The Pennsylvania State University

The Graduate School

College of Engineering

A HOMEOWNER ASSESSMENT TOOL SUPPORTING HOME ENERGY AUDITS

A Thesis in

Architectural Engineering

By

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

May 2012

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ABSTRACT

The growth in residential energy consumption is an increasing problem in the U.S. from both environmental and economic standpoints. Interventions have been put in place by federal, state and local institutions to target near-term home energy reductions through the use of available technologies and shifts in homeowners' behavioral habits. In the realm of these interventions, home energy audits have a promising potential to foster the implementation of energy-saving measures by providing personalized recommendations adapted to the specific state of the homes. Insights from behavioral sciences research suggest that a better understanding of the factors influencing homeowners' decisions to perform energy-saving measures can assist auditors in their interaction with the homeowners and increase the uptake of these measures. This research aims to formalize and embed the assessment of these factors in the energy audit process.

An intake survey was developed to assess homeowners' knowledge, motivation, and skills with regard to the performance of home energy improvements and the adoption of conservation behaviors. A scorecard was also created to present the results of the survey to the auditors prior to their home inspection. The survey was tested with customers of two auditing firms. Observations were made by the researcher on the administration of the tool and the management of the data. Feedback was collected from the participants on the design of the survey. The researcher's observations and the participants' feedback helped define some guidelines for future iterations of the survey. The feedback collected from two groups of energy auditors confirmed that the tool could aid them in their interventions and their interactions with the homeowners. This feedback also indicated additional work needed to facilitate the integration of the survey in the audit process and improve the usability of the information collected for the auditors.

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1.1 Background

1.1.1 Fostering Home Energy Conservation: New Challenges

In the United-States, the residential building sector accounts for about 17% of the country's greenhouse gas emission (EPA 2011) and about 23% of its energy consumption (EIA 2011). Policy approaches to cut the nation's energy use and reduce its carbon footprint, and building codes that reduce energy mainly for heating and cooling by increasing buildings' envelope insulation and airsealing, still need to overcome technical, economic, institutional and societal issues that delay the apparition of tangible effects (Gardner and Stern 2008). New technologies for energy efficiency and low CO2 emissions will need time to penetrate the market. Interventions targeting near-term home energy reductions through altered homeowners' behaviors and the use of available technologies have a promising potential for augmenting and complementing the deployment of policies and building codes, and the development of new energy-efficient technologies (Gardner and Stern 2008). Interventions of this type have been put in place by federal, state and local institutions, utility companies and private businesses, with the intent to encourage a broad range of households to take action in their home to conserve energy and make improvements that will stimulate the energy efficiency industry (e.g. DOE Weatherization Assistance Program, Bonneville Power Administration weatherization programs cited in Hirst et al. 1983). Information campaigns have been implemented broadly to raise people's awareness about their energy consumption and measures they can take to reduce energy costs (e.g. conservation programs run by the California Public Utility Commission cited in Condelli et al. 1983). Financial incentives have also been created to alleviate the cost of home energy retrofits and encourage homeowners to save energy (Keystone HELP program, PA; Clean Energy Works Oregon, OR).

Despite those efforts, there is limited success to date to motivate American households to invest in comprehensive home energy improvements (Fuller et al. 2010). Current programs fail to provide adequate support to translate households' awareness and motivation into energy-saving actions, and maintain their engagement. Homeowners belong to a wide segmentation of demographic and belief systems and respond differently to specific appeals to reduce their energy consumption (Shelton Group 2011). Behavioral science research over the last three decades provided some insights into the determinants of pro-environmental behavioral change, including energy conservation, and behavioral strategies to influence individuals' engagement in pro-environmental actions (Abrahamse et al. 2007; De Young 1993; Fischer 2008; Gonzales et al. 1988; Lutzenhiser 1993; Stern 1992; Van Raaij and Verhallen 1983). At the same time, new approaches for energy conservation programs turned to the determinants of behavior changes and the use of behavioral strategies to influence individuals' engagement in energy conservation (e.g. Community Energy Challenge, WA, presented in Collins and Davies 2011; Energy Smackdown, MA, cited in Fuller et al. 2010; Take Charge Challenge, KS, cited in Fuller et al. 2010). Integrating the lessons learned from research on behavioral strategies in the process of energy audits may be useful to improve their effectiveness.

1.1.2 The Case for Home Energy Audits

Home energy audits are an important and representative example of intervention targeting near -term home energy reductions. During a typical energy audit, an auditor visits a home to diagnose its conditions, characterize it, and offer the owners energy-saving recommendations based on the house characteristics. The homeowner-auditor interaction is an important element of the success of this type of intervention in translating into energy-saving actions (Fuller et al. 2010; Parnell and Popovic Larsen 2005). Home energy audit programs have the incentive and potential to tailor this interaction to homeowners' individual characteristics because of their individualized attention to the homeowners. As a result, homeowners can receive specific and personalized information that is more likely to influence and guide their decision.

Professional energy audits can be valuable for identifying large-scale home energy improvements. They can be, however, time consuming and costly to perform, as informal discussion with energy auditors from the Mark Group and Envinity revealed. A survey of accredited Residential Energy Services Network rating providers (RESNET certified auditors) revealed that the average cost of RESNET home energy performance ratings across the nation was $413 (RESNET 2009). Moreover, energy audits reach a small fraction of the housing stock. About 100,000 homes are serviced per year by auditors from the Department of Energy Weatherization Assistance Program and one million of homes have been assessed through RESNET since 2005 (Department of Energy 2010; RESNET 2011). The number of audits will need to increase to reach the 111 millions of homes of the U.S. housing stock (Buildings Energy Data Book, DOE Energy Efficiency and Renewable Energy).

Discussion with Envinity and Mark Group auditors also indicated that energy audits are sometimes not profitable in themselves for specialized audit-contractor firms if they do not result in the performance of construction services to complete energy upgrades. New models of energy audits that differ by their comprehensiveness and the workforce qualifications they require have started emerging as lower cost alternatives to traditional comprehensive audits. For example, the Mark Group offers one-hour free walk-through audits as a substitute to a comprehensive three-hour audit which costs $450. In the years of 2009 and 2010, the nonprofit energy services company Vermont Energy Investment Corporation launched a community program training volunteers to conduct walk-through audits in the residences of their community.

The traditional process of home energy audits involves a physical monitoring of the house. It sometimes adds occupancy satisfaction questionnaires. Relating quantitative and qualitative feedback is rarely performed because it requires inputs from both building sciences and social sciences that most of the current audit tools and professionals do not apply as a system (Stevenson and Leaman 2010) . As a result, the home energy analysis and the recommendations made by energy auditors are mostly based on

the technical assessment of the house and may fail to address the diversity of homeowner perceptions, lifestyle and aspirations.

Surveying or interviewing homeowners can help define their needs, expectations and motivation which may in turn help determine the type of energy efficiency and conservation behaviors that would be the most suitable to the homeowners' situation. They can also serve as indicators to frame retrofit recommendations in a way that aligns them with aspirational goals or perceived objectives of homeowners and make them more achievable or palatable. For example, energy conservation measures may be implemented for reasons other than energy savings such as improving the aesthetic of the house, increasing resale value, increasing comfort, and achieving energy independence (Feldman 1987). Thus, the decision to emphasize the financial or the non-economic benefits greatly depends on the audience. Though saving money would be considered by energy experts as a rational reason for investing in energy efficiency, homeowners' choice of energy-efficiency measures does not seem to follow the same rationality. Understanding how they make decision can improve the message of energy audits (Feldman 1987).

Behavioral science research is needed to re-tool existing energy audit processes. The contribution of behavioral science to the design of state and utility energy conservation programs has already been studied, though there is room for expanded research in this field (Condelli et al. 1983; Craig and McCann 1978). More research is needed to determine how to best integrate behavioral science insights to sustainable and market-driven home energy audit practices (Friedrich et al. 2010). Researchers in the social science have highlighted that interventions tailored to homeowner's profile and situation are more likely to influence individual's decisions to follow through the recommendations (Abrahamse et al. 2007). Tactics such as generating enthusiasm about weatherization by showing its positive effects on the economy, advancing customers' awareness about their energy consumption, comparing their behavior to their peers, or increasing the perceived ease of an action can be directly extrapolated from state and utility campaigns to professional home energy audits (Friedrich et al. 2010).

1.2 Problem Statement

Homeowners' behavioral characteristics are key factors that can influence the evaluation of household energy consumption and the design of energy-saving recommendations. Indeed, households' energy consumption is not just a function of the physical characteristics of their homes but also a function of the behavior patterns of the individuals and the decisions they make for home energy improvements. Homeowners' behavioral characteristics have the potential to provide valuable information for energy auditing programs because they can improve the auditors' understanding of the market and help them frame their interventions and recommendations in a way that will best resonate with their customers. Thus, an individual-centered approach may improve the effectiveness of home energy audits and increase the uptake of energy efficiency and conservation measures. This approach can benefit the energy auditing industry by saving time and money on the implementation of comprehensive evaluations that do not meet homeowners' needs or expectations.

However, despite these benefits, exploratory field observations made by the researcher through an internship with an auditing firm and informal discussions with professional energy auditors showed that energy auditors are still unfamiliar with this approach. They lack the background and means needed to assess homeowners' behavioral characteristics and incorporate this assessment in their current practices.

1.3 Research Hypothesis

A homeowner intake survey can be developed to adequately assess homeowners' knowledge, motivation, and skills to make energy effective changes to their home and lifestyle.

1.4 Integrating an Individual-Centered Approach in the Energy Audit Process

1.4.1 Understanding the Homeowner

Lessons learned from previous energy conservation programs and insights from the behavioral sciences highlight the need to profile U.S. households by energy conservation objectives, knowledge, motivation and skills. Assessing this information can help energy auditors:

- Understand the mindset of the homeowners with regard to energy conservation
- Situate the homeowners on their path towards energy-efficiency and learn about the obstacles and opportunities they experience
- Understand homeowners energy-efficiency priorities and what criteria they think influence them in their decision (e.g. comfort, financial savings, or the environment)
- Ultimately design audit feedback that resonates best with the homeowners and assist them down the path towards energy-independence.

1.4.2 An Information-Motivation-Behavioral Skills Assessment of Energy-Saving Behaviors

The Information, Motivation, and Behavioral Skills (IMBS) model was proposed in this research as a conceptual framework of the determinants of homeowner's energy-saving behaviors. The IMBS model includes three predictors of behavioral change: information relevant to the behavior, motivation towards the adoption of the behavior, and behavioral skills for performing the said behavior (Fisher et al. 1999). According to the IMBS model, an individual who is well-informed, motivated to act, and possesses the appropriate behavioral skills to engage in a specific behavior is expected to engage in this behavior. These three predictors encompass the main psychological variables influencing environmental behaviors frequently found in the literature such as variables found in the Theory of Planned Behavior (TPB) and the Value, Belief, Norm (VBN) theory (Bamberg and Möser 2007). This model of behavior change was applied to understand and conceptualize the range of factors that predict personal health behaviors (Fisher and Fisher 1992; Fisher et al. 1999).The IMBS model can be applied to frame and assist home energy audits. Based on the initial assessment of the homeowner's IMBS, the auditor can determine and address the lacking components of an optimal or near optimal state where the homeowner will be the most likely to engage in energy-efficiency and conservation behaviors.

1.5 Research Goal

This exploratory research is aimed at the formalization, standardization, and embedment of the assessment of homeowners' Information, Motivation and Behavioral Skills profile in the process of the home energy audits.

Chapter 2
Literature Review

2.1 Introduction

The residential housing sector has been identified as a significant contributor to global energy use and greenhouse gas emissions (EIA 2011, EPA 2011). Poor considerations for energy efficiency in the design of the houses and lack of energy awareness among buildings' occupants have triggered the development of energy conservation programs at multiple levels. Those programs are aimed at improving the energy performance of residential buildings by fixing existing issues and implementing new energy-efficient technologies, as well as educating and motivating homeowners to adopt energy-conscious behavior patterns. Despite these efforts and the pressure of increasing energy costs, no significant reduction in residential energy consumption has been observed in the last five decades (EIA 2011). Faced with this challenge, new considerations have been given to integrate behavioral sciences insights and strategies in the development of energy conservation programs. Research on this topic showed promising results and highlighted important determinants of individuals' energy-related behaviors (Abrahamse et al. 2005; Fuller et al. 2010; Lutzenhiser 1993). However, more research needs to be done to integrate this multidisciplinary approach into energy auditors' current practices.

The present literature review is an investigation into the challenges facing the energy efficiency industry, and more specifically the energy auditing sector, with fostering energy-saving measures and behaviors at home. It investigates traditional energy audit practices, as well as new promising forms of energy audits and tools that have emerged from the combination of technology progress and inputs from behavioral sciences. This literature review also investigates the contribution of social science and pro-environmental psychology to the design of home energy audits. It presents one model of behavioral change, the Information, Motivation and Behavioral Skills model, which was used as a framework for the design of an assessment tool of homeowners' characteristics in this research. The important determinants of individuals' commitment to energy saving this model includes are highlighted through an exploration

of different studies from the field of behavioral sciences. Some outcomes of the assessment of these individual determinants on the design of interventions aimed at motivating individuals to save energy, such as energy audits, are discussed.

2.2 Residential Energy Use in the United-States

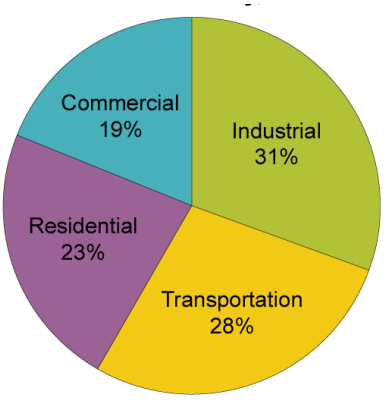
This section introduces the background of the present research by giving an overview of U.S. households' energy consumption, its economic and environmental impacts which make the growth in private energy consumption a pressing problem. It highlights the need for developing effective energy conservation programs, including energy audits, to mitigate the effects of residential energy use. It also shows the importance of homeowners' behavior on home energy consumption to emphasize that interventions to reduce households' energy use should go beyond physical improvements of the house and its equipment. When doing so, these interventions should include considerations for homeowners' characteristics and energy usage pattern.

2.2.1 Overview of U.S. Households' Energy Consumption

U.S. households, excluding transportation, consume 23% of U.S. energy as shown in Figure 2-1 (EIA, 2011). Natural gas is the first energy source in American homes, followed by electricity, fuel oil and propane. Single-family homes account for 80% of the energy use in the residential sector, multi-family dwellings and mobile homes accounting for 15% and 5% respectively. A large part of the housing stock from the last century was built with little consideration for energy efficiency. Recent houses built between 2000 and 2005 use 14% less energy per square foot than homes built in the 1980s and 40% less energy per square foot than homes built before 1950 (Buildings Energy Data Book, RECS 2005, DOE Energy Efficiency and Renewable Energy). However, increase in house size has partially offset the energy improvements brought to the house design.

The average household energy expenditure accounts for 3.1% of U.S. household annual income, according to the 2005 Residential Energy Consumption Survey (U.S. Energy Information Administration,

2005). However, the burden placed on household incomes by the cost of energy is much more significant for low income than for higher income households, with up to 21% for households with income level less than $9,999, while typically 3% for households with income level over $100,000. The larger part of energy consumed by U.S. households is used for heating, cooling and hot water supply (U.S. Energy Information Administration, 2005 Residential Energy Consumption Survey). Without renewable energy sources present on site, the entire house energy load is met by fossil fuel sources, natural gas being the most used.



Source: U.S. Energy Information Administration, *Annual Energy Review 2009*, and *Monthly Energy Review (June 2011)*, preliminary 2010 data.

Figure 2-1: Share of energy consumed by major sectors of the economy, 2010 (Source: EIA, 2011)

With the development of new home appliances, mechanical systems, and electronic equipment, American households have achieved a level of comfort and equipment that was not possible 100 years ago. But this increase in comfort came with an increase in energy consumption. Thus the residential sector has experienced a continuous increase in energy consumption over the last 50 years as illustrated in Figure 2-2.

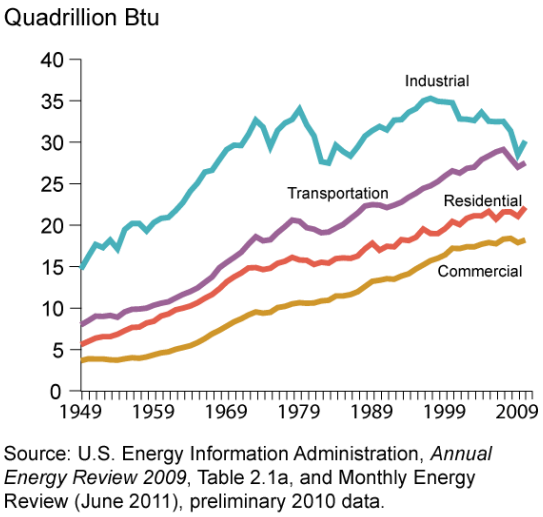


Figure 2-2: Energy consumption by sector, 1949-2010 (Source: EIA, 2011)

2.2.2 Economics Concerns

Energy conservation gained impetus with the energy crisis of the 1970's, which started raising concerns about a possible depletion of fossil fuels and the related volatility of fuel prices (Wilhite et al. 2000). As the U.S. energy consumption increased over the last four decades, the country began to import more energy to meet its needs, increasing the reliance on foreign fuels as illustrated in Figure 2-3.

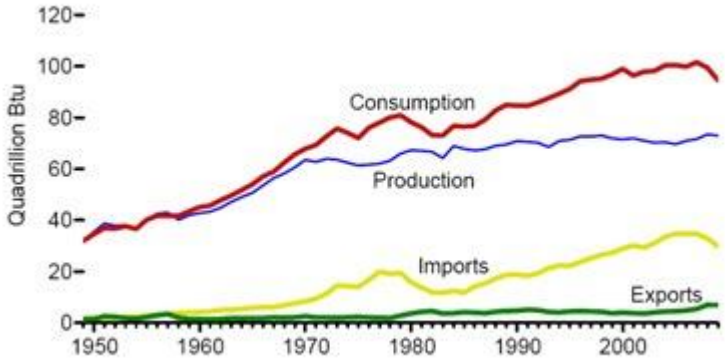


Figure 2-3: Primary energy overview (Source: EIA Annual Energy Review, 2009)

2.2.3 Concerns about Climate Change

Global increase of energy consumption has raised concerns over its related environmental impacts, including the increasing emission of greenhouse gases and the associated global warming phenomenon, over the last decades (Pérez-Lombard et al. 2007). Climate change has become one of the current most pressing problems. In the residential sector, these emissions come from day-to-day energy-related behaviors involving gas or electricity use, and the use of energy-intensive products. Accounting for 17% of the country's greenhouse gas emissions in 2009, including electricity-related emissions, U.S. households are an important targeted group for energy conservation (EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009, April 2011, table ES-8). Home energy-related behaviors have a great potential for reducing household energy consumption, as well as its impact on the environment. Small shifts in individuals' behaviors and the use of available technologies, such as lowering the water heater temperature and buying energy-efficient appliances, could reduce households' greenhouse gas emissions by nearly 8 percent if implemented nationally (Dietz et al. 2009).

Moreover, according to research on public attitudes and opinions about climate change and energy conservation, though concerns about global warming are waning in certain segments of the population (Gallup 2010), a majority or near-majority of Americans still believe that climate change is a serious problem, that it is caused by human action, and that reduced energy use through individual action can help reduce climate change (Krosnick and MacInnis 2011; Leiserowitz 2007). Thus, many U.S. households are willing to adopt behavioral changes to reduce their energy consumption and greenhouse gas emissions. However, a large amount of cost-effective opportunities to quickly and directly reduce energy consumption and mitigate climate change have remained underutilized (Dietz et al. 2009; Gardner and Stern 2008).

2.2.4 Importance of Homeowner Behavior in Home Energy Consumption

The energy efficiency industry tends to consider the house type, design and equipment as major factors of residential energy consumption. However, large variations in energy consumption exist

between houses of similar design located in a same climate (Gram-Hanssen 2010). This observation highlights the importance of homeowner's energy usage pattern in home energy consumption. Thus, for example, practices related to home heating are functions of several components related to both the homeowner, such as preferences of heat comfort, routines, technical knowledge about heating systems and its regulation, and the house technologies. As technology enables and constrains energy use practices, changing technology can help develop new practices and maintain them. Behavioral science research has also emphasized the influence of social and cultural factors in households' energy use and aspects of comfort in particular (Lutzenhiser 1991, 1993; Wilhite et al. 2000).

