.263476	0.236577	1.25	0.212	0.875358	1.823679
like_social fabric	0.519741	0.2729027	-1.25	0.213	0.185713	1.454558
like_live free or die	0.630647	0.2483612	-1.17	0.242	0.291452	1.364603
Hhd_multi_AC	0.706477	0.2250673	-1.09	0.275	0.378377	1.319081
like_outdoors	1.506297	0.5813524	1.06	0.288	0.706954	3.209447
Hhd_lawn_service	0.571243	0.3069383	-1.04	0.297	0.199277	1.637516
concern_resale	0.86248	0.1275437	-1.00	0.317	0.645465	1.152457
...for full model including other independent variables see Appendix C						

For example, the odds of a yes answer decline by 35.4% (100%-64.6%) for every $1000 increase in the upfront cost, *ceteris paribus*, whereas the odds of a yes answer increase by 32.6% for every $100 savings in annual energy costs, *ceteris paribus*. Odds of a yes answer also increase with every additional year of education, and with

increased support for the state's renewable energy policy (indicated on a scale of 1-5). The odds of a yes answer decline, however, the longer the respondent has lived in their home (by 30% for every 10 years of residency) and the more children that live in the home (by 42% for each child).

The remaining independent variables can be separated into several broad categories, though none show statistical significance. The first set of variables were generated from the first question on the survey, "Please check your top three favorite things about living in New Hampshire" followed by a series of possible answers. This question was designed to provide a welcoming opening for the survey taker, and also to tease out any possible marketing approaches that might be particularly effective with those willing to consider solar hot water. As it turned out, none of these variables was found to have statistically significant relationship to the independent variable.

The second set of variables was generated from the question, "Please rate your level of concern, if any, with each of the following issues as they affect you and your family", with respondents asked to select an answer on a 5 point scale from "not at all concerned" (1) to "very concerned" (5). These variables begin with the word "concern" in Table 13. The third set of independent variables appeared on the next question in the survey with the heading, "Which of the following apply to you (check all that apply)" with answers coded as 0 for not checked and 1 for checked. These variables begin with "Hhd" in Table 13.

Finally, the survey included all the standard demographic variables, as well as some particular to the respondents' housing situation, such as the likelihood of a member of the respondent's household undertaking home repairs or improvements

themselves, the age of the home, plans for improvements to be made, and how long the respondent had lived in the home.

Those who answered 'yes' to the question of whether or not they would consider solar hot water were asked how likely they would be to actually commit to purchasing such a system, answering on a scale of 1 ("would look but would not purchase") to 7 ("would definitely purchase"). Given this ordinal ranking, researchers were also able to run an ordered logistic regression (OLR) to test the relationship between various independent variables and the seriousness of commitment. Tested were demographic variables such as respondent age, income, education, and household composition, as well as the age of the home, the length of time the respondent has lived there, whether household repairs are typically undertaken by the homeowner or a contractor, whether the respondent plans to stay in their home at least another five years, and whether the homeowner has a plan to spend at least $5,000 in the next 24 months.

Eliminated from the OLR analysis were the respondents' concerns, what they like about New Hampshire, and several of the least promising household practice variables. Results are displayed in Table 14. Many independent variables that had not shown promise in the simple logit model now are seen to have an impact on the strength of conviction of those saying yes to solar hot water. Again listed in order of decreasing statistical significance, the variables in Table 14 showing statistical significance at α = .10 include three variables relating to homeownership a) the propensity to take on home repairs oneself (strong positive correlation), 2) the length of tenure in the home (negative correlation), and 3) the age of the home itself (very weak positive correlation). The DIY variable consists of three possible values: 1 for "I/we almost never do repairs or upgrades", 2 for "I/we do only small repairs or upgrades", and 3 for "I/we do all but the

biggest repairs or upgrades". The analysis shows that the greater the self-reliance on home repairs, the higher the commitment to SDHW.

We also find that gender plays a role not in choosing yes or no, but in stating a strong commitment once a choice has been made, with women being much less likely to be strongly committed to their initial 'yes' than men.

Table 14: Respondent Demographics and Commitment to SDHW

```
Iteration 0:   log likelihood = -618.29344
Iteration 1:   log likelihood = -557.49822
Iteration 2:   log likelihood = -556.02388
Iteration 3:   log likelihood = -556.01792
Iteration 4:   log likelihood = -556.01792

Ordered logistic regression                     Number of obs   =        347
                                                LR chi2(15)     =     124.55
                                                Prob > chi2     =     0.0000
Log likelihood = -556.01792                     Pseudo R2       =     0.1007
```

Solar Commitment	Coef.	Std. Err.	z	P>z	95% Confidence Interval	
upfront_cost	-0.33325	0.045624	-7.3	0	-0.42267	-0.24383
annual_savings	0.117793	0.067681	1.74	0.082	-0.01486	0.250445
respond_educ	0.179101	0.044132	4.06	0	0.092604	0.265598
Support RE Policy	0.570278	0.126201	4.52	0	0.322928	0.817628
Hhd_DIY	0.491517	0.162678	3.02	0.003	0.172675	0.810359
home_age_decades	0.040568	0.022232	1.82	0.068	-0.00301	0.084142
Decades in home	-0.15171	0.089044	-1.7	0.088	-0.32623	0.022811
respond_gender	-0.38487	0.243009	-1.58	0.113	-0.86116	0.091418
Hhd_Spend $5k annually	0.153161	0.124482	1.23	0.219	-0.09082	0.39714
respond_income	2.03E-06	2.11E-06	0.96	0.335	-2.10E-06	6.16E-06
respond_urban (1=yes)	-0.11793	0.227477	-0.52	0.604	-0.56378	0.327914
political position (5=very conservative)	0.055886	0.117676	0.47	0.635	-0.17476	0.286526
# children in home	-0.04486	0.106469	-0.42	0.673	-0.25354	0.163814
Hhd_plan to stay in home 5 years or more	-0.06056	0.188091	-0.32	0.747	-0.42921	0.308096
Hhd_improvements planned	-0.05271	0.217544	-0.24	0.809	-0.47908	0.373671

Interestingly, several variables that one might assume would be correlated with strength of commitment to solar hot water adoption do not show statistical significance, including respondent's intention to stay in their home for five years or more, plans for make improvements to the household, and household income. Finally, the presence of children in the home, while apparently correlated to an initial yes or no decision, have no impact on the strength of conviction to follow through on a yes answer.

Binomial Logit Model

Having tested a variety of variables using OLR, researchers returned to the original contingent valuation question. A greatly simplified binomial logit model was run using only those independent variables that the OLR analysis showed had statistical significance on respondents' strength of commitment to SDHW. The results are shown in Table 15.

Table 15. Binomial Logit of Reduced Set Independent Variables on Choice for Solar Domestic Hot Water

```
Logistic regression                                   Number of obs   =        361
                                                      LR chi2(6)      =      95.31
                                                      Prob > chi2     =     0.0000
Log likelihood = -187.07965                           Pseudo R2       =     0.2030
```

Yes to SDHW	Coef.	Std. Err.	z	P>|z|	95% Confidence Interval	
Upfront cost	-0.3985	0.054969	-7.25	0	-0.50624	-0.29077
Annual savings	0.208783	0.085287	2.45	0.014	0.041624	0.375942
Opin_support RE Policy	0.599735	0.139736	4.29	0	0.325858	0.873612
respond_educ	0.167441	0.055505	3.02	0.003	0.058652	0.276229
Decades in home	-0.20493	0.110598	-1.85	0.064	-0.4217	0.011836
# children in home	-0.22918	0.126127	-1.82	0.069	-0.47639	0.018023
_constant	-3.50094	1.136456	-3.08	0.002	-5.72836	-1.27353

Like linear regression, binomial logit model analysis results in a set of coefficients that show the various weights that can be assigned to each of the independent variables to help determine the influence of that variable on the likelihood of the dependent variable being positive (for example, that the respondent will answer 'yes' to adoption of SDHW). Unlike ordinary least squares (OLS), the binomial logit model uses iterative estimation to determine maximum likelihood of a specific set of characteristics (independent variables) leading to a 'yes' answer. Binomial logit measures the impact of a one-unit increase in the independent variable on *the log* of the odds of a 'yes' answer, rather than on the simple odds of a 'yes' answer.

Eq. 1: $$\ln (D_i/ [1 - D_i]) = \beta_0 + \beta_i X_{1i} + \beta_1 X_{2i} + \beta_2 X_{2\,i} + \text{error}_i$$

The log of the expected probability that the *i*th person will make the choice described by D_i=1 (i.e., 'yes' to willing to adopt SDHW) is equal to a constant (β_0) added to the products of each coefficient and their associated independent-variable mean values, plus the error. The coefficients presented in Table 15 describe the effect of each independent variable on the log odds that a given respondent will say 'yes' to SDHW. Each unit increase in the value of the coefficient association with the independent variable multiplies the predicted odds of a 'yes' answer by the constant ***e*** raised to the coefficient value.

Using the independent variable "education" as an example, we can calculate that each additional year the respondent stayed in school (holding all else constant) multiplies the odds of a 'yes' answer to SDHW by ($e^{.167441}$) or 1.18. Statistical software provides a shortcut for this calculation through the *logistic* test, displayed in Table 16.

Variables are displayed in order of decreasing significance (see column P > |z|). Notice that what were negative coefficients in Table 15 now become odds of less than 1 and those that were positive coefficients are odds of greater than one.

Table 16. Equivalent Logistic Analysis of Reduced Set Independent Variables on Choice for Solar Domestic Hot Water

```
Logistic regression                                   Number of obs   =        361
                                                      LR chi2(6)      =      95.31
                                                      Prob > chi2     =     0.0000
Log likelihood = -187.07965                           Pseudo R2       =     0.2030
```

Yes to SDHW	Odds Ratio	Std. Err.	z	P>z	95% Confidence Interval	
Upfront cost	0.671323	0.036902	-7.25	0	0.602757	0.747689
Annual savings	1.232178	0.105088	2.45	0.014	1.042503	1.456362
Opinion support RE	1.821636	0.254548	4.29	0	1.385218	2.395548
Respond_educ	1.182275	0.065623	3.02	0.003	1.060406	1.31815
Decades in home	0.814702	0.090105	-1.85	0.064	0.65593	1.011906
# children in home	0.795184	0.100294	-1.82	0.069	0.621024	1.018186

Running a post-estimation test shows how accurately our model predicts actual responses from the sample. As can be seen from Table 17, the expected values of the independent variables selected leads to an accurate prediction 76% of the time. Of the respondents that answered 'yes' to SDHW, the model predicted 201 out of 233 correctly (86%). However, of those that answered 'no', the model was less successful, only getting it right 72 out of 128 'no' answers, or approximately 56% of the time.

Table 17. Classification Table for Predicted Values of SDHW Question

Classified	True D	True ~D	Total
+	201	56	257
-	32	72	104
Total	233	128	361

Classified + if predicted Pr(D) >= .5
True D defined as solar_num != 0

Sensitivity	Pr(+ | D)	86.27%
Specificity	Pr(- | ~D)	56.25%
Positive predictive value	Pr(D | +)	78.21%
Negative predictive value	Pr(~D | -)	69.23%
False + rate for true ~D	Pr(+ | ~D)	43.75%
False - rate for true D	Pr(- | D)	13.73%
False + rate for classified +	Pr(~D | +)	21.79%
False - rate for classified -	Pr(D | -)	30.77%
Correctly classified		75.62%

Breaking the sample down based on the annual savings options ($400 or $700) revealed that our model is better at predicting "yes" answers at the higher annual savings amount of $700, getting it right 91% of the time, compared to a success rate of 80% predicting 'yes' answers at the $400 savings level. However, the model only correctly predicts 47% of 'no' answers at the $700 level, whereas for respondents offered the $400 annual savings, 'no' answers are predicted correctly 63% of the time. Given these results, it is clear that there are reasons for respondents' answering 'no' that are not well captured by the model, particularly at the higher savings price. These are the non-price barriers that the survey was unable to adequately capture. It is possible, though researchers did not test for this, that some respondents said 'no' to SDHW because of what they perceived to be an unrealistically high annual savings estimate.

