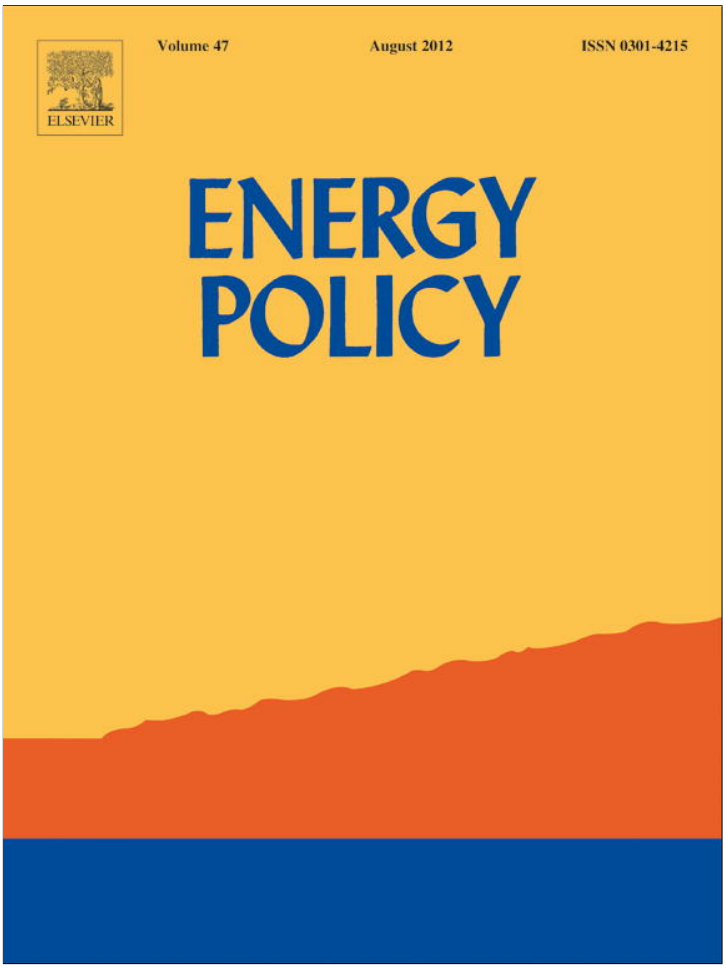

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Consumer responses towards home energy financial incentives: A survey-based study

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HIGHLIGHTS

- We investigated consumer responses to energy efficiency incentives.
- These included tax credits and interest-free loans for six types of energy products.
- We found that tax credits are more effective than interest-free loans.
- The current tax credit rates are insufficient for expensive products (e.g., solar panels).
- A higher amount of incentives is required for the lower-income (< $50 K/yr) households.

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ABSTRACT

Residential energy-efficient and renewable energy (EERE) products play an important role in energy conservation and carbon emissions reduction. Various financial incentive programs have been developed to promote the adoption of these products. However, their effectiveness in attracting consumers is not very well understood. In this study, we investigated impacts of financial incentives on homeowner's decision making towards six EERE products. Two forms of incentives, tax credits and interest-free loans, were examined through a household mailing survey in Florida, the United States. Results showed that, although half of the respondents were interested in EERE products, the high investment cost was a major concern that hindered their purchase activities. Homeowners were attracted to financial incentives and valued tax credits much higher than interest-free loans. The current federal home energy tax credit levels were found to attract only 2–12 percent of homeowners to buy EERE products. The willingness of participation was especially low for the costly products (such as solar panels). The participation rate was also very low for lower income (i.e., annual household income below $50,000) families living in older residences. This study contributes to the understanding of economic and social aspects of consumer decision making on energy efficiency and alternative energy.