2.2.5 Energy Audit and Retrofit Market

With about 111.1 million homes in 2005 in the U.S., the housing sector is facing increasing economic and environmental pressures to reduce energy consumption (Buildings Energy Data Book, DOE Energy Efficiency and Renewable Energy). In 2005, single-family housing, multi-family housing and mobile homes accounted for 71.7%, 22% and 6.2% of the total housing stock respectively. Within single-family housing, houses occupied by owners accounted for 61.5% of the total housing stock. 77% of the 2005 housing stock has been built before 1980, when the regulation in terms of energy efficiency were not as stringent as today (Buildings Energy Data Book, 2005, DOE Energy Efficiency and Renewable Energy). These statistics illustrate the extent of the market for home energy audit and energy retrofit businesses.

Various programs aimed at reducing residential energy consumption have been developed on multiple scales to face the rising concerns about environmental problems and fossil fuel depletion. For example, the DOE Weatherization Assistance Program is aimed at providing energy efficiency retrofits for low-income families to reduce their energy bills. The DOE Weatherization program requires all states to use energy audits or priority lists to determine the most cost-effective weatherization measures to implement. These programs complement other efforts that have been made in the field of renewable energy and energy efficiency products and technologies, by sustaining the implementation of those products and technologies.

Among residential buildings, detached and semi-detached houses have a great potential for energy reduction, because they often have accessible basements and attics, have their own mechanical systems, often have a washing machine and a dryer (for 95% and 92% of them respectively according to EIA (2005)), and have no more than one party wall. This potential can either be achieved by changing behavior or by technical measures.

The observation of households' energy consumption by end use should draw the attention of energy conservation programs on the major areas of household energy use, such as space conditioning and water heating as shown on Figure 2-4 (Gardner and Stern 2008). These areas have high potential for energy savings, but also for carbon dioxide emission reduction.

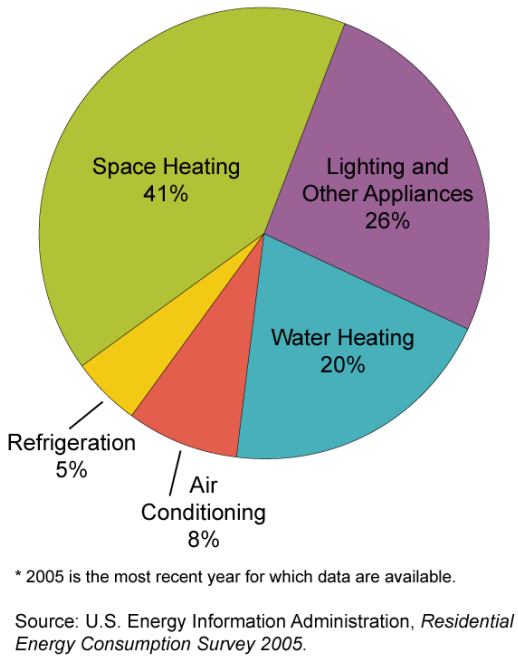


Figure 2-4: Household Energy Use by End-Use (Source: EIA, 2005)

2.2.6 Conclusion

The growth in residential energy consumption, which came mostly as a consequence of an increased level of comfort, new appliances and electronic devices, is an increasing problem due to its economic and environmental consequences. Concerns about energy conservation have increased mainly for environmental reasons. Reducing demand for energy is essential to meet the challenges of global warming and energy security. Technologies are already available to improve building energy performance and, with more than 110 million homes, the energy retrofit market is significant. However, the understanding of private energy use is more subtle than the simple consideration of the home design and equipment. Though these latter are two important factors of household energy use, the homeowner's behavior plays also an important role in residential energy consumption. Therefore a better understanding of homeowners' energy-related behaviors and what influence them can improve interventions aimed at reducing households' energy consumption.

2.3 Role and Challenges of the Energy Audits in the Residential Sector

2.3.1 Home Energy Audits

Various approaches have been undertaken to assist homeowners in reducing their energy consumption and alleviating the impact of their energy usage on the environment. Government-backed programs have been implemented at federal, state and local levels to improve energy efficiency in the building sector. Training programs, tools and credentials have been developed to form a qualified workforce in the energy efficiency industry. In the realm of residential energy conservation programs, home energy audits have used a tailored approach focused on the house characteristics. A home energy audit is an assessment of how much energy a home consumes and the development of a plan to make the home more energy efficient. This assessment is aimed at pinpointing where the home is losing energy, such as air leaks, as well as ways to maximize energy usage, such as with more efficient lighting and heating/cooling systems.

Forms of energy audit vary. In some cases, the procedure can be conducted by the homeowners themselves. This type of home energy audit is called Do-It-Yourself (DIY) energy audit and often

consists of a diligent tour of the house supported by a checklist of potential energy efficiency issues. Numerous guides have been developed to assist homeowners, such as the guidelines offered by the DOE website for do-it-yourself assessments (DOE website: http://www.energysavers.gov/your_home/energy_audits/). Many web-based tools are also accessible to help homeowners measure their actual home energy consumption, formulate recommendations to save energy and estimate the cost savings generated by energy-efficiency upgrades.

Another possibility is for the homeowners to have a professional energy auditor carry out an energy assessment. This type of home energy audit is called professional energy audit and is usually more thorough than a DIY energy audit, as the auditor uses special equipment to assess the sources or locations of energy loss and ensure occupants safety. The professional auditor should also examine past utility bills to detect trends in energy use over seasonal periods. By interacting with the homeowner, the auditor can establish what to look for during the audit, detect the primary concerns of the homeowner, and analyze the residents' behaviors, such as the number of occupants, the residents' daily schedule, their thermostat setting, the number of rooms in use to name a few. The requirement for professional energy auditors to be certified by an official organization is increasing. These certifications are a guarantee that auditors went through a training program on building science principles and energy assessment practices and passed an examination at the end of the training.

The present research focuses on professional energy audits whose procedure has been described above. This type of audit involves a face-to-face interaction between the auditor and the homeowners and therefore offers more opportunities for a behavioral approach tailored to homeowners' characteristics.

2.3.2 Professional Accreditations for Auditors and Related Assessment Methods

There are two main authoritative bodies in the U.S. residential energy efficiency industry: the Residential Energy Service Network (RESNET) and the Building Performance Institute (BPI). Both authorities deliver certifications for professional auditors.

RESNET has developed three types of energy audits for existing homes which vary with the depth of the conducted survey and tools used. These types of audits range from a visual inspection of the house to an in-depth assessment involving diagnostic testing and computerized simulation analysis. RESNET energy audits focus on the design and performance of the building envelope, mechanical systems, and electrical appliances, and address comfort, moisture, health and safety issues. They include an analysis of the households' utility bills. In 2010 the number of RESNET certified professionals, both auditors and contractors, was over 4000 in the U.S.

The Building Performance Institute (BPI) delivers different types of certifications for people of the residential energy efficiency industry, such as the building analyst and the building envelope certifications. BPI certified auditors use the house-as-a-system approach, which considers that the interaction of the different components and systems of a house affects the performance of the entire house, and conduct whole-home assessments. This assessment consists of an interior and exterior walk-through, and can include several technical tests to assist the auditors in their evaluation. Individuals with BPI credentials, auditors and contractors, can make their clients benefit from state incentive programs. In 2010, there were 17,077 BPI certified auditors, as the sum of auditors certified in each state.

Energy audits are a tailored approach to the performance of home energy retrofits aimed at reducing households' energy consumption. Both auditor certifications, RESNET and BPI, and their related assessment methods emphasize mostly the technical characteristics and energy performance of the house through an inspection of its envelope and equipment. Fewer considerations are given to the occupants. BPI auditors are advised to start their assessment with an interview of the homeowner to find out potential problems they should investigate in priority. This interview usually includes the evaluation of the homeowners' energy bills. Questions asked to the homeowners mostly deal with comfort or safety issues they have experienced and the type of systems present in their homes. The interview does not generally address homeowners' lifestyle, knowledge, motivation and skills with performing energy related

upgrades. The provision of educational information on how to save energy at home is often left up to the auditors' discretion.

2.3.3 Impact of Occupants' Behaviors on Home Energy Models

Energy simulation software, including eQuest and Energy Plus, used by auditors to model the home energy consumption and predict the energy savings resulted from the installation of efficiency upgrades are very sensitive to occupancy related inputs such as occupancy schedule and energy device usage (Clevenger and Haymaker 2006). Current software does not account for occupants' energy usage pattern, even though those may have significant impact on the total energy consumption (Hoes et al. 2009). For example, occupants living in similar residential units showed a variation of 200-300% in their energy consumption according to an empirical study (Lutzenhiser 1987). This oversimplification adds to other sources of errors to make the energy estimates obtained from energy simulation tools sometimes significantly different from the actual energy consumption.

Today's energy models remain sufficiently accurate to compare the efficiency of alternative efficiency upgrades, but lack accuracy to predict actual energy performance (Clevenger and Haymaker 2006). One of the main reasons for this inaccuracy is software's inability to properly model occupants' behaviors. The occupancy factor is currently modeled as a static parameter in energy simulations (Clevenger and Haymaker 2006). Potential differences in energy consumption between occupants with different levels of energy consciousness or changes in occupant energy usage resulting from the adoption of energy conservation practices or bad consumption habits are not considered.

In order to increase the accuracy of energy models, more work needs to be done to characterize and account for homeowners' energy consumption characteristics and their evolution over time (Clevenger and Haymaker 2006). As a pre-requisite, more work is needed to develop processes enabling auditors to gather and use this occupant information in their models.

2.3.4 Current Issues with the Traditional Audit Process

Accounting for 23% of the country's energy use and 17% of its greenhouse gas emissions, U.S. households are an important market for energy efficiency improvements. Considering that two-thirds of all buildings that will be in use in 2050 have already been built, the 110 million existing residential units can benefit from home energy audits and subsequent performance upgrades (Baden 2011). Experts agree that the implementation of currently available technologies would allow to achieve significant energy savings and reduce the impact of residential energy use on the environment (Dietz et al. 2009; Ross and Williams 1976; Stobaugh and Yergin 1979). Yet only a small fraction of the potential energy savings is being realized (Yates and Aronson 1983). Economic savings is assumed to be consumers' rational choice for energy-related technologies. However, effective and cost-efficient technologies are not accepted by the public at the rate that would be expected from consumers facing rising energy prices and technological improvements (Jaffe and Stavins 1994; Wilk and Wilhite 1987).

Furthermore, despite constant initiatives from federal and local organizations to promote the deployment of home energy audits nationwide and facilitate the diffusion of energy conservation and efficiency measures, homeowners are slow to implement improvements. For example, the two auditing firms the researcher was in contact with experience an uptake ratio of audit recommendations of 30% and 50% respectively. Many reasons can explain this inertia from energy consumers. Traditional auditing practices target a one-time intervention focusing mostly on the assessment of the house performance characteristics. This intervention results in a list of recommendations left to the homeowners who must fend for themselves to find contractors. Overwhelming lists of recommendations, consumers' natural skepticism of contractors and the difficulty to find qualified contractors are just a few of the reasons that can prevent homeowners from taking action (Baden 2011). Energy-efficient actions are sometimes taken but do not lead to the anticipated results potentially leading to discouragement from future efforts.

Traditional audit practices tend to overlook an important factor in both the actual home energy consumption and the adoption of energy efficiency and conservation measures which is the homeowners'

behaviors. Standards and guidelines for the conduct of energy audits focus on the technical performance of the home (Building Performance Institute 2005; RESNET 2010). Little is said about energy conservation behaviors the occupants could adopt such as switching their washer temperature setting from hot to cold. The decision to address conservation behaviors varies between auditors. For example, the Mark Group auditors do not address conservation behaviors, whereas Envinity auditors sometimes touch upon energy usage tips.

Some auditing firms, such as the Mark Group or Envinity, do not charge their residential audits enough to make them profitable unless these audits translate into a retrofit. Therefore they are interested in developing their customer approach to better identify customers' needs and design audits that meet those needs and are profitable for their businesses.

From both a customer and business perspectives, improving the efficiency of the energy audit process becomes necessary. A better understanding of homeowners' energy-related behavior, including current energy usage pattern, but also perception, motivation and obstacles to conserve energy would increase the accuracy of the analysis of the household's energy use and focus the energy audit on relevant measures. Moreover knowledge of what people perceive as motivators and obstacles to change their behaviors can help frame the presentation of the information. New forms of home energy audits and audit tools started emerging with promising results for the future of the energy auditing industry.

2.3.5 Emerging Forms of Residential Energy Audits, Tools, and Approaches

2.3.5.1 Web-Based Support

The development of web-based energy auditing tools represents a cheaper alternative to the traditional audit process. The SENTECH, Inc. Review of selected home energy auditing tools (2010) provides an overview of different web-based energy auditing tools. Websites provide calculators, survey instruments, asset rating tools and prioritized lists of measures to answer key questions from energy consumers, calculate their actual energy consumption and the energy savings resulted from specific measures

(SENTECH, Inc 2010). Web-based calculators, such as the DOE Home Energy Saver, the Home Energy Checkup offered through the Alliance to Save Energy, the ENERGY STAR Advisor and the Energy Yardstick, are usually offered at little or no cost to perform energy analysis on homes. The software company Opower partners with utilities and provides them with software that creates individualized Home Energy Reports for their customers. The typical outputs from these tools are a list of energy saving measures or links to a description of building system improvements (SENTECH, Inc 2010). Some tools also provide a comparison of the house actual energy consumption to other households across the nation. The Home Energy Saver calculates the energy savings and payback period of the energy efficiency measures recommended based on the user's inputs. These tools are intended to a general audience without specific knowledge in building sciences. They also illustrate the increasing consideration for personalized energy-saving recommendations and motivational strategies, such as social comparison.

Though these web-based tools allow a cheap, convenient, do-it-yourself home energy audit, most of them still generate a list of generalized improvement measures to reach a broad range of homeowners. However, this list may not be always relevant to the homeowner's situation or lead directly homeowners to action without additional research. The user does not always get an idea of the cost savings of those measures. Moreover most of these tools do not account for individual occupant behaviors which can have a significant impact on the house actual or predicted energy consumption. These constraints show that a personal interaction between the auditor and the homeowner, though more costly and time-consuming, remains a better way to increase the accuracy of the home energy performance analysis and recommend tailored energy-saving measures.

2.3.5.2 "Assisted" Energy Audits

The research that is the subject of this paper can also contribute to the development of an alternative form of energy audit referred to as assisted audits. The objective of this form of energy assessment is to reduce the time spent on traditional audits and deploy the limited capacity of auditing firms at making

thorough house inspection in the most effective way. Assisted audits are seen as a preliminary step to make traditional audits more effective.

Assisted energy audits are characterized by an intermediate level of complexity ranging between a self audit performed solely by the homeowner and a comprehensive audit using diagnostic equipment, sophisticated energy simulation software and computerized data analysis. Unlike a self audit, an assisted audit involves the intervention of an external auditor who has received a training covering basic building science and weatherization.

Assisted audits were conducted by Penn State students as part of the American Indian Housing Initiative class in 2009 and 2011. The model of energy audit developed for this class will be used to describe the characteristics of an assisted energy audit

The purpose of an assisted audit is to assess the general energy performance of an existing house and the existence of safety issues. It consists of a visual inspection of the house and the documentation of its general conditions. When available, the audit can include a review of utility use and billing history. It does not include the use of diagnostic testing equipment, such as blower door or duct leakage test. It can include the use of an infrared camera to determine the location of air leaks in the building envelope and the effectiveness of insulation inside walls and in the attic. The auditor can use web-based energy auditing tools, such as the Home Energy Saver, to create a report of the complete assessment. This report includes professional retrofits for improving the home's energy efficiency, low-cost do-it-yourself upgrades and energy usage tips to conserve energy. The energy savings estimates provided are only generalized. The report also includes some information on available rebate, financing, and tax incentive programs that will help homeowners. It does not include a detailed work scope for improvements.

One of the objectives of an assisted energy audit is to educate the homeowners about energy efficiency and conservation measures they can take inside their house. In this regard, the auditor starts the assessment with a conversation with the homeowners aimed at creating awareness about energy and

potential strategies to reduce energy use and cost. This conversation is also an opportunity for the auditor to interview the homeowners about comfort complaints, energy billing concerns, moisture issues, and interest in potential home energy improvements. At that point, the auditor can inform the homeowners of low cost/no cost improvements that can be implemented by the homeowners themselves.

Assessing homeowners' knowledge of behaviors they can do to save energy, and motivation and skills to do so prior to the visit of the auditor could help focus the conversation the auditor has with the homeowners on specific points relevant to their situation and help better customize assisted energy audits.

2.3.6 Conclusion

Energy audits are an important and representative example of energy conservation programs aimed at reducing residential energy use. During a professional energy audit, an auditor visits a home and provides energy saving recommendations to the owners based on the home design . Like other energy efficiency programs, the goal of an energy audit is also to deliver information aimed at encouraging the customer to take action. However, a major advantage traditional energy audits have over other programs is that they can, by definition and by their process, that is, a face-to-face interaction between the auditor and the homeowners, tailor the message delivered to the homeowners. With this approach, participants receive relevant information only, rather than receiving generalized information which may not always pertain to their situation (Abrahamse et al. 2005). More consideration for the diversity of homeowner lifestyle, aspirations, knowledge of energy-saving measures and capacity to pursue these measures are likely to optimize the auditor-homeowner interaction and increase the accuracy of the home energy analysis,

2.4 Categorization of Energy-Saving Behaviors

Reducing households' energy consumption can be accomplished through multiple actions that differ by their attributes such as their cost, their frequency or their impact on homeowners' lifestyle. Most of these attributes fall into the conservation/efficiency distinction that has been predominantly used for behavior categorization (Karlin 2011). Energy-efficiency and conservation behaviors are aimed at

reducing homeowners' direct energy use, that is, the use of gas, electricity and fuel embedded in home heating and cooling, domestic water heating, lighting and the use of appliances. Reducing indirect energy use, that is, the energy use embedded in the production, transportation and disposal of consumer goods and services is not considered in this research.

The tool developed in this research is aimed at improving the outcomes of energy audits and consequently impacting homeowners' choices and behaviors. Therefore an initial step in the process of developing this tool consists in determining the behaviors of interest. This section first describes one of the main categorization of energy-saving behaviors found in the literature. It second provides some insights into individuals' perceptions of energy-saving behaviors based on current research, as well as a representative list of household actions aimed at reducing energy use. It lastly introduces specific strategy and tools to promote and sustain the adoption of energy-saving behaviors.

2.4.1 Efficiency versus Conservation

Though the terminology differs between the articles used as references, the term "behavior" is used in this literature review to refer to any action, including purchase, home improvement or change in one's everyday behavior, taken by an individual to reduce his or her energy consumption. While there are many ways to categorize energy-saving behaviors (Stern and Gardner 1981, Van Raaij and Verhallen 1983, Black et al. 1985, Abrahamse et al. 2005, Gardner and Stern 2008, Dietz et al. 2009), the two main categories of conservation behaviors and efficiency behaviors are prominent in the literature. Both categories can be described as follow:

- Conservation behaviors, also known as curtailment, consist of restricting the use of existing energy equipment by using the equipment less frequently or intensively. This category includes other possible classifications of behaviors. For example, it includes "stop behaviors" and "start behaviors" such as stopping using the clothe dryer and line-dry, and "increase" or "decrease" behaviors such as increasing the thermostat setting for the air-conditioning in summer and using

the home appliances less often. Conservation behaviors must be repeated or continuous to lead to energy savings. They rarely cost money but involve a loss of amenities (Black et al. 1985).

- Efficiency behaviors consist of adopting more energy-efficient equipment. They include insulating walls and attics, replacing furnaces and appliances. Efficiency improvements usually involve a one-time purchase decision, but no loss in the amenities energy produces (Black et al. 1985).