Deriving a Demand Curve

While contingent valuation cannot account for all market influences, it is still instructive to estimate a demand curve. After running the logit model, a new variable was generated equal to the predicted probability of a 'yes' answer for each respondent. The values of these probabilities range from 0 to 1 due to the particular mathematics of the logistic function. These predicted results are graphed against the upfront cost of SDHW installation and displayed in Figure 5.

The dichotomous choice willingness to pay responses (Y_i) are regressed against a constant, the upfront cost amount (cost), and a vector of independent variables using a traditional logistic function shown in Equation 2.

Eq. 2:

$$\text{Prob of } Y(1) = \frac{1}{1 + e^{-(\beta 0 + \beta 1(\text{Cost})i + \beta 2(\text{Savings})i + \beta 3(\text{Opinion})i + \beta 4(\text{Educ})i + \beta 5(\text{HomeTenure})i + \beta 6(\#\text{children})i)}}$$

This function estimates the probability that an individual is willing to consider SDHW given the cost presented and a given set of demographic and other characteristics. As described above, the variable Y is binomial, taking on a value of 1 for a 'yes' response, and 0 for a 'no' response. In estimating this function, the probability of a 'yes' response can be modeled for varying upfront cost amounts (dollar values).

Median WTP is calculated using the regression coefficients (β_2 through β_6), the constant term (β_0), and the upfront cost (β_1). The median willingness to pay displayed in Equation 3 is calculated using a technique developed by Hanemann (1989):

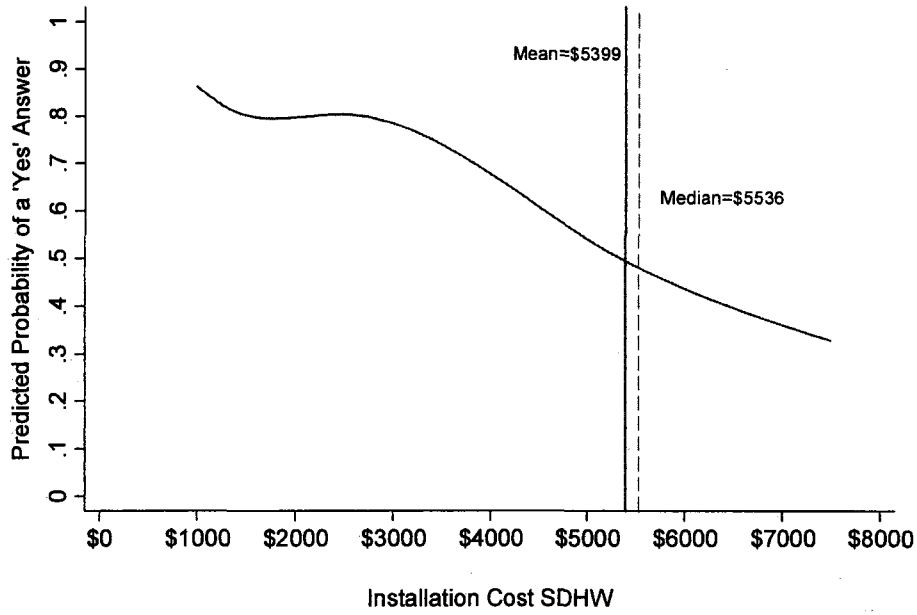
Eq. 3:

$$\frac{\beta_0 + \beta_2(\text{Savings}) + \beta_3(\text{Opinion}) + \beta_4(\text{Educ}) + \beta_5(\text{HomeTenure}) + \beta_6(\#\ \text{children})}{|\beta_1|}$$

The mean willingness to pay, indicated by the red vertical line in Figure 5, is $5399, while the median willingness to pay, indicated by the dashed line, is $5536. While both mean and median are useful measures of general tendency, median is preferred by contingent valuation practitioners since Hanemann's discussion of the topic in 1984 and 1989. Hanemann's main concern is the potential undue influence of outliers in skewing the results. In this small sample, where the upper limit of upfront cost is modest compared to the lower limit, mean and median are comparable. Utilizing six significant, independent variables, this model predicts that 50% of New Hampshire homeowners would consider SDHW if they would save $550 a year (the average of the $400 and $700 annual savings options offered) and pay $5536 to install.

If one subtracts the 30% federal tax credit eligible on Energy Star solar hot water systems from an estimate of $7500 (GDS Associates), the average cost to the homeowner is $5250. The survey results are therefore encouraging for those interested in promoting SDHW as a renewable energy option for New Hampshire residents, and suggest that there is a large and untapped market for solar hot water in the state.

Figure 5. Predicted Probability of a 'Yes' Answer, Entire Sample



Strength of Commitment

While results indicate there might be greater interest in solar hot water than the fledgling market for SDHW in New Hampshire currently suggests, the apparently encouraging results of this survey should not be exaggerated. Predicting who would say 'yes' to a survey question is quite different from knowing who would *actually* follow through with the installation of SDHW. While still inadequate to predict actual behavior, Table 18 shows the logit results when only those indicating strong conviction (5, 6 or 7 on a scale of 1-7) are considered to have answered 'yes' to the question 'would you install solar hot water'. This can be compared to the results of an initial 'yes' answer as displayed in Table 15. Note that three of the six independent variables now become statistically insignificant: annual savings, the number of children in the respondent's home, and how long the respondent has lived in the home.

Table 18. Binomial Logit Regarding Choice for Solar Domestic Hot Water for Respondents with High Commitment

```
Logistic regression                               Number of obs   =        361
                                                  LR chi2(6)      =      52.02
                                                  Prob > chi2     =     0.0000
Log likelihood =  -182.0472                       Pseudo R2       =     0.1250
```

solar_hi_commit	Coef.	Std. Err.	Z	P>|z|	95% Confidence Interval	
Upfront cost	-0.24848	0.060191	-4.13	0	-0.36645	-0.1305
Annual savings	0.043721	0.086559	0.51	0.613	-0.12593	0.213373
Respond education	0.165533	0.051683	3.2	0.001	0.064237	0.26683
Opinion Support RE	0.637062	0.162555	3.92	0	0.31846	0.955664
# children in home	0.070987	0.124261	0.57	0.568	-0.17256	0.314533
Decades in home	-0.16976	0.117459	-1.45	0.148	-0.39998	0.06045
_constant	-5.49404	1.215885	-4.52	0	-7.87713	-3.11095

Now the predictive power of the model is reversed, and we find that most (90%) of the not-highly-committed respondent answers are accurately predicted (i.e., the nos and not-reallys) but only 20% of the highly-committed yeses are accurately captured by the model. Further analysis shows that at the $5536 median WTP price found in the earlier model, only about 15% of respondents would rate their likelihood to actually follow through at a 5 or higher on the 1-7 scale. According to this model, even a free solar hot water system would not be enticing enough to result in half the population saying 'yes' with strong conviction.

Reasons Cited for Accepting or Rejecting SDHW

After being asked to accept or reject the solar hot water offer, respondents were asked to select their reasons for considering or rejecting SDHW. A series of options were presented in random order to those respondents who answered 'yes' to the question of whether they would consider installing SDHW. The results, for homeowners only, are displayed in Table 19. By far the most common reason checked was to save money, with 91% of those respondents who answered 'yes' to the initial SDHW question indicating that this was a factor for them. The next two most common factors, with two-thirds of respondents citing it as a factor, were 'to help the environment' and 'to reduce dependence on fossil fuels'. Carbon footprint was only a factor for 53% of respondents.

Perhaps surprisingly, nearly half selected 'to increase the resale value of my home' as a factor incentivizing them to answer 'yes', despite the statistical insignificance of concern for resale value on the logit results (see Table 13) . 'To invest in the development of solar technology', which suggests a motivation beyond self-interest, was a factor for nearly 30% of respondents.

More than one in five of respondents answering 'yes' thought their home was 'a great place for solar', while 'setting a good example', and 'liking innovative technology' influenced slightly fewer respondents. Interestingly, the need for a new hot water system, which in the actual market place might be a very significant factor, only applied to 8% of respondents who answered 'yes'.

Table 19. Reasons Stated for Considering SDHW

Why would you consider purchasing a solar hot water system? (please check all that apply to you).		
To save money	217	91%
To help the environment	161	67%
To reduce dependence on fossil fuels	161	67%
To reduce my carbon footprint	126	53%
To increase the resale value of my home	101	42%
To invest in the development of solar technology	70	29%
My home is in a great place for solar	54	23%
I like having innovative technology in my home	47	20%
I want to set a good example for others	42	18%
My current hot water system needs replacing	18	8%
Other, please specify	8	3%

As for those respondents who answered 'no' to the question of installing SDHW, the reasons for declining, displayed in Table 20, are much more diverse. As with those who answered 'yes', those who answered 'no' cited cost as an important consideration, with high upfront installation costs being cited as a reason not to install by 66% of nay-saying respondents. This relatively low relevance of cost for those who answered 'no' helps to explains why the model developed was relatively poor at predicting 'no' answers

Table 20. Reasons Stated for Not Considering SDHW

Why would you not consider purchasing a solar hot water system (check all that apply)?		
The up-front installation costs are too high	86	66%
I won't live in the home long enough to make it worthwhile	42	32%
I am waiting for the cost to come down	39	30%
My home does not get enough sun	33	25%
This area does not get enough sun	27	21%
I don't believe I will save money in the long run	20	15%
Other, please specify	17	13%
I don't trust the technology to work reliably	14	11%
I don't know who I would call to make it happen	9	7%
The costs should be shared by everyone, not just me	5	4%
Community rules prevent installation of solar panels	4	3%
Solar energy is not the right answer to conserving energy	3	2%
My neighbors would be upset	2	2%

Other reasons for declining included a) not enough sun for their home or b) not enough sun for the region, as a reason to decline. Of the 41 respondents who selected one or both of the not-enough-sun reasons, just fewer than half (19) thought both the region and their home was a poor place for solar. An additional 16 respondents cited either their mistrust of the technology or the idea that it was the wrong approach to conserving energy as a reason not to invest.

Seventeen respondents wrote in an answer to describe why they would not consider purchasing a solar hot water system. Many responses related to the cost of such a system, but not all. One respondent faced foreclosure, another a pending job loss, one felt they were 'too old', another felt the home was too old, another just installed a new hot water system, another had tried it before and did not like it, yet another did not like the way they looked, two stated that they did not have hot water heaters, and two did not believe they used enough hot water to justify it. Understandably, many of the reasons offered by the survey, as well as these other unanticipated reasons for saying 'no' were not captured by any of the independent variables in the logit model. The no answer explanations can help shed light on the high error rate of the model, particularly in predicting 'no' answers.

Getting More Information

Those respondents who affirmed their willingness to invest in SDHW were asked a follow-up question regarding where they would go to get more information about installing alternative energy systems at their home. This randomized question was asked in order to understand which sources of information or service were most trusted by the public. Given that this was an internet-based survey, it is not at all surprising that

respondents showed a high degree of comfort utilizing a search engine to find out more about alternative energy options. As shown in Table 18, more than three-quarters indicated that they would first go to the internet. This was, by a margin of 3 to 1, the most common response. Of the 60 who picked the next most popular option, "nonprofits engaged in alternative energy options," only 21 picked nonprofits but *not* the internet. Similarly, of the 44 who picked 'friends and coworkers' only 13 did not also select the internet.