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1. Introduction

Home energy consumption has significant impacts on long-term energy conservation and carbon emissions reduction, given that it accounts for a large proportion of total energy use and that it continues to grow (Barr et al., 2005; Benders et al., 2006; Dietz et al., 2009). In the United States (U.S.), the increasing number of households and improved living standards have resulted in nearly doubled usage of home appliances and electronics during the last three decades (EIA, 2011). Such increase in energy demand, if continued, will make energy conservation difficult without improving energy efficiency. It also calls for the adoption of renewable energy resources, such as solar power, to reduce carbon emissions associated with the burning of fossil fuels.

The purchase of energy-efficient and renewable energy (EERE) products is a consumer investment that requires the expected future savings to compensate for the initial investment cost (Gillingham et al., 2009). The higher the investment cost is compared with the perceived amount of savings in return, the lower the chance is for homeowners to buy these products. Even if the return over investment is considered high enough, some people may not be able to invest because they cannot afford it (Steg, 2008). For example, they may not have enough savings and/or income to pay for the purchase and installation.

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Consumer financial incentives promote the adoption of EERE products through either lowering the investment cost (such as through tax credits) or bringing down the initial out-of-pocket payment (such as by loan subsidies). Thus, they are expected to attract people who are interested in EERE products but are bound by their financial constraints. In the U.S., the federal and many state and local governments offer financial incentives for the home adoption of EERE products (http://energy.gov/savings). For example, the 2011 federal tax credits program offered credits at 30 percent of cost (with no upper limit) for qualified solar panels and solar water heaters; credits at 10 percent of cost (up to $500) for qualified house insulation; and credits at specific amounts ranging from $50 to 300 for some qualified heating and air conditioning systems.

However, it is not very clear whether these financial incentives are effective in terms of attracting consumers. In particular, research rarely investigates how the design of home energy incentives (such as types and amount of incentive to be applied) may help increase the rate and range of participation. To fill this research gap, we designed a household survey that aims at understanding consumer responses towards tax credits and interest-free loans for several commonly-available EERE products. We were particularly interested in the following research questions: (1) which type of incentives is more attractive to homeowners for the purchase of EERE products? (2) How much tax credit is needed for homeowners to make such purchase? And (3) what are the relationships between those responses and people's demographic, socioeconomic, and behavior characteristics. Our research contributes to public policies that facilitate the increasing adoption of EERE products, which in turn benefit energy conservation and carbon emissions reduction.

2. Research background

2.1. Barriers for adopting EERE products

Energy-efficient products refer to those requiring less energy input than the inefficient alternatives for a given energy service (Gillingham et al., 2009). Renewable energy products utilize energy harvested from renewable energy resources such as sunlight, wind, and geothermal heat. For homeowners, renewable energy products may be solar electric or photovoltaic systems, wind electric systems, and other energy generating systems at small scales (Verbruggen et al., 2010). The reduction of home energy consumption through using EERE products is normally associated with long-term alterations to the structure and/or appliances of a dwelling unit, for example, replacing incandescent light bulbs with compact fluorescent light bulbs. It is different from energy curtailment, which is defined as reducing energy use through habitual changes such as turning off lights when they are not in use (Barr et al., 2005).

A variety of social and economic issues hinder the adoption of home EERE products. Among the top influential barriers is the investment of purchasing these products (Steg, 2008). For example, evidence from a study of consumer attitudes towards solar power systems in the United Kingdom demonstrated that high purchase prices are a major obstacle to solar panels adoption (Faiers and Neame, 2006). In addition, the energy-efficient models of many commonly-owned home appliances (such as refrigerators, washers, and driers) are usually more expensive than their lower-efficiency rivals that are identical in all other aspects (Brown, 2001).

Besides the purchasing price, other factors contributing to energy-efficiency gap may also delay the adoption of EERE products. Energy-efficiency gap refers to the fact that the technically achievable level of energy efficiency fails to happen in reality (Hirst and Brown, 1990; Jaffe and Stavins, 1994; Koopmans and Velde, 2001). For example, the perception about possibility of drops in utility price may lower the estimated potential savings associated with the usage of EERE products, and hence decreases the chance of purchase (Hirst and Brown, 1990). The underestimate of saving potentials through using EERE products, plus the time and effort needed for researching these new products, may have also discouraged purchases (Attari et al., 2010; Dietz, 2010). The conflict of interests between home builders (who tend to minimize the short-term construction cost) and home buyers (who tend to maximize the long-term overall energy savings) further complicates the decision on whether to use EERE products when building a house (Jaffe and Stavins, 1994).