In a comparison of energy saved by both conservation and efficiency behaviors, Gardner and Stern (1981) observed that the purchase of more energy efficient equipment generally saves more energy than curtailing the use of inefficient equipment. This finding counteracts the general belief that energy savings require curtailment and sacrifice of amenities. However, the purchase of more energy efficient equipment will be effective only if homeowners maintain the same consumption pattern they had prior to the purchase. The benefits can be offset if homeowners take advantage of the efficiency of their new equipment to consume more energy or increase their level of comfort. This phenomenon is known as the rebound effect (Jevons 1866; Khazzoom 1980).

In addition to being more effective in saving energy, efficiency behaviors have the psychological advantage of often being one-time action with a lasting effect, like purchasing and learning how to operate a new programmable thermostat (Gardner and Stern 2008). Curtailing actions, like turning down the thermostat at night, need to be repeated over time requiring the establishment of a new behavioral habit, as well as effort and attention to maintain this habit. However, the relative simplicity of energy efficiency actions is often offset by the fact that they require the selection and purchase of a product while curtailing actions have no financial costs (Gardner and Stern 2008). Moreover even if energy efficient equipment has a good return on investment, few people will compare the return on energy efficiency with the return from a savings account. Consequently the upfront cost penalizes most of efficiency behaviors restricting them to higher income consumers. These behaviors can also be more difficult to apply to rental housing (Gardner and Stern 2008). As efficiency actions tend to lead to greater savings than curtailment

actions, people of different income level or ownership position may save different amounts of energy even if their actions are driven by the same beliefs and attitudes (Black et al. 1985).

Efficiency and conservation involve different sorts of behaviors and may consequently be influenced by different motives, skills and barriers (Black et al. 1985). Therefore to evaluate individuals' propensity to perform energy-saving behaviors, separating them out into categories based on their attributes and assessing individuals' knowledge, motivation and perceived capacity to perform specific behaviors of each category will be done in this research as those factors may differ between different types of behaviors.

2.4.2 Individuals' Perception of Energy Saving Actions

Current research indicates that the general public has a poor knowledge of the energy consumption associated with households' activities and that these activities can have an effect on climate change. Individuals' are more aware of conservation behaviors than efficiency improvements as ways to save energy at home (Attari et al. 2010). Though people approximately know which home devices and activities are associated with greater energy use and savings, they have an imperfect knowledge of the size of the difference in energy use and savings. They especially underestimate the potential of actions generating high energy savings.

Understanding individuals' knowledge about energy consumption and energy-saving actions can benefit programs aimed at promoting energy savings and conservation. People misperception about the potential energy savings resulting from the adoption of specific behaviors may be an important reason why people tend to disregard these behaviors (Gardner and Stern 2008). If this case, educating individuals can be a preliminary step toward the implementation of the recommended behaviors.

2.4.3 Examples of Energy-Saving Behaviors

Dietz, Gardner, Gilligan, Stern and Vandenberg (2009) showed that the needed cut in greenhouse gas emission can be accomplished through basic households' actions. Their 17 energy-saving behaviors, which rely only on altered energy usage pattern and the use of available technologies at homes and in nonbusiness travel, followed previously established list of behaviors including the one done by Gardner and Stern in 2008. Dietz et al list is an example of lists of behaviors that look at what households can reasonably expect to save on a short term with feasible changes in their consumer behaviors, in-home equipment and personal transportation technologies, and by means of behaviorally oriented policies and interventions such as the provision of appropriate information, financial assistance, and social interaction.

Table 2-1 shows the actions considered by Dietz and his colleagues. The actions were divided into 5 categories based on their attributes: W (home weatherization, including attic insulation, airsealing, and high-efficiency windows, and upgrades of heating and cooling equipment); E (more efficient vehicles and non-heating and cooling home equipment); M (equipment maintenance); A (equipment adjustments); D (daily use behaviors). Dietz and his colleagues advanced previous research by estimating the plasticity of behavior, that is, the percentage of the population that could be induced to adopt the behavior with the most effective interventions. This estimate was taken into account when calculating the achievable emissions reduction from each behavior.

Table 2-1: Achievable carbon emissions reduction from household actions (adapted from Dietz et al. 2009)

Behavior Change	Category	Behavioral Plasticity	Reasonably Achievable Emission Reduction within 10 years in MtC/yr
Weatherization	W	90	21.2
HVAC equipment	W	80	10.7
Low-flow showerheads	E	80	1.1
Efficient water heater	E	80	5.4
Appliances	E	80	11.7
Low rolling resistance tires	E	80	6.5
Fuel-efficient vehicle	E	50	31.4
Change HVAC air filters	M	30	3.7
Tune up AC	M	30	1.4
Routine auto maintenance	M	30	4.1
Laundry temperature	A	35	0.2
Water heater temperature	A	35	1.0
Standby electricity	D	35	3.2
Thermostat setbacks	D	35	4.5
Line Drying	D	35	2.2
Driving behavior	D	25	7.7
Carpooling and trip-chaining	D	15	6.4

This type of list appears as a good example of a prioritized, accessible and actionable list of effective behaviors that can guide households to set up their priorities. The homeowners can give high priority to actions with the greatest emission reduction and, therefore, energy saving potential. Actions are categorized in function of their attributes such as their initial monetary cost and their frequency. Some of

the actions involve curtailment, other efficiency improvement. Furthermore such a list points out interesting energy-saving behaviors that tend to be overlooked by individuals, such as home weatherstripping (Wilk and Wilhite 1987).

Some behaviors including in this type of list go beyond the scope of recommendations typically provided by energy auditors, as, for example actions related to individual transportation. These behaviors will therefore not be considered in this research. Moreover this research will stick to the conservation-efficiency distinction presented earlier that encompasses the categories defined by Dietz et al. Maintenance behaviors are one-time low-cost behaviors that span across the efficiency and conservation categories. It will also consider two other categories of behaviors recommended by energy auditors that do not appear in Dietz et al. list. One is energy generation behaviors that include the production of electricity and thermal energy from renewable sources such as solar or wind. While such behaviors concern only a small fraction of the population (Shelton Group 2011), they are still under consideration in this research as they complete the spectrum of measures homeowners need to take to be more energy independent. Furthermore, audit customers, who are targeted in this research, are more likely to be concerned by this type of behaviors than the general public. The second other category is safety and protection behaviors, such as the installation of a carbon monoxide detector, which, while not saving energy, ensure that the home and the operation of equipment are safe to the health of the householders.

2.4.4 Making Consumption Visible through Home Energy Management Systems

The last category of behaviors this research will consider includes feedback mechanisms through the use of home energy management systems. Such behaviors do not save energy directly, but foster and sustain energy efficiency and conservation behaviors over the long term. Home Energy Management Systems (HEMS) are intermediary devices that can visualize, manage, and/or monitor the households' energy use of certain products or of the whole house (van Dam et al. 2010). They provide homeowners with a direct feedback on their energy consumption for the overall household and/or disaggregated by appliances. Feedback makes energy consumption more visible and consequently easier for individuals to

understand and control. It gives an idea of how energy is used, whether electricity consumption is high or low, and if it has increased or decreased over time. Feedback can be considered as a learning tool. It allows energy consumers to teach themselves through experimentation by observing how changes in their behaviors or investments in efficient equipment can make a difference in their energy consumption (Darby 2006). Indicating to occupants how they are performing is also a means to encourage them in the accomplishment of a difficult goal (Abrahamse et al. 2005).

Two different types of feedback exist – direct and indirect - and can be combined together (Darby 2006). Direct feedback is an instantaneous form of feedback provided by a meter or an associated display monitor. Indirect feedback can consist of either an improved billing method where raw data are processed by the utility and sent out to customers, or web-based tracking tools. Feedback can be really effective in fostering a conservation behavior. By simply displaying how much occupants consume, an in-home display system can lead to 5 to 15% of energy savings on average. Savings from indirect feedback range from 0 to 10% depending on the context and the quality of the information given (Darby 2006).

Savings generated by the provision of feedback will persist if individuals develop new habits or invest in energy efficient measures to control their energy consumption. Habits formed over three months or more are likely to persist but continuous feedback is still needed to maintain the habits and encourage other changes (Darby 2006).

2.4.5 Conclusion

Energy-saving behaviors vary based on their characteristics, such as their cost, their impact on households' lifestyle or their resulting savings. As a result, individuals' reaction to those behaviors may not be the same. A major conclusion from studies focusing on the determinants of pro-environmental behaviors is that the influence of socio-demographic and psychological variables on behaviors is more conclusive when behaviors are distinguished by their attributes, including repetitiveness, cost and associated amenity losses (Wilson and Dowlatabadi 2007). Therefore separating out behaviors into

different categories and assessing homeowners' knowledge, motivation and perceived capacity to perform those behaviors can be in the interest of targeted interventions such as energy audits. The present research considers five types of behaviors that can be potentially recommended by energy auditors and lead, when combined, to a state of energy independence: safety and protection behaviors, conservation behaviors, efficiency behaviors, generation behaviors and feedback mechanisms. While conservation and efficiency behaviors are commonly found in lists of effective actions household can take to save energy, the general public is less familiar with generation behaviors. Safety and protection behaviors, though they do not necessarily save energy, are addressed in priority by energy auditors. By providing individuals with feedback on their energy consumption, energy monitoring systems promote the adoption of the other types of behaviors.

2.5 Contribution of Behavioral Science to the Design of Energy Conservation Programs

Psychological constructs believed to be critical for predicting and modifying environmental behavior, including energy conservation, have emerged from behavioral science research over the last four decades. Theoretical models have been defined and tested to confirm the interrelationships between proposed psychological constructs and actual pro-environmental behaviors. The resulting findings provide valuable inputs on potential energy savings opportunities and the theory behind behavioral change. Their application to energy conservation programs has already shown promising results (Abrahamse et al. 2005; Fuller et al. 2010).

An exhaustive review of this literature is beyond the scope of this paper, but reviews of models of behaviors and theories of change exist (Darnton 2008**).** The Theory of Planned Behavior (Ajzen 1985) and the Value-Belief-Norm theory (Stern 2000) have been prominent in environmental research and received empirical support. The Information, Motivation and Behavioral Skills model (Fisher and Fisher 1992), which has emerged from psychology research on factors predicting personal health behaviors, has been recently applied to pro-environmental behaviors. It encompasses behavioral factors from the Theory of Planned Behavior and the Value-Belief-Norm theory. The IMBS model, however, goes beyond

describing predictors of behavior, which is more descriptive of the Theory of Planned behavior and the Value-Belief-Norm theory. The IMBS model is used as a framework in this research because it can be tied to factors that auditors can potentially address (information and behavioral skills) and can inform auditors about how to frame recommendations (motivation). Thus, the IMBS model has the potential to be a useful tool to integrate within energy audits to assist in behavioral change.

The following paragraphs first introduce the IMBS model. They also present the factors influencing energy-related behavior changes unearthed by behavioral science and pro-environmental psychology researches that are used to define the variables assessed by the tool. These factors are sorted into the three components of the IMBS model. Socio-demographic variables that supplement the psychological variables assessed by the tool are lastly introduced.

2.5.1 The Information Motivation and Behavioral Skills Model of Behavior Change

2.5.1.1 The Theory

The IMBS model proposes three core determinants of behaviors: information that is relevant to the personal practice of behaviors, motivation to practice these behaviors and behavioral skills for performing these behaviors (Fisher et al. 1999). According to the IMBS model, an individual who is well-informed, motivated to act and possesses the appropriate behavioral skills to engage in a specific behavior is expected to engage in this behavior. On the other hand, deficits in any of these areas of information, motivation and behavioral skills decrease the likelihood that individuals engage in specific behaviors. The predictors in the IMBS model are broad enough that they include those from other models such as the Theory of Planned Behavior (TPB) and the Value Belief Norm (VBN) theory. In addition, the IMBS model transforms these predictors in a way that matches an intervention/learning approach which becomes more actionable.

In contrast to the TPB and VBN theory, the IMBS model acknowledges the importance of individuals' level of information about desired behaviors in predicting engagement in these behaviors (Seacat and

Northrup 2010). Knowledge about specific behaviors can be produced through different channels, such as research institutions, governmental organization, utilities or media, or obtained through feedback mechanisms. It can also be driven by personal experiences. Though knowledge is an essential prerequisite to the adoption of a behavior, increase in knowledge is not sufficient in itself to cause the adoption or the change of a behavior (Schultz and Kaiser, in press).

Motivation is a second critical determinant to the performance of a behavior. The IMBS model distinguishes different types of motivation. Self-interest motivation and positive attitude towards a behavior, which are also emphasized in the TPB, are based upon individual perceived ability to successfully engage in this behavior and the fact that personal benefits will result from the performance of this behavior. Expectancy about the outcomes associated with a behavior and an evaluation of these outcomes form the individual's attitude towards this behavior (Ajzen 1991). Furthermore, the sum of the positive outcomes of the behavior needs to exceed the sum of the costs or negative consequences resulted from the performance of the behavior. Social motivation is another type of motivation that is also promoted by the TPB and more examined in the VBN theory (Ajzen 1991; Fisher and Fisher 1992; Stern et al. 1999). It is based upon individuals' perceptions of social norms and moral obligation for engaging in a given behavior. The IMBS model integrates both models by considering both personal and social levels of motivation (Fisher and Fisher 1992; Seacat and Northrup 2010).

The possession of appropriate behavioral skills to perform a specific behavior is the third critical determinant of the IMBS model of individuals' engagement in this behavior (Fisher et al. 1999). Behavioral skills include objective skills to perform behaviors, as well as perception of self-efficacy, that is, individual assessment of how well they can act to deal with a situation, and the difficulty for doing so. The moderating role of behavioral difficulty on other determinants of behavior appears also in the TPB in the form of perceived behavioral control which interacts with the two other determinants of behavior change, positive attitude and perception of social pressure associated with the behavior (Ajzen 1991). Self-efficacy may determine whether an individual attempts and persists with a given action. An

individual's past experience and perceived skills, as well as the influence of others, impact his or her self-efficacy (Bandura 1994).

The determinants of the IMBS model encompass relevant predictors of pro-environmental behaviors found in the literature. In 2007, Bamberg and Möser conducted a meta-analysis of numerous studies to determine the variables that were the most reliably associated with environmental behaviors and the strength of these relationships. Their findings were similar to those reported by Hines et al twenty years before (1986). The most predictive variables align with elements of the IMBS model. Specifically, these predictors were: information-related (problem awareness/knowledge), motivation-related (causal attribution of harmful behavior/guilt and social norms) and skills-related (perceived behavioral control). Pro-environmental behavioral intention was found to mediate the impact of all other psycho-social variables on pro-environmental behavior suggesting that asking participants about their intent to engage in energy-saving behaviors can be useful in understanding the role that IMBS plays in predicting behaviors.

2.5.1.2 Applications of the IMBS model

The Information, Motivation and Behavioral Skills model has been mostly used to predict personal health behaviors, such as adolescent AIDS risk behavior, and ultimately modify those behaviors (Fisher et al. 1999). More recently Seacat and Northrup (2010) adapted the IMBS model to explain curbside recycling behavior. Following Nisbet and Gick (2008), they highlighted the relevance of models of health behaviors to the prediction of pro-environmental behaviors and the similarities between the predictors of both types of behaviors. Indeed Seacat and Northrup (2010) found that both pro-environmental and health behaviors were shown to be motivated by the same intrinsic and extrinsic motivations, that is individuals' perception that the behavior will be beneficial for themselves and beneficial to others/the environment.

The IMBS model also overlays with three types of knowledge that have been argued to predict pro-environmental: impact knowledge refers to an individual's beliefs about the consequences of a behavior;

procedural knowledge is information on how to perform a behavior; normative knowledge refers to what people believe about the behavior of others (Schultz 2002). Impact knowledge is consistent with information about behaviors. It appears, through the causal attribution of harmful behaviors, as a cognitive precondition for developing moral norms as it generates guilt feelings (Bamberg and Möser 2007). Procedural knowledge is consistent with behavioral skills. Normative knowledge is relevant to motivation.

In the case of health behaviors, information and motivation are believed to be constrained by the behavioral skills component of the model (Fisher et al. 1999). Information and motivation may have a direct effect on behaviors which do not require complex or particular skills to be executed (Fisher et al. 1999). These relationships are represented in Figure 2-5 in the case of AIDS preventive behaviors.

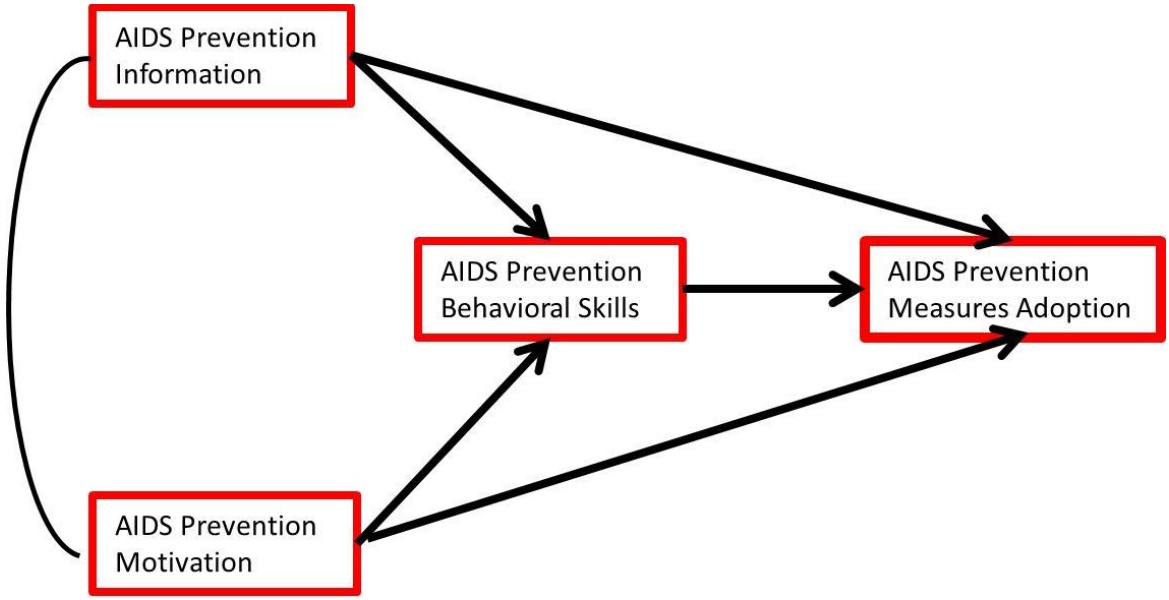


Figure 2-5: The information-motivation-behavioral skills model of AIDS risk and AIDS preventive behavior (Fisher et al 1999)

As with health problems, many environmental problems can be mitigated by individuals' actions. The IMBS model suggests that interventions aimed at changing behaviors should focus on improving information, motivation and behavioral skills required to adopt desired behaviors. The first step of

interventions using the IMBS model as a conceptual framework should consist of conducting research, most often in the form of individual interviews, to determine levels of participant information, motivation and behavioral skills related to specific behaviors (Seacat and Northrup 2010). Conclusions from studies that focused on the promotion of health preventive behaviors emphasized the need to tailor interventions to address empirically identified deficits in information, motivation and behavioral skills in a target population (Fisher et al. 1999). They also emphasized the need to capitalize on existing strengths in these areas. Similarly the present research attends to the creation of a tool that will assess individuals' IMBS profile with regard to the practice of energy conservation behaviors. This tool is designed to help energy auditors identify their customers' level of knowledge, motivation, and perceived-capacity to perform energy-saving measures and tailor their intervention to address potential deficits in one of these areas or target specific measures their customers are more likely to follow.

2.5.2 Psychological Factors Influencing Individual's Environmental Behaviors

The following paragraphs detail and sort out the different predictors of environmental behaviors, including energy conservation, found in the literature into the components of the IMBS model. These predictors are the ones the present research attends to impact through the development of an assessment tool of audit customers allowing auditors to better target their interventions.

2.5.2.1 Information/Knowledge

The first factor this research attends to impact is individuals' knowledge. The lack of consumers' awareness and information on home energy retrofits has been identified as a main barrier to the implementation of those measures (Council on Environmental Quality 2009). According to Rogers's Diffusion of Innovation model (2003), individuals need to be aware of and understand behaviors in order to embrace them.

