MOTIVATIONS AND BEHAVIORS OF SOLAR PV AND GEOTHERMAL SYSTEM OWNERS IN NORTH CAROLINA

UNC Kenan-Flagler Business School | NC Sustainable Energy Association

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Executive Summary

North Carolina has experienced significant growth in its clean energy markets. As of 2012, these state industries accounted for over 18,591 full-time equivalent employees across 1,100 businesses accounting for $3.7 billion in annual gross revenues.[1] This growth is especially noteworthy in the solar industry. Total registered capacity has increased from less than 1 megawatt (MW) in 2006 to 632 MW in 2012,[2] which amounts to an average annual growth rate of 1,243%. Powered by over 500 state businesses working in the solar space,[3] this trajectory ranks North Carolina as the 3rd most active state in the nation in terms of new solar additions in 2013 Q3.[4] Geothermal (ground-source) heat pumps have grown in popularity globally with annual increases of approximately 10% in many areas.[5] Growth in North Carolina's renewable energy and energy efficiency sectors is driven by many factors, including the falling price of installation, rising electricity prices, and the predictability of state renewable energy incentives. The price of solar panels has fallen 60% since 2011,[6] and it is expected that, for the majority of electricity ratepayers, utility scale and commercial scale solar PV systems in North Carolina will deliver at grid parity without any solar subsidies within the next five years.[7] Residential scale solar PV systems will deliver at grid parity around the year 2020.

In light of these trends, the purpose of this report is to assess the financial, personal, and policy drivers that have influenced residential owners of solar PV and geothermal systems in North Carolina to make these investments. In January 2012, the NC Sustainable Energy Association and the University of North Carolina at Chapel Hill Kenan-Flagler Business School conducted a survey of 1,323 solar PV owners and 1,023 geothermal system owners to assess the motivations behind their decision to purchase a renewable energy system, challenges faced in the process, energy efficiency behaviors in which they engage, energy efficiency products and design they have chosen, and characteristics of these consumers.

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[1] NC Sustainable Energy Association, "North Carolina Clean Energy Industries Census." December 2013.

[2] State of North Carolina Utilities Commission, "Order Adopting Final Rules in the Matter of Rule Making Proceeding to Implement Session Law 2007-397.Docket No. E-100, Sub 113." http://www.ncuc.commerce.state.nc.us/selorder/rules/SW022908.pdf.

[3] NC Sustainable Energy Association, "North Carolina Clean Energy Industries Census." October 2012. http://energync.org/assets/files/2012Census.pdf.

[4] Cox, Charlotte. SNL, "Solar continues to shine in Q3'13 with 282 MW installed." Last modified October 14, 2013. Accessed November 8, 2013. http://www.snl.com/InteractiveX/Article.aspx?cdid=A-25354226-13358.

[5] Lund, J., B. Sanner, L. Rybach, R. Curtis, and G. Hellstroem, "Geothermal (Ground-Source) Heat Pumps: A World Overview." Geo-Heat Bulletin. September 2004.

[6] Solar Energy Industries Association, "Solar Industry Data Q2 SMI Fact Sheet." http://www.seia.org/research-resources/solar-industry-data.

[7] Makhyoun, Miriam, Rich Crowley, and Paul Quinlan. NC Sustainable Energy Association, "Levelized Cost of Solar Photovoltaics in North Carolina." http://energync.org/assets/files/LCOE of Solar PV in North Carolina-FINAL.pdf.

Among other objectives, the results of this study can be used for the following:

- To assess which policies and incentives are working and need to be reinforced,
- To understand which incentives require greater education to enable their full effect,
- To expand residential and commercial solar PV and geothermal adoption in North Carolina and other states, and
- To inform outreach messaging that encourages individuals to adopt energy efficient technologies and energy-saving behaviors.

Key findings from this report include the following:

- The most important consumer motivations for installing solar PV and geothermal system were, in order of importance, federal and state tax credits, concern about the cost of electricity, concern about environmental impacts, and a desire to do the right thing.
- Renewable energy system owners reported high levels of satisfaction regarding their experience obtaining the federal and state tax credit, the performance of their system, cost savings realized, and the performance of the company that installed the system.
- Owners of PV solar systems reported high levels of satisfaction with NC GreenPower.
- For PV solar system owners, the easiest steps in the process were the installation process itself, finding an installer, and securing project permits; for geothermal system owners, the easiest steps were securing utility and project permits and finding information about renewable energy systems.
- State and federal tax credits and the availability of cash were the most important sources of financing reported by both PV solar and geothermal system owners.
- For PV system owners, the most commonly installed energy efficient technologies are high-efficiency lighting, Energy Star appliances, and attic insulation, with each having an adoption rate of over 85%. For geothermal system owners, besides their energy efficient heating and cooling system, the most commonly adopted technologies were Energy Star appliances, duct sealing and insulation, and attic insulation.
- The moment of installation of a renewable energy system, and immediately thereafter, emerged as the critical windows for increased utilization of energy efficient technologies.
- For PV system owners, the most common energy-saving behaviors are turning off lights when not in use, washing a full load of dishes, and setting the thermostat to 78°F or higher in summer and 70°F or lower in the winter. The most commonly adopted energy-saving behaviors by geothermal users were washing a full load of dishes, moderating the temperature of the water heater, and turning off lights when not in use.