2.2. Home energy financial incentives

Home energy financial incentives are distributed in different forms, such as tax credits, purchasing rebates, and loan subsidies. In the present study, we focused mainly on tax credits and interest-free loans (a form of loan subsidies). Mixed results have been reported about consumer preference for these financial incentives. For example, several studies in the 1980s indicated that people were not very interested in loan subsidies (including interest-free loans) due to indebtedness concerns (Stern et al., 1986). However, a more recent study suggested that zero-interest loans were effective in terms of attracting consumers to buy high-efficiency refrigerators (Revelt and Train, 1998).

The contradictory patterns of consumer responses may result from design differences across survey instruments. Many previous studies were limited to only one type of product; in other words, research dealing with questions about refrigerators did not bother with air conditioners or solar panels (Faiers and Neame, 2006; Meier and Whittier, 1983; Ward et al., 2011). Studies aiming to establish general patterns usually focused on comparing curtailment activities and efficiency approaches; therefore, only a few energy-efficient products (such as light bulbs and appliances) were included as examples (Attari et al., 2010; Barr et al., 2005; Benders et al., 2006).

Demographic and socioeconomic characteristics have been documented to influence decision making towards different financial incentives. For example, high-income households tended to select tax credits and loan programs (Dubin and Henson, 1988; Faberi et al., 2001; Long, 1993; Pitts and Wittenbach, 1981; Stern et al., 1986). Previous studies also suggested the important role of lifestyle and cultural characteristics in energy conservation (Abrahamse et al., 2005; Arpan et al., 2010; Lutzenhiser, 1993; Sardianou, 2007). Some argued that consumers who are more environmentally conscious may not actively seek to improve energy efficiency because they can save energy through curtailment activities (Faiers and Neame, 2006). Nevertheless, behavior variation is seldom explicitly accounted for in quantitative models of how financial incentives affect choices on energy efficiency and renewable energy.

In this study, we used a survey that included different types and amounts of incentives for a variety of EERE products, in order to compare effects of various financial incentives consistently. The rationale is that the base price varies greatly by product categories; appliances such as refrigerators, costing hundreds of dollars, are much cheaper than some home modifications (such as installing solar panels) costing tens of thousands of dollars. The gross investment cost (before deducting incentives) and the size of incentives are both potential factors that influence the attractiveness of incentives. In addition, both socioeconomic and behavior characteristics were considered in our statistical models of survey responses towards home energy financial incentives.

We used several variables to represent consumer's behavior characteristics. These include the count of curtailment activities being practiced at home, whether the house has been audited for energy efficiency, and sources of social pressure for home energy improvement.

3. Survey and analysis

We designed a household survey questionnaire (http://myweb.fsu.edu/tzhao/zhao_EnergySurvey.pdf) that sought people's responses towards tax credits and interest-free loans for six types of home EERE products. To relate these responses to socioeconomic and behavior characteristics, we asked questions about respondent's demographic information, housing characteristics, and energy conservation behavior. Four thousand mail questionnaires were sent to residents of Leon County, Florida, during the time period between November, 2010 and January, 2011. Leon County is home to Florida's capital city, Tallahassee. The demographics of Leon County are diverse in terms of ethnic groups, household income, education level, and household size. They resemble the nation's characteristics in many ways except that the ratio of African Americans and that of college/post-college graduates is higher. The completed surveys were integrated with geographic information systems (GIS) data. Descriptive analyses and ordinal regression models were performed on the finalized dataset, which included only respondents from the single-family owner-occupied residences and excluded observations with missing data.