Knowledge-based interventions, such as information campaigns, have been commonly used to promote recycling behaviors based on the idea that increasing people's knowledge about a certain

behavior is a prerequisite to behavioral change (Schultz 2002). In the VBN theory, impact knowledge acts with values and norms as a determinant of a behavior (Schultz 2002). Impact knowledge is a variable of interest for the assessment of people's IMBS with regard to energy conservation and translates into appraising their estimate of the amount of energy they can save through specific behaviors. Evaluating people perception of the energy savings resulting from specific behaviors can help address popular misconception about what actions are the most effective to save energy (Council on Environmental Quality 2009; Gardner and Stern 2008). Indeed, householders are more likely to adopt highly visible actions that can reduce energy use if repeated regularly, such as lowering thermostat setting in winter, or turning off the lights when living a room. They tend to discard more energy-efficient actions with less visibility, such as installing storm windows, and underestimate the potential energy savings of these actions (Kempton et al. 1985). Moreover, Gardner and Stern (2008) propose that the public opinion perceives curtailment as a more significant source of energy savings, whereas energy experts perceive more energy savings in efficiency.

Awareness and knowledge about environmental issues play an important indirect role on behaviors by influencing motivational factors such as the internal attribution of responsibility, the influence of social norms, feelings of guilt, or the perceived behavioral control over a behavior and the attitude towards this behavior (Bamberg and Möser 2007). However, the increase in knowledge that may, for example, result from information campaigns often produces only small, short-term changes in behavior. Though a lack of knowledge is a barrier to the adoption of environmental behaviors, knowledge is not a motive for those behaviors (Schultz 2002). Moreover, many information-based interventions rely on the assumption that individuals' decision process is rational and therefore informing people about the benefits of energy-saving measures is sufficient to engage them in conservation behaviors. The fact that some energy-efficient technologies with a short payback remain underutilized undermined this assumption (Wilson and Dowlatabadi 2007). Therefore other variables need to be taken into account for the design of effective interventions.

2.5.2.2 Motivation

The second factor that this research attends to impact is motivation. Individuals' motives to engage in pro-environmental behaviors, including energy conservation, can be multiple and of different natures (Steg and Vlek 2008). This section reviews some of the motives that may affect homeowners' decision to adopt energy-saving behaviors. Motives and goals influence the type of information people will be sensitive to and how they will act when provided with alternatives (Lindenberg 2001, 2006). Therefore knowledge of a person's motives may help frame the message to induce this person to save energy in a more appealing way. The motivational factors detailed below include economic and non-economic motives associated with energy-saving behaviors that individuals are likely to take into account when comparing the costs and benefits of specific behaviors. They also include moral and social pressures for the adoption of energy-saving behaviors; and potential discrepancies between representations of actual behaviors and behaviors one would like to or should do that may encourage one to act to reduce these discrepancies.

2.5.2.2.1 Costs and Benefits

Environmental behaviors such as energy conservation can be driven by personal motives. Various energy conservation programs and the underlying models of behavioral change rely on the assumption that, when facing multiple alternatives, individuals make decisions that maximize individual benefits for the lowest cost (Amann 2006; Train 1985; Tversky and Kahneman 1981; Wilson and Dowlatabadi 2007). The Theory of Planned Behavior is an influential framework in this regard (Ajzen 1991). According to the TPB, the sum of perceived positive and negative consequences of a behavior determines individuals' attitude towards this behavior (Bamberg and Möser 2007). The TPB views self-interest as a predominant motive for pro-environmental behavior. The belief that personal benefits can come from energy efficiency can encourage investments in energy efficiency (Black et al. 1985).

Therefore, according to this rational perspective of individual decision making, measures such as replacing an old heating system with a new one or installing insulation in the attic could be taken by a

reasonable homeowner if the payback period was sufficiently short. However, it has been observed that homeowners carry out only a small fraction of the range of measures that would be profitable for them. People do not always maximize the economic benefits associated with pro-environmental behaviors. The difference between cost-effective energy-saving measures that could be implemented and the measures actually implemented has been called the energy efficiency gap (Jaffe and Stavins 1994). Moreover, consumers tend to underestimate gains and overestimate risks and losses associated with their choices (Kahneman et al. 1991). To solve the discrepancy caused by the energy gap, many energy conservation programs design their campaign on the assumption that the gap could be closed if the homeowners could realize the cost-effectiveness of these measures. Therefore financial subsidies and low-interest loans have been created to increase the profitability of these measures. They can be effective if they are set to appropriate levels (Stern & Gardner, 2008). As a motivator, these forms of assistance can be considered as a form of extrinsic motivation.

2.5.2.2.2 Other Considerations Affecting Cost-Benefit Calculation

Benefits from energy efficiency and conservation behaviors have often been framed in terms of financial savings. Indeed the economic aspects of energy efficiency measures matter, but they are only one aspect of a group of factors that homeowners integrate in their decisions. More recent approaches go beyond economic considerations to integrate additional non-monetary benefits, such as comfort and convenience, in the homeowner cost-benefit calculation (Amann 2006; Zundel and Stiess 2011). Motivation can be associated with a specific behavior such as in the case where homeowners want to fix a special issue in their house. The assessment of individuals' motivation to perform energy-saving behaviors must be broad enough to include other benefits that may constitute additional leverages to foster the implementation of these behaviors.

According to Stern (1992), homeowners make decision coherent with their attitudes towards their house and towards energy-saving measures. In their study identifying the key factors influencing homeowners' decisions regarding energy-efficiency upgrades, Zundel and Stiess (2011) found that

homeowners who opted for an energy-efficient option when renovating one or more systems in their houses were pursuing economic objectives of reducing energy costs in the long run, as well as a more comfortable indoor environment. Investment in energy-efficient technologies may come from individuals' desire to save energy without changing their lifestyle and may not always be synonym of energy-savings (Van Raaij and Verhallen 1983).

Zundel and Stiess (2011) have identified several factors affecting homeowners' motivation to implement energy-efficiency retrofits. When considering the renovation of their house, homeowners' objectives and attitudes towards renovation process have also a strong influence on the decision to invest in energy-efficient technologies or to invest in standard technologies. Homeowners who do not want to do more than necessary to maintain their house have usually little motivation to invest in energy-efficient technologies. Also, the fact that homeowners perceive their house as in good conditions decreases their desire to conduct energy-efficient retrofits. This perception is often not confirmed by the actual energy performance of the house but influenced by past undertaken actions like the installation of insulation, regardless of whether these actions have been done properly and in accordance with up-to-date standards. Homeowner's willingness to raise a loan to finance the house renovation has a significant positive impact towards energy-efficient retrofit. Energy savings and the use of low carbon technologies are also two important factors. They include a broad range of individual's objectives around the ideas of cost- and energy-efficient renovation and climate protection, but also around the attractiveness of low carbon technologies. However, amenities expenditures still dominate what households are spending money on when retrofitting their houses (Wilson 2010). Therefore energy-efficiency improvements can raise more interest if packaged with the total renovation job. Homeowners place a greater importance on increasing the value of their property than saving money on their energy costs when conducting retrofit work (Wilson 2010). Therefore energy-efficient retrofits should be marketed for their propensity at increasing the property value.

2.5.2.2.3 Moral and Social Normative Concerns

Another aspect of people's motivation to engage in environmental behavior is considered by the Value-Belief-Norm theory of environmentalism or the Norm-Activation Model (NAM). They both view pro-environmental behaviors primarily as pro-socially motivated with moral and personal norms acting as direct determinants of behaviors (Bamberg and Möser 2007). These models can explain low-cost environmental behaviors and "good intentions" (Steg and Vlek 2008). Moral or personal norms are perceived as feelings of strong personal obligations to act in a certain manner in specific situations. They were found to have an important influence on people engagement in pro-environmental behaviors including energy conservation (Bamberg and Möser 2007). "Awareness and knowledge about environmental problems are important cognitive preconditions for developing moral norms" (Bamberg and Möser 2007). Moral norms for curtailment influence low-cost energy efficiency activities. For example, people who felt a personal obligation to save energy by curtailment reported lower temperature settings (Black et al. 1985). The influence of moral norms is, however, more limited for behaviors with important structural constraints.

Beliefs about what other people do (descriptive social norms) or what other people think should be done (injunctive social norms) are good predictors of a variety of environmental behaviors including home energy conservation and household recycling (Cialdini 2007b; Cialdini et al. 1990). Descriptive norms have been demonstrated to be more important than financial incentives and environmental messages (Cialdini 2007a). Disseminating information about the behavior of others can be very persuasive in producing a desirable behavior (Schultz 2002; Cialdini 2007b). An effective approach used by utility companies to motivate their customers to change their energy use consists in sending customers information on their energy consumption patterns and how they compare to their neighbors or households of similar size or number of occupants. By using this approach, a reduction by 2% in home energy consumption has been reported among Sacramento Municipal Utility District's customers (Carroll et al. 2009). Though they seldom admit it, individuals are motivated much more by their perceptions of what

other people do and find acceptable than they are by other factors such as financial savings or resources conservation (Cialdini 2007b). The closer the comparison group is from an individual, the bigger the impact of this information on the individual is (Schultz 2002). However, the influence of social norms as a predictor of a behavior can decrease in the instances where a behavior is perceived as desired but not commonly observed (Schultz 2002). Social norms are a more indirect determinant of behavior than moral norms (Bamberg and Möser 2007). They add to problem awareness, internal attribution, and feelings of guilt as contributors to moral norms. Also people may use social norms as indicators of how easy or beneficial the performance of a behavior can be (Bamberg and Möser 2007).

2.5.2.2.4 Self-Discrepancy Theory

The influence of injunctive norms mentioned above relates to a difference between two representations of the self: the actual self, defined as the attributes one thinks one possesses, and the ought self, defined as the attributes that one believes one should or ought to possess. These two representations, along with a third one, the ideal self, defined as the attributes that an individual wishes, ideally, to possess, constitute the basic domains of the self considered by Higgins (1987). The ideal and ought self-states are considered as self-directive standards or self-guides whereas the actual self forms a person's self-concept. These three perspectives of the self can also be the ones of a significant other (e.g. mother, father, sibling, spouse, closest friend) and are, in this case, considered as different standpoints than someone's own standpoints.

People tend to maintain a sense of consistency between their various self-perceptions. Problems occur when differences exist between people's individual aspirations and actual behaviors (Adler 1964; Allport 1955; Cooley 1964; Freud 1961; Rogers 1961). Higgins self-discrepancy theory (1987) relates discrepancies between these different domains of the self to specific types of negative emotional conditions. Discrepancy between a person's self-perceived actual attributes and the ideal state that he or she would like to reach is associated with dejection-related emotions such as dissatisfaction, disappointment, sadness. Discrepancies between actual and ought state are associated with agitation-

related emotions such as guilt, self-contempt, and uneasiness. The self-discrepancy theory asserts that people are motivated to minimize differences between their self-concept and their personal self-guides to avoid the negative psychological situations these discrepancies can cause (Higgins 1987). Therefore people may welcome behaviors that minimize these differences. These discrepancies can potentially be relevant to home energy conservation because they can be sources of motivation for home improvements that will bring the actual state of one's home to his/her ideal or ought state.

2.5.2.3 Behavioral Skills

Literature on behavior change and social marketing emphasizes that while enhancing people's motivation for behavior change is necessary, it is not sufficient (Maibach et al. 2008; McKenzie-Mohr 2000b). To be effective, behavior change programs must remove the barriers that impede the target audience from performing the desired behaviors. Therefore, the third factor this research attends to impact is behavioral skills including both one's perceived capacity to perform behaviors but also the contextual variables that tend to impede or facilitate behaviors. The barriers that prevent the adoption of energy-saving behaviors are multiple and the effectiveness of intervention's strategies varies with the nature of these barriers (Steg and Vlek 2008). Therefore the initial assessment of individuals' perceived lack of self-efficacy to perform a behavior is necessary and should be followed individually to identify specific barriers.

The concept of behavioral control/self-efficacy is first introduced in the next paragraph. The individual barriers/facilitators considered in the following paragraphs include factors that come into play when comparing the cost and benefits associated with energy-saving behaviors such as the financial and transaction costs, as well as reward and penalties associated with the performance of the behaviors, and the lack of information on how to perform the behaviors. Some barriers come from energy policies and the energy industry. However, this research considers only individual barriers.

2.5.2.3.1 Perceived Behavioral Control/Self-Efficacy

Perceived self-efficacy is defined as ones' beliefs about their capabilities of performing in a certain manner to attain certain goals (Bandura 1994). Self-efficacy beliefs influence how people think, motivate themselves and behave. Individual's perceived high level of self-efficacy for energy conservation coincides with a higher willingness to conserve energy (Van Raaij and Verhallen 1983). The next paragraphs introduce barriers and facilitators to the performance of energy-saving behaviors. Those factors work through perceived behavioral control or self-efficacy to influence the relationship between motivational factors and behaviors. This interaction appears in the IMBS and TPB theories (Ajzen 1991; Fisher and Fisher 1992).

2.5.2.3.2 Financial Costs

The energy-efficient versions of technologies often have a higher purchase price than the regular versions. For example, compact fluorescent light bulbs are more expensive than their less energy-efficient counterpart incandescent light bulbs. This difference in price put energy-efficient technology models at a disadvantage, especially because the average homeowner will not compute and compare the energy savings generated by an energy-efficient technology with the upfront cost of this technology. Few energy-efficient products can compete on a first cost basis (Brown 2001). Some actions such as improving home insulation or investing in a more energy-efficient furnace or air-conditioning system can yield significant energy savings but require a financial investment that people can sometimes not afford (Gardner and Stern 2008). A negative attitude towards loans to finance the investment into energy-efficient retrofits has been identified as one of the main barrier to the implementation of those retrofits (Zundel and Stiess 2011).

2.5.2.3.3 Transaction Costs

A noticeable increase in energy costs is believed to encourage people to invest in energy efficiency. However, no noticeable household's shift in investments in energy efficiency have attended the increase in energy prices experienced over the last decades (Gardner and Stern 2008). The cost in time and effort

required to calculate the actual return on investment of a technology, find the best products, vendors and installers, and oversee the installation of new products appears as one of the primary reasons of this inertia (Gardner and Stern 2008). Information can be expensive and difficult to obtain. The time and cost required for the customers to gather and process information, make decisions, design and enforce contracts relating to the purchase and installation of energy-efficient technologies can be viewed as transaction costs associated with the decision of investing in energy efficiency (Brown 2001). Those costs are strongly associated with the difficulty of performing energy-efficient retrofits. They are born by the homeowner and can be sometimes significant. They can impede the implementation of upgrades that homeowners can financially afford.

In most cases, house's energy costs are relatively small in comparison to other costs to operate a house: 3.1% of household's annual income versus 15% for any expenses for mortgage interest, property taxes, maintenance, repairs, and insurance (DOE Energy Efficiency and Renewable Energy, 2005). Since energy costs are not significant for the typical U.S. citizen, they usually receive little consideration in the face of information gathering and transaction costs (Brown 2001).

2.5.2.3.4 Rewards and Penalties

Disincentives and penalties, often in the form of fines, have been used by local, state and federal governments to motivate pro-environmental behaviors. This approach tends to generate negative affect, feelings or attitudes which become associated with the performance of the targeted behavior. Behavioral scientists are more favorable to an incentive or reward approach that generates a positive attitude towards a behavior, which in turns will be more likely embraced (Geller 2002). Though financial incentives can be considered as motivators, they also act as means of developing skills by facilitating the adoption of a behavior. Financial incentives in the form of grants, low-interest loans, or tax credits can encourage people to invest in energy-efficient technologies by lowering the burden of the upfront cost of those technologies. Weatherization assistance programs can also help address the financial barrier encountered by low-income households (Brown 2001). However, individuals may need some skill to figure out these

financial incentives which can be sometimes hard and bothersome to follow-through. Furthermore, though reward contingencies can produce significant increase in the desired behaviors, those behaviors are not further maintained as soon as the reward contingencies are withdrawn (Geller 1995).

2.5.2.3.5 Lack of Procedural Knowledge and Contextual Factors

Investment in energy efficiency is unlikely if the homeowner is not knowledgeable about how to best achieve energy savings. Householders willing to reduce their carbon emission and energy use, and aware of the financial and environmental benefits that can be obtained by doing so, will not proceed unless they know which actions to take (Gardner and Stern 2008). This aspect of knowledge is referred to as procedural knowledge and impacts one's capacity to perform a behavior. In several studies, procedural knowledge has been found to be strongly correlated to recycling behavior (Schultz 2002). Individuals engaged in recycling are usually very knowledgeable about recycling activities. Furthermore, in the case of energy conservation, householders often do not have a good understanding and knowledge of the actions that will help them save energy at the least cost and effort (Council on Environmental Quality 2009).

Contextual factors can affect behaviors directly by annihilating its feasibility (Steg and Vlek 2008). For example, people cannot have retrofits done if they do not have access to contractor's services and close retail stores.

2.5.2.4 Conclusion on Psychological Factors

Decision for energy-efficiency improvements is the result of a combination of motives and goals of different natures including economic, functional and moral. The influence of these motives on the actual performance of energy-saving behaviors is moderated by barriers that increase the cost one associates to these behaviors and undermine his or her perceived capacity to act. Information and awareness about energy consumption, its impact on the environment and actions that can mitigate this impact act towards the development of motivational factors and means to save energy.

The predictors detailed above are major determinants of pro-environmental behaviors relevant to the assessment of individuals' IMBS profile with reference to the performance of energy-saving measures that is the subject of this research. General energy-related attitudes including financial concern, environmental concern, energy concern, belief in science and technology, and attitude toward personal comfort and health are also related to behaviors but are not necessarily determinants of behavior (Black et al. 1985; Van Raaij and Verhallen 1983). Changing individuals' attitudes in a more energy-conscious direction may not result in energy-saving behaviors (Van Raaij and Verhallen 1983). Situational factors, lack of information, or lack of social incentives can form obstacles to the translation of individual energy-conscious attitude into actions (Van Raaij and Verhallen 1983). Attitudinal factors can help identify segments of energy consumers, for marketing purpose for example (Shelton Group 2011). But Geller et al. (1979) conclude that efforts to change attitudes in an energy conserving direction are less effective than action-oriented efforts to change behaviors.

2.5.3 Socio-demographic variables

While psychographic variables have been found to predict pro-environmental behaviors, it is also important to consider socio-demographic variables because these variables influence the psychological variables previously described and therefore have an indirect effect on behaviors. Furthermore socio-demographic variables, such as family composition or income conditions, determine household lifestyle and, thus, energy usage pattern (Van Raaij and Verhallen 1983). These demographic variables can be considered distal predictors of behaviors, having their impact, for instance, via their association with homeowner's information, motivation, and behavior skills. They can be useful for energy auditors to consider because they may be easier to assess. However, because they are distal predictors, there may be less precisely predictive of behaviors then directly knowing homeowners information, motivation, and behavioral skills. The following types of demographic variables are considered below: personal education, occupation, income level, gender, family composition and home ownership.

2.5.3.1 Education and Profession

Personal education, professional activity, interests and opinions influence energy-saving behaviors. Indeed these variables form individual values, attitude, beliefs and social norms which in turn influence behavioral intention (Van Raaij and Verhallen 1983).

2.5.3.2 Income

Household income plays also an important role in home energy use (Van Raaij and Verhallen 1983). Lower income households tend to use less energy. Indeed financial issues due to energy costs induce them to commit to minor curtailments (Black et al. 1985). However, their houses are often poorly insulated thus leading to waste of energy. They are, therefore, unable to reduce their energy use any further. On the other hand, high incomes tend to use more energy to heat bigger houses; however, energy expenses represent a smaller percentage of their budget (Van Raaij and Verhallen 1983). They are, therefore, not significantly incentivized to save energy. Some studies have found early adopters of energy conservation measures to be in the middle-income range (Black et al. 1985; Van Raaij and Verhallen 1983). High income consumers may accept longer payback periods for their energy-efficiency investments that low income consumers cannot afford. Low-income consumers are more often renters which change their perspective on energy conservation measures.

2.5.3.3 Family Composition and Gender Perspective

Family size, composition and routine have a direct effect on household energy use (Van Raaij and Verhallen 1983). Households with children at home have a higher use of energy, which gradually decreases when children leave home and increases again with age because older people need higher temperatures (Van Raaij and Verhallen 1983; Black et al. 1985). Also the presence of someone at home during the day increases the ambient temperature probably because of the lack of opportunity to lower the ambient temperature when the home is vacant. The influence of moral norms to curtail energy use is mitigated by the presence of someone at home who may suffer from cold temperatures (Black et al. 1985).