Methodology

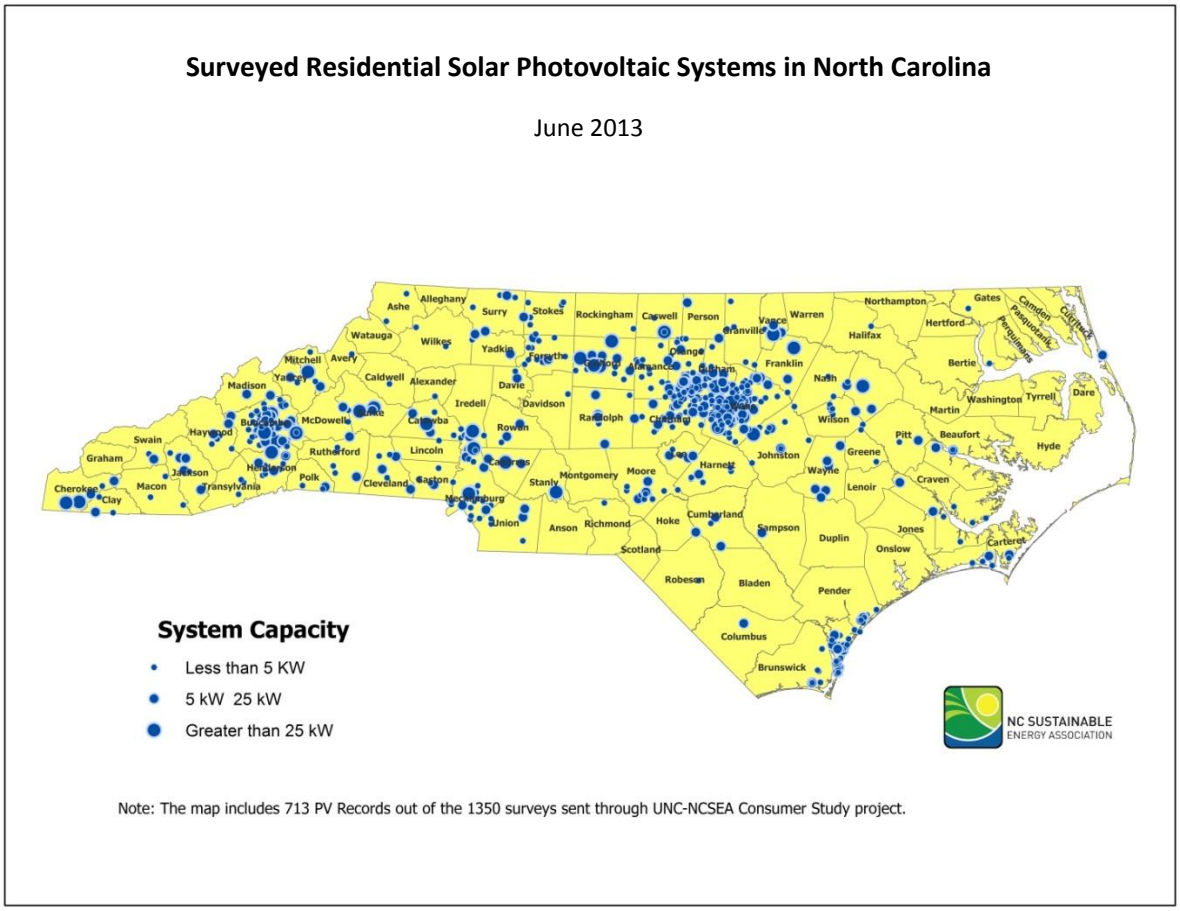
Surveys were sent to 1,323 North Carolina residents who installed solar PV systems and 1,023 North Carolina residents who installed geothermal energy systems based on data from the N.C. Utilities commission (for PV) and from the Groundwater Protection Unit at N.C. Department of Environment and Natural Resources (for geothermal) via U.S. mail or via email (if there was a valid email address on file). The survey inquired about the motivations of system owners for installing a renewable energy system, experience with various components of the installation process, and the importance of various forms of financing. Additionally, the surveys included

questions about whether system owners have also installed energy-saving technologies or engaged in energy-saving behaviors. Finally, demographic data was collected in order to ascertain whether there are trends or commonalities among NC residents who have chosen to install solar PV or geothermal systems.

The survey is available here.

Survey Results and Implications

Responses were received from 760 solar PV owners (equivalent to a response rate of 57%) and from 453 geothermal system owners (equivalent to a response rate of 44%). [See **Figure 1** for maps showing the geographic distribution of residents surveyed.] This response rate is relatively high compared to that documented in studies of average response rates (0.5-1.5%% for online surveys and 3-5% for paper surveys).[8] Reasons for this may include that those who have installed a renewable energy system hold strong opinions about this decision, that the survey did not require much time to complete, and that the organizations conducting the survey are well respected by this population. Of solar PV respondents, the vast majority own systems installed at their residence. Less than 15% of respondents indicated that the solar PV system was located at a corporate, educational, government, or nonprofit location.



[8] Resnick, Robert. "Comparison of postal and online surveys: Cost, speed, response rates, and reliability." Working Paper. Education Market Research, 2012. http://www.mchdata.com/wp-content/uploads/2012/10/Comparison_of_Postal_and_Online_Surveys.pdf.