Of the government sources of information, state government was much more likely to be seen as a source of information than either the federal government or local government, with 26 citing state, 19 citing federal, and just 10 citing local leadership as a place to go. Nearly tying with state government as a source of information were do-it-yourself stores while local hardware stores were the least likely place for information. The Better Business Bureau was selected as a good source by 13 respondents.

Table 21. Where to Start for Information about Alternative Energy Options

If you were interested in finding out more about installing alternative energy options at your home, where do you think you would start first?		
internet search engine	181	76%
nonprofits engaged in alternative energy options	60	25%
friends or co-workers	44	18%
state government agency	26	11%
do it yourself home store	24	10%
federal government agency	19	8%
Better Business Bureau	13	5%
Other, please specify	12	5%
yellow pages of the phone book	13	5%
town or city leaders	10	4%
local hardware store	8	3%

Of those who wrote in a response, six described their current energy provider, which was a response that, in retrospect, should have been included in the list of options. Another two respondents mentioned home show or trade show, while two others referred directly to a specific local business. Clearly, many respondents recognize that there are a variety of existing options for getting information about SDHW and other alternative energy options.

In the next chapter, I will investigate the implications of these results and provide context for policy making and marketing of renewable energy adoption.

CHAPTER III

ENERGY MARKET TRANSFORMATION

The data from the New Hampshire energy survey does not reveal for whom financial cost is *not* a factor, and it is apparently not related to household income, political identification, or education, or even whether one keeps a budget, or plans to stay in their home a long time. Indeed, identifying the actual non-monetary barriers in this case proved extremely elusive.

Further complicating the identification of barriers is the fact that even when people express a willingness to change their behavior in order to reduce their energy consumption, they may remain incapable from a practical, social or psychological point of view to actually do so. Until and unless certain circumstances make such change not only possible but *normal,* many individuals will continue to postpone a behavior change until they are in the uncomfortable position of feeling like they are not meeting social expectations.

Paul Stern's research in this area is illuminating. In an article published in 2000 regarding environmental behavior, he warns that "Studies that examine only attitudinal factors are likely to find effects only inconsistently, because the effects are contingent on capabilities and context." (Stern, p. 418). Stern's so-called ABC Theory posits that *attitude* (A) will lead to certain *behaviors* (B) where *context* (C) is neutral. Accordingly, where contextual issues, such as cost, information, location and the like pose few

barriers, attitudes will have a strong influence on behavior, and conversely, where context poses challenges, attitudes will have less impact on decision making. The lesson for researchers is that if *actual* behavior is not studied, respondents' stated intentions will not necessarily correlate to behavioral outcomes.

Expanding Upon Traditional Economic Explanations

New Institutional Economics

"At the heart of all social theory is the contrast between humans as motivated almost exclusively by narrow self-interest, and humans as motivated by concern for others or for society as a whole." (Ostrom, p. 4). From the opening chapter of the book "The Drama of the Commons", this quotation challenges traditional neo-classical economic assumptions regarding individuals as rational maximizers of personal utility. Nobel Prize-winning economist Elinor Ostom and her colleagues' work on community-based (rather than government-imposed) environmental management systems shows that a group of individuals responsible for a common resource such as a fishery, forest, body of water, etc., can in many cases develop a system of rules and regulation to protect that resource more effectively than can an externally imposed regulatory regime. The concept here takes self-regulation by the individual to the level of a community or interest-sharing group.

Collaborative research models referred to as Participatory Rural Appraisal (PRA) and Participatory Action Research (PAR), are discussed in "The Drama of the Commons" (Berkes), and share some characteristics of community-based participatory research (CBPR), which is very common in the health arena. With a commitment to engaging the population of interest in the identification *and* implementation of health-

promoting strategies as part of the research, rather than simply studying subjects objectively and at arms-length, CBPR has been shown to be effective at influencing policy changes (Minkler). Policy changes have the potential to impact far more people than one-by-one intervention strategies aimed at individuals. Indeed, Minkler's review of ten CBPR case studies credits CBPR's multiple-stakeholder process and robust statistical analysis with providing a best-of-both-worlds kind of impact wherein change is realized at both the micro-scale of individual participants as well as at the broad scale of the larger society of which the individuals are members (Minkler). In addition to its acceptance as a proven method for improving success rates in health interventions, these models have also been used in environmental protection and adolescent welfare (Dick).

Unfortunately, there is as yet no comparable model to CBPR in the field of consumer energy research. The typical framework for policy making around energy and electricity provision in the United States - public utility commissions - has not been very friendly to broad-based participation. New Hampshire may be improving or expanding upon this model with more participatory forums, such as the Energy Efficiency and Renewable Energy Board, and the Energy and Climate Collaborative, but the presence of consumers in these forums is largely absent. Instead, those who take part are employed by government, the building trades, the utilities, or other energy service providers and represent those entities' various interests and concerns. The perspective of the lay public is, for the most part, missing.

Ostrom and colleagues' work on community-based resource management regimes is part of an entire sub-field in economics referred to as *new institutional economics*, which began to self-organize in the 1990s. Concerned with the impact of

institutions such as the courts, political system, social organizations and the like on economic activity and behavior, this new field is multi-disciplinary in its approach (Rose, p. 239). The founding president of The International Society for New Institutional Economics was another Nobel Prize-winning economist, Ronald Coase, who wrote in the organization's inaugural newsletter in 1998,

> The level of transaction costs depends on the institutions of a country, its legal system, its political system, its culture and so on. This is why we must include the influence of these institutions in our study of the working of an economic system... (Coase, p. 3).

The notion of transaction cost is fundamental to new institutional economics, and extremely relevant to the adoption of new technologies, including renewable energy adoption. Given the time and effort needed to obtain reliable information about renewable technologies, including which ones are available and appropriate, what resources exist for subsidizing and financing the purchase price, who can be relied on to supply and install the equipment, and the risk inherent in committing to a technology that is in the midst of rapid change and future uncertainty, early adopters must have a high tolerance for risk.

In a well-referenced 1979 article discussing transaction costs, economist Oliver Williamson, referring liberally to economist Ian MacNeil, divides contracts into three major types, each with differing transactional cost burden. In the classical conception of the contract, conditions are ideal, competition is perfect, and remedies in the case of default by either party to the transaction are clear. In the neo-classical contract,

according to Williamson, not all risk or cost can be easily anticipated or converted to a present value. This might be the case in a long-term contract or situation in which one party has to trust the other party to act in good faith but is unable to anticipate every future situation in which such action would be called for. Clearly, transaction costs in this more realistic contract scenario are significantly greater than in the classical contract. Finally, the third type relates to 'relational contracting' in which the contract evolves over time based on events and changing relations, as may be present in a service contract (Williamson, pps. 235-238).

In the slowly maturing energy efficiency and renewable energy markets, both the second and third type of contract described by Williamson are in play, with power purchase agreements, net metering, municipal financing, on-bill financing, and performance contracting providing new forms of transactional challenges to suppliers, consumers, financers, and even energy market regulators. Many of these arrangements are poorly understood, under-regulated, and are liable to abuse by the energy service providers. While consumers may in theory be willing to pay more for an appliance or service that uses less energy and saves them money, this willingness is likely offset by the added risk of relying almost wholly on a new and unfamiliar provider to deliver a service in a new way, over a long term, replacing a previous arrangement where the service provider (namely an electric or gas utility) was highly regulated and at virtually no risk of going out of business. Further study could attempt to quantify what role such financial uncertainty and transaction cost plays in preventing consumers from making changes in their energy provisioning.

Diffusion of Energy Innovations

One of the pre-eminent experts in the field of diffusion studies, Everett Rogers claims in the preface to his seminal work Diffusion of Innovations that "No other field of behavior science research represents more effort by more scholars in more disciplines in more nations" than does diffusion research (Rogers, p. xv). Indeed, a successful market economy depends not only on successful innovation but also on the successful marketing of those innovations. According to Rogers' framework, there are five primary factors impacting the success of an innovation: a) *relative advantage* of the new product or practice over what is being replaced; b) *compatibility* of the innovation with the values, norms and experiences of the adopters; c) *complexity* of adopting, incorporating, or understanding the new product or practice; d) *trialability*, or the degree to which the innovation can be tested prior to an adopter fully committing his or her time and resources; and e) *observability*, which refers to how easily the benefits of the innovation can be observed by new adopters prior to adoption (Rogers, pps. 15-16). On the basis of these factors, residential renewable energy innovations such as solar hot water, clearly face challenges in adoption.

Ramsey Raafat and colleagues, in a meta-study of how information is disseminated to individuals, point to *mechanisms of transmission* on the one hand and *patterns of connection* on the other, which, in less prosaic terms, can also be considered acting locally and thinking globally. The mechanisms of transmission from one individual to another can in turn be broken down into two further divisions, a) unconsciously accepted and adopted and b) deliberately or rationally chosen (Raafat). Given that surveys almost necessarily call upon the respondent to make considered choices of type b, the impact of unconscious psychological or emotional factors is difficult to measure

directly. Rogers' factors, noted above, extend our understanding of how to bring about actual behavioral change, and it is worth looking a little more closely at *compatibility* based on others' research into behavioral economics.

Social network analysis has allowed psychologists and others to better understand how individuals, when acting as members of a group or *herd*, sometimes behave in seemingly illogical and irresponsible ways that run counter to that indivdiual's normal self-identification. So-called 'diffusion of responsibility' can help explain how, for example, a group of teenagers can fail to call for help while a classmate is taunted or assaulted, or how individual ratepayers feel little personal responsibility for reducing their energy consumption (Latané, Guerin).

This research can help to explain why targeting outreach at social leaders with wide networks is more effective than a mass marketing approach that tries to change everyone at once regardless of their status or influence (Valente). Referred to as *opinion leaders* by Everett Rogers and other diffusion researchers, these individuals play a crucial role in synthesizing and effectively transmitting information to the rest of us. These opinion leaders have the ability to communicate effectively with other members of their group and provide an example that others emulate. (Rogers, p. 354).

Not every early adopter of a technological innovation like SDHW is an opinion leader, and in fact many early adopters may be different enough from the rest of the population that they are ineffective in convincing others to adopt their practices. *Homophily* is the degree to which people share demographic and social traits, and research shows that the most effective change agents and opinion leaders are those who are most homophilous with those whose opinions they are trying to influence or whose behavior they are attempting to change (Rogers, p. 346). The early adopters,

may be different enough from the rest of the population that their behavior is actually *not* emulated but seen as 'other'.

Just as opinion leaders' positions may stand in for independently arrived at individual decisions, they may also cue those who do not identify with a given opinion leader to reject their positions (Guerin, Hogg). For example, Al Gore is broadly associated with the issue of 'global warming'. If you respect and trust the former Democratic Vice President, then you may be inclined to accept his view on this controversial issue, even in the absence of thoroughly researching the science and coming to an independent position on your own. But if you do not respect and trust him, then you may simply reject what he is saying because you reject *him*.

Through messaging and selection of spokespeople, advocates of energy efficiency, conservation, and sustainability should take care not to inadvertently trigger social and political identifications related to *environmentalism* and *global warming,* which can have polarizing effects. The survey discussed here does not show a statistically significant correlation between political identification and willingness to adopt renewable energy technologies, which suggests that such technologies are politically neutral, for now. Marketing research has shown, for example, that hybrid car drivers tend to be more politically liberal than the general population (Scarborough Research), and this association could inhibit the adoption of the technology among those who do not identify as liberal.