Weak and ambiguous correlation exists between gender and pro-environmental behavior (Wilson and Dowlatabadi 2007). Gronhoj and Ölander (2007) found that the relationship between gender and pro-environmental behaviors was consistent with the division of household roles within families, since this division makes the pro-environmental activities associated with these roles, such as waste disposal or energy consumption monitoring, the responsibility of either one of the spouses. This finding suggests that programs promoting environmental practices such as energy conservation should target their information or promotional efforts at the individual of the family most in charge of the desired behavior change (Gronhoj and Olander 2007).

The distribution of responsibilities and the possible differences of opinion within the family tend to be overlooked in the study of households' decision making process. Understanding who makes the final decision and how families arrive at a consumption decision can help target the message delivered to the households. Also, as different actors are involved in the household consumption process, a conservation behavior must be accepted by the entire family to be effective (Gronhoj and Olander 2007).

2.5.3.4 Home Ownership

Home ownership has been found to have a strong direct effect on households' capital investment in energy efficiency. Indeed, investments in energy efficiency tend to be made on the basis of self-interest (Black et al. 1985). The gain in energy savings or property value resulted from investments in energy efficiency is more limited for renters. Renters are less affected by consideration of costs and benefits, they are also less subject to the feeling of responsibility for improving the energy efficiency of their residence (Black et al. 1985). Furthermore, renters usually have little power of decision for the installation of energy-efficient upgrades. Landlords are not incentivized to buy more energy-efficient technologies, since the tenants, typically, pay the energy bills (Brown 2001). High household energy bills and the direct payment for home heating incentivize people to commit to low-cost energy improvements which save primarily on heating fuel (Black et al. 1985).

2.5.3.5 Conclusion on Socio-Demographic Variables

Evidence of a direct relationship between demographic and socio-economic factors and energy related behaviors has not been fully established (Wilson and Dowlatabadi 2007; Zundel and Stiess 2011). The effects of demographic and socio-economic factors on energy conserving behaviors are mostly indirect. Those factors often limit behavioral choice, as in the case of income level, and influence households' lifestyle and energy usage pattern (Black et al. 1985; Van Raaij and Verhallen 1983). They can therefore inform the assessment of psychological factors including knowledge, motivation and skills to save energy.

Home characteristics are another type of factors influencing energy use because variations in home size, degree of insulation, heating equipment and appliances affect household behavior and, thus, energy use (Van Raaij and Verhallen 1983). This type of characteristics is usually assessed by energy auditors during their inspection of the house and is not considered as part of the assessment tool developed in this research.

2.6 Making the Assessment of Factors Influencing Behavior Change Actionable

Successful interventions targeting behavior changes focus on the determinants and the barriers to the desired behaviors. Identifying these determinants and barriers is a preliminary step to the design of the interventions (Steg and Vlek 2008). For example, selecting behaviors to be promoted and attending to barriers and benefits associated with the selected behaviors are the first steps in the development of effective Community Based Social Marketing programs (McKenzie-Mohr 2000a). The behaviors of interest for this research have been identified earlier in this paper. Barriers (e.g. information deficits, skills, capacity) and benefits (motivators) have also been considered. The assessment of homeowners' IMBS during the intake phase of energy audits can allow auditors to identify appropriate strategies that they can use to encourage homeowners to take action. This section will connect the factors assessed by the assessment tool to examples of follow-up actions and strategies.

2.6.1 Targeting Specific Strategies to Address Motivation and Skills

Assessing the determinants of behaviors previously described leads to the establishment of an individual's IMBS profile, which in turn can guide the development and implementation of interventions addressing potential deficits in information, motivation or skills and/or taking advantages of existing strengths in one or several of these areas. For example, identifying barriers to the implementation of energy retrofits would allow energy auditors to seek for solutions, such as incentives programs as a means of overcoming economic barriers. Knowing homeowners' motives to save energy can help determine messages they will be responsive to.

Various strategies for interventions targeting behavior changes have been identified that differ by the set of behavioral determinants they focus on (Steg and Vlek 2008). Therefore the selection of a specific strategy may vary based on the factors to be addressed. A first distinction exists between strategies targeting antecedents of behaviors and strategies targeting consequences following behaviors (Geller 1995; Steg and Vlek 2008). Another related distinction exists between informational strategies and structural strategies. Informational strategies are strategies aimed at "changing perceptions, motivations, knowledge, and norms, without actually changing the external context in which decisions are made" (Steg and Vlek 2008). For example, informational strategies can be aimed at increasing individuals' knowledge of environmental issues and the existence of behavioral alternatives that can mitigate individuals' impact on energy use and the environment. They also include persuasion strategies, by strengthening people values and principled motives, and commitment strategies which appear to be a successful way to foster conservation behaviors, especially when people are asked not only whether they plan to change their behavior but also how they plan to do so (Steg and Vlek 2008). Goal setting, which consists of giving households an energy-saving goal to strive for, can also be effective especially when combined with a commitment to save energy or with feedback (Abrahamse et al. 2005). Normative beliefs through information about the perception and behaviors of others can also be used to support the desired behaviors (Schultz 2002). Incorporating social norm-based appeal into messages aimed at producing a desirable

behavior can be particularly persuasive (Cialdini 2007b). Informational strategies are mainly effective when few constraints exist to the adoption of a particular behavior. Structural strategies are strategies aimed at changing contextual factors affecting behavioral choices (Steg and Vlek 2008). These strategies are particularly effective when a behavior or action is difficult because of external barriers such as the costs or the availability of behavioral alternatives (Steg and Vlek 2008). These strategies can therefore indirectly affect motivation by making the desired behavior more feasible. Structural strategies include strategies aimed at increasing the availability of products and services and financial strategies. Financial incentives, such as loan subsidies, deferred-payment loans, or rebates, are important to reduce the burden of the initial cost of energy-efficient products. They must be combined with interventions to facilitate homeowners' access to these incentives (Gardner and Stern 2008).

Determining which strategies will be the most effective depends on the specific barriers that prevent individuals from implementing energy-saving behaviors, which suggests that interventions agents should have a good understanding of the situation and considerations of the people they speak to (Steg and Vlek 2008). As households are often prevented from action by different barriers, interventions should combine different strategies to address a larger number of barriers (Steg and Vlek 2008). An intervention combining tailored information, goal setting and tailored feedback gave successful results in the reduction of household direct energy use, the increase of knowledge of energy conservation and changes in energy-related behaviors (Abrahamse et al. 2005).

Some barriers such as anxieties about the retrofit process cannot be addressed by providing more information or more money. Professional energy auditors can assist homeowners to perceive the energy saving potential of their house that they tend to underestimate. But auditors' strategies when limited to showing the cost-effectiveness of recommended measures do not give enough consideration to the homeowner's mindset and situation. For example, homeowners may be willing to implement measures such as a solar heating collector that are not the most cost-effective option they have to increase the

energy performance of their home, but will satisfy their energy independence and their reputation among their neighbors (Zundel and Stiess 2011).

2.6.2 Framing the Information

Potential deficits in homeowners' level of information should be addressed as information can help develop their awareness of the environmental impact of energy-related behaviors. Information is also important to teach homeowners how to save energy (Abrahamse et al. 2005).

Key issues exist for the development of effective information material such as the complexity of the information delivered, the medium used to deliver the information, the framing of the message and the credibility of the source (Schultz 2002). Available sources of behavioral advice are not always helpful or in a form that leads people to take action (Gardner and Stern 2008). The availability of the information is not the only factor to consider; the framing is also important. Information that is simple, salient, personally relevant and related to a specific outcome appears more effective at encouraging behavioral changes (Abrahamse et al. 2005; Wilson and Dowlatabadi 2007; Yates and Aronson 1983). This finding suggests that a good understanding of one's objectives, knowledge, motivation and barriers with regard to energy-related behaviors is important to provide appropriate energy-saving recommendations and frame these recommendations in a way that will make them more appealing to this person. Such considerations can be applied to the home energy report made by the energy auditors which provides an analysis on the actual energy performance of a house as well as recommendations to reduce homeowners' energy consumption. The effectiveness of the home energy report substantially increases if this report accounts for the situation of the householders, their expectations, aspirations and capabilities (Parnell and Popovic Larsen 2005). The report should communicate not only the financial gains for various measures but also their benefits in terms of quality of life such as comfort, convenience and health, as those may be more relevant in the eyes of the homeowners.

The evaluation of people's knowledge, motivation and perceived capacity with reference to specific behaviors can also guide the selection of specific behaviors to target. Interventions focusing on a small number of highly effective actions appear more effective in leading people to act (Gardner and Stern 2008). The message should arrive when people are about to make a decision about energy conservation, which is for example often the case when people have requested an energy audit or are already planning on making improvements to their home.

Home energy audits have the potential to provide households with tailored face-to-face information about energy-saving behaviors. This type of information may have a greater impact on the homeowners' decision than a generic list of recommendations. Professional energy auditors can help cutting down the transaction costs for the householders associated with the collection, process and use of information and simplify the decision making by helping them directly focus on effective actions (Brown 2001). If needed, information should also cover very practical issues to increase homeowners' confidence in the process (Zundel and Stiess 2011).

2.6.3 Building Trust

Some barriers such as homeowners' uncertainty or anxieties about the retrofit process cannot be addressed by providing more information or more money. Establishing a trustful relationship with customers is also an important factor for the success of energy audits. Stern (1992) found that, beyond economic factors such as the existence of incentives, participation to energy-savings programs depends on their marketing and implementation. Thus, programs marketed by trusted organizations can experience a higher success than other programs. Gathering information about the homeowners prior to the inspection of the house can prepare energy auditors to their interaction with their customers and facilitate the building of a trustful relationship. For example, auditors can have a better idea about the persons they will be talking to through the collection of homeowners' socio-demographic characteristics. Moreover the knowledge of homeowners' IMBS profile can also help auditors prevent some unintended effects of the communication that would be detrimental to the building of a trustful relationship with their customers.

2.6.4 Conclusion

The assessment of homeowners' information, motivation and perceived capacity to perform energy-saving behaviors can be used by energy auditors in multiple ways, including selecting appropriate strategies that will support the adoption of recommendations by addressing barriers to behavior changes, framing the recommendations delivered to homeowners in a way that align with their perception, motivation, capacity and needs, and building a trustful relationship with their customers through better prepared and tailored interventions.

2.7 Summary

Home energy savings create benefits for the homeowners themselves in the form of lower energy bills, increased comfort, increased property value, and for the community in the form of reduced dependence on foreign fuels and reduced environmental impacts. However, despite these benefits, few consumers behave as energy-conscious citizens. Many reasons can explain this lack of involvement. Many consumers do not see energy conservation as a problem that concerns them. Consumers' social environment does not always incentivize them to save energy. They do not know what actions to take. They are poorly informed about the cost savings they can expect at the time of their decision. They are not always aware of the energy costs of household behaviors. They are not willing to put effort and money in conservation or efficiency measures, especially when those may affect their lifestyle.

The model of an informed rational decision maker that has been used by energy conservation programs and policies is misconceived. Decisions to make energy-efficiency improvements are the result of a combination of motives and goals of different natures. Those motives are associated to issues of everyday life, beliefs and orientations. Personal and situational barriers come also into play in individuals' decision. Large-scale interventions aimed at reducing residential energy use often fail to recognize the heterogeneity of the barriers and motivations existing in their targeted sample of homeowners. Psychology and social sciences research has contributed to the understanding of the mechanisms and associations causing participants to engage and sustain their motivation. Insights from this research have

highlighted the need to tailor interventions to customers' state of knowledge, motivation, needs, and objectives. New approaches for residential energy conservation programs taking into account individuals' determinants of behavioral changes have shown promising results in the literature. Those approaches rely on different models of behavioral changes that have been extensively used to promote pro-environmental behaviors. The three determinants of the Information, Motivation and Behavioral Skills (IMBS) model connect most of the predictors of behavioral changes found in the literature. This model has been successfully used to explain and predict health behaviors and its first applications to the field of pro-environmental behaviors showed promising results. The IMBS model has the advantage of transforming predictors of behaviors in a way that matches an intervention/learning approach which becomes more actionable.

Though they deliver detailed recommendations tailored to a specific house, home energy audits still miss some opportunities to generate the implementation of upgrades and retrofit that could be expected. Indeed these recommendations, though effective, may not suit customer's motives, lifestyle and aspirations. Another reason may be that auditors overlook personal and situational obstacles experienced by homeowners that may impede the implementation of those measures.

The conclusion that emerges from this literature review is that the assessment of homeowners' profile needs to be embedded in home energy audit practices. This research proposes to start this process by developing an assessment tool for home energy auditors to gather intelligence about the homeowners. The IMBS model will be used as a framework for this tool. The information collected will influence the intervention of the energy auditors and the recommendations formulated so as to increase the likelihood that homeowners follow through these recommendations.

Chapter 3
Research Objectives and Methodology

3.1 Problem Statement

Homeowners' behavioral characteristics are key factors that can influence the evaluation of household energy consumption and the design of energy-saving recommendations. Indeed, households' energy consumption is not just a function of the physical characteristics of their homes but also a function of the behavior patterns of the individuals and the decisions they make for home energy improvements. Homeowners' behavioral characteristics have the potential to provide valuable information for energy auditing programs because they can improve the auditors' understanding of the market and help them frame their interventions and recommendations in a way that will best resonate with their customers. Thus, an individual-centered approach may improve the effectiveness of home energy audits and increase the uptake of energy efficiency and conservation measures. This approach can benefit the energy auditing industry by saving time and money on the implementation of comprehensive evaluations that do not meet homeowners' needs or expectations.

However, despite these benefits, exploratory field observations made by the researcher through an internship with an auditing firm and informal discussions with professional energy auditors showed that energy auditors are still unfamiliar with this approach. They lack the background and means needed to assess homeowners' behavioral characteristics and incorporate this assessment in their current practices.

3.2 Research Goal

This exploratory research is aimed at the formalization, standardization, and embedment of the assessment of homeowners' Information, Motivation and Behavioral Skills profile during the intake process of home energy audits.

3.3 Research Questions

This research addresses the following questions:

1) What are the critical individual factors to be included in the assessment of homeowners' Information, Motivation and Behavioral Skills (IMBS) with regard to the implementation of energy-efficiency and conservation measures?
2) What considerations should be made for the design of an assessment tool of homeowners' IMBS and its integration in the intake process of energy audit customers?
3) How can the use of the IMBS model characterize homeowners in a way that suggests auditors what behavioral changes to target and how to tailor the audit communication in order to increase the likelihood that homeowners pursue energy-saving behaviors?

3.4 Research Objectives

This exploratory research examines the criteria affecting the development of an assessment tool of homeowner behavioral characteristics designed to improve the home energy audit process and the uptake of energy-saving measures. The following research objectives were formulated to guide the execution of this research:

Objective 1: Conduct background research and perform literature review

Conduct a review of behavioral science studies on the theories of behavior change, the determinants of pro-environmental behaviors associated with these theories, and strategies to foster pro-environmental behaviors. Conduct a study of traditional and new forms of home energy audits and tools.

This literature review constitutes Chapter 2 of this thesis. It presents the need for effective energy audits to mitigate the economic and environmental issues associated with the growing residential energy consumption. It also emphasizes the importance of occupants' behavior in household energy consumption. The literature review then details the determinants of pro-environmental behaviors that fit

the IMBS model of behavior change used as a conceptual framework for this research. Lastly it shows how the assessment of these determinants with audit customers can provide actionable information to the energy auditors allowing the design of tailored communication strategies and energy-saving recommendations that are more likely to induce homeowners to take action.

Objective 2: Develop a survey tool to assess the behavioral characteristics identified through the literature review with the energy audit customers. Develop a plan to evaluate the usefulness of the information collected by the tool and the impact of the tool on the auditors' interventions.

This objective concentrates on the development of the assessment tool of homeowners' behavioral characteristics using the determinants of pro-environmental behaviors identified in the literature review. This assessment tool is designed to be used by energy auditors during the intake process of energy audit customers. Several sub-objectives are outlined below to meet this particular objective and ensure the quality of the information collected:

1. Launch pilot tests of the assessment tool with 14 energy audit customers.
2. Collect participants' feedback and experts' inputs about the design of the tool.
3. Revise the assessment tool to incorporate the suggested improvements.
4. Develop a template of a homeowner assessment scorecard to summarize the information collected by the survey. This template was used for the next round of test of the assessment tool to present the profiles of the homeowners to the auditors.
5. Develop an evaluation plan to evaluate the usefulness of the information collected by the tool and the impact of the tool on the auditors' interventions. Part of this evaluation was performed during the following test of the assessment tool which was conducted in its intended settings, that is, as part of the intake process of an energy auditing firm.

Objective 3: Implement the assessment tool in the intake process of energy audit customers.

This objective requires administering the revised version of the assessment tool during the intake process of energy audit customers for a period of one month. Participants' answers are summarized into a homeowner assessment scorecard using the previously developed template. This assessment scorecard is provided to the auditors prior to their home inspection.

Objective 4: Collect feedback from energy auditors on the relevance and usability of the information included in the homeowner assessment scorecard. Evaluate the usefulness of the assessment tool and its outcomes on the auditor interventions.

This objective focuses on conducting a focus group of energy auditors to get their feedback on the assessment scorecard and the use of the information provided about the homeowners during the audit process.

Objective 5: Make conclusions about the study outcomes and lessons learned

This objective focuses on the development of guidelines and recommendations for the integration of the assessment tool in energy auditing practice. The lessons learned, limitations and results of the research are provided.

3.5 Research Steps

The following research steps were formulated to guide the completion of each individual research objective.

Objective 1: Conduct background research and perform literature review

Task 1: Highlight the potential of households' energy-saving behaviors to mitigate current economic and environmental concerns associated with residential energy consumption.

Task 2: Review the two main existing home energy audit programs, RESNET and BPI. Based on this review, field observations, as well as informal discussions with professional energy auditors, identify the challenges associated with the lack of consideration for consumer knowledge, motivation and behavioral adaptation in the traditional audit process. The review was completed by a study of emerging alternative forms of energy audit tools and approaches that integrate occupant-related factors to foster the adoption of energy efficiency and conservation measures.

Task 3: Identify the prominent theories of behavior changes applied to the field of pro-environmental behaviors. Analyze the determinants of behavior changes those theories consider through a review of social science and pro-environmental psychology research. Evaluate correlation of these theories with the Information, Motivation and Behavioral Skills model of behavior change, which is used as a conceptual framework for this research. Connect the behavioral determinants of these theories with the components of the IMBS model.

Task 4: Identify intervention strategies from the field of behavioral science aimed at fostering pro-environmental behaviors, including energy conservation. Describe how the assessment of individuals' IMBS profile can provide actionable information for energy auditors. To do so, connect the IMBS predictors to the design and performance of intervention strategies tailored to individuals.

Task 5: Conclude from this literature review the importance of using an individual-centered approach in the energy audit process that takes into account homeowners' knowledge, motivation and perceived self-efficacy.

<u>Objective 2:</u> Develop a survey tool to assess the behavioral characteristics identified through the literature review with the energy audit customers. Develop a plan to evaluate the usefulness of the information collected by the tool and the impact of the tool on the auditors' interventions.

Task 1: Define the objectives of a tool that allows auditors to assess homeowners' IMBS profile prior to conducting an energy audit.

Task 2: Identify homeowners' characteristics that are representative of their Information, Motivation and Behavioral Skills profile with regard to energy-saving measures, and can help energy auditors get a better understanding of their customers and target their interventions.

This task was performed by mapping out the theoretical factors found in the literature and sorted into the IMBS components (e.g. impact information, cost-benefits analysis, social norms, perceived self-efficacy) with their practical counterparts in the field of households' energy conservation behaviors (e.g. knowledge of energy saved by performing specific behaviors, motives to save energy at home, comparison with neighbors' behaviors, capacity to pay for energy retrofits). These counterparts were found through the literature review, exploratory field observations and informal discussions with professional auditors.

Task 3: Identify the energy-related behaviors of interest to be included in the assessment tool. This task was performed through a cross comparison of several lists of energy-saving behaviors. These lists included Dietz et al. list, the DOE Home Energy Saver list, and the marketing firm Shelton Group list. Behaviors that overlapped the different lists and fit the five categories of behaviors defined by the National Energy Leadership Corps program (safety and protection, conservation, efficiency, energy monitoring and generation) were selected.