3.1. Survey questionnaire

The survey was composed of four major areas. The first component examined the financial incentives needed for one to consider purchasing EERE products. These products included solar panels, solar thermal pool heaters, products used to improve house insulation, high-efficiency heating and air conditioning systems, Energy Star appliances, and programmable thermostats. For each of these products, the respondent was asked to indicate the minimum amount of tax credits required that would compel them to make a purchase. The tax credits were listed by 10 percent increments, ranging from 10 to 60 percent of the purchase price. Alternatively, the respondent could choose "Not Applicable" or "No interest", if they were not able to adopt this product or not interested in it regardless of incentives. Respondents also rated the likelihood of purchasing these products if an interest-free loan were available, using the scale of "Very Likely", "Likely", and "Not Likely".

The second component addressed behavioral characteristics of the respondents in the area of energy conservation. One question asked whether the respondent practices a number of energy curtailment activities. A question recorded the respondent's sources of information regarding energy efficiency. A question dealt with the sources of pressure for energy saving, i.e., whether the respondent would consider energy conservation if it is recommended to them through personal relationships (such as through families, friends, and co-workers) and outside sources (such as their homeowner association, elected officials, and utility company representatives). Additionally, we asked about their opinions on a number of factors that could influence the purchase of EERE products. These factors included the investment cost of products and their installation, the availability of tax credits, access to financing programs, the amount of savings, their enthusiasm for cutting-edge technology, and if they supported environmental protection.

The last two survey components captured respondent's demographic and housing characteristics. Questions on demographic conditions included gender, age, ethnic group, education level, household size, the number of children living in home, and household income as of the year 2009. Questions about the respondent's residence included the primary type of fuels that are used for cooking, space heating, and water heating, their primary method for space cooling, and the estimated monthly electricity and natural gas bills. In addition, we asked whether the respondent's residence had been through any home energy audit.

3.2. Survey deployment

The survey questionnaires were mailed to 4000 randomly selected residences from Census block groups where at least half of the total housing units were owner-occupied according to the 2009 Census estimates. Geographic units were constrained for sample selection to minimize the chance of selecting apartment and home renters, since most of the surveyed home energy improvements are applicable to homeowners only. Previous research has indicated that, for the leased apartments or homes, landlords are reluctant to invest in appliances and other home features that save energy on their tenants' bills. Meanwhile, tenants tend not to invest in home energy products for which they have no long-term benefits (Sovacool, 2009). The Census housing-unit estimates came from Nielsen Claritas demographic estimates (Nielsen, 2009b). Nielsen Claritas provides a number of population and housing estimates every year at various geographic scales used by the decennial U.S. Census. The 2009 product follows the Census 2000 attribute categories, and provides demographic estimates for 2009 based on estimates for the previous year and new construction data (Nielsen, 2009a).

The residential mailing addresses came from a Tallahassee-Leon County GIS database. They were stored in a point data file that contains geographic coordinates, residence site address, owner mailing address, and other residence information extracted from the county's Property Appraiser's Office (such as type, age, and square footage of the residence). This point data file was compiled before our survey. It was the best available geocoded address dataset at the time of our study. It was also considered the most reliable source of deliverable mailing addresses since it was carefully checked for mail delivery of the Census 2010 survey (Weisman, 2010). For our study, we used the residence site address to ensure that all responses refer to the decision making for homes in Leon County, Florida.

3.3. Analysis of data

We received 564 returned survey questionnaires. Excluding renter-occupied residences (88 households) and non-single family houses (56 households), the number decreased to 437 residences. The response rate was low for some of the questions; for example, in 124 of the 437 returned questionnaires respondents did not reply to the question about their monthly natural gas bill (even though they were given the options to circle "Not Sure" or "Not Applicable"). We excluded those questions from further analyses to minimize the loss of observations for statistical models due to missing data. Then, observations with missing data values for the remaining questions were removed. The final dataset was composed of 320 observations. Descriptive statistics, such as frequency analysis and bar charts, were examined for individual variables based on these 320 observations.