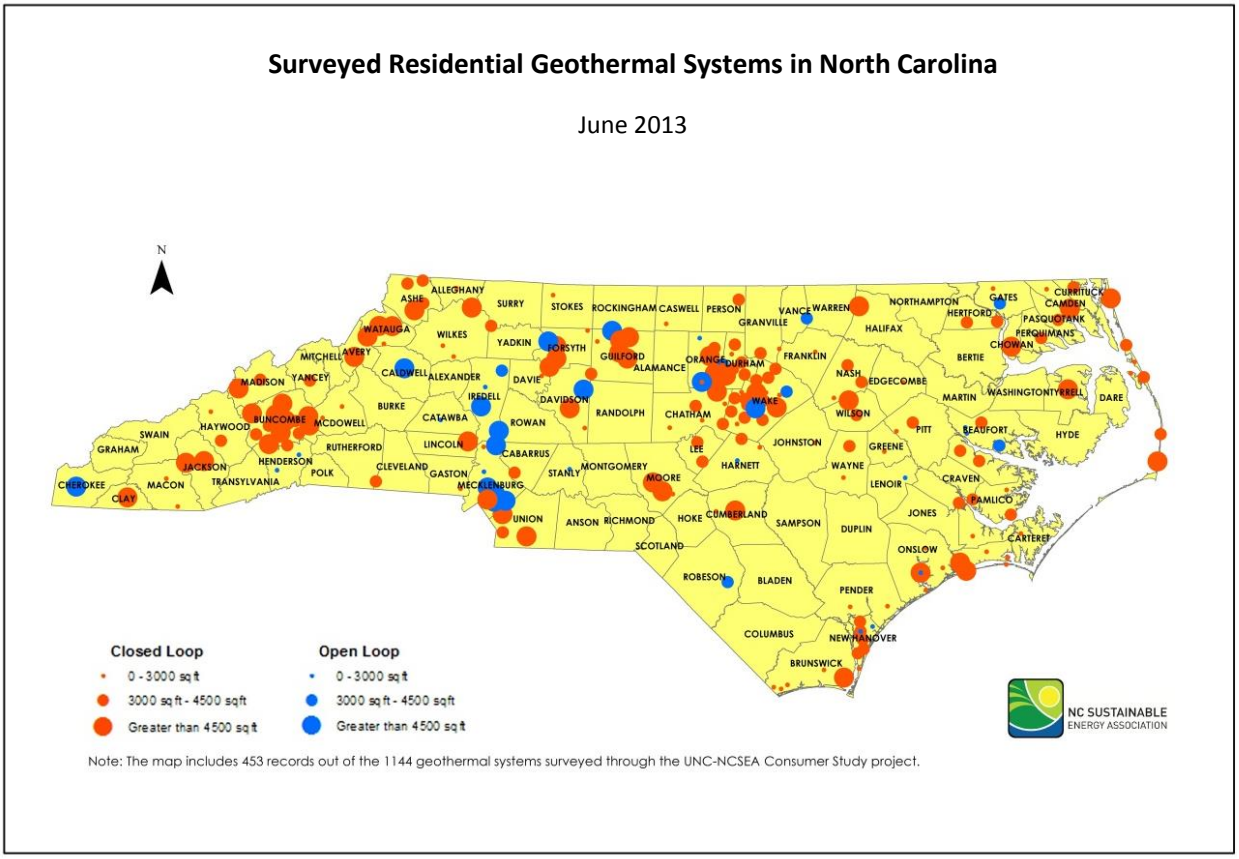


Figure 1: Surveyed Solar PV (a) and Geothermal System Owners (b)]

Motivating Factors

Solar PV and geothermal system owners responded slightly differently when asked about the importance that various factors played in their decision to install a renewable energy system. These results are summarized in **Table 1**.

These data show clearly that federal and state tax credits were important determinants in the purchase of a renewable energy system. This is not surprising considering the high upfront cost of installing a renewable energy system ($4.81/W for residential systems)[9] and the relatively low cost of electricity for residential customers in North Carolina (average cost of $0.10/ per kilowatt hour).[10] Nevertheless, owners of geothermal systems cited the cost of electric bills as overwhelmingly significant in their purchase decision.

For both PV and geothermal system owners, concern about the environment and a belief that installing a renewable energy system was "the right thing to do" ranked highly, with between 85 and 92% of respondents

[9]Solar Energy Industries Association, "U.S. Solar Market Insight, Executive Summary." Last modified September 12, 2013. http://www.seia.org/research-resources/us-solar-market-insight.

[10] U.S. Energy Information Administration, "North Carolina Electricity Profile 2010." Last modified January 30, 2012. http://www.eia.gov/electricity/state/NorthCarolina/.

indicating that this was either a very or somewhat important criterion. These responses indicate that, beyond financial considerations, environmental stewardship and a sense of obligation are significant drivers behind the adoption of renewable energy. This finding is consistent with previous research showing that a "conservation ethic" or "the feeling of doing one's share by reducing [energy] usage" was a significant motivator.[11] While the influence of neighbors in an individual's decision to install a renewable energy system has been shown to be significant in other studies (e.g., in California by Dastrop *et al*. 2010[12] and in the Greater Chicago Area by Noonan *et al.* 2013[13]), this factor was of relatively low importance among North Carolina renewable system owners, perhaps because the relative density of installed systems in North Carolina is low.

Factors Motivating Solar PV System Owners	*Rank**	% Very Important	**% Somewhat Important**	Factors Motivating Geothermal System Owners	*Rank**	% Very Important	**% Somewhat Important**
Using tax credits	*1*	64.3	29.1	Cost of electric bills	*1*	74.1	22.9
Concern about environmental impact	*2*	68.0	23.8	Concern about environmental impact	*2*	48.5	37.6
It was the right thing to do	*3*	62.3	26.1	It was the right thing to do	*3*	47.6	37.1
Generating my own energy	*4*	56.2	30.9	Using tax credits	*4*	64.5	18.9
Cost of electric bills	*5*	37.2	44.4	Concern that the price of electricity is likely to rise in the future	*5*	41.7	38.2
Concern that the price of electricity is likely to rise in the future	*6*	27.5	44.1	Generating my own energy	*6*	19.5	23.1
Influence of a neighbor or friend	*7*	2.7	8.2	Influence of a neighbor or friend	*7*	5.5	13.5

Table 1: Motivating Factors behind the Decision to Install a Renewable Energy System
*Rank was determined based on the percentage respondents replying that the factor was "very" or "somewhat" important.