Task 4: Develop a first version of the assessment tool in the form of a questionnaire measuring the previously determined homeowner's characteristics. This questionnaire was first implemented in the web-based tool Survey Monkey.

Task 5: Work with the energy auditing firm Envinity (State College, PA) to find energy audit projects for which the tool could be tested. These projects included two sets of audits conducted in residential communities and gave an opportunity to have access to a larger number of participants in a small amount of time.

Task 6: For each energy audit project identified, provide homeowners with a short description of the research study and request their consent for survey participation.

Task 7: Administer the survey face-to-face to a first set of three homeowners. Observe participants' reactions to and interpretation of the questions of the survey.

Task 8: Analyze comparatively the observations made when administering the survey to the different homeowners and identify commonalities in the encountered problems. Potential problems included lack of clarity of the questions due to the use of technical jargon, not well-defined concepts, vague questions, lack of question user-friendliness and potential discomfort due to indiscreet questions. Identify the questions that homeowners have no difficulty to answer and receive a good response rate. Make appropriate changes and adjustments to the survey.

Task 9: Administer the online version of the survey to a second set of eleven homeowners through Survey Monkey. Collect homeowners' feedback through informal post-survey interviews about the survey length and clarity, and potential discomfort felt by the participants when answering the survey.

Task 10: Familiarize oneself with the preliminary rating system of the survey developed by Dr. Swim, Professor of Psychology at Penn State, and how to assess results from surveys using the Statistical Package for the Social Sciences (SPSS) software. The rating system provides a qualitative and quantitative description of respondents' level of knowledge, motivation and skills with reference to energy-saving measures. In order to perform this task, some of the surveys filled out by the eleven homeowners were rated using the rating system.

Task 11: Develop a template of a homeowner assessment scorecard using the results of the rated surveys. This scorecard serves to summarize homeowners' answers to the survey and turn them into IMBS profiles of the homeowners to be used by energy auditors.

Task 12: Establish a working relationship with the marketing firm Shelton Group. Request their feedback about the assessment tool design and the approach used to assess homeowners' profile.

Task 13: Make adjustments to the survey based on Shelton Group's inputs and homeowners' feedback. Make adjustments to the homeowner assessment scorecard to match the updated version of the survey.

Task 14: Develop a plan to assess the impact of the tool on the energy audit process and outcomes. Identify the items to be assessed and their according tools. The first item to be evaluated was the design of the survey. This evaluation was conducted by means of questions included at the end of the survey pertaining to its length and its clarity. The second item to be evaluated was the usefulness of the assessment scorecard and the impact of the information about the homeowners collected by the tool on auditors' interventions and interactions with their customers. This evaluation was conducted through two focus groups of energy auditors. The third item to be evaluated was the impact of the assessment tool on homeowners' behavioral factors (e.g. satisfaction, trust, motivation, and perceived efficacy), and short-term and long-term success of the audits. Recommendations for the process and the necessary instrument to conduct this evaluation were developed but were not implemented due to time constraints and communication issues with the energy auditing firm.

Objective 3: Implement the assessment tool in the intake process of energy audit customers.

Task 1: Contact the auditing firm Mark Group and present the assessment tool to the Director of Training and Product Development. Obtain the Mark Group agreement to ask their customers to participate in the research study.

Task 2: Define a procedure to implement the assessment tool in the Mark Group's audit process including timeline, recruitment of the participants, administration method, person in charge of administering the surveys, and rating of the surveys.

Task 3: Make potential changes to the survey to make it more suitable to use in the context of the Mark Group audits. Implement the updated version of the survey in Qualtrics.

Task 4: Obtain the IRB approval to use the survey for a set of audits conducted by the Mark Group.

Task 5: Revise the initial version of the rating system to match the updated version of the survey using SPSS.

Task 6: Send an email with the link to the web-based survey to the Mark Group customers who scheduled an audit and agreed to take the survey. These participants were recruited during a period of three weeks.

Task 7: Download participants' responses to the intake survey in SPSS. Score the responses, summarize the results into a homeowner assessment scorecard using the template developed Send the scorecard to the auditors in charge of the audits.

Objective 4: Collect feedback from energy auditors on the relevance and usability of the information included in the homeowner assessment scorecard. Evaluate the usefulness of the assessment tool and its outcomes on the auditor interventions.

Task 1: Analyze homeowners' feedback about the design of the survey by sorting their feedback collected through the questions at the end of survey into the categories they relate to: clarity, length, and comfort.

Task 2: Develop a questionnaire to guide two focus groups with the Mark Group and Envinity energy auditors. Define the elements to be evaluated and formulate questions to assess these elements.

Task 3: Conduct a focus group with four energy auditors from the Mark Group using the questionnaire developed. Organize and report their observations about the usefulness of the information included in the

assessment scorecard, ways this information can be used, the benefits of the assessment tool for the auditing business and improvements needed to better integrate its use in their audit practices.

Task 4: Conduct a focus group of two Envinity auditors using the questionnaire developed. Organize and report their observations about the usefulness of the information included in the assessment scorecard, ways this information can be used, and the benefits of the assessment tool for the auditing business.

Task 5: Identify issues with the administration of the assessment tool and process of the responses based on observations made by the researcher when administering the tool and scoring the responses. Make recommendations to address these issues. Make recommendations regarding the administration and the design of the tool and the design of the homeowner assessment scorecard to address the issues identified through the interview of the energy auditors and the feedback from the homeowners.

Task 6: Identify potential limitations with the applicability of the assessment tool.

Objective 5: Make conclusions about the study outcomes and lessons learned

Develop guidelines and recommendations for the integration of the assessment tool of homeowners' behavioral characteristics in the energy auditing practice.

3.6 Research Design

3.6.1 Objectives of the Assessment Tool of Homeowners' Behavioral Characteristics

This research focuses on the development of an assessment tool of homeowners' characteristics to help with energy audit practices. This tool is designed to be implemented in the form of a survey during the intake process of energy audit customers. The goal of the tool is to gather valuable intelligence about audit customers with a minimal amount of cost, effort, or intrusion upon them. The information collected by the survey is aimed at assisting energy auditors in framing their interventions in a way that is best aligned with the customers' aspirations, knowledge and motivation, and address potential barriers to the

implementation of energy-saving measures. Moreover, being part of the intake process, the assessment tool has to establish homeowners' confidence, generate their interest and manage their expectations regarding the upcoming energy audit.

The Information, Motivation and Behavioral Skills (IMBS) model of behavior change is proposed as a conceptual framework to determine the individuals' predictors of energy-saving behaviors assessed by the survey. The IMBS model combines three predictors of behavioral change: information relevant to the behavior, motivation towards the performance of the behavior, and behavioral skills for performing the said behavior (Fisher et al. 1999). Those three predictors encompass the main psychological variables influencing environmental behaviors identified in the literature (Bamberg and Möser 2007; Hines et al. 1986).

Using the IMBS model, the dimensions of the homeowners' profile the assessment tool assesses are:

- Individuals' knowledge about actions they can take to save energy at home, the impact of different home improvements and conservation behaviors on their home energy consumption
- Individuals' motivation to save energy at home and perform specific types of energy-related measures and behaviors
- Individuals' perceived self-efficacy to perform energy-efficiency home improvements or conserve energy through their everyday behavior
- Individuals' goals and aspirations for home energy improvements

Components of those dimensions are detailed in Chapter 4. Additionally, the assessment tool provides a measure of homeowners' current energy-related behavior pattern through an assessment of the energy conservation and efficiency measures they have already undertaken. It also includes some demographic questions that inform the psychological variables of the IMBS model.

Information gathered about each homeowner by the intake survey is summarized into an assessment scorecard so as to suggest auditors how to use this information for their interventions. In particular, this

information could help auditors analyze the energy consumption of the households, identify the type of recommendations that best matched their customers' profile and frame these recommendations in a way that resonates with their customers' needs and motives. Such a tailored approach is likely to increase homeowners' satisfaction with the audit, their trust in the energy-saving predictions made by the auditor and their confidence in the decision to do energy-efficiency improvements. The use of the assessment tool in the intake phase of an energy audit is therefore expected to improve the outcomes of the audit for the homeowners and increase the likelihood that homeowners pursue energy-saving recommendations. This will be accomplished through more personalized, targeted and appealing assessments and recommendations, and by better empowering homeowners to act.

3.6.2 Design and Integration of the Tool in the Energy Audit Process

This research examines the behavioral characteristics of the homeowners that need to be taken into account for the design of effective energy audits and the considerations made for the development and implementation of a tool assessing these characteristics. A prototype of this assessment tool was therefore developed and implemented in the process of an energy auditing firm to test the use of this tool in a real world setting and provide recommendations for future use and development.

The assessment tool was first tested as part of its development process through community-based energy audits conducted by the energy auditing firm Envinity in the Fall of 2011. Feedback from the participants was collected through informal interviews to identify problems with the clarity and length of the tool, as well as its ability to assess individuals' characteristics in a non-invasive manner. Additional inputs on the design of the tool were collected from the Shelton Group, a marketing firm leader in the conduct of energy consumer surveys. The Shelton Group's lessons learned and consumer insights were gathered through a set of workshop conference calls and added to homeowners' feedback. Some observations were also made during the first testing of the tool. These different data sets served as guidelines for the development of a revised version of the tool incorporating modifications aimed at

making the tool more clear, shorter and user-friendly. The final version of the survey was implemented on Qualtrics survey software.

This revised version of the tool was then tested in the Spring of 2012. The researcher worked with the auditing firm Mark Group that agreed to allocate a portion of its clientele for the purpose of this research. The sample of participants was made up of householders from the Greater Philadelphia area who self-selected for a free home energy assessment. The process of recruiting participants to take the survey is described in details in Chapter 5.

3.6.3 Research Techniques

The link to the survey was emailed to the participants using Qualtrics. An advantage of this method is the instantaneous track of the data. A panel was created with the names and email addresses of the participants. The use of a panel allowed the researcher to track whether the respondents had answered the survey or even looked at it, and manage the sending of reminders accordingly. When using a panel, the name of the participants, instead of their IP address, appears on Qualtrics with their answers.

The participants' responses were downloaded from Qualtrics to the Statistical Package for Social Science (SPSS). A scoring system was developed to translate some participants' answers into quantitative data that could be then reported on an assessment scorecard. The scoring system was programmed into SPSS by the researcher to automatically score the survey results.

3.6.4 Methods for the Evaluation of the Tool

Testing the assessment tool with the Mark Group energy audit customers allowed evaluating the outcomes of the tool and the usefulness of the collected data for the auditors' interventions.

This evaluation was conducted through a focus group led by the researcher with four energy auditors from the Mark Group and the employee in charge of the intake phone call. The issues that were intended to be analyzed during this discussion included:

- the perceived usefulness of the information included in the homeowner assessment scorecard,
- the ways this information could be used by the auditors for the design of their interventions,
- the outcomes of the tool on the auditors' interaction with their customers,
- the improvements needed in the administration of the tool and the design of the assessment scorecard to better integrate the assessment of homeowners' characteristics in the energy audit practice.

A questionnaire was developed to guide the discussion with the energy auditors, organize the data collection process by setting a list of specific issues to be addressed and ensure that all the problems were covered for the evaluation of the tool. The face-to-face approach of the focus group allowed the researcher to ask probing questions to deeply explore the auditors' opinions about the tool and encourage them to share some examples to support their opinions.

Another focus group of two Envinity energy auditors was conducted using the same questionnaire to evaluate the assessment tool and the homeowner scorecard from a different perspective. The information collected supplemented the insights from the Mark Group energy auditors and confirmed the conclusions drawn from these focus groups. The collected qualitative data was organized and reported in a descriptive manner.

Observations were also made by the researcher throughout the administration process of the assessment tool. These observations were aimed at revealing potential issues with the tool management and data collection process that required more attention for future administration of the assessment tool.

3.6.5 Reliability Analyses of the Assessment Tool

Another step in the analysis of the assessment tool was to evaluate the reliability of the sum scales used to measure the different behavioral factors included in the survey. In statistics, reliability concerns the consistency of a set of measurements or of a measuring procedure. There are different classes of reliability. The one considered in this research was the internal consistency of responses across items

within measures. Some of the scales used in the survey questions are made up of multiple items. For example, homeowners' general motivation to save energy is measured as the average of their motivation with regards to different reasons that can affect people's motivation to save energy such as saving money on their energy bill, increasing the comfort of their home or protecting the environment. Internal reliability tests can help determine the items that do not support the reliability of the construct measured by the scale.

The assessment of the scale reliability following the classical testing theory model is based on the correlations between the individual items that make up the scale, relative to the variances of the items. A response to an item of the scale reflects the true score for the intended concept that this item contributes to measuring, and, to some extent, esoteric aspects of the respective question, also known as random error. A measurement is reliable if it reflects mostly true score relative to the error. In the case of a multiple-item scale, random error or fluctuations that vary across responses to the items are sources of inconsistency in the item scores that can make the scale unreliable. Multiple items on a single scale (question) should converge on the same conclusions about true scores, called internal consistency. When they do not, the lack of consistency is revealed by a low reliability coefficient. The index of reliability used, called Cronbach's coefficient, estimates the proportion of true score variance that is captured by the items of a scale. This is done by comparing the sum of item variances with the variance of the sum scale. A Cronbach's coefficient higher than 0.7 means that the items can be considered as measuring the same thing and can be combined into one scale to reliably measure a particular concept.

In addition to the internal reliability tests, a principle component factor analysis is used to determine how the items of the questions group together to form factors. These factors should represent the underlying scales measured by the questions. If a question has been conceptually designed to measure a single scale (e.g. motivation), only one factor should hypothetically be identified in the question. Otherwise the question does not perfectly reflect the underlying scale and inconsistencies potentially exist between the items of the question.

The number of responses collected from the testing of the survey with the Mark Group customers was not sufficient to conduct reliability analyses. Therefore the survey was distributed to members of the Penn State CFS listserv to collect more responses to run a statistical analysis. The number of responses was still low, but it was improved and provided more confidence in the factor analyses. The respondents were not customers of an energy auditing firm. Therefore their answers only served the purpose of doing reliability tests on the scales used in the survey.

3.7 Recommendations for Future Evaluation of the Assessment Tool

The evaluation of the tool should be completed by the examination of its short-term and long-term effects on homeowners' behaviors and decisions. Additionally, this evaluation should also focus on measuring changes in behavioral determinants of homeowners' actions and decisions following the audit. This measurement can increase the understanding of why the use of the assessment tool in the auditors' interventions was successful or not (Steg and Vlek 2008). For example, it may be found that the tool did not produce the expected short-term effects on the homeowners' decision because the use of the tool did not address some of the barriers experienced by the homeowners.

By providing information about the homeowner IMBS profile, the assessment scorecard aims to help auditors better target and personalize their communication to the homeowners and address potential barriers to the implementation of energy saving measures. The short-term outcomes of such improved auditors' communication would be:

- Homeowners know what actions to take and perceive these actions as feasible
- Homeowners perceive the actions recommended by the auditor as more relevant to their personal motives and objectives in terms of home improvements
- Homeowners increase their trust in the auditor
- Homeowners are confident in the potential benefits resulted from the recommendations of the auditor

- Homeowners are overall more satisfied with the energy audit.

Such outcomes are likely to translate in the increase of the likelihood that homeowners take actions in the long-term.

The procedure and the instrument allowing the evaluation of these factors were prepared but not implemented due to time-constraints and communication issues with the Mark Group. They are described in Chapter 6 to provide some guidelines for future research.

3.8 Expected Outcomes and Contributions

The intent of this research is to improve the effectiveness of home energy audits and increase the homeowners' uptake of energy-saving recommendations by fostering considerations made for the characteristics of the homeowners in the audit process. The expected outcomes of this research include the determination of the individuals' behavioral factors that need to be taken into account, the process and the tools to integrate the assessment of these factors in energy auditing practices. A survey was developed to conduct the assessment of homeowners' behavioral characteristics in the intake phase of energy audits. A coding system and an assessment scorecard were also developed to rate and summarize the answers of the homeowners, and present this summary to the auditors prior to the home inspection. The primary goal of providing more information about the homeowners' behavioral characteristics to the auditors is to make the energy audits:

- more accurate by considering homeowners' current energy-related behaviors in addition to the physical characteristics of the home,
- more meaningful for the homeowners by addressing their specific needs, aspirations and motivation
- more effective in leading to the implementation of energy efficiency upgrades by tailoring the information and recommendations provided to the homeowners and empowering the homeowners to act.

It is also feasible that, once proven as a non-invasive instrument, the survey process and results could also contribute to:

- Identifying homes or homeowners that are more or less likely to pursue upgrades and therefore increasing the profitability of the audits for the auditing firms by selecting interventions with high potential of success.
- Helping establish the confidence and expectations of the homeowners prior to a home visit by an auditor.

Recommendations made for the future iterations of the survey will point towards the development of a stand-alone tool to be used by energy auditors that is clear and allow for broader applications in the energy auditing industry.

This research also provided the ground-work for future research that will study how the factors assessed by the survey interface with the information, resources, motivational tools, and behavioral recommendations by the auditors.

3.9 Research Limitations and Bias Factors

Due to time constraints, the focus groups of auditors were led by the researcher, while the ideal design for a focus group would have required the assistance of another person to manage the discussions. This condition introduced a potential for research bias in the way feedback from energy auditors was collected due to the goal to demonstrate the validity of the research hypothesis and develop a tool that successfully assesses relevant characteristics of energy audit customers. Some methods were used to minimize this risk. Some criteria for the evaluation of the survey were defined. The auditors were encouraged to identify areas for improvements in the design of the tool and the assessment scorecard.

A follow-up survey for the homeowners was also developed. Once scored and comparatively analyzed between two groups of homeowners who did and did not fill out the intake survey, this follow-up survey would provide a measure of the impact of the intake tool on the homeowners' experience with the audit.

However, this survey could not be implemented due to time constraints and communication issues with the energy auditing firm with whom the researcher worked.

Due to the research timeframe, the survey was tested on a small number of homeowners. The sampling technique used to test the assessment tool was not as rigorous as the techniques employed in large quantitative studies. The researcher did not have control over the sampling selection, and consequently, the respondent-related variables. The conduct of a statistical analysis to test the internal reliability and factor structure of the scales used in the assessment tool would have required a larger sample to be reliable and generalizable. The tool should also be tested with a greater number of auditors and in other environments to reliably assess its applicability.

Some limitations came from the use of a web-based survey to assess homeowners' knowledge, motivation and behavioral skills to take energy efficiency and conservation measures. This method of survey implementation limited the control the researcher could have on the respondents. For example, the web-based survey gathered the answers of one member of the household which may not reflect the levels of knowledge, motivation and skills of the entire household. The respondent may not have been the member of the household who made the final decision concerning energy-saving home improvements. Moreover, the use of a self-report questionnaire poses a social desirability bias, which occurs when people answer questions so as to "look good" in the eyes of others. However, the use of a web-based survey instead of a face-to-face interview was likely to reduce the risk of social desirability bias. Furthermore, the assessment tool was introduced as a means to improve the quality of the audit to encourage homeowners to give genuine responses.

This research was aimed at making an incremental step towards the development of more effective and accurate energy audits where auditors are better prepared, and homeowners more confident and excited about the assessment. Yet the research did not assess whether the use of the survey led to an increase of homeowners' uptake of energy saving measures. This would require the researcher to come back after

several months to the homeowners to assess what home improvements have been performed. This research was a preliminary step in the integration of a behavioral approach in energy audits. A next step could consist of training the auditors to interpret and use the information gathered by the assessment tool through behavioral strategies. This research did not involve training auditors to use the tool and therefore limited its potential as a way to improve auditors' intervention. Furthermore providing a tool to gather information about homeowners' energy usage patterns was believed to be the first step in the integration of behavioral characteristics in energy simulation models that would increase the accuracy of energy saving predictions. Yet the implications of the assessment tool on the accuracy of energy models were not tested.