Self-Regulation

Another concept from the social sciences, *self-regulation* can help to shed light on how (and if) decisions are made to change behaviors or habits. Self-regulation is a process by which individuals identify a deficiency in their situation, and then find a

means to overcome it, often choosing among multiple possible courses of action. Self-regulation requires a variety of skills, and necessitates risk taking in the face of the uncertainty about the actual outcome of changes (Nenkov, p. 126). Aversion to risk and first cost bias (i.e., not wanting to pay more for something up-front even if there is high likelihood that such additional expense will be more than covered by future cost savings) may be in part a result of an under-developed ability to self-regulate. Helping consumers to better self-regulate when it comes to energy provision and planning is essential to success in voluntary adoption of energy efficiency measures.

Another barrier to effective household energy regulation is the lack of information or even lack of recognition that superior alternatives to the status quo exist. American consumers have, in recent history, had very little responsibility or practice when it comes to regulating their own energy use, in part because there has apparently been an endless and inexpensive supply of it, provided with little interruption in service by utility companies and other energy suppliers. Even those with a desire to self-regulate or control their electricity use have had little access to information, data or feedback mechanisms, which are pre-requisite to *effective* self-regulation. This is akin to expecting a diabetic to control insulin levels without the ability to test for blood sugar, perhaps with the added challenge of there being few signs of disease to provide incentive to the patient to make dietary changes. As with many human diseases, the prevention of which should be started prior to the onset of symptoms, energy shortages, outages, and the environmental impact of emissions are not yet so severe or obvious to consumers in the developed world that they in and of themselves force change. In other words, the *context* is not sufficiently powerful to bring about change.

One possible exception to this relates to significant and wide-spread service interruption due to severe weather-induced power outages in New Hampshire in the winters of 2008-9 and 2009-10. Such outages typically result in a spike in the number of households acquiring back-up power generators to avoid the inconvenience of losing power; as of 2004 market penetration nationwide of portable electric generators was about 6% ("Study Shows Big Untapped DE Residential Market"). Most of these generators run on fossil fuels such as propane, natural gas, or gasoline, and the purchase, installation and maintenance of these systems is often quite expensive, polluting, and potentially dangerous due to the possibility of carbon monoxide poisoning, damage to household appliances, or injury to line workers due to faulty installation. Clearly there are negative associations with portable power generators, but to many consumers, these are outweighed by the benefit of having power even when the electric grid is unavailable.

Unlike outright outages where the problem is immediately evident and can instigate corrective action (i.e., buying a backup generator from a local supplier), excessive day-to-day household energy consumption in the home is not easily quantifiable by the average homeowner. The energy demands of electric appliances, lighting, and thermal control equipment is largely unknown, and the homeowner has little to no understanding of the impact of various appliances on the home's overall energy performance either at the time of purchase or during operation. Returning to the example of the diabetic, this is like trying avoid sugar without having food nutrition labels. Thus, for many, the prospect of reducing household energy use seems equivalent to outright deprivation (i.e., live without it) rather than substitution to products providing the same level of service and satisfaction, e.g., a television with an equivalent picture but which

requires less energy input. Self-regulation norms predict that people will not willingly deprive themselves of something that they can afford to have, unless the consequences of not doing so are immediately obvious and obviously bad.

Fortunately, much attention is being paid to providing consumers the tools they need for better energy self-regulation. The experience of utilities implementing smart meters and in-home displays of real-time energy utilization, use of detailed energy reports comparing usage to that of neighbors, labeling systems such as Energy Star, HERS ratings for new home performance, time of use pricing, computerized access to utility data, and computer-based carbon and energy calculators all provide examples of the increasing availability of information and messaging helping consumers to make better choices both at the point of purchase and during operation (Carroll, Cialdini 2003 and 2004, Allcott). There is tremendous opportunity for further research on the efficacy of non-economic interventions in reducing energy consumption and fuel switching in New Hampshire and beyond.

Researchers interested in measuring the efficacy of feedback mechanisms to change the behavior of electricity consumers would do well to review a recent study prepared by the Electric Power Research Institute (Sullivan and George). This study addresses the increased interest in smart grid technology, which provides consumers with real-time information about their electricity usage, and how to design experiments that will shed light on the immediately measurable impact of various feedback types, as well as how behavioral tendencies are formed and altered (Sullivan and George, p. 1-2). Given the tremendous amount of funding currently being invested by both the public sector and private utilities in feedback technologies and services, the report urges

researchers to undertake evaluations based on sound methodology. Report writers point to a series of questions that should be addressed and evaluated including:

1. Do feedback devices and services actually cause electricity consumption to change?
2. Does the degree of change vary across of *[stet]* feedback mechanisms?
3. What other aspects of consumer behavior (e.g., satisfaction with service) are affected?
4. What are the likely participation levels in feedback program under real world operating conditions?
5. Does dynamic pricing complement or compete with the impact of various feedback mechanisms?
6. Do impacts of feedback mechanisms vary across customer segments (e.g., lifestyle categories, income, household family structure, etc.)? (Sullivan and George, p. 2-6).

Studying Intervention Efficacy

Covering far more types of intervention than feedback mechanisms alone, Wokje Abrahamse and colleagues reviewed thirty-eight published scientific studies aimed at influencing household energy use and behavior, in a 2005 article published in the Journal of Environmental Psychology. This article raises several salient points regarding the effectiveness of information campaigns, commitment and goal setting, rewards, continuous feedback, tailored information, and other strategies deliberately aimed at reducing household energy use in the short and long term. Abrahamse's article suggests that "a problem diagnosis is necessary in examining which behaviors and which behavioral determinants should be targeted by the intervention" (Abrahamse, 2005, p. 283).

Abrahamse's meta-study emphasizes the importance of identifying the specific barriers preventing the targeted individuals from making the desired choices *prior* to selecting an effective strategy or strategies of intervention to overcome them. While this may seem obvious, most studies reviewed by Abrahamse took a one-size-fits-all

approach, or carried out several different types of interventions at the same time, and lost the ability to identify which strategies were efficacious with which types of targets (Abrahamse, pps. 271-291).

These failings on the part of academic researchers is not improved upon by product marketers, according to Dan Ariely, MIT Professor of Behavioral Economics, whose body of work points to the conclusion that human decision-making is largely irrational. Having extensively studied human behavior, Ariely reports that companies typically eschew statistically sound sampling methods in favor of focus groups comprised of no more than a dozen people (Ariely). The reason for this, according to Ariely, is that these focus groups provide story-lines that marketers can utilize to promote their products. Like Abrahamse, Ariely suggests that "We [researchers] need to find a way to base our judgments and decisions on real facts and data even if it seems lifeless on its own." (Ariely).

From the Individual to Society

A study by David Goldblatt on the effectiveness of targeted interventions in the Netherlands questions the effectiveness of focusing solely on the consumer side of the energy equation by pointing out the massive structural inefficiencies that have become embedded on the production side of the equation. These inefficiencies are not lost on the consuming public, which recognizes that their own behaviors alone, or even done in concert with their neighbors, are unlikely to make much of a dent in the problem of energy over-consumption. Goldblatt's thesis is built on a more holistic and comprehensive analysis of consumer society referred to as social construct theory,

whose proponents include Thomas Princen, Elizabeth Shove, and Gert Spaargaren (Goldblatt).

Addressing this difficulty head on, Britain's National Consumer Council and Sustainable Development Commission undertook an 18 month study between 2004-2006 that invited to public to identify both problems and potential solutions to consumption issues. The title of the resulting study – "I will if you will" – sums up the aversion of citizen-consumers to being taken advantage of, or sacrificing for some hard-to-measure general public benefit. The study compellingly advocates for government and policy makers to fully engage energy consumers in the identification of barriers to change, as well as in discovering the means for overcoming such barriers, "The distinguishing feature of sustainable consumption policy will be the way in which it engages honestly and courageously with people to create and retain its mandate." (I Will if You Will, p. 12).

Social construct theorists point to the fact that for every kilowatt hour of energy provided to a consumer at the electrical outlet, three more have been lost to heat and other generation, transmission and distribution inefficiencies by suppliers of the energy. Even more is lost within the electrical appliances used within the home. If the producers of these appliances changed their production practices, either by switching to more efficient or cleaner sources of energy, and/or producing more efficient appliances, then the need for consumptive changes would be dramatically reduced. Goldblatt writes, "In general people's ability to choose and chart their consumption is limited by the prevailing socio-economic-technical framework." (Goldblatt, p. 16).

The foregoing analysis may help shed some light on why it is apparently so difficult for the market to change, in spite of a general desire on the part of consumers to

do so in the abstract. The kinds of changes contemplated by the survey, and by energy efficiency and sustainable energy proponents, require consumers not only to acquire information about the familiar variables of quality, reliability, and durability, but a whole set of new and unfamiliar details about products and vendors, financing, safety, and social impact variables. As a result of the entire social and economic system in which they exist and make daily decisions, few consumers in New Hampshire are as yet making the switch to renewable energy solutions such as solar domestic hot water.

To overcome this, it may be helpful to more fully engage *all* parties in society in addressing the challenge of sustainability, rather than relying on one sector, e.g., government or industry on the one hand, or homeowners on the other, to lead the way. Rather than focus primarily on the production side (with its emphasis on regulation and technology), or on the consumption side (with its emphasis on voluntary action within oppressive constraints), policy makers should aim to engage both simultaneously and integratively. While demand for solar domestic hot water or green electricity may be present on paper, until there is easy market availability without all the barriers (including cost), that demand will not translate into market transformation. As with the "I will if you will..." research, the input of consumers in their related role as citizens should be explicitly sought in order to arrive at the most effective and widely acceptable form of public policy possible.

New Hampshire-Based Intervention Strategies

A variety of initiatives are currently at play in New Hampshire both the public and private spheres, most very well intentioned, but perhaps not effectively coordinated. As the comprehensive climate and energy bills are taken up by Congress, the debate over federal carbon cap and trade, as well as a national renewable portfolio standard will bring these issues into greater public focus. How this legislation may impact the individual homeowner, and what responsibility will be assigned to them as we move toward a more carbon neutral future is unclear. Our New Hampshire survey found that respondents attribute much more responsibility for increasing the use of renewable energy to the utilities, gas and oil companies, and state and federal government than they do to homeowners or other residents.

As described earlier, New Hampshire residents have never had to make decisions about the source of their electricity; the monopoly company serving their region has always provided it. While ratepayers may notice price increases, or worry about reducing their own usage for budgeting purposes, the impact of their use has always been personal, rather than social or political. However, as the survey shows, more than 50% of respondents state that they are moderately or very concerned about the amount of energy they use, and over 75% believe that customers should have a choice about where their electricity comes from (i.e., renewable sources or not). Given this, the challenge for those who wish to change actual behavior should perhaps be first to remove barriers faced by those with a stated willingness to make change, and secondarily to try to convince laggards that change would be beneficial.

Rebates and Other Incentives

One barrier associated with the current market for energy efficiency and renewable energy relates to the confusion created by the dizzying and ever-changing array of rebates and tax incentives sponsored by the utilities, as well as state and federal government aimed at lowering the cost of improvements to the end user. There are also logistical and technical issues of tying to the grid, getting permits from the town, and analyzing tax implications. Learning about, complying with, and taking advantage of all that is available can be a significant and time-consuming undertaking that poses a significant transaction cost on the consumer.

Rebates for renewable energy in both the residential and commercial sectors are becoming more and more popular across the country, including in New Hampshire, where the Public Utilities Commission recently began offering residential rebates on small solar photovoltaics and wind installations. As of May, 2010, rebates are also available for solar domestic hot water. These funds will be temporarily supplemented by the New Hampshire Office of Energy and Planning, which is adding Recovery Act funds to provide rebates on energy efficient heating appliances, including SDHW. A separate program will provide rebates for residential, whole-house, wood-pellet heating systems with bulk delivery. Incentives for residential energy efficiency are also being expanded.