Satisfaction of Renewable Energy System Owners

Owners of PV and geothermal systems reported high levels of satisfaction with similar items (**Table 2**). The federal tax credit, performance of the system, and the company that installed the system ranked highest for both PV and geothermal owners. Satisfaction with cost savings and the state tax credit was also high. The positive reports of satisfaction with the federal and state tax credit complements the findings above that showed these tax credits were a primary driver in the decision-making process. Additionally, the high level of satisfaction with the company that installed the PV system reflects positively on this industry sector in North Carolina. In total, 525 PV system owners reported having received installation services from 79 different companies. The ten companies that installed the most systems are listed in **Table 3**. Nine companies were reported as having installed systems at 10 locations or more; Southern Energy Management installed the

[11] Niemeyer, Shirley. "Consumer Voices: Adoption of Residential Energy-Efficient Practices." *International Journal of Consumer Studies*. 34(2). February 2010.

[12] Samuel Dastrop, Joshua Graff Zivin, Dora L. Costa, and Matthew E. Kahn. "Understanding the Solar Home Price Premium: Electricity Generation and Green Social Status." University of California Center for Energy and Environmental Economics. E3WP-001. December 2010.

[13] Douglas Noonan, Lin-Han Chiang Hsieh, and Daniel Matisoff. "Spatial Effects in Energy-Efficient Residential HVAC Technology Adoption." *Environment and Behavior.* Volume 45(4): 476-503. May 2013.

greatest number of systems (108 or 21.2%). Twenty-nine (29) companies installed between 2 and 9 systems; whereas, 40 companies installed only one. PV system owners also reported high levels of satisfaction with NC GreenPower (53.5% "very satisfied" and 25.4% "somewhat satisfied"). NC GreenPower is a nonprofit organization that disburses payments to owners of small solar-electric systems in the form of a subsidy of $0.06/kWh, funded by voluntary donations from electricity consumers across the state.[14] Geothermal system owners are not offered a subsidy by NC GreenPower. This may explain why only 21% of respondents with geothermal systems answered this question (which should have been marked as relevant only for solar PV owners). However, 30% of geothermal owners who answered this question reported being very or somewhat satisfied with NC GreenPower. Reported levels of dissatisfaction could result from geothermal system owners feeling disappointed that they are not eligible for a subsidy like owners of solar, wind, small hydro, and biomass systems are; alternatively, the low response rate may simply reflect that this question was not applicable to geothermal system owners who may not even be aware of the subsidy offered to PV system owners.

Reported Levels of Satisfaction by Solar PV Owners	*Rank*	% Very Satisfied	**% Somewhat Satisfied**	Reported Levels of Satisfaction by Geothermal System Owners	*Rank*	% Very Satisfied	**% Somewhat Satisfied**
Federal tax credit	*1*	74.9	20.0	Performance of your renewable energy system	*1*	76.8	19.3
Company that installed the system	*2*	78.4	15.6	Federal tax credit	*2*	77.8	15.6
Performance of your renewable energy system	*3*	62.5	30.8	Company that installed the system	*3*	65.3	26.8
State tax credit	*4*	61.4	28.0	Cost savings on your electric bill	*4*	58.4	32.5
Cost savings on your electric bill	*5*	34.8	44.2	State tax credit	*5*	60.6	24.3

Table 2: Percentage of Respondents Very Satisfied or Somewhat Satisfied with Their Experience
*Rank was determined based on sum of % respondents replying that the factor was "very" or "somewhat" satisfied.

Company Name	# of Systems Installed	Company Name	# of Systems Installed
Southern Energy Management	108	First Light Solar	34
Sundance Power Systems	44	Alternative Energy Concepts	20
Strata Solar, LLC	41	Southeastern Energy Corporation	16
NC Solar Now	38	Cape Fear Solar Systems	10
Yes! Solar Solutions	36	Solar Tek of NC	9

Table 3: Companies which Have Installed the Most Residential PV Solar Systems in NC

[14] U.S. Department of Energy, Interstate Renewable Energy Council, and NC Solar Center, "NC GreenPower Production Incentive." Last modified June 11, 2013. http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NC05F. *[N.B. This credit varies and has been declining.]*

There was also a low response rate for the question concerning cash grants in lieu of a federal tax credit. (For PV system owners: 23% response rate in comparison to a 99% response rate to the question about system performance; for geothermal system owners, the comparable rates were 17% and 85%). The low response rate to this question may partially reflect the fact that the cash grant was only available for systems for which construction began between 2009 and December 31, 2011.[15] Among survey respondents, 499 solar PV system owners (70%) and 219 (52%) geothermal system owners had systems installed during this time period. These data may indicate that the awareness among residential customers of incentives is limited because incentive programs are introduced, change, and sunset more quickly than knowledge of them spreads.

Experience with the Process

The data concerning system owners' experience with the installation process—from finding information about renewable energy systems to finding an installer to obtaining financing and permits and including the installation itself—are quite positive overall (**Table 4**).