3.10 Research Organization

This research started with conducting a literature review to organize the landscape of behavioral science research around lessons learned and strategies to foster the implementation of energy-saving measures and behaviors (Chapter 2). This literature review helped determine the behavioral characteristics of the homeowners that should be taken into account in the design of the auditor's intervention and the formulation of energy-saving recommendations. The objectives and criteria for the development of an assessment tool of homeowners' behavioral characteristics were defined. The tool was developed in the form of an intake survey to embed the assessment of these factors into the energy audit process (Chapter 4). Two iterations of the tool through community-based energy audits helped refine the questions. The tool was finally tested in its actual setting with the customers of the energy auditing firm Mark Group (Chapter 5). Lessons learned from this testing through the observations made by the researcher and some feedback from the energy auditors allowed to conclude on the considerations to be made for the development of the assessment tool. Recommendations were then formulated for the energy auditing industry on the integration of homeowners' behavioral characteristics in energy audit practices (Chapter 6).

Chapter 4
Development of the Assessment Tool of Homeowners' Characteristics

4.1 Introduction

This chapter presents the rationale for developing an assessment tool of factors influencing homeowners' decision to save energy. A prototype of this tool was designed in the form of a survey to be implemented in the intake phase of energy audit customers. This chapter first introduces the objectives of the tool which served as criteria for its design and evaluation. The assessment tool was tested as part of its development process with customers of Envinity energy auditing firm in the Fall of 2011. The purpose of this preliminary testing was to identify issues with the length and clarity of the tool, collect homeowners' immediate feedback, and revise the tool accordingly. The impact of the tool on auditors' interventions was not measured at this stage. Insights from the marketing firm Shelton Group also contributed to the development of the final version of the tool which is described in this chapter. A scoring system was developed to translate participants' answers into their Information, Motivation, and Behavioral Skills profile. An assessment scorecard was created to summarize and present each individual profile to energy auditors. The final version of the assessment tool was then tested and evaluated in a different setting with an auditing firm in Philadelphia in the Spring of 2012. This process is described in Chapter 5.

4.2 Background of the Tool

Home energy audits targeting near-term home energy reductions through altered homeowners' behaviors and the use of available technologies have a promising potential for mitigating current economic and environmental concerns associated with households' energy use (Dietz et al. 2009; Gardner and Stern 2008). Through the audit process, homeowners can receive specific and personalized recommendations to save energy at home. Such a tailored approach can assist them in their decision and lead them to the performance of appropriate energy retrofits (Abrahamse et al. 2005).

Exploratory research in the field was conducted by the researcher through field observations, informal discussions with professional energy auditors from the auditing firms Mark Group (Philadelphia, PA) and

Envinity (State College, PA), participation in the training for the BPI- Building Analyst certification exam at the Penn College Weatherization Training Center and attendance to conferences. This exploratory research led to the conclusion that, in traditional audit practices, the recommendations made by the energy auditors are often based on the assessment of the home physical characteristics and not the homeowners themselves. In the case of the auditing firms the researcher was in contact with, the auditors' interaction with the homeowners is often limited to assessing their concerns with their homes and collecting information about the home systems and design. Little information is collected about homeowners' knowledge, motives and skills to adopt energy-saving behaviors.

Furthermore, the perception of the homeowner as a rational decision maker may induce energy auditors to emphasize the cost-effectiveness of the measures they recommend (Zundel and Stiess 2011). The homeowners own self-report suggests that personal gain motivates their behaviors (Wilson 2010). Yet, despite measurable and clearly defined monetary benefits, efforts to encourage homeowners to make energy improvements to their homes have not achieved the expected results (Fuller et al. 2010; Parnell and Popovic Larsen 2005; Wilk and Wilhite 1987). The discrepancy between cost-effective energy-saving measures that could be implemented and the measures actually implemented may be addressed by a better understanding of homeowners and the factors influencing their decisions.

Lessons learned from behavioral science research on predictors of pro-environmental behaviors emphasize the need to adjust interventions aimed at promoting energy conservation to individual behavioral and psychological characteristics (Ajzen 1991; Bamberg and Möser 2007; Black et al. 1985; Fishbein 1975; Hines et al. 1986; Lutzenhiser 1993; Stern 1992). To do so, conceptual models of behavior change can be applied to the field of energy audits to organize the assessment of homeowners' behavioral characteristics. These models can form decision tools for the auditors to determine the type of recommendations that best suit an individual household and frame the message that will best resonate with the homeowners. The premise of this research is that tailoring the approach of the auditors to the homeowners' profile can ultimately increase the uptake of energy efficiency and conservation measures.

Assessing homeowners may also benefit the energy auditing industry by saving time and money on the conduct of comprehensive home energy audits that do not meet homeowners' needs or expectations.

This research proposed the creation of an assessment tool of homeowners' behavioral characteristics. The collected data were then summarized into an assessment scorecard and presented to the energy auditors prior to the home inspection. The assessment tool and associated scorecard aimed to assist energy auditors in tailoring their approach to engage homeowners into the pursuit of energy-saving measures, and, more importantly, keep them engaged through a continuous audit process and coaching tools.

The Information, Motivation and Behavioral Skills (IMBS) model of behavior change was proposed as a conceptual framework to organize the assessment of homeowners' characteristics. The IMBS model combines three predictors of behavioral change: information relevant to the behavior, motivation towards the adoption of the behavior, and behavioral skills for performing the behavior (Fisher et al. 1999). Those three predictors encompass the main psychological variables influencing environmental behaviors identified in the literature (Bamberg and Möser 2007; Hines et al. 1986). According to the IMBS model, an individual who is well-informed, motivated to act and possesses the appropriate behavioral skills to engage in a specific behavior is expected to engage in this behavior.

An advantage of the IMBS model is that it goes beyond describing and understanding predictors of behaviors. It transforms these predictors in factors that the auditors can potentially address during their interventions or use to frame their interaction with the homeowners. For instance, auditors can address possible lack of information of the homeowners about actions they can take to save energy at home. Knowledge of homeowners' motives to save energy can help the auditors frame their recommendations in a way that aligns them with these motives. Auditors can also provide assistance to overcome potential barriers experienced by the homeowners for the implementation of energy-saving measures.

This research also proposed to apply the IMBS model to auditing practices so as to understand homeowners' view of specific types of energy-saving behaviors. The specific information, motivation,

and behavioral skills of the homeowners may vary for different types of behaviors. An auditor may wish to either choose some behaviors that match homeowners current IMBS or develop their IMBS in order to promote other behaviors. Furthermore, understanding homeowners' current behavior, which is not always evident in an intake interview, can help auditors understand sources of energy use within the home. Thus, the assessment tool includes both a general assessment of homeowner's information, motivation, and behavioral skills with regard to saving energy at home and an assessment of these three factors with regard to specific types of energy-saving measures.

4.3 Objectives of the Assessment Tool

4.3.1 Integration with the Energy Audit Intake Process

The energy audit process is structured around multiple interactions with the customers starting from the intake where information about the customer is taken down and the auditor visit scheduled, to upgrades follow-up. A primary purpose of this ongoing relationship with the homeowners is to keep them engaged into the performance of energy-saving measures.

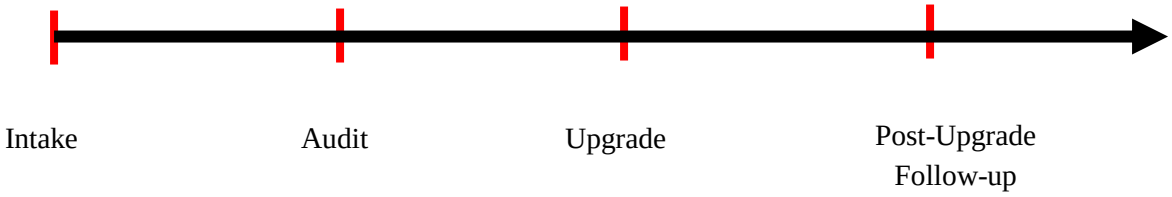


Figure 4-1: Energy audit process and customer interaction

By initiating the audit process, the intake phase is a major step where auditors can learn about their customers, their type of home and equipment, and any issues their customers experience. Information collected at this stage can aid auditors in preparing their intervention and providing assistance that has more lasting benefits to the homeowners than the mere resolution of the issue driving their call. The intake phase is therefore appropriate for the assessment of homeowners' behavioral characteristics since the information collected can be used throughout the auditor's intervention and audit follow-up.

This research proposes the development of a survey tool to integrate the assessment of homeowners' profile into the intake process. The survey will be administered to the homeowners after they schedule an audit. The targeted audience of the assessment tool is therefore individuals who self-selected into an energy audit and thus demonstrated some interest in behavioral change.

The assessment tool seeks to provide a mechanism for energy auditors to profile their customers. The dimensions of this profile are:

- Individuals' information/awareness defined in terms of homeowners' beliefs about the extent to which different actions can save energy, and their knowledge about measures and behaviors that would be the most useful to save energy in their home.
- Individuals' motivation defined in terms of homeowners' aspirations and goals for saving energy. Different types of motives are considered, including a) principled stands versus personal self-enhancement, and b) a variety of types of norms (personal norms, community standards, and descriptive norms) and how one's behavior aligns with these norms.
- Individuals' behavioral skills defined in terms of their perceived capacity to engage in energy-efficiency actions. These include a) their general skills for changing their behaviors and doing efficiency improvements to their home including their ability to do the work by themselves or with the help of someone else, their ability to change their lifestyle to save energy, their ability to pay for the home improvements, their ability to take the time to do these improvements, and b) behavioral specific skills.

In addition to these behavioral characteristics, the tool collects some demographic information that can have an influence on the households' energy consumption and decision to invest in energy efficiency improvements. For instance, this demographic information includes the household composition and the time people intend to stay in their current residence.

Being part of the intake process, the assessment tool is an important element in the establishment of homeowners' trust in the auditor work. Therefore it has to be carefully designed to avoid discouraging customers by giving the idea that the audit process is complex or costly, or generating some reticence from them due to the feeling of being judged. The survey has to be clear, of an appropriate length, and avoid any phrasing that would have a negative effect on participants' mindset. A well-designed survey is expected to help establish homeowners' confidence and expectations regarding the visit of the auditor.

4.3.2 Tailor the Intervention of the Auditor to the Homeowners' Profile

The assessment tool aims to assist energy auditors in providing appropriate resources and recommendations by separating out their customers based on their information/knowledge, motivation and skills to perform energy-saving behaviors and home improvements.

More specifically, the objectives of the tool are to:

- Determine homeowners' base-line knowledge, motivation and skills to perform energy-saving behaviors and home improvements.
- Provide characterization data for auditors to assist them in determining what type of information to convey to homeowners and how to frame this information, such as in terms of homeowner interest in safety, efficiency, conservation, monitoring, and generation.
- Determine specific measures and behaviors that are more likely to be considered by homeowners such as measures for which the homeowners reported having plans for, reasons why homeowners requested an audit, measures the homeowners have already thought about, and measures the homeowners are willing and able to do.
- Establish a measure of homeowners' current energy-related behavior pattern.
- Create an output of this assessment that auditors can use for their interaction with the homeowner and the creation of the audit report.

The survey results can help energy auditors identify the type of recommendations that best match their customers' profile and tailor their communication to homeowners' aspirations, knowledge, motivation and needs. This approach is likely to increase homeowners' satisfaction with the audit, their trust in the energy-saving predictions made by the auditor and their confidence in the decision to do energy-efficiency improvements to their homes. Therefore the assessment tool may contribute to the development of effective energy audits more likely to translate into retrofits through an improved interaction between the auditors and the homeowners. It can benefit energy auditors by adjusting their time and effort to individuals' specific motives and difficulties. It can avoid auditors to spend time and money in comprehensive home energy audits when homeowners' motivation, interest and objectives do not justify them.

4.3.3 Tie Energy-Related Behaviors in with Building Sciences

Most analysis techniques used in building energy simulation models use a set of standard operating conditions to objectively compare home energy use before and after a series of retrofits is completed. Actual occupant behavior is an important parameter of these simulation models because it influences the cost-effectiveness of a retrofit package. Current energy analysis techniques rely on assumptions made about occupants' behaviors. These assumptions mostly concern equipment set points and operational parameters including house occupancy, maintenance of the equipment, use of appliances and lighting, hot water consumption and thermostat settings (Hendron and Engebrecht 2010). Assessment of those parameters is sometimes part of traditional energy audits and may lead to a tedious list of questions on the use of the appliances, lighting, heating and cooling systems.

The data collected through the survey can inform the behavioral assumptions embedded in building energy simulation tools in the future. These data can lead to the development of alternative occupant profiles that will modulate the set of operating conditions and load profiles that currently apply to all simulations. The survey deals with behaviors that are representative of behavioral assumptions underlying energy simulation models, such as thermostat set points, water heater set point, appliances usage, and hot

water consumption. Assessing homeowners' intention and propensity to change those behaviors in a more effective way can help replace uncertain assumptions with valuable homeowners-dependent inputs that would increase the accuracy of the model.

Thus, additional objectives of the survey are to

- Provide auditors information about homeowners' energy-related behaviors to help auditor identify sources of energy use in the home
- Provide information to the auditors that would assist them in determining what type of behavioral recommendations to give to the homeowners.

4.3.4 Promote an Educational Interaction

Raising homeowners' awareness about their own energy consumption and how they can save energy at home is increasingly recognized as a crucial aspect of energy conservation programs (Stevens 2011; Stevenson and Leaman 2010). Alternative forms of energy audits that integrate this educational dimension started emerging to cope with homeowners' misperception of effective ways to save energy and help them better prioritize energy saving measures (Markowitz 2010).

The assessment tool represents an opportunity to impart some information to increase homeowners' awareness about energy-saving opportunities and lead them to educated decisions about their home. Therefore, consideration was given in the design of the tool to the educational value it could convey to homeowners. Furthermore, by teaching homeowners energy improvements and behaviors they could do to reduce their consumption, the tool is likely to help establish homeowners' expectations of the energy audit.

4.3.5 Sustain Alternative Models of Energy Audits

The intake survey can also support the development of commercially viable alternatives to the traditional energy audit process by allowing auditors to identify the audience they can target with lighter

versions of energy audits. Results of the survey can highlight the key points that still need to be addressed in alternative versions of energy audits. Moreover, in the future, this intake survey could be part of a screening energy audit process that would assess the potential need for a comprehensive energy audit and provide substantial recommendations that could make up for a comprehensive audit if there was no need for it.

4.4 Development Process of the Assessment Tool

4.4.1 Introduction

The survey was first developed on Survey Monkey and tested with customers of the energy auditing firm Envinity in the months of September and October 2011. The survey was progressively modified based on the issues encountered during these initial tests and the feedback of the participants. This iterative process aimed to make sure that the survey met its objectives and that the objectives that were initially defined for the survey were achievable. A working relationship was established with the marketing firm Shelton Group. Their inputs contributed to revising the survey. The version of the survey that resulted from these progressive revisions and that was used in the Spring of 2012 for another set of energy audits is presented in this section. The initial tests of the survey also contributed to the development of a scoring system used to define participants' levels of information, motivation, and behavioral skills with regard to energy-saving measures. A homeowner assessment scorecard was also created in anticipation of the set of audits conducted in the Spring of 2012 to summarize the results of the survey and present the profile of the homeowners to the energy auditors.

4.4.2 Preliminary Testing of the Survey

As part of its development phase, the survey was tested on the occasion of the screening energy audits of two residential communities that were conducted by the auditing firm Envinity in the months of September and October 2011. These energy audits were aimed at providing energy auditors with a first overview of the home conditions based upon which recommendations could be formulated. The first community was Menno Haven retirement community, located in Chambersburg, PA. A paper version of

the survey was administered by Dr. Swim to three residents of Menno Haven. Dr. Swim was present with these persons at the time they took the survey. The second community was the faculty homes of the Kiski School, located on the school campus in Saltsburg, PA. An online version of the survey was administered by the researcher. Due to the timing of this testing, the link to the survey was sent to the residents one day prior to the visit of the energy auditor.

The purpose of these two rounds of test was to rapidly get some feedback on the survey during its development phase, progressively improve the clarity of the questions and transform the survey into a stand-alone instrument that could then be tested in its real setting with the auditing firm Mark Group. Participants' observations were collected either through informal conversations or through questions included at the end of the survey. Because of the timing of the audits and since emphasis at this stage was placed on getting immediate feedback on the design of the survey, the process followed for this testing where survey and energy audit occurred concurrently did not reproduce the forecasted process where the survey would be administered during the intake process. Therefore energy auditors did not have access to the survey results before they conducted the audits as it should be the case in subsequent use of the tool.

The first iterations of the survey guided the revision of the assessment tool. The tool was simplified by eliminating questions that led to ambiguous answers or answers that could not be used to determine homeowners' IMBS profile. The list of behaviors included in the survey was also expanded based upon the review of published lists of energy-saving behaviors, insights from the marketing firm Shelton Group, publications from the Department of Energy, and information from the auditing firm Envinity. The first iterations of the survey also led to a first attempt to develop a rating system of participants' answers and a summary of the results to be provided to energy auditors.

The first experiences administering the initial version of the survey made it salient that the survey was not just an assessment tool but also an educational tool for the homeowners. The survey raised the homeowners' interest for energy conservation and efficiency. The thorough questions induced

participants to think about how energy was used in their home and some measures they could take to save energy. Several participants were interested in getting the "right" answers to the survey, especially concerning the measures and behaviors they could do to save energy.

4.4.3 Insights from the Shelton Group

Another step in the development of the assessment tool consisted in getting some feedback from the Shelton Group, a marketing and advertising agency specialized in taking energy-efficient products and green services to market through research-driven targeted work. The Shelton Group conducts annual consumer opinion studies and has deep insight into what energy efficiency improvements Americans are likely to undertake, which ones they are not and what their motives are to undertake those improvements. The firm has developed a consumer segmentation system that stayed fairly consistent over the years.

Collaborative work with three employees of the Shelton Group was undertaken through a set of conference calls during the months of November and December 2011. They were asked to give their impressions about the survey and share their expertise in the energy efficiency market. The Shelton Group also shared its Utility Pulse survey with the researcher. This survey explores consumers' perceptions of energy-saving measures, utility demand-side management and energy efficiency programs. Consumers are asked what energy efficiency and conservation measures they have taken. More details about the way the measures included in the survey are selected by the Shelton Group are provided later.

The Shelton Group's survey is not limited to self-reported behaviors to assess homeowners' profiles. It also includes attitudinal questions aimed at unearthing participants' behavioral drivers. Behavior-oriented questions and attitudinal questions constitute their segmentation methodology. The attitudinal questions deal with individuals' opinion about energy conservation, global warming, as well as individuals' political affiliation. The homeowner assessment tool did not have the same objective of segmenting people. If a segmentation similar to the Shelton Group's one was used for energy audit customers,

auditors would need to receive some tools and training to use the results of the survey to frame their recommendations, such as, for example, different scripts corresponding to the different segments.

Inputs from the Shelton Group are mentioned in the description of the survey with the specific questions they relate to. Some inputs were not applicable to the assessment tool developed in this research because the audience targeted by the tool differed from the audience the Shelton Group targets. The audience targeted by the assessment tool is made of people who signed up for an audit and are therefore likely to be more interested than the average in doing energy efficiency improvements. The Shelton Group studies target the general public. Therefore their questions aim to target the greatest number of people.

4.5 Design of the Survey

4.5.1 Administration Method

The administration method chosen for the homeowner assessment tool was an online survey. A first version of the survey was developed on Survey Monkey. The final version used for the energy audits conducted by the Mark Group was developed on Qualtrics. This software allowed the researcher to download participants' answers to the Statistical Package for the Social Sciences (SPSS) software where they could be scored.

Web-based surveys offer several advantages that justified the choice of this method of administration. They provide a scalable, time- and cost-saving option to collect data that was appropriate for the integration of the assessment tool in the energy audit process. Respondents are free to complete the questionnaire at their convenience. Furthermore, the software used to develop the survey allowed to program some skip patterns that could be combined with filtering questions. A drawback of this method was the necessity for the participants to have access to a computer and internet. The choice of this method also increased the importance of the clarity of the questions, since no interviewer was present to clarify ambiguous questions.

The research protocol and the survey were submitted to Penn State Institutional Review Board for approval. The research project met the criteria for being exempt of IRB review. Approval from the IRB was obtained in November 2011. The subsequent changes that were made to the survey and research study in January did not require any additional review, since they did not affect the determination for exemption as per IRB Policy III. The IRB submission form can be found in Appendix A.