Rebates do work to increase the number of installations, as can be seen by data displayed in Table 22. Based on data collected from the state's electric utilities and compiled by the Office of Energy and Planning, Table 22 shows the rapid expansion of renewable energy installations and installed capacity in recent months. Before installations were eligible for rebates from the Public Utilities Commission (i.e., prior to July 1, 2008), there were 184 grid tied systems in the state, a number which includes

both residential (128) and non-residential (56) systems. Following the availability of state rebates (on top of federal tax breaks), the number of installations increased dramatically. On the residential side, there were a total of 338 residential systems as of the end of 2009, an increase of 164% in just 18 months. Nearly 90% of the electric renewable energy systems put in place since July 1, 2010 were in the residential sector, though the total installed capacity on the residential side was just 54% of the total.

Table 22. Installations of Grid-tied PV in New Hampshire (NH OEP)

NH Net Metered Renewable Energy Installations Through 2009						
Time Period	**# System Installations (All types)**	**Total kW (All types)**	**# System Installations (Residential)**	**Total kW (Residential)**	**Residential as % of total Installations**	**Residential as % of total kW**
Pre July 1, 2008	184	708.6	128	499.1	69.6%	70.4%
	43.4%	34.9%	37.9%	41.2%		
July 1 – Dec 31 2008	55	234.4	45	138.3	81.8%	59.0%
	13.0%	11.5%	13.3%	11.4%		
Full Year 2009	185	1089.1	165	572.8	89.2%	52.6%
	43.6%	53.6%	48.8%	47.3%		
Grand Totals	**424**	**2032.1**	338	1210.2	79.7%	59.6%
	100.0%	100.0%	100.0%	100.0%		
Installed since July 1, 2008 (since rebates)	**240**	**1323.5**	**210**	**711.1**	**87.5%**	**53.7%**
	56.6%	**65.1%**	**62.1%**	**58.8%**		

However, when funding for these rebates is inconsistent or inadequate, unintended consequences can result. If rebates are established and then become unavailable either temporarily or permanently, the demand for the rebated product can disappear while interested parties wait for the rebate program to be re-funded, or for the price of the product to decline to levels comparable to what was available with rebates. This drop off in demand can have a crippling effect on the businesses that adapted to

meet the rebate-driven increase in demand, impacting their ability to keep prices stable, or invest in equipment, personnel, or training. Given that the funds for New Hampshire's current rebates are temporary in nature, dependent on the unpredictable outcome of carbon trading and the price of renewable energy credits, and subject to seizure by the state legislature, there is a danger that the existing rebates will not provide an adequate or reliable bridge between the emerging market and a more mature cost-competitive market.

For its part, the federal government is utilizing tax credits to reduce the cost of energy efficiency and renewable energy to end users, and promoting finance mechanisms such as PACE (Property Assessed Clean Energy) to remove the upfront cost barrier to the installation of energy efficiency measures and renewable energy technologies. Recently passed in New Hampshire, PACE was designed to authorize towns and cities to raise funds to lend to residents and businesses so that they can cost-effectively finance energy efficiency and renewable energy measures and pay it back through a special property tax assessment. Theoretically, this will remove the barrier posed by a high upfront cost, at least for some measures, and allow homeowners to borrow the money for the capital cost and pay it back over a longer period of time than traditional financing allows. The legislation passed in New Hampshire stipulates that the monthly finance payment must be less than or equal to the amount of money saved through reduced energy use, for at least the first year of the loan. Unfortunately, institutional lenders Fannie Mae and Freddie Mac, which set underwriting standards for a large proportion of residential mortgage loans, are opposed to PACE on the grounds that it puts their traditional mortgage liens at unacceptably greater risk.

Demand side management is a strategy used by power utilities, as well as by policy makers, to reduce the demand for energy through the use of technology and pricing (e.g., more efficient appliances, peak pricing, and the like). Several new demand side management tools and approaches have been implemented in New Hampshire in recent years to supplement the traditional CORE programs. Funded by a systems benefit charge, these programs are significantly oversubscribed in both the residential and commercial sectors and their cost effectiveness is not well measured given limitations in the computer models used to recommend measures as well as in the difficulty attributing actual energy savings to the implemented measures.

Non-profit and Advocacy Interventions

The New England Carbon Challenge (NECC) is a New Hampshire-based nonprofit organization with a sophisticated carbon calculator and a social marketing campaign aimed at engaging citizens in identifying personal opportunities to reduce their use of fossil fuels. Funded in part by a grant from the Greenhouse Gas Emissions Reduction Fund, which was set up in New Hampshire as a result of the Regional Greenhouse Gas Initiative (RGGI), NECC leverages participants' desire to be seen as 'normal' and doing one's part to bring about personal commitment and behavior change. By focusing their 'challenge' on individuals who identify as part of a larger community, whether that is a town or city, school, faith community, or business, NECC taps into the power of social pressure to engage and inspire participants.

While impressively stating on their website that 'Carbon Challenge takers' have reduced their total CO2 emissions by nearly 19 million pounds, and saved an average of $731 per year each in energy bills; these claims are based on the results of the on-line

questionnaires that participants have filled out. Like the results of any survey, including the one that is the subject of this paper, the halo effect must be taken into consideration. Just as two-thirds of those who initially said 'yes' to installing SDHW were non-committal when asked to rate their actual likelihood of following through, many of those taking the Carbon Challenge are unlikely to actually undertake the changes they state they will.

Does this mean the Carbon Challenge calculator is an ineffective tool? no, but its true impact may have less to do with the total amount of energy saved by participants, and more to do with reducing or removing existing barriers regarding adoption of energy efficiency and sustainable energy measures and practices. Some of these barriers have been identified in this study, but others exist as well. Barriers that the tool does address include identifying priorities for action, helping residents become familiar with the terminology surrounding energy use and generation, normalizing interest in and action on household energy use, and increasing the sense of responsibility that residents have for their own energy use.

The New England Carbon Challenge is also working with several other advocacy groups in the state, including the New Hampshire Sustainable Energy Association (NHSEA), the UNH Cooperative Extension, and the Plymouth Area Renewable Energy Initiative (PAREI) to help promote energy efficiency and renewable energy adoption. One of their approaches is to expose carbon challenge participants to opinion leaders, and early adopters. Currently, the Green Buildings Open House is a once a year opportunity in which early renewable energy adopters open their homes to those interested in renewable energy technologies. These hosts are now being asked by organizers from NHSEA and NECC to increase their role as innovation models by opening up their homes more frequently than once a year, or to participate by

showcasing their home through pictures and video on the internet, allowing the public the opportunity to try out the innovation before fully committing.

PAREI has developed a model that would not be unfamiliar to those involved in community-based resource management. While global climate change and energy scarcity is still largely perceived only on an intellectual basis in New Hampshire, PAREI has successfully translated concern about these issues into personal and collective action on the part of its members. This is done through a highly interactive, peer-group community in which members volunteer their time and expertise to help each other install energy efficiency measures or a renewable energy system, much like an old fashioned barn raising. In fact, such installations are called *energy raisers*. The peer-to-peer support network has been so successful in Plymouth, resulting in over 125 solar installations, that it has spun off sister organizations in the New Hampshire seacoast area, as well as in the Concord region (PAREI website).

New Hampshire has a long and rich history of citizen participation in governance at the local and state level. This tradition played a significant role in the passage of so-called Climate Change Resolutions in 164 of the state's 234 towns and cities at town meetings and elections in 2008, establishing in most cases a local energy committee (LEC) comprised of volunteers tasked with reducing energy use in the public sphere. This initiative was driven by yet another New Hampshire based energy advocacy organization, Clean Air-Cool Planet, as well as local advocates. The LECs provide an excellent means for engaging citizens in a participatory process of learning about and teaching fellow residents as well as office holders how to reduce energy use and generate from sustainable sources. They are supported by a steering committee, an interactive website and wiki, and a highly popular annual conference.

CONCLUSION

Widespread adoption of a new way of doing things, whether that is a behavioral practice, adoption of a particular type of technology, or a combination of the two, depends on both the individual actions of demanders and the provision of goods and services by suppliers. Clearly price is an important consideration to both buyers and sellers, but it is not the only variable, and its importance can be manipulated by the messaging surrounding the presentation of the good or service (Carmon). The diffusion of an innovative good or technology has typically been examined from the point of view of the entity wishing to diffuse, or sell, the innovation, which has resulted in a bias that tends to see the potential adopters as a market needing to be cracked. This can result in an attitude on the part of the disseminators akin to, as Everett Rogers puts it, "if the shoe doesn't fit, there's something wrong with your foot" (Rogers, pps. 114-115).

In the field of energy conservation and renewable energy, policy makers, and sellers of energy efficiency and renewable energy technology and services typically try to convince their potential customers that there is a problem that can be solved using their product or service. That problem, from the point of view of policy makers and many business owners, is the expectation of future energy scarcity and the unpredictability of energy prices, and all the environmental and social problems that such scarcity and unpredictability may engender. Perhaps even more narrowly, some providers may view the need to meet certain legislatively-mandated Renewable Portfolio Standard targets for the adoption of renewable energy as the primary challenge or problem. Yet for many

consumers, these global or macro-economic problems are either not yet evident, or they do not believe that their own individual adoption of the proposed solution will actually solve those problems.

A more effective approach might be for to determine what problems related to energy consumption exist from the consumers' point of view, and how those problems could effectively be addressed. Where those problems overlap with the issues identified by suppliers' and policy makers, meaningful solutions can be found. Using a participatory action research approach to identify these areas of common ground as well as solutions that address the needs of both the diffusers and the adopters could be very valuable.

In the field of planning, active engagement of stakeholders in the initial process of problem identification as well as in the development of solutions is not a new idea, yet it is not often undertaken effectively. In an article from 1994, Altman and Petkus discuss the potentially positive role of social marketing in the public policy process, with an emphasis on two-way communication between stakeholders (i.e., residents, business owners, workers) and policy makers. A more effective public policy process would actively engage (rather than passively allow) stakeholders to communicate their needs, and offer potential solutions. For their part, policy makers and planners in a stakeholder-based policy process would make it a priority to inform the affected parties as to why the problems need to be addressed by society, and to educate them regarding the impact of various proposed solutions, including inaction (Altman and Petkus, Clark).

A stakeholder-based policy process, including a participatory action research (PAR) approach, could result in another benefit as well. PAR has been shown to be very effective at engaging typically marginalized communities. Traditional diffusion research

has found that there tends to be a disparate impact of innovation dissemination on socio-economically privileged groups compared to deprived groups. This is due to, among other things, the greater access the socio-economically privileged groups have to information and other resources (Rogers, pps. 429-442). When new ideas and innovations are adopted at greater rates by higher status groups, the income and status gap between the haves and the have-nots actually increases. For innovations that result in greater energy efficiency and self-sufficiency, it is particularly important from a social justice perspective to specifically target innovation adoption among the lowest income consumers in order to *reduce* rather than increase the benefit gap. To succeed in that effort, it will be necessary to go beyond simply undertaking efficiency measures *for* this population and begin to engage *with* this population.

Further research could be done to quantify and analyze the relative impact of various energy rebates, tax incentives, intervention strategies, feedback mechanisms and the like on upper and lower income market segments. Common sense and informal observation suggests that these approaches have so far been most effective with well-educated, income stable households. Programs aimed at lower-income consumers, such as the low income home energy assistance program and the federal weatherization program may be too paternalistic, leaving the consumer with little control or even participation in identifying their own energy problems (other than cost), or potential strategies for solving them. Engaging these most vulnerable consumers, who have a greater and more urgent problem than their better-off neighbors, could result in energy conservation program design that increases the effectiveness of traditional weatherization programs.