Solar PV Owners' Experience with the Process	*Rank**	% Very Easy	% Somewhat Easy	Geothermal System Owners' Experience with the Process	*Rank**	% Very Easy	% Somewhat Easy
The installation process	*1*	54.3	36.1	Securing utility permits	*1*	48.0	41.5
Finding an installer	*2*	49.8	37.9	Securing project permits	*2*	45.6	37.8
Securing project permits	*3*	48.6	34.5	Finding information about renewable energy systems	*3*	33.7	48.7
Finding information about renewable energy systems	*4*	36.6	45.1	Obtaining financing for the system	*4*	43.4	35.6
Obtaining financing for the system	*5*	44.4	36.0	Finding an installer	*5*	38.6	37.0
Securing utility permits	*6*	43.9	31.8	The installation process	*6*	29.9	40.4
Selling the renewable energy for a fair price	*7*	33.6	27.2	*Not Applicable*	*7*	--	--
Selling the REC for a fair price	*8*	28.6	31.6	*Not Applicable*	*8*	--	--

Table 4: Relative Degree of Ease or Difficulty with the Process
*Rank was determined based on sum of % respondents replying that the factor was "very" or "somewhat" satisfied.

The installation process and finding an installer for solar PV systems were reported as relatively easy compared to that for geothermal systems. In contrast, geothermal system owners reported the most ease with securing the required permits. With 82% and 83% of solar PV and geothermal system owners replying that finding information about renewable energy systems was either "very" or "somewhat" easy, one can conclude that improvements in the accessibility of information would be of benefit to individuals considering installing a system. Improvement to the process of securing utility permits for those installing PV solar systems should also

[15] U.S. Department of Treasury, "Payments for Specified Energy Property in Lieu of Tax Credits under the American Recovery and Reinvestment Act of 2009: Frequently Asked Questions and Answers, Begun Construction." http://www.treasury.gov/initiatives/recovery/Documents/FAQs for Begun Construction web4.pdf.

be considered as 76% of respondents reported that this step was either "very" or "somewhat" easy. This statement and the preceding comment about access to information should be taken within context—while there is room for improvement, data showing that >75% of respondents found information and secured permits without difficulty are generally positive. However, it would be more informative to consider differences in responses by county because North Carolina counties charge different fees. It is also interesting to note that the installation of geothermal systems was generally regarded as easy by a clear majority of respondents. This may be surprising to some because the process of installing a geothermal system involves heavy equipment and disturbance to a property's landscape. A mitigating factor may have been that it is common to install a geothermal system when a house is built, so the owner in these cases would not have been living at the property at the time of the install.

The lowest level of ease was reported for the process of selling the renewable energy or the renewable energy certificate (REC) for a fair price (only 61% of solar PV owners said this was "very" or "somewhat" easy). However, it is unclear whether the trouble lies in actually selling the energy or the REC or whether the dissatisfaction is a result of the system owners thinking that the price itself is unfair. To disentangle these factors, it would be instructive to monitor whether customer satisfaction with this step of the process changes as the price changes or whether the level of dissatisfaction remains the same. If the latter were true, it would indicate the selling process is more difficult.

Sources of Financing

Data regarding the sources of finances used to purchase and install a solar energy system are shown in Table 5. The most commonly used sources of financing were the federal tax credits and state tax credits. Federal tax credits were regarded as either "very " or "somewhat" important by 96.5% of PV solar respondents and 95.4% of geothermal respondents. Similarly, state tax credits were regarded as either "very " or "somewhat" important by 95.3% of solar PV system owners and 92.7% of geothermal system owners. Ninety-four (94.0%) of solar PV respondents and 93.2% of geothermal respondents indicated that the availability of cash on hand was either "very" or "somewhat" important. The high percentage of respondents indicating that the availability of cash on hand was either "very" or "somewhat" important underscores the importance of programs that help offset the upfront cost of installing a renewable energy system for people who do not have large reserves of cash savings. Additionally, these data show the significant role that tax credits play in providing a source of funding and, importantly, that these tax credits are as important as the availability of cash on hand.

Source of Financing for Solar PV System Owners	*Rank*	% Very important	**% Somewhat Important**	Source of Financing forGeothermal System Owners	*Rank*	% Very Important	**% Somewhat Important**
Federal tax credit	*1*	82.0	14.5	Federal tax credit	*1*	84.3	11.1
State tax credit	*2*	78.5	16.8	Availability of cash on hand	*2*	81.0	12.2
Availability of cash on hand	*3*	76.2	17.8	State tax credit	*3*	80.5	12.2
NC GreenPower	*4*	56.1	25.5	Availability of loan	*4*	58.2	16.3
Availability of loan	*5*	45.7	31.0	Incentives from the utility company	*5*	21.2	26.0
Incentives from the utility company	*6*	40.0	31.2	NC Green power	*6*	9.6	13.5
Cash grant in lieu of federal tax credit	*7*	20.1	9.7	Cash grant in lieu of federal tax credit	*7*	6.7	2.2
Grant	*8*	22.8	3.3	Grant	*8*	3.8	.00

Table 5: The Importance of Various Sources of Financing

*Rank was determined based on sum of % respondents replying that the factor was "very" or "somewhat" important.

A potential solar PV owner's inability to pay the upfront capital cost for a solar PV system is a common financial barrier for consumers, however, alternative business financing programs would allow consumers to eliminate the upfront costs and increase solar PV adoption in neighborhoods that are less affluent and with younger families.[16] Industries selling comparably priced products, such as new cars and trucks, enable consumers to overcome the upfront capital cost barrier through the offering of monthly financing options not currently available to potential solar PV system owners. North Carolina's state energy policy does not allow solar PV system retailers to own and operate a solar PV system on a residential customer's property and enter a contract with that customer to sell only the solar power to the customer, but this kind of a program would attract a new demographic of customers because of the low upfront capital costs and immediate savings. We would intuitively surmise that this legal limitation of retail financing options precludes the average median North Carolina household from being able to access the solar PV market. Additionally, although incentives from utility companies were ranked sixth in importance for solar system owners, these incentives were critical to the financing of fully 75% of PV system owners. Relatively few respondents indicated that a cash grant in lieu of a federal tax credit was an important source of financing, which aligns with the results reported above which indicated a lack of awareness of this incentive program.