Ordinal regression was used to model the relationships between reactions towards incentives and demographic, housing, and behavior characteristics. For each of the six EERE products, a regression model was built with regard to tax credits and

interest-free loans separately. Therefore, in total, twelve ordinal regression models were constructed. For responses towards tax credits, the dependent variable was the amount of tax credits measured as the percentage of purchase price in the order of 10, 20, 30, 40, 50, and 60 percent. For responses about interest-free loans, the dependent variable was the likelihood of making a purchase in the order of very likely, likely, and not likely. The ordering of these dependent variables naturally leads to analysis using ordinal regressions with either logit or complementary log–log transformation. The independent variables for this analysis included factors (such as income level, ethnic group, education level, whether the residence has been audited for energy efficiency, and whether energy conservation is driven by personal relationships and/or outside pressure) and covariates (such as household size, number of children living in home, building age, square footage of residence, and the count of conservation curtailment activities). The income variable was re-grouped to two categories, annual income equal to or less than $50,000 vs. those above $50,000, to ensure the adequate number of observations in each group. The $50,000 threshold was selected given that the median annual household income was estimated to be $48,000–51,000 for the nation, Florida, and Leon County in 2009 (Nielsen, 2009b). A bivariate correlation analysis was performed on independent variables and only the less correlated ones (Pearson correlation $-0.5 < r < 0.5$) were retained as independent variables for the ordinal regression models (Belsley et al., 1980; Cohen et al., 2003).

4. Results and discussion

4.1. Respondent's characteristics

The demographic profile indicated that the survey respondents were mainly white, well-educated, and in the upper middle age. Approximately 78 percent of the respondents held a college or graduate degree, a ratio much higher than the state or nation's statistics (which were around 20 percent). The mean age of respondents was approximately 54 years old. Our sample, through retaining only single-family homeowners due to the nature of survey, must have precluded younger people who tend to rent. Therefore, the age of our sample was greater than the county, state and national average.

The sample covered the entire range of income levels, which were identical to categories used in the decennial U.S. Census. Compared to the county's income distribution, the lowest groups (i.e., annual household income lower than $35,000 in 2009) were moderately underrepresented and the highest (above $150,000) were slightly overrepresented. In terms of household size, the sample well represented Leon County and followed closely to the distribution of that variable for Florida and the United States. More than 65 percent of the respondents did not have children living in their residence at the time of this survey. Only a small number of large families, which have more than four children, participated in this household survey.

4.2. General responses to EERE products

The survey responses indicated that homeowners were generally interested in EERE products. For each of the six products, at least half of the survey respondents expressed their interest when the adoption is applicable to their homes (Fig. 1). The level of interest, however, varied by the types of products. Solar thermal pool heaters (53.6 percent of the eligible homes) and solar panels (69.3 percent) attracted the least number of respondents, whereas

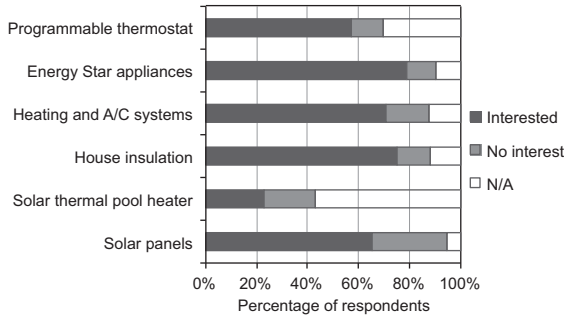

Fig. 1. Percentage of respondents interested (or not interested) in the adoption of each EERE product.