Insights from the SDHW survey point to several areas for further study, including the role of self-reliance on interest in and capacity to successfully adopt energy efficiency and renewable energy innovations. Respondents who are likely to undertake their own home repairs are also more likely to consider SDHW, and many of these would approach do-it-yourself stores for more information – information the personnel at those stores typically lack. As potentially effective points of information dissemination, big box DIY stores deserve greater attention from policy makers and marketers.

One statistically significant factor in willingness to adopt renewable energy technologies that was uncovered by the study is the length of time a homeowner has lived in their home, which has an apparent dampening effect on the homeowner's willingness to adopt SDHW. Further study should be done on quantifying the apparent inverse relationship between renewable energy investment in the home and the length of tenure. It is possible that this inverse relationship could be overcome, or that policy makers and innovation sellers should focus their resources on those who are new or nearly new homeowners.

Another area for further study relates to upfront cost and payback periods. For most homeowners in the study, the cost of the SDHW played a significant role in their stated decision, yet as the offered price increased, the predictive power of cost decreased. Further analysis and comparative research could shed light on whether consumers' sensitivity to cost signals decreases after a certain price threshold is reached. If the survey had stated financial benefits in terms of monthly savings, or as a percentage of current energy expenditures, it is possible the results would have differed. Communicating the benefits of energy efficiency and renewable energy to consumers in

ways that make the most sense to *them* is an area that could be elucidated by both traditional survey methods as well as participatory action research.

While not specifically structured to identify opinion leaders, the survey did attempt to determine what authorities respondents would be most likely to trust in their search for information about renewable energy. More in depth and participatory research with hemophilic groups of consumers could help those interested in renewable energy diffusion identify specific individuals and organizations throughout the state that could effectively deliver energy conservation messages for different market sectors.

Recommendations

1.) Engage consumers directly in problem identification and resolution. Consumers have largely been left out of policy discussions surrounding energy in the state, and should be more meaningfully engaged. To date, the focus has been on identifying the problem from the point of view of society at large rather than on the distinctly different problems and needs that consumers themselves face in terms of cost, comfort, uncertainty, service interruption, etc.

Consumer engagement could be pursued by the Energy Efficiency and Sustainable Energy Board, the Energy and Climate Collaborative, and/or by New Hampshire-based nonprofits already effectively engaging consumers. In addition, local energy committees are uniquely positioned to engage residents at the local and regional level. It is relevant that for the British study "I Will if You Will", gatherings were sponsored by a consumer organizations, where participants felt they were helping solve their own problems rather than somebody else's.

2.) Reduce the cost of renewables. While financial considerations are certainly not the only issues, both upfront cost and annual savings are critical factors in the decision making regarding renewable energy, and by extension, energy efficiency. Financial incentives in the form of rebates or tax credits must be deep enough to attract a meaningful portion of the population, and those rebates should be consistent, predictable, and easy to understand and obtain. Inferring from the results of this survey, half the population would consider installing a solar hot water system if the price were $5536 and the annual savings $550. Roughly translated, this suggests that consumers will consider a system with a 10-year payback. In addition to rebates, policy makers should consider other more sustainable means of reducing the cost to consumers as well, including feed-in tariffs for small producers of electricity, systems benefit charges for thermal fuels, and public aggregation of renewable energy credits from small generators.

3.) Sell products not concepts. The strong support shown in this study for renewable energy policy, electricity choice, and personal adoption of renewable energy systems suggests that proponents should focus on removing barriers rather than expending effort trying to convince people that renewable energy is a good idea. Proponents should also avoid politicizing energy conservation. References to climate change, global warming, carbon footprints, offshore drilling and other hot-button concepts cue social and political identifications that can motivate some and dissuade others. Messages should be developed that focus on practical solutions to consumer-identified problems, with emotional messaging handled very carefully. Diffusion research suggests that once a certain relatively small

threshold of adoption is reached, such messaging will be less important, as normative cues and the removal of certain market barriers will provide sufficient incentive to larger portions of the population.

4.) Make it simple(r). Proponents and sellers should advertise final cost of installation to consumers, rather than expecting them to do the math themselves, which requires subtracting the federal and then the state incentives, and then adding back in tax liability. As much as possible, the paperwork burden should be borne not by the consumer, but by the proponents and sellers. The Cash for Clunkers model of government intervention in stimulating a market is worth studying (Dietz). Consumers should also be able to find information, products, and displays in the places they already frequent for home improvements, which includes internet-based sites, large do-it-yourself stores, department stores, etc.

5.) Government should set clear and predictable rules that allow energy innovations to flourish. An essential role of government is to provide a predictable marketplace where rules are clear to all, enduring, fairly enforced, and conducive to commerce. Without these conditions, transaction costs become intolerably high, and contracts are subject to greater dispute and risk.

Recently the Government of Spain, facing enormous financial pressure, reduced the value of the feed-in-tariff that had led that country to be one of the world's leaders in renewable energy, and thereby threatened the financial viability of an entire industry (Lorinc). Similarly, albeit on a smaller scale, New Hampshire's fledgling Renewable Energy Fund, Greenhouse Gas Emissions Reduction Fund, and various Recovery Act funds all face enormous uncertainty in part due to the financial difficulties of state government. This uncertainty

translates to the marketplace and increases risk for both the suppliers and the consumers, depressing participation in emerging markets.

New Hampshire should update its performance contract rules, provide a level playing field for third parties to sell electricity generated through power purchase agreements, and make it easier for towns to utilize lease-to-own contractual arrangements that would allow them to benefit from renewable energy generating projects and partnerships.

6.) Ensure that consumers have adequate information to optimize decision making around energy use. While much of the responsibility for efficiency standards and product labeling lies with the federal government, the State should mandate that energy companies provide customers with more information about their energy use. Recent legislation mandates that the electric utilities report to their customers the sources from which their electricity derives on an annual basis. Utilities should also be required to provide accurate and timely data to consumers in electronic format accessible through the internet, particularly as smart grid technology becomes more common throughout the state.

The energy survey shows that willingness to adopt renewable energy is higher earlier in homeowners' tenure in their home, which suggests that there is a window of opportunity at or near the time purchase during which energy improvements are more likely to be considered. If government required greater disclosure of energy information at the time real estate changes hands, as is currently being considered by the Department of Energy's National Energy Rating Program for Homes, buyers would be better equipped to make decisions, and sellers would have incentive to improve their properties' performance prior to

sale. The easier to understand this disclosure is, the more likely it is to be effective. Like miles per gallon for vehicles provides a standard energy consumption benchmark that consumers understand will change with vehicle type and driver behavior, homes could be labeled with their BTU per square foot that is impacted by home type, age and resident behavior (W. Golomb, personal communication July 26, 2010).

7.) Subsidize or guarantee loans for cost-effective energy efficiency and renewable energy improvements for low income home owners. Currently, both USDA Rural Development and the New Hampshire Housing Finance Authority provide low interest emergency loans for low income borrowers to replace furnaces or repair roofs. These and other lenders should consider more deeply subsidizing energy efficiency and renewable energy improvements at the time of purchase or when there is a major system failure in the home. Such investments should pay for themselves through the savings realized, and ease the monthly operating burden on the homeowners.

At the same time, these lenders should mandate education focused on the benefits of energy efficiency as part of the mandated pre-purchase homeownership curriculum that is already required as a condition of obtaining a subsidized loan. In addition to educating potential home buyers, these lenders should also require continuing education and training for REALTORS, lenders, and appraisers to improve their understanding of energy efficiency and renewable energy and the value that it contributes to a home.

Given limited resources, government and nonprofit proponents of energy efficiency and renewable energy must carefully consider the impact and cost-effectiveness of the interventions that are implemented to stimulate and sustain reductions in energy use and promotion of distributed energy generation. The results of the survey, and the associated review of diffusion literature and institutional economics, can be seen as a source of encouragement that the energy market is ripe for change, if appropriate interventions and incentives are implemented.

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APPENDIX A – INSTITUTIONAL REVIEW BOARD APPROVAL

University *of* New Hampshire

Research Conduct and Compliance Services, Office of Sponsored Research
Service Building, 51 College Road, Durham, NH 03824-3585
Fax: 603-862-3564

24-Apr-2008

Cullen, Kelly
Resource Economics & Dev., James Hall
Durham, NH 03824

IRB #: 4289
Study: Home Energy in New Hampshire
Approval Date: 23-Apr-2008

The Institutional Review Board for the Protection of Human Subjects in Research (IRB) has reviewed and approved the protocol for your study as Exempt as described in Title 45, Code of Federal Regulations (CFR), Part 46, Subsection 101(b). Approval is granted to conduct your study as described in your protocol.

Researchers who conduct studies involving human subjects have responsibilities as outlined in the attached document, *Responsibilities of Directors of Research Studies Involving Human Subjects.* (This document is also available at http://www.unh.edu/osr/compliance/irb.html.) Please read this document carefully before commencing your work involving human subjects.

Upon completion of your study, please complete the enclosed pink Exempt Study Final Report form and return it to this office along with a report of your findings.

If you have questions or concerns about your study or this approval, please feel free to contact me at 603-862-2003 or Julie.simpson@unh.edu. Please refer to the IRB # above in all correspondence related to this study. The IRB wishes you success with your research.

For the IRB,

Julie F. Simpson
Manager

cc: File

APPENDIX B - ENERGY AND HOUSING IN NEW HAMPSHIRE - SURVEY RESULTS

Energy and Housing in New Hampshire

Section 1 - Your Home in New Hampshire. This is the first of three sections in the survey and asks questions about your home in New Hampshire.

1. Please check your top three favorite things about living in New Hampshire:

Small town government	123	22%
Quality of education	66	12%
No income tax	363	64%
Environmental quality	178	31%
"Live free or die" independence	206	36%
Outdoor activities	171	30%
My job is located here	109	19%
Friendliness of the people	132	23%
My family is located here	241	43%
Strong economy	28	5%
Strong social fabric	51	9%
None of the above	11	2%

2. Approximately what year was your home built?

559 Responses		
1700s	7	1%
1800s	60	11%
1900-1950	63	11%
1951-1970	94	17%
1971-1985	117	21%
1986-2000	126	22%
2001-2005	45	8%
2006-2009	10	2%
null or false	45	8%
Total	567	100%

3. Approximately how long have you lived in your home (in years)?

564 Responses		
< 2 years	45	8%
2 years	41	7%
3 years	35	6%
4 years	26	5%
5 years	48	8%
6 years	29	5%
7 years	25	4%
8 years	26	5%
9 years	18	3%
10 years	29	5%
11-15 years	72	13%
16-20 years	43	8%
21-25 years	54	10%
26-30 years	21	4%
>30 years	47	8%
null or false	8	1%
Total	567	100%

4. When your home needs a repair or an upgrade, do you or other adults in your household typically consider doing the repair, or do you typically hire somoene to do it for you?

I/we do all but the biggest repairs or upgrades	221	39%
I/we do only small repairs or upgrades	207	37%
I/we almost never do repairs or upgrades	75	13%
Other, please specify	63	11%
Total	566	100%

5. Do you plan to remain in your current home for at least five more years?

Yes	356	63%
No	76	14%
Don't Know	129	23%
Total	561	100%

6. Do you have a specific plan to spend $5,000 or more on a single home improvement or *renovation project in the next 24 months*?