Utilization of Energy Efficient Technologies

The survey also inquired whether renewable energy system owners utilized energy efficiency technologies in their homes. The results of these questions are presented in **Table 6** for both solar PV and geothermal system owners. These data provide quantitative support for what one might consider intuitive—that is, individuals who install renewable energy systems are also very likely to utilize available technology, whether high- or low-tech, to reduce the amount of energy consumed.

[16] Easan Drury, Mackay Miller, Charles M. Macal, Diane J. Graziano, Donna Heimiller, Jonathan Ozik, Thomas D. Perry IV. "The transformation of southern California's residential photovoltaics market through third-party ownership." *Energy Policy.* Volume 42: 681-690. March 2012.

Solar PV System Owners' Utilization of Energy Efficient Technologies						
	Total installed at any time (%)	Never considered (%)	Considered but did not install (%)	Installed prior to PV System (%)	Installed at the same time as PV System (%)	Installed after PV System (%)
High-Efficiency Lighting (CFLs or LEDs)	**93**	3.2	4.5	67.1	16.5	8.7
Energy Star Appliances	**91**	3.1	5.4	72.1	15.0	4.4
Attic Insulation	**87**	5.3	7.8	62.9	18.7	5.2
High-Efficiency Heating System	**77**	9.5	13.0	52.6	16.9	8.0
High-Efficiency Cooling System	**76**	9.9	13.4	51.3	16.3	9.1
Duct Sealing and Insulation	**75**	11.1	13.5	55.2	1.2	4.0
Programmable Thermostat	**74**	9.1	17.2	52.2	15.5	6.0
Air Sealing	**72**	16.1	2.73	47.9	18.5	4.8
Low Emissivity Window Treatments	**62**	23.1	14.5	46.3	13.4	2.7
Slab-Edge Insulation	**35**	55.7	9.7	19.6	12.8	2.2

Geothermal System Owners' Utilization of Energy Efficient Technologies						
	Total installed at any time (%)	Never considered (%)	Considered but did not stall (%)	Installed prior to Geothermal System (%)	Installed at the same time as Geothermal System (%)	Installed after Geothermal System (%)
Energy Star Appliances	**93.2**	3.7	3.1	46.9	37.7	8.6
High-Efficiency Heating System	**93.1**	4.4	2.5	10.6	81.6	0.9
High-Efficiency Cooling System	**92.8**	4.4	2.8	10.4	81.1	1.3
Duct Sealing and Insulation	**91.3**	4.9	3.8	21.3	66.9	3.0
Attic Insulation	**88.9**	4.1	7.0	43.5	40.3	5.1
Programmable Thermostat	**88.3**	3.6	8.2	22.7	61.0	4.6
High-Efficiency Lighting (CFLs or LEDs)	**84.4**	7.2	8.5	43.2	26.8	14.3
Air Sealing	**79.4**	10.9	9.7	31.2	42.7	5.5
Low Emissivity Window Treatments	**70.0**	18.7	11.4	32.9	33.5	3.5
Slab-Edge Insulation	**42.6**	52.8	4.7	10.6	29.8	2.1

Table 6. Adoption of Energy Efficient Technologies by Owners of PV Solar and Geothermal Systems Relative to Time of Installation of the Renewable Energy System

Survey responses indicate that with the exception of installing slab-edge insulation, over 60% of respondents had installed the energy efficient technologies about which the survey inquired. For PV system owners, the most commonly installed technologies are high-efficiency lighting, Energy Star appliances, and attic insulation, with each having an adoption rate of over 85%. Most commonly, these technologies were installed prior to the solar PV system. For geothermal system owners, besides their energy efficient heating and cooling system, the

most commonly adopted technologies were Energy Star appliances, duct sealing and insulation, and attic insulation. In contrast to PV system owners, geothermal system owners more often reported installing these technologies at the same time as the geothermal system.

The least commonly adopted technologies were slab-edge insulation and low emissivity window treatments. Interestingly, only 84% of geothermal system owners reported having installed high-efficiency lighting despite 97% and 86% having responded that the cost of electric bills and concern about environmental impact were very or somewhat important motivating factors. The low adoption rate of slab edge insulation likely reflects the fact that this must be done during the construction of the home and so would not have been an option for many respondents.

Interestingly, an average of 16% of responders installed energy saving technology at the same time as installing their solar energy system, and very few respondents indicated installing an energy efficient technology after the installation of their renewable energy system. This indicates that the time a system is being installed is a favorable time to increase the number of energy-saving technologies utilized. Supporters of energy efficiency would thus do well to ensure effective outreach during this critical timeframe. This conclusion is supported by the meta-analysis of Guerin *et al.* which examined 25 years of energy studies and showed increased adoption of energy-saving technologies in response to an incentive or energy audit.[17] One of the studies included in the Guerin *et al*. paper reported that 50% of participants in an energy audit made specific efficiency improvements in their homes after the program; another showed that participation in an energy audit reduced household energy consumption 2.5% more than was reduced by households where an energy audit was not conducted.[18]

Adoption of technologies that promote energy efficiency has the potential to play a significant role in reducing consumption of electricity. The large scale of this opportunity is evident in data showing that, among developed countries, the United States has one of the highest ratios of energy consumption to GDP.[19] The National Academy of Science estimates that adoption of energy-saving technology would reduce by 30% the predicted energy consumption in 2030.[20] A 2009 survey by the National Academies showed that among South Atlantic States North and South Carolina (data is not available for NC alone) have the highest household energy consumption and second highest household energy expenditure per square foot.[21] Furthermore, with its average electricity price 25th lowest in the nation,[22] North Carolina was ranked 26th out of the 50 states and DC for its adoption and implementation of energy-efficiency policies by American Council for an Energy Efficient

[17] Guerin, D.A., Yust, B.L. & Coopet, J.G. "Participants Predictors of Household Energy Behavior and Consumption Change as Found in Energy Studies Since 1975." *Family and Consumer Sciences Research Journal.* 29 (1):48–80. July 2000.