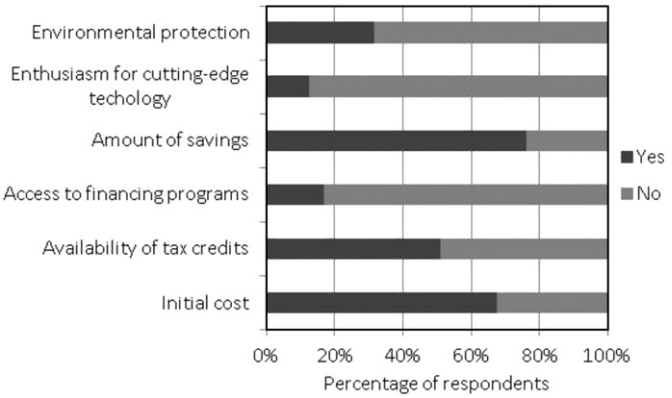

Fig. 2. Factors that influence respondent's decision making on the purchase of EERE products.

the remaining four types appeared to draw a greater amount of interest (> 80 percent of the eligible homes).

Our survey included a question to capture factors influencing the purchase of EERE products (Fig. 2). This sheds some light on the varying amount of interest towards different types of products. According to our survey, approximately 76 percent of respondents expressed that the amount of savings was a major factor contributing to their decision-making on home energy efficiency improvement. Additionally, 67.5 percent regarded the investment cost of products as an influential factor. Both were leading factors chosen by survey respondents. This indicates that people tend to avoid high-priced EERE products, such as solar panels that may cost $10,000–20,000. A solar thermal pool heater is cheaper than solar panels, but may still cost $3000–4000. An expensive solar thermal pool heater may not seem to be worth the investment, since it will not be used very often in the subtropical climate in Florida.

4.3. Homeowner responses to tax credits

According to the survey, approximately half of the respondents indicated that the availability of tax credits is an important factor influencing their decision-making on whether to purchase EERE products (Fig. 2). While many people sought higher rates of tax credits, the amount of such financial stimulus required for each type of products differed substantially (Fig. 3). The purchase of programmable thermostat and Energy Star appliances needed a small amount of tax stimulus. Approximately 50 percent of respondents said that they would make a purchase of these products at the 30 percent tax credit rate. House insulation, high-efficiency heating and air conditioning system, and solar thermal pool heater were associated with the intermediate level of tax stimulus. One out of four to five (i.e., 20–25 percent) survey

respondents would make these purchases at the 30 percent tax credit rate. Homeowners need a large amount of tax stimulus to purchase solar panels. Only approximately 12 percent of survey respondents indicated that they would consider adopting solar panels at the 30 percent tax credit rate. Even if consumers were to get half of their investment back through tax credits, only 41 percent of the survey respondents said that they would consider purchasing solar panels.

Our analyses indicated that the current level of tax credits offered by the federal program is insufficient to attract homeowners for the adoption of EERE products. Participation rate was expected to be about 12 percent for solar panels at the 30 percent level provided by the 2011 federal tax credits program. It was expected to be around 3 percent for home insulation at the 10 percent level offered by the 2011 federal tax credits program. A qualified central air conditioning system was eligible for $300 federal tax credits in 2011. This was equivalent to approximately 10 percent of the cost for adding central air conditioning to an existing forced-air heating system in a small- to mid-sized house (http://home.costhelper.com/). At this level of tax stimulus, the participation rate was expected to be about 2 percent based on our survey.

4.4. Who pursues a higher amount of tax credits?

Regression analyses showed that the lower-income families tended to seek higher tax stimulus than their counterparts for all six types of EERE products (Table 1). The odds ratio in relation to income was extremely high (approximately 410) for solar panels.

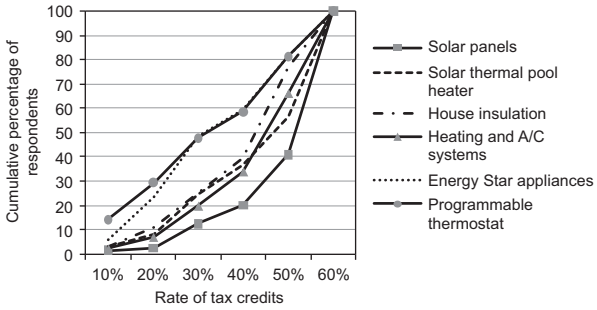

Fig. 3. Cumulative percentage of respondents who would purchase each EERE product at a given amount of tax credits.