Yes	119	21%
No	352	62%
Don't Know	93	16%
Total	564	100%

7. Please rate your level of concern, if any, with each of the following issues as they affect you and your family.

Top number is the count of respondents selecting the option. Bottom % is percent of the total respondents selecting the option.	**not at all concerned**	**a little concerned**
The cost of gasoline	15 3%	47 8%
The cost of heating your home	31 5%	45 8%
The resale value of your home	120 21%	51 9%
The cost of health care	24 4%	31 5%
The amount of energy you use	32 6%	66 12%
Your job security	169 30%	82 15%
The cost of food	21 4%	56 10%

	somewhat concerned	**moderately concerned**	**very concerned**
The cost of gasoline	130 23%	175 31%	199 35%
The cost of heating your home	92 16%	153 27%	244 43%
The resale value of your home	127 22%	121 21%	146 26%
The cost of health care	85 15%	136 24%	289 51%
The amount of energy you use	173 31%	167 29%	129 23%
Your job security	100 18%	82 15%	131 23%
The cost of food	140 25%	185 33%	163 29%

8. Which of the following apply to you (check all that apply)

Recycle at home	432	76%
Use compact fluorescent lightbulbs at home	389	69%
Keep a household budget	280	50%
Own more than one residential property	46	8%
Use an accountant or service to complete income taxes	200	35%
Use a lawn service	51	9%
Personally own more than one car	269	48%
Take an airline trip at least once a year	159	28%
Spend at least $1,000 a year on home maintenance/improvements	214	38%
Have solar panels for heat or electricity	4	1%
Use more than one air conditioner in the home in summer	203	36%
Regularly use the internet for news and information	464	82%

9. Please select the last digit of your home telephone number (or cell phone if you do not have a landline). This will help us randomize an element of the survey. Thank you!

0	59	10%
1	55	10%
2	59	10%
3	55	10%
4	56	10%
5	51	9%
6	61	11%
7	62	11%
8	60	11%
9	49	9%
Total	567	100%

Section 2 - Energy Usage and Opinions. In this section, we will be asking you about your use of energy in your home. We understand that some of these questions are difficult to answer, but ask you to give us your best estimate given the information provided.

10. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $1,250 that would reduce your utility bill by $400 a year, would you consider purchasing the system?

Yes	32	54%
No	27	46%
Total	59	100%

11. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $1,000 that would reduce your utility bill by $400 a year, would you consider purchasing the system?

Yes	42	76%
No	13	24%
Total	55	100%

12. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $2,500 that would reduce your utility bill by $400 a year, would you consider purchasing the system?

Yes	39	66%
No	20	34%
Total	59	100%

13. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $5,000 that would reduce your utility bill by $400 a year, would you consider purchasing the system?

Yes	24	44%
No	31	56%
Total	55	100%

14. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $7,500 that would reduce your utility bill by $400 a year, would you consider purchasing the system?

Yes	16	29%
No	40	71%
Total	56	100%

15. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $1,000 that would reduce your utility bill by $700 a year, would you consider purchasing the system?

Yes	44	86%
No	7	14%
Total	51	100%

16. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $1,250 that would reduce your utility bill by $700 a year, would you consider purchasing the system?

Yes	41	67%
No	20	33%
Total	61	100%

17. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $2,500 that would reduce your utility bill by $700 a year, would you consider purchasing the system?

Yes	39	63%
No	23	37%
Total	62	100%

18. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $5,000 that would reduce your utility bill by $700 a year, would you consider purchasing the system?

Yes	38	63%
No	22	37%
Total	60	100%

19. Using solar energy to heat water in the home is one way for homeowners to reduce their fossil fuel use. If a solar hot water system with a 25 year warranty could be installed at your home for $7,500 that would reduce your utility bill by $700 a year, would you consider purchasing the system?

Yes	18	37%
No	31	63%
Total	49	100%

20. How likely would you be to actually purchase a solar hot water system?

I would look, but could not buy	23	7%
	30	9%
	56	17%
	100	30%
	75	23%
	32	10%
I would absolutely buy	17	5%
Total	333	100%

21. Why would you consider purchasing a solar hot water system? (please check all that apply to you).

To save money	296	89%
To help the environment	224	67%
To reduce my carbon footprint	165	50%
To invest in the development of solar technology	89	27%
I like having innovative technology in my home	58	17%
To increase the resale value of my home	126	38%
I want to set a good example for others	65	20%
My current hot water system needs replacing	25	8%
My home is in a great place for solar	67	20%
To reduce dependence on fossil fuels	221	66%
Other, please specify	12	4%

22. If you were interested in finding out more about installing alternative energy options at your home, where do you think you would start first?

internet search engine	245	74%
do it yourself home store	40	12%
yellow pages of the phone book	17	5%
friends or co-workers	63	19%
nonprofits engaged in alternative energy options	80	24%
town or city leaders	17	5%
state government agency	39	12%
federal government agency	28	8%
local hardware store	18	5%
Better Business Bureau	18	5%
Other, please specify	17	5%

23. Why would you not consider purchasing a solar hot water system (check all that apply)?

Community rules prevent installation of solar panels	20	9%
The up front installation costs are too high	122	52%
I don't believe I will save money in the long run	32	14%
I don't trust the technology to work reliably	21	9%
I won't live in the home long enough to make it worthwhile	71	30%
My home does not get enough sun	50	21%
This area does not get enough sun	42	18%
I don't know who I would call to make it happen	15	6%
Solar energy is not the right answer to conserving energy	4	2%
I am waiting for the cost to come down	57	24%
The costs should be shared by everyone, not just me	8	3%
My neighbors would be upset	6	3%
Other, please specify	53	23%

24. New Hampshire has recently passed legislation mandating that an increasing percentage of our energy come from renewable energy sources such as wind, solar (sun), landfills, and water. Please rate your level of opposition to or support for this policy.

Totally oppose	14	3%
Somewhat oppose	15	3%
Neither oppose nor support	126	23%
Somewhat support	169	30%
Strongly support	235	42%
Total	559	100%

25. If you even slightly support increasing the use of renewables (wind, solar, landfills, water) and *decreasing the use of fossil fuels (oil, gas, coal, natural gas)*, please select the level of responsibility you believe each of the following has for bringing about such a change. If you oppose the increased use of renewable energy, please select NA for not applicable.

Top number is the count of respondents selecting the option. Bottom % is percent of the total respondents selecting the option.	**no responsibility**	**very little responsibility**	**some responsibility**
homeowners	12	28	189
	2%	5%	34%
all residents	12	29	198
	2%	5%	35%
state government	9	12	121
	2%	2%	22%
town and local government	12	19	135
	2%	3%	24%
regulated utility companies	7	11	88
	1%	2%	16%
businesses	5	25	148
	1%	4%	26%
federal government	14	22	116
	2%	4%	21%
oil and gas companies	10	19	101
	2%	3%	18%

	moderate responsibility	total responsibility	NA
homeowners	235	86	14
	42%	15%	2%
all residents	231	81	13
	41%	14%	2%
state government	264	144	12
	47%	26%	2%
town and local government	271	109	14
	48%	19%	2%
regulated utility companies	274	170	13
	49%	30%	2%
businesses	274	95	12
	49%	17%	2%
federal government	229	167	13
	41%	30%	2%
oil and gas companies	249	170	14
	44%	30%	2%

26. Please select the activity you think uses the most energy over the course of an entire year for your household:

heating your home	211	37%
using your household's cars/trucks	81	14%
providing electricity to your home	214	38%
don't know	59	10%
Other, please specify	2	0%
Total	567	100%

27. Do you think electricity customers in NH should be givent he choice of where their personal household electricity comes from (in other words, traditional sources or renewable)?

Yes	433	77%
No	32	6%
Don't Know	101	18%
Total	566	100%

28. Would you choose to get your electricity from renewable sources?

Yes	339	60%
No	16	3%
Don't know	210	37%
Total	565	100%

About You In order to interpret the results of our survey, it is important for us to gather some information about you. Please know that any identifying information will be kept in strict confidence per the policies of the University of New Hampshire and will be used for research purposes only.

29. What is your gender?

Female	417	74%
Male	150	26%
Total	567	100%

30. What is your age (in years)?

567 Responses		
21 or younger	9	2%
22-25	19	3%
26-30	29	5%
31-35	37	7%
36-40	49	9%
41-45	59	10%
46-50	82	14%
51-55	79	14%
56-60	69	12%
61-65	61	11%
66-70	43	8%
older than 70	30	5%
null or false	1	0%
Total	567	100%

31. How many years of education have you received (e.g., if you finished high school and did not go to college, select 12, if you completed 2 years of technical school, select 14, etc.)

less than 9 years	0	0%
9 years	3	1%
10 years	2	0%
11 years	4	1%
12 years (high school grad)	158	28%
13 years	56	10%
14 years	118	21%
15 years	30	5%
16 years (college grad)	109	19%
17 years	13	2%
18 years	35	6%
19 years	13	2%
20 years	12	2%
more than 20 years	14	2%
Total	567	100%

32. What is your current housing situation? (if more than one option applies to you, please select the one that best describes your primary home in New Hampshire).

Own a house or half a duplex	361	64%
Own a condominium	30	5%
Own a mobile home unit with lot rent	42	7%
Rent a home	83	15%
Own a multi-family home and live in one of the units	7	1%
Other, please specify	44	8%
Total	567	100%

33. How many people currently live in your home, including yourself?

566 Responses		
1	83	15%
2	231	41%
3	101	18%
4	82	14%
5	45	8%
6	17	3%
>6	6	1%
null or false	2	0%
Total	567	100%

34. How many children under the age of 18 currently live in your home?

562 Responses		
0	380	67%
1	81	14%
2	64	11%
3	30	5%
>4	7	1%
null or false	5	1%
Total	567	100%

35. What is your race?

Caucasian	543	97%
African American	0	0%
Asian	3	1%
Native American	3	1%
Some other race	1	0%
Two or more races	9	2%
Total	559	100%

36. What is your total annual household income (please include all wages andd government support, before taxes are taken out)?

less than $15,000	39	7%
between $15,000 and $24,999	42	7%
between $25,000 and $34,999	69	12%
between $35,000 and $49,999	105	19%
between $50,000 and $64,999	81	14%
between $65,000 and $74,999	53	9%
between $75,000 and $99,999	83	15%
between $100,000 and $149,999	62	11%
between $150,000 and $200,000	22	4%
more than $200,000	11	2%
Total	567	100%

37. Please check the box that best represents your political views

very liberal	24	4%
liberal	101	18%
neither liberal nor conservative	258	46%
conservative	142	25%
very conservative	36	6%
Total	561	100%

38. What is your zip code?

567 Responses

39. If you have comments for the researchers, please include them here. Thank you for taking the time to complete this survey.