[18] *Ibid.*

[19] America's Energy Future Energy Efficiency Technologies Subcommittee; National Academy of Science; National Academy of Engineering; National Research Council. "Real Prospects for Energy Efficiency in the United States (Report in Brief)." *The National Academies Press.* Washington DC, 2010. http://books.nap.edu/catalog.php?record_id=12621.

[20] America's Energy Future Energy Efficiency Technologies Subcommittee; National Academy of Sciences; National Academy of Engineering; National Research Council. "Real Prospects for Energy Efficiency in the United States (Free Summary)." The National Academies Press Washington, D.C., 2010. http://books.nap.edu/catalog.php?record_id=12621.

[21] U.S. Energy Information Administration, "2009 Residential Energy Consumption Survey: CE1.4. Summary Totals and Intensity, South Homes." Last modified December 14, 2012. http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=consumption

[22] Institute for Energy Research, "North Carolina: An Energy and Economic Analysis." Last modified August 01, 2013. http://www.instituteforenergyresearch.org/2013/08/01/north-carolina-an-energy-and-economic-analysis/.

Economy in its 2009 State Energy Efficiency Scorecard.[23] A study by Duke University and Georgia Institute of Technology demonstrated that improved policies such as incentives for appliances and weatherization could reduce North Carolina's projected residential energy consumption by approximately 10% in 2020 and 16% in 2030, resulting in a savings estimated at $320 per household.[24] Additionally, a report by NC DENR's Energy Efficiency Workgroup demonstrates that the increased adoption of energy efficiency measures can stimulate job growth, foster economic development, and promote domestic energy security.[25] These data underscore the potential for residents of North Carolina to save energy and money by adopting energy efficient technologies and energy-saving behaviors and the need for policies that incentivize this behavior.

The survey also inquired whether system owners engaged in particular energy-saving behaviors. These results are presented in **Table 7**. The data show that solar PV system owners are more likely than geothermal system owners to engage in energy-saving behaviors. For solar PV system owners, the most common energy-saving behaviors are turning off lights when not in use, washing a full load of dishes, and setting the thermostat to 78°F or higher in summer and 70°F or lower in the winter. In contrast, because geothermal systems provide such an energy efficient means of heating and cooling, geothermal system owners were much less likely to adjust their thermostats to more moderate levels. This fact may also explain why 20% of geothermal system owners report using a ceiling fan rarely or only sometimes, as compared to less than 10% of solar PV system owners. The most commonly adopted energy-saving behaviors by geothermal users were washing a full load of dishes, moderating the temperature of the water heater, and turning off lights when not in use.

[23] American Council for an Energy-Efficient Economy, "The 2009 State Energy Efficiency Scorecard." Last modified October 01, 2009. http://aceee.org/research-report/e097.

[24] Brown, Marilyn, Joy Wang, Matt Cox, Youngsun Baek, Rodrigo Cortes, Benjamin Deitchman, Elizabeth Noll, Yu Wang, Etan Gumerman, and Xiaojing Sun. Georgia Institute of Technology School of Public Policy and Duke University Nicholas Institute for Environmental Policy Solutions, "Energy Efficiency in the South: State profiles of Energy Efficiency Opportunities in North Carolina." Last modified April 13, 2010. http://www.nicholas.duke.edu/instituteold/climate/seclimate/EE in the South -North Carolina.pdf.

[25] North Carolina Department of Environment and Natural Resources, "Policy Suggestions to Address Barriers to Energy Efficiency Summary Report." Last modified October 19, 2010. http://www.energync.net/Portals/14/Documents/EnergyPolicyCouncil/11-05-2010_EnergyEfficencyDraftPolicyOptions.pdf.

Energy-Saving Behaviors Adopted by Solar PV System Owners				
	Regularly (%)	Often (%)	Sometimes (%)	Rarely (%)
Turn off lights when not using them	87.1	11.4	1.6	0.0
Wash a full load of dishes	87.3	9.2	2.6	0.8
Set water heater to "normal" (140°F) or "low" (120°F)	85.0	7.4	3.7	4.0
Use ceiling fans	71.8	13.3	9.0	5.9
Set thermostat to 78°F or higher in summer and 70°F or lower in the winter	70.7	13.5	10.4	5.4
Regularly check filters in heating and cooling equipment for changing	70.6	22.0	6.1	1.3
Wash clothes in "cold" (not "warm" or "hot") water	55.9	20.6	16.1	7.4

Energy-Saving Behaviors Adopted by Geo. System Owners				
	Regularly (%)	Often (%)	Sometimes (%)	Rarely (%)
Wash a full load of dishes	84.4	12.1	2.7	0.7
Set water heater to "normal" (140°F) or "low" (120°F)	80.6	9.6	2.8	7.1
Turn off lights when not using them	80.2	17.4	2.4	0.0
Regularly check filters in heating and cooling equipment for changing	71.2	21.5	7.0	0.2
Use ceiling fans	63.3	17.1	11.8	7.8
Set thermostat to 78°F or higher in summer and 70°F or lower in the winter	57.3	15.1	13.6	14.1
Wash clothes in "cold" (not "warm" or "hot") water	47.5	24.8	20.8	6.9