This means that the odds of selecting a greater minimum tax credits for a lower-income family (annual household income $<$$50,000) to install solar panels are about 410 times what they would be for a higher-income family. Similarly, the odds of a lower-income resident pursuing a greater rate of tax credits are very high for the heating/air conditioning systems (approximately 21) and home insulation (approximately 13), compared to those whose annual household income was above $50,000.

Results also indicated that owners of older homes were inclined to require a greater amount of tax stimulus to make EERE purchases (Table 1). Each ten year increase in the age of a home would boost the chance of seeking a higher amount of tax stimulus by 16–17 times for the adoption of solar panels, high-efficiency heating and air conditioning systems, improved home insulation, and solar thermal pool heater.

An increased number of curtailment activities appeared to be associated with greater odds for pursuing a higher rate of tax credits (Table 1). Residents who had their homes audited for energy efficiency also tended to seek a higher rate of tax credits. These indicate that people who are conscious about energy conservation still prefer tax stimuli to make energy efficiency improvements. Finally, for most products, the encouragement from personal relationships appeared to be more effective than outside pressure in persuading the adoption of home EERE products. It should be noted that the count of curtailment activities, whether the house has been audited for energy efficiency, pressure from personal relationships, and pressure from outside sources were barely statistically significant in most of our regression models.

4.5. Effects of interest-free loans

The accessibility to financing programs was valued the least important among all factors ranging from bank savings to environmental protections (Fig. 2). Only 17 percent of the respondents considered it a factor for home energy efficiency improvement. None of the ordinal regression models were statistically significant with the set of independent variables generated based on our household survey. This indicated that factors other than income level, household size, and house age etc. contributed to people's decision making on whether to take interest-free loans for EERE products.

The frequency analysis showed that, provided with interest-free loans, a higher percentage of respondents (above 50 percent)

Table 1
Odds ratios for ordinal regression models (*Curtail count*: number of energy curtailment activities in practice at a respondent's home; *Bldg age*: age of a respondent's residence; *Personal*: whether the adoption of energy efficiency is influenced by personal relationships such as family, friends, and coworkers; *Outside*: whether the adoption of energy efficiency is influenced by outside resources such as homeowner association, elected officials, and utility company representatives; *Audited*: whether a respondent's residence has been audited for energy efficiency).

		Solar panels[a]	Solar pool heater[a]	Insulation[a]	Heating/AC[a]	Energy star[b]	Prog. thermostat[b]
Model fitting	Sig.	0.001*	0.056	0.000*	0.000*	0.000*	0.011*
	Nagelkerke *R*-square	0.130	0.195	0.158	0.124	0.126	0.108
Odds ratio[c]	Household size	1.504	1.390	2.153*	2.188*	1.197	1.002
	Curtail[d]count	1.778	1.431	1.410*	1.735	1.052	0.849
	Bldg age	1.674*	1.631*	1.675*	1.678*	0.984*	0.987
	Income $<=$$50K	410.551*	7.007	12.960*	20.822*	3.745*	3.838*
	Personal: yes	1.432	1.788	1.552	1.417	1.345	1.375
	Outside: yes	1.332	6.989	0.726*	1.715	0.735	0.613
	Audited: yes	3.360	4.695	2.317	2.141	1.856*	1.583

[a] The complementary log–log transformation was used.
[b] The logit transformation was used.
[c] The odds ratio was calculated based on coefficients of the ordinal regression models.
[d] The surveyed energy curtailment methods included eight activities, i.e., thermostat set to 78 °F or higher in summer, thermostat on water heater set to 120 °F or below, using ceiling fans, cold-water dish rinse, minimizing usage of dishwasher, cold-water laundry, line-drying of laundry, and turning off lights when not using them.
* Sig. $\leq$ 0.05.

were not likely to purchase solar panels or solar thermal pool heaters than to purchase other products (Fig. 4). This again implies the large investment cost may be a barrier for the adoption of expensive EERE products. Other concerns such as the unfamiliarity or doubts regarding the necessity of using these products may also contribute to the low rate of interest (Faiers and Neame, 2006).