89 Responses

All the utilities want home owners to be very conservative. Then they don't make the profits that they demand so they raise the cost of energy. If by conserving, our costs went down, more people would be encouraged to cut back.
Arguments for Global Warming are not substantiated and should not be part of any legislation or mandate.
As a home owner I would heavily support a grant system to help home owners put renewable power options installed in their homes.
Do not know much about renewable energy at this time
even tho information on renewable sources is available, most persons in the area have a mcdonalds mentality and dont understant anything
Federal and state governments HAVE NO BUSINESS 'mandating' (translate: ORDER!) private citizens to use a specific energy source. When govt. is involved trying to make more, they ALWAYS make less..and vise-versa. They need to get the hell out of the way.
For the questions you asked you didn't explain enough, for instance buying renewable energy would it be cheaper?
going green is very very expensive - most peoples have to want to care enough about alternative energy - we do but know we cannot afford to
great questions!
help for lower income should be provided. the whole idea in language that people can understand.
I am all for getting away from fossil fuels however until people are ready to stand up to the oil companies unitedly it will never happen completely
I am very interested in solar.
I beleive the property taxes in NH should be lowered so homeowners can afford renewable energy alternatives
I believe everyone has a responsibility when it comes to preserving our environment

I believe that every business and homeowner has the responsibility to move forward with renewable energy. Companys need to make it as affordable as possible. It should not be more expensive to use renewable resources!!! It should be cheaper.
I don't think the government should force anyone into converting their energy sources. It should remain a freedom of choice.
I enjoyed this because it was about my state, and I love NH! I would like to know what this survey is for.
I have looked into other sources of energy the problem is the cost and where the company is located. The web sites do not give a lot of information
I liked this survey. Keep them coming.
I LIVE IN A VERY SMALL TOWN WITH VERY HIGH ELECTRIC BILLS.I PAY FOUR TIMES AS MUCH AS MY FRIEND WHO LIVES 4 MILES FROM ME IN ANOTHER SMALL TOWN.DOESN'T SEEM FAIR.I ONLY HAVE MY CHILDREN HALF OF THE MONTH AND MY FRIEND HAS AN EMBROIDERY BUSINESS IN HER HOUSE WITH TWO GIANT MACHINES THAT ARE ON ALL THE TIME.SHE PAYS UNDER $30 A MONTH.MINE IS ALWAYS OVER $110.REALLY DOES NOT SEEM RIGHT.I HAVE TALKED TO THE ELECTRIC COMPANY.THEY HAVE MY TOWN.NOTHING CAN BE DONE.
I moved from New Hampshire last December, but I answered the questions as if I still lived there.
I only wish I could afford to get solar or wind power equipment here!
i think renewable energy is the way to go.it should have started back in the 70s. the problem was oil companeys did not want the compation. and the general populas could be least concerned at that time. now it is unafordable for low income fasmlies. so what do you do.with the way the economy is now who wants to take a chance, you could be out of a job at any time. so any money you spent on converting over could have helped you to survive the crunch. right now only the well to do and the rich can afford it. people like me on fixed income can barly afford gas every week. i could go on and on .but you get the picture.
I think we are all responsible for using/implementing alternative energy sources. However, the choices need to be there for the consumer.
I think we should drill for oil in Alaska and also explore elsewhere so we will not be dependent on other countries. Also use more natural gas. Alternative energy is great, but it should not be shoved down our throats when there is still oil to be drilled and natural gas to be obtained within US territory.
I work at a school in the maintenance department and have switched to green products and practices several years ago and enjoy learning anything new that we can do to improve our planet
i would love to use renewable energy, but the overall initial cost is too much for me to put up, even if i would be saving money later.
If these types of things were to be an option, they would have to be affordable as well to install. In the long run we know it's going to save people money and help/save the environment, but the cost of being able to do this is just out of many people's budget.. How would this problem be resolved? There are many people, such as myself, that would LOVE to help the environment more and save lots on costs to live, but the cost to say turn my house over completely to solar electricity...I can't even begin to imagine the cost it would be....
Im barely holding onto my house as is,my spouse is disabled lost quite a bit of income hurt our credit so I would not be able to do any upgrades Oh Yeah with this state I make a couple of dollars more for any fuel assistance or house upgrades the electricity in this house is 60amps,the heating system is old
Interesting. Thanks!
I've had solar water for 5 years and just installed a 2.7kw solar voltaic. Both are great and the NH solar incentives are a good beginning.
My income is my business. My answer is not correct.
My responses regarding home improvements were very conservative given the current economic climate. Once real estate values recover, then I will be willing to invest further in my home.

New Hampshire is just the right state to spearhead the environmental movement without infringing on our personal rights such as the right to hunt wild animals- Go New Hampshire!
no comments, hope that the rate for electricity was become low for the poor family
Nothing at this time
Nothing to add
please have cah incentives
PSNH has gotten so expensive that alternative energy seems a good alternative. I expect that PSNH rates will continue to rise and make it hard for a familty to afford electricity
Race is not an important question on any survey. That is my opinion
Renewable HAVE to be zero sum with fossil if not less. One of the main reasons, in my opinion, renewable has not taken off is it is not profitable enough for the producers of energy. to keep it competative the margins are too tight and changes needed to acommadate different sources are too costly for the producers to eat and the consumer to pay for. These technologies have been around decades just not very profitable. If John D Rockerfeller owned a battery company instead of an oil company we would now be looking for alternatives to lead batteries, possibly fossil fuels.
Small town New Hampshire is being killed by National, State, County and Regional School Districds that impose regulations and costs related to them on us.
Solar and geothermal are very interesting. Some tax incentives would help get over the initial cost.
Solar energy: If you want people to mass adopt it - it needs to be way cheaper. Look at the advent of the PC - make it cheaper and everyone will buy one - make the price for a starter kit (that can be added to) within the reach of the average family and they will buy it!!!
Some states offer rebates over and above the federal government. If NH did this, we might be more apt to make additional modifications to our home.
tax refund's on green heating and cooling and solar power. If use of green products in the home and offices and any other time should go towards making the earth a better place for generations to cool
Thank You
thank you
thank you
thank you for allowing me to participate in your survey. if you need further assistance in the future, please don't hesitate to contact me. I'd be more than happy to do whatever I can to help make our state more energy independent, and resourceful.
The fact that someone is actually taking the time to look into this is great.Good luck.
The question on why I live in NH should not have a limit of 3 as I only have 2 reasons. My husband wants to live here and there's no income tax. Only 2 reasons.
There should be free or greatly reduced opertunities for low income to install alternative power ie. wind solar etc.
this has been something different
This is all well and good but has to be affordable for all
This survey was very interesting and different, and is something that I think more people need to be made aware of.
this was very interesting
vehicles that don't need oil or gas ; solor panels to collect sun and wind power for enegy ; decrease the garbage and landfills by decreasing so much waste. USE more recycled products. THIS WORLD MAKES TO MUCH PACKAGES THAT CAN NOT BE RECYCLES AND ITEMS PRODUCTS AND CRAP THAT LANDS IN WASTE FIELDS. We need to reduce at least 50% to see a big difference. In the early 1900s we did not have these big problems. May be we need to think of this.

We believe nuclear energy should also be considered. We have purchased a Rinnai water heater in order to cut down on oil usage for our hot water supply.
We garden for much food, burn our own wood & have 85% of our Window glass & a greenhouse for Winter extra heat located on the broad S. side of the house.
We need all the help we can get.
We need to find different ways to save our earth.
We, as a country, NEED to find ways to help this planet and each other.
Wife in nursing home.Income reduced by over $10,000 per year in real estate taxes and over $7,000 for *extended care insurance*
WOOD IS ALSO A RENEWABLE RESOURSE
would love solar panels on my roof; excellent location for them; have found them not to be cost effective
yOU DIDN'T ASK ANY QUESTIONS ABOUT PROPERTY TAXS. THEY ARE ASTRONOMICAL
You should ask whether people rent/ own in the beginning of this questionnaire, as most of the questions didn't apply to me as a renter. I wouldn't improve my home or spend money on repairs simply because I don't own one!
Your Welcome
Researcher note: 'NA' responses were not included

APPENDIX C – FULL LOGISTIC REGRESSION MODEL

Logistic Regression Results for Concerns and Practices

Logistic regression

Log likelihood = -155.27574

Number of obs	= 341
LR chi2(47)	= 133.01
Prob > chi2	= 0.0000
Pseudo R2	= 0.2999

Yes to SDHW	Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
Upfront cost	0.645591	0.0434901	-6.5	0	0.56574	0.736713
Annual savings	1.326382	0.136315	2.75	0.006	1.084398	1.622364
Years of education	1.244821	0.0950369	2.87	0.004	1.071818	1.445748
Support RE Policy	1.756553	0.3523729	2.81	0.005	1.185513	2.602654
Decades in home	0.698249	0.1087657	-2.31	0.021	0.51454	0.947548
Children at home	0.581624	0.1641864	-1.92	0.055	0.33447	1.011411
like_ecomomy	0.281316	0.2177358	-1.64	0.101	0.061713	1.282378
concern_gas	0.741571	0.1462382	-1.52	0.129	0.503843	1.091465
Hhd_repair~m	1.469126	0.374207	1.51	0.131	0.891756	2.420315
Hhd_CFL	1.68482	0.6043489	1.45	0.146	0.834114	3.403153
like_no_tax	1.645178	0.6136332	1.33	0.182	0.791998	3.417446
home_age	1.004637	0.0035194	1.32	0.187	0.997763	1.011559
# ppl in home	1.302286	0.2751253	1.25	0.211	0.860753	1.970308
Hhd_spend_5k	1.263476	0.236577	1.25	0.212	0.875358	1.823679
like_social fabric	0.519741	0.2729027	-1.25	0.213	0.185713	1.454558
like_live free or die	0.630647	0.2483612	-1.17	0.242	0.291452	1.364603
Hhd_multi_AC	0.706477	0.2250673	-1.09	0.275	0.378377	1.319081
like_outdoors	1.506297	0.5813524	1.06	0.288	0.706954	3.209447
Hhd_lawn_service	0.571243	0.3069383	-1.04	0.297	0.199277	1.637516
concern_resale	0.86248	0.1275437	-1.00	0.317	0.645465	1.152457
Hhd_recycle	0.628395	0.2968782	-0.98	0.325	0.248938	1.586257
Hhd_improvement this year	0.71326	0.2454522	-0.98	0.326	0.363351	1.400134
concern_energy use	1.19141	0.2204618	0.95	0.344	0.828997	1.712261
like_nothing listed	3.510042	4.762064	0.93	0.355	0.245748	50.13432
respond_age	1.015304	0.0173224	0.89	0.373	0.981914	1.049829
Opin_echoice self	2.958217	3.610015	0.89	0.374	0.27057	32.34305
like_job	0.703242	0.3201935	-0.77	0.439	0.288101	1.716587
respond_urban (1=yes)	0.778663	0.2557208	-0.76	0.446	0.409078	1.482152
like_friends	0.741865	0.3053593	-0.73	0.468	0.331102	1.662219
Hhd_budget	0.805395	0.2608728	-0.67	0.504	0.426873	1.519563

like_small town	0.760995	0.3241214	-0.64	0.521	0.330248	1.753573
Opin_Echoice option	1.637785	1.464221	0.55	0.581	0.283963	9.4461
like_family	0.81852	0.3157375	-0.52	0.604	0.384313	1.743305
respond_gender (female=1)	0.835446	0.3294585	-0.46	0.648	0.385697	1.809631
concern_job	1.043826	0.1142712	0.39	0.695	0.842256	1.293635
concern_food	0.940426	0.1908301	-0.3	0.762	0.631829	1.399746
Hhd_plan to stay 5 years	1.089412	0.3165178	0.29	0.768	0.61643	1.925308
Hhd_air trip 1x yr	1.11558	0.414381	0.29	0.768	0.53867	2.310355
Hhd_2 homes	0.871142	0.4632327	-0.26	0.795	0.307227	2.470121
Political identity (5 =very conservative)	1.038575	0.1879292	0.21	0.834	0.728473	1.480683
Respond_income ($)	1	3.69E-06	-0.13	0.894	0.999992	1.000007
like_environmental quality	0.954993	0.3530294	-0.12	0.901	0.462742	1.970885
concern_healthcare	1.020644	0.1765743	0.12	0.906	0.727133	1.432632
Hhd_use accountant	0.967779	0.3084108	-0.1	0.918	0.518222	1.807325
like_quality of educ	1.040781	0.5255207	0.08	0.937	0.386868	2.799986
Concern heat cost	1.003491	0.1931142	0.02	0.986	0.688186	1.463257
Hhd_multi cars	0.995537	0.3169745	-0.01	0.989	0.533382	1.85813