Table 7. Adoption of Energy-Saving Behaviors by PV Solar (PV) and Geothermal (Geo) Systems Relative to Time of Installation of the Renewable Energy System

It is interesting to note that practice of washing laundry in cold water is the least commonly adopted behavior inquired about in the survey. However, up to 85% of the energy used to wash clothes is expended to heat the water, and washing clothes in cold water can save an average of $63/year as compared to washing in warm water.[26] These data suggest that while an economic case can be made for making the switch from hot or warm water to cold water washing, other factors, such as a belief that warmer water is required to properly clean clothes, can act as a barrier to one's adoption of this behavior even if that individual is likely to adopt many other energy-saving behaviors. Similar to the untapped potential to save electricity and money with energy efficient technologies, behavior changes can also save energy and money. While a financial barrier may prevent some home owners from purchasing energy-efficient technology, the adoption of energy-saving behavior can be restricted by a lack of information, a limited awareness of the benefits of saving energy, preconceptions about the negative trade-offs of energy-saving behaviors, and behavioral inertia.[27]

[26] Ottman, Jacquelyn A., Edwin R. Stafford, and Cathy L. Hartman. "Avoiding Green Marketing Myopia: Ways to Improve Consumer Appeal for Environmentally Preferable Products" *Environment: Science and Policy for Sustainable Development*. 48(5): 21-36. June 2006.

[27] Jaffe, Adam and Robert Stavins. "The Energy-Efficiency Gap." *Energy Policy.* 22(10): 804-810. 1994.

Demographics of Renewable Energy System Owners in North Carolina

The responses to the optional questions about demographics help paint a picture of the renewable energy system owner in North Carolina.

Solar PV System Owners

For solar PV systems, the median age range for a system owner is 55-60. The median income range is $100,000-149,999. However, there are 193 missing responses (26% of the population). This is significant enough to create a non-response bias to this question; however, even if all non-respondents were in the lowest earning income level (under $15,000 per year), which is unlikely, the median income would still fall in the $75,000-$100,000 range—well above the median household income of the state ($41,550).[28] Among solar system owners, 56% have post-graduate degrees, while 88% of system owners graduated from a four-year institution. Regarding the racial mix of PV system owners, 95% of system owners who responded to the survey indicated they were white; whereas 1.5% indicated their race as Asian; 1.37% African-American; 1.07% Hispanic; 0.45% Native American; 0.45% "other single race;" and 2.76% were listed as living in a household with 2 or more races. Forty-two (42) respondents indicated that their solar system was located on leased property; of these, 40 indicated that they were the property owner. This corresponds to what we would intuitively surmise—that the land owner, not the lessee would install a renewable energy system.

Geothermal System Owners

For geothermal system owners, the median age is 55-60 and the median income is $150,000-$199,999. Of geothermal system owners, 49% have post-graduate degrees, while 78% of system owners graduated from a four-year institution. Compared to PV solar system owners, the income range is higher but the education levels achieved are slightly lower. Regarding the racial mix of geothermal system owners, 97% of system owners who responded to the question about race indicated they were white; whereas 1 system owner indicated their race as Asian; 3 system owners identified as Hispanic; and 8 responded "two or more races." Three (3) geothermal system owners indicated the system was on leased land; and each of these respondents indicated that they were the property owner.

Conclusions

This survey provides instructive insight into the motivations and behaviors of North Carolina residents who have installed solar PV or geothermal systems. Survey results indicate that financial considerations and incentives, such as federal and state tax credits, are among the most important drivers in individuals' decisions to install a renewable energy system. It is noteworthy that the state and federal tax credits sunset at the end of 2015 and 2016, respectively. An abrupt removal of these incentives could undermine the growth of the solar and geothermal sectors, putting job creation and economic and environmental benefits at risk. A majority of residential North Carolina households lack sufficient tax liability to utilize tax incentives for five consecutive years as a means to overcome the upfront capital cost barrier to using a solar PV system on their property. It could be inferred from these survey results that current state energy policies in North Carolina do not provide a diversity of financing methods and, as seen in other states, this diversity would allow households at

[28] U.S. Census Bureau, "State Median Income." Last modified September 19, 2013. Accessed November 12, 2013. http://www.census.gov/hhes/www/income/data/statemedian/. Reported median is single-year estimate in current dollars for 2012.

lower to middle income levels to also participate in the state's growing solar PV market. Policy makers should carefully consider how to bridge the gap between the sunsetting of these credits and the time required for solar PV and geothermal energy to reach grid parity and/or to compete on a more level playing field with traditional energy fuels and technologies.

There were a number of positive lessons for the renewable sector in North Carolina. First, renewable energy system owners hold a very favorable perception of the process they went through to install their system, including satisfaction with the incentive programs and with the installation companies. Additionally, no obvious points of significant difficulty emerged in responses to questions about the process from learning about options through the installation process and the selling of the renewable energy. A clear majority of renewable energy system owners had already installed energy efficient technologies before or at the same time as installing the system. System owners were also highly likely to engage in energy-saving behaviors, although a few opportunities for increased adoption were evident. Finally, the demographic data collected indicate that the majority of solar PV and geothermal system owners are white, wealthy, and highly educated, indicating that there is a significant opportunity to expand the market for renewable energy systems to a greater diversity of North Carolina residents.

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