4.6. Future work

A limitation of this study is that the above results were drawn based on a survey conducted in a county with a rather small population. While it helps us to understand people's behavior locally, it may not well represent the State of Florida or the entire nation. Also of a concern is the low response rate of the present survey. Improved sampling and survey deployment strategies, such as using phone interviews, shall be developed in future research. The major contribution of this work is to demonstrate an effective approach, i.e., the survey instrument and analyses used in this study, for understanding people's responses towards home energy financial incentives. This approach may be applied to larger geographic areas so as to identify broader patterns of decision-making towards home energy efficiency and renewable energy adoption. Results based on empirical studies are useful inputs for models that simulate household energy decision making (Horner et al., 2011; Zimmerer, 2011) and for evaluation of environmental impacts (Zhao et al., 2011).

5. Conclusion

Society is becoming increasingly aware of benefits associated with an increasing adoption of EERE products, which include extending the supply of fossil fuels, increasing energy independence, and reducing emissions (Loughran and Kulick, 2004). In addition, from the household's perspective, improving energy efficiency also means saving on energy expense in the long run (Sanchez et al., 2008). However, not many homeowners have made purchases to improve energy efficiency, nor have they widely adopted renewable energy resources for their homes (Dietz et al., 2009; Whitmarsh et al., 2011).

Our study confirmed that the concern about high investment costs is among the top barriers for the adoption of EERE products. Homeowners value the availability of financial incentives regardless whether they are conscious about energy conservation. They are more inclined to take tax credits than interest-free loans, which may be attributable to the fact that tax credits reduce the actual cost of purchase. In addition, the economic downturn beginning around 2008 may have reduced consumer willingness to borrow money for non-essential home products.

Our study contributes directly to public policies regarding energy conservation and clean energy adoption. We found that the current U.S. federal home energy efficiency tax credits program is not very effective in terms of attracting consumers. In order to boost the adoption of EERE products, a higher level of federal tax stimulus and/or supplements from state's or local funds are needed. Financial incentives that help industries and business to reduce the manufacture costs may also promote consumer EERE purchase through lowering the market price of those products (Brown, 2001). For example, giving tax credits or loan subsidies to home builders may reduce construction cost of energy-efficient residential buildings. The ineffectiveness of consumer energy incentives also calls for non-financial alternatives, for example, energy efficiency labeling. Consumers may be more inclined to purchase EERE products, if they are well-informed about the energy saving potentials of these products as well as potential savings of their long-term energy bills (Dietz, 2010). Other approaches, such as increasing building code standards and improving public awareness of energy conservation, may also promote the adoption of EERE products.

Our analyses also indicated that a higher rate of tax credits is needed especially for expensive products such as solar panels, and that a greater amount of tax credits is required to draw interests from lower income families and/or people living in older houses. Successful tax incentives need to be tailored to feature different types of products and fit different kinds of homeowners. Our study provides quantitative references for tuning the amount of tax credits according to the socioeconomic conditions of homeowners or by types of products, if such policy modification is desired in the future.

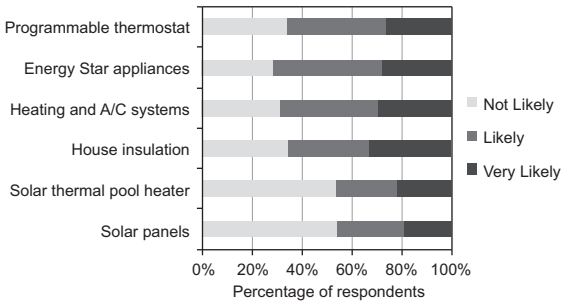

Fig. 4. Likelihood of respondents to take interest-free loans for each EERE product.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.enpol.2012.04.070.

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