For the testing of the survey in the Spring of 2012, the link to the survey was sent in an email to the participants. The survey started with a short introduction including some information about the purpose of the survey, the expected amount of time it took, and the confidentiality of the results. This introduction can be found in Appendix B. It aimed to motivate individuals to take the survey by emphasizing that their participation would increase the effectiveness and value of the energy audit they would receive.

This introduction was followed by an informed consent form meeting the different requirements of Penn State Institutional Review Board. This informed consent form can be found in Appendix C. Participants who did not consent to take the survey were directed to the end of the survey.

4.5.2 Considerations for the Selection of the Measures and Behaviors Included in the Survey

The objectives of the assessment tool include identifying specific energy-saving measures that homeowners believe would be useful for their homes or that homeowners are motivated to do, and assessing whether homeowners think they are able do these measures. Therefore a first step in the creation of the assessment tool was to review the different types of energy-saving measures, categorize them and select exemplars of measures within the defined categories to be included in the survey.

A review of the literature on energy-saving behaviors was conducted and presented in Chapter 2. In addition to the two categories of conservation and efficiency behaviors frequently found in the literature, this research considered three other categories of behaviors that complete the spectrum of home energy-saving measures auditors can recommend. This characterization of behaviors into five categories was

used in an Architectural Engineering class at Penn State taught by Dr. Riley that trained students to perform screening audits. The five categories of behaviors are:

- Safety and protection measures which are defined as measures that ensure that home and equipment operation, as well as the actions homeowners take are safe. These measures are mostly aimed at preventing indoor air quality issues and fire risks.
- Conservation behaviors which are defined as behaviors homeowners can do without monetary investment in their home. Thus, these are everyday behaviors that homeowners can change to restrict the use of existing energy equipment or use this equipment more effectively.
- Energy efficiency behaviors which are defined as home improvements or investments in appliances that would reduce homeowners' energy consumption.
- Monitoring systems which include system providing a real time display of home energy consumption and automated control of heating and cooling. Those systems form feedback mechanisms that allow homeowners to monitor their behavior toward a goal.
- Energy generation systems which are defined as systems or products that allow homeowners to produce their own energy to run their home or to purchase energy produced from renewable sources.

Those five types of behaviors form a theoretical path ranging from basic low-cost improvements to extensive energy retrofits. Though they do not save energy, safety and protection measures are also included in the survey because they are typically addressed by energy auditors. It should also be noted that monitoring systems differ from conservation behaviors, efficiency measures and energy generation systems because they themselves do not reduce households' energy consumption. However, they act as a means to identify sources of energy consumption in the house and encourage homeowners to save energy through the implementation of measures and behaviors from the three other categories.

Figure 4-2: The five general types of behaviors

Little literature exists on the measures most often recommended by energy auditors. Identifying these measures and their effectiveness is beyond the scope of this research. The selection of specific behaviors among the five categories presented above that were included in the survey was guided by a cross comparison of published lists of behaviors, behaviors recommended by the Department of Energy, and information from both the auditing firm Envinity about the behaviors they typically recommend and the marketing firm Shelton Group about the behaviors they include in their Utility Pulse survey. Guidelines from the Building Performance Institute were used for the selection of safety and protection behaviors as this category of behaviors is rarely present in published lists.

The energy-saving behaviors recommended by the Department of Energy can be found in the Energy Savers Booklet (National Renewable Energy Laboratory 2009). This document provides an extensive list of behaviors. The selection of behaviors was therefore narrowed down with the information provided by the auditing firm Envinity about the behaviors they most often recommend as well as the list of behaviors published by Dietz and his colleagues (2009). This list was specifically considered in this research because it provides a good example of lists of behaviors that look at what households can reasonably expect to save on a short term with feasible changes in their consumer behaviors, in-home equipment and personal transportation technologies, though this latter category was not considered in this research. Furthermore, Dietz and his colleagues advanced previous research by estimating the plasticity of behavior, that is, the percentage of the population that could be induced to adopt the behavior with the most effective interventions (Dietz et al. 2009). This estimate is taken into account in their calculation of the achievable emissions reduction from each behavior. Dietz et al. list was introduced in Chapter 2.

The researcher also had access to the list of measures used by the Shelton Group in their surveys. These measures range from everyday conservation behaviors such as unplugging small appliances when not in use, to means for the implementation of energy-saving behaviors such as having an energy audit. These measures come from different sources:

- Information from the Shelton Group's utility clients about behaviors promoted through their rebate programs
- Behaviors recommended by the DOE through the Shelton Group's partnership with ENERGY STAR
- Inputs from consumer studies done by other marketing companies

The Shelton Group narrowed down its list over the years by cutting the behaviors most homeowners do not do and keeping those that are measurable and allow the marketing firm to profile and target energy consumers.

Moreover the behaviors promoted by utilities in their demand-side management programs and selected by the Shelton Group for its studies are subjected to a Total Resource Cost Test. This test compares the benefits of a demand-side management program in terms of avoided supply costs, reduction of transmission, distribution, generation and capacity costs to the program costs paid by both the utility and the participants. This test ensures that the behaviors selected are not too costly to utility customers and have an acceptable payback period. Most of the behaviors included in the list from Dietz and his colleagues are also used by the Shelton Group which is a good indicator of their cost-effectiveness.

From the above, exemplars of behaviors representative of the five different categories were selected based upon the following criteria:

- The behaviors are energy reduction behaviors recommended by energy auditors after the inspection of the house. This excludes behaviors that are means to energy reduction, such as having a home energy audit, and behaviors that would not be part of a retrofit process, such as

buying a LEED certified house. Energy monitoring systems are means to energy reduction that will be included in the survey in a distinct category. Safety and protection behaviors do not themselves reduce energy consumption but were included in the survey because they are typically addressed by energy auditors.

- The behaviors can be applied to a large range of individuals and homes. This excludes behaviors that are so specific that they apply to a small fraction of people. For example, improving the efficiency of one's swimming pool is only important for those who have a swimming pool. Though some behaviors are more likely to apply to homeowners than renters, limiting the behaviors included in the survey to behaviors both renters and homeowners could do would have excluded efficient behaviors often recommended by energy auditors that require the possibility to make structural and/or equipment changes. Examples of such behaviors are adding air sealing/insulation or upgrading heating appliances. Therefore some behaviors were kept, though they are less likely to apply to renters.
- The behaviors are not dependent upon existing conditions to be applicable to participants' situation. This criterion mostly applies to safety and protection behaviors. For instance, having lead problems checked and corrected by a professional is not applicable if homeowners know that they do not have lead in their homes.
- The behaviors can be done cost-effectively independently of any other home improvements. For instance, adding insulation to the exterior walls is not cost-effective if the homeowners are not considering residing their exterior walls.
- The behaviors can be addressed by the auditing firm the researcher will work with. The Mark Group wanted to make sure that its auditors would have a solution to offer in case their customers would be interested in any of the measures listed in the survey.
- The behaviors are described as single actions instead of a set of actions. For instance, the behavior "Change habits at home to save energy" includes a variety of behaviors. People

motivation and capacity may differ between these different behaviors. Therefore such a behavior is not precise enough to be accurately evaluated through homeowners' self-report.

Through their segmentation studies, the Shelton Group found that most people think that renewable energy systems are expensive and therefore may associate energy audits with the idea of expensive investments if this type of measure was mentioned in the survey. Therefore, "purchasing power produced from renewable energy sources" was mentioned in the survey as an exemplar of energy generation measures to counteract the idea that renewable energy is necessarily synonym of expensive investments.

The behaviors included in the survey are listed in Table 4-1 along with the sources in which they appear.

Table 4-1: Selection of measures and behaviors for the homeowner assessment tool

MEASURES	SOURCES
Safety and Protection	
Install a Carbon Monoxide detector	BPI
Have your water heater, boiler and/or furnace regularly checked by a professional	BPI, Energy Saver Booklet
Check and replace your smoke detector batteries	BPI
Control moisture sources in your house, and have a professional checked for moisture issues, if any	BPI
Do not operate unvented appliances, such as portable space heater or stove, in a closed living space	BPI
Energy Conservation	
Set thermostat to energy-saving settings (68F in winter and 78F in summer)	Dietz et al., Shelton Group, Energy Saver Booklet
Unplug or turn off the power strip for the electronic devices (computer/TV/DVD/VCR/ Xbox/Wii) when not in use	Shelton Group, Energy Saver Booklet
Set the water temperature of the water heater to 120F	Dietz et al., Shelton Group, Energy Saver Booklet
Change the washer temperature settings from "hot wash, warm rinse" to "cold wash, cold rinse"	Dietz. et al.
Line dry	Dietz et al.

Energy Efficiency	
Seal drafts, add weather-stripping around windows and doors, caulk cracks	Dietz et al., Shelton Group, Energy Saver Booklet
Insulate the attic up to R-49, that is, 16 inches of fiberglass or 15 inches of cellulose (Department of Energy recommendation for Pennsylvania)	Dietz et al., Shelton Group, Energy Saver Booklet
Replace the windows with high-efficiency/ENERGY STAR qualified windows	Dietz et al., Shelton Group, Energy Saver Booklet
Replace most incandescent light bulbs with compact fluorescent light bulbs or Light Emitting Diode (LED) bulbs	Shelton Group, Energy Saver Booklet
Replace the heating system with a more efficient one	Dietz et al., Shelton Group, Energy Saver Booklet
Install a higher-efficiency or tankless water heater	Dietz et al., Shelton Group, Energy Saver Booklet
Purchase some higher-efficiency/ENERGY STAR qualified appliances	Dietz et al., Shelton Group, Energy Saver Booklet
Install aerating low-flow faucets and shower heads	Dietz et al., Energy Saver Booklet
Energy Monitoring	
Install an energy monitoring system	
Energy Generation	
Install a solar array	Shelton Group, Energy Saver Booklet
Install a solar hot water system	Shelton Group, Energy Saver Booklet
Install a geothermal heat pump	Shelton Group, Energy Saver Booklet
Pay a premium on my utility bill to purchase electricity produced through renewable sources such as solar or wind	

The assessment tool provided auditors with homeowners' self-reported perceptions of the five types of behaviors and a measure of their current practice with regard to these five types of behaviors.

4.5.3 Questions of the Survey

Below are the objectives of the questions and observations emerging from the initial testing of the survey. The entire survey is available in Appendix D for reference. The scoring system used for these questions is detailed later. The questions are annotated in order to explain changes that were made to the survey based on participants' feedback, some observations made during the testing of the survey in

Menno Haven and Kiski residential communities, as well as insights from the Shelton Group. These annotations also show the reasoning behind the development of the final version of the survey that was used in the Spring of 2012.

Questions 1 to 3 are included in order for the auditors to know the expectations of the homeowners about the audit without imposing the framework of this research upon their expectations.

Question 1: Which of the following best describes your situation?

1) *I requested a free home energy assessment*
2) *I requested a home energy audit*
3) *I requested neither a free home energy assessment nor a home energy audit*

This question was added following the initial audits conducted in a retirement community in fall 2011. The administrators of the retirement community were the initiators of the audit and the homeowners themselves had not requested it. Therefore a filter was needed prior to the next question which asks people their reasons for requesting an energy audit. This question was then tailored for the purpose of testing the survey with the customers of the Mark Group in spring 2012. The Mark Group offers two types of home energy evaluations: a home energy audit, which is a three-hour long comprehensive home energy evaluation, and a free home energy assessment, which is a shorter version of the home energy audit. As the survey was intended to be distributed to customers of both types of energy evaluations, a question was needed to distinguish them. As the scope and cost of both types of home energy evaluations differ, it is likely that the profiles of the homeowners who requested each type of home energy evaluations differ.

Question 2: What are the reasons for which you requested a home energy assessment?

(Alternative) What are the reasons for which you requested a home energy audit?

These questions allow energy auditors to anticipate the type of upgrades/retrofits homeowners are specifically interested in and that are therefore more likely to be completed. Energy auditors should address those upgrades/retrofits in priority to meet their customers' expectations. Addressing measures the homeowners are motivated for can pave the way for other measures the homeowners may not have thought about or may not be willing to do in the first place.

Question 3: Do you have any plans or dreams for home improvements for the upcoming year? If so, what are they?

This question looks for the possibility of piggy backing energy-saving recommendations with other home improvement plans or dreams so as to increase their likelihood of completion. Past research indicates that money is not what limits people to make home improvements because they are willing to spend money on home improvements that are not related to energy efficiency but are driven by other motives, such as aesthetics (Wilson 2010). Thus, to the extent that auditors can make recommendations that are consistent with homeowner's aspirations and can be combined with other home improvement projects, then they should be more successful at motivating improvements. This question can also encourage homeowners to share issues they would like to fix other than those that precipitate the call to an energy auditing firm. Some customers may not be aware that other issues exist for which the assistance of the auditor can be provided.

Question 4: Below is a list of reasons people give for wanting to save energy in their home. Please indicate the extent to which you agree that these reasons apply to you.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Save money on my utility bills.	❍	❍	❍	❍	❍
Get more control over my personal energy consumption and costs.	❍	❍	❍	❍	❍
Increase the comfort in my home.	❍	❍	❍	❍	❍
Keep-up or improve the condition of my home.	❍	❍	❍	❍	❍
Improve the value of my home.	❍	❍	❍	❍	❍
Do what I can to increase my personal independence from energy companies.	❍	❍	❍	❍	❍
Do my part to help protect the environment.	❍	❍	❍	❍	❍
Do my part to decrease my contribution to climate change/global warming.	❍	❍	❍	❍	❍
Do my part to help make the world better for future generations.	❍	❍	❍	❍	❍
Be responsible and not waste.	❍	❍	❍	❍	❍
Do my part to help reduce our country's reliance on foreign fuels.	❍	❍	❍	❍	❍

This question assesses homeowners' general motivation to save energy in their home. This question includes two types of motives: personal motives (items 1, 2, 3, 4, 5, and 6) and principled motives, both environmental (items 7, 8, and 9) and conservative (items 10 and 11).

While saving money remains the most common motivator of energy conservation, significant proportions of American also report that reducing global warming, acting morally and feeling good about themselves are also important motivations (Leiserowitz et al. 2009). Some of the motives were added based on the Shelton Group recommendations. "Have more control on my utility bill" and "not waste energy and money" are two reasons that are often reported in the Shelton Group consumer survey.

Knowing the type of motives homeowners have to save energy in their home at the time they schedule an audit can help auditors adjust their communication in a way that best align with these motives.

Question 5: To what extent do the following statements describe you (or if applicable someone else in your household)?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I like making improvements to my home by myself.	❍	❍	❍	❍	❍
I am confident in my ability to make improvements to my home by myself.	❍	❍	❍	❍	❍
I am confident in my ability to find others to make improvements to my home.	❍	❍	❍	❍	❍
I am confident in my ability to pay for improvements to my home.	❍	❍	❍	❍	❍
I am confident in my ability to take the time to do home improvements.	❍	❍	❍	❍	❍
I am confident in my ability to change my lifestyle in such a way that would save energy.	❍	❍	❍	❍	❍

This question assesses homeowners' perceived general self-efficacy (i.e. perceived capacity and behavioral skills) to perform improvements to their home. Informal discussions with energy auditors helped determine common barriers to the implementation of energy conservation and efficiency measures that are addressed here. These barriers include: lack of time to search for information about energy-saving measures, find a contractor to do the work, and oversee the installation of the measures; difficulty with finding a "good" contractor to do the work; and lack of financial means to pay for the upgrades. Some professional auditors the researcher worked with mentioned that the presence of a do-it-yourself person in the household was often a facilitator to the implementation of energy-saving measures. The last item of this question, "I am confident in my ability to change my lifestyle in such a way that would save energy", assesses homeowners' perceived general self-efficacy to adopt conservation behaviors.

It was first considered to have a filter for this question to allow renters to skip the part asking about their ability to make improvements to their home. Assessing participants' ability to perform energy-efficient improvements to their homes was considered irrelevant if they did not own their homes. The residential communities in which the survey was first tested had their own maintenance crews that were in charge of home upgrade work. Moreover renters have often little power of decision to make improvements to their homes. However, the filter was removed following some discussions with the Shelton Group which revealed that renters do make some improvements to their homes to increase their energy efficiency, such as purchasing ENERGY STAR appliances or CFL bulbs. Renters' ability and willingness to do efficiency improvements largely depends on the type of their residence. For instance, renters of single-family homes are more likely to do home efficiency improvements than renters of multi-family homes or apartments.

Question 6: Please indicate how much money you think can be saved on a typical monthly utility bill by each of the measures noted below? This is not about the savings that would be achieved if the measure was implemented into your home, but, in general, how much can be saved by each measure.(Check one percentage for each).

	Nothing	<5%	Between 5 and 9%	Between 10 and 19%	Between 20 and 29%	30% +	Don't know
Turn down thermostat from 72F to 68F in winter, and turn up thermostat from 73F to 78F in summer	❍	❍	❍	❍	❍	❍	❍
Unplug or turn off the power strip for the electronic devices (computer/TV(s)/DVD(s)/VCR(s)/Xbox/Wii) when not in use	❍	❍	❍	❍	❍	❍	❍
Turn down water heater thermostat from 140F to 120F	❍	❍	❍	❍	❍	❍	❍
Change the washer temperature settings from "hot wash, warm rinse" to "cold wash, cold rinse"	❍	❍	❍	❍	❍	❍	❍
Line dry when possible instead of using the clothes dryer	❍	❍	❍	❍	❍	❍	❍
Seal drafts, add weather-stripping around leaky windows and doors, caulk cracks	❍	❍	❍	❍	❍	❍	❍
Insulate an uninsulated or under insulated attic up to R-49, i.e. 16 inches of fiberglass or 15 inches of cellulose (Department Of Energy recommendation for Pennsylvania)	❍	❍	❍	❍	❍	❍	❍
Replace single-pane windows with high-efficiency/ENERGY STAR qualified windows	❍	❍	❍	❍	❍	❍	❍
Replace most incandescent light bulbs with compact fluorescent light bulbs or Light Emitting Diode (LED) bulbs	❍	❍	❍	❍	❍	❍	❍
Replace the heating system with a more efficient one (92% efficient)	❍	❍	❍	❍	❍	❍	❍
Install a higher-efficiency (0.7 energy factor) or tankless water heater	❍	❍	❍	❍	❍	❍	❍
Purchase higher-efficiency/ENERGY STAR qualified appliances (dishwasher, clothes washer, clothes dryer, refrigerator)	❍	❍	❍	❍	❍	❍	❍
Installing aerating low-flow faucets and shower heads	❍	❍	❍	❍	❍	❍	❍
Install a geothermal heat pump to replace a conventional heating system	❍	❍	❍	❍	❍	❍	❍

This question assesses homeowners' knowledge about the energy-saving potential of conservation, efficiency, and generation behaviors. It is aimed at addressing potential misperceptions from the homeowners. The actual answers were estimated by comparison across different sources including the Department of Energy, the ENERGY STAR website and utility websites. These sources are detailed in Appendix F.

The first testing of the survey suggested that this could be a valid measure of knowledge because, on average, respondents tended to overestimate the extent to which low energy use behaviors used energy and underestimate the extent to which high energy use behaviors used energy, which is consistent with previous research (Attari et al. 2010). The energy auditors the researcher was in contact with mostly addressed the savings that can be generated by the measures they recommend and may not cover the entire list of measures included in the survey. However, the auditing firm Mark Group confirmed that they were interested in broadening the educational aspect of their assessments in the future making the use of this question more relevant.

Some difficulties arose with participants from the use of technical jargon in the description of the behaviors. For instance, some participants did not know what a "R-value" meant. A concrete description of the equivalent of the R-value in terms of thickness of insulation layers was therefore added. It was also important to specify the initial state for the measures listed, like "turn down thermostat from 72F to 68F in winter, and turn up the thermostat from 73F to 78F in summer", to prevent participants from taking their own home as a reference and, for example, indicating that implementing a specific measure would not save anything in the case where they had already taken this measure or a more stringent one.

The initial version of the survey tackled, with another question, homeowners' knowledge about the different sources of energy consumption in their home. It was not clear, however, if this information would be addressed by the energy auditors during their assessment. Therefore, in an attempt to reduce the length of the survey, this question was dropped in favor of the present knowledge question.

Questions 7 to 18: Behavior type questions

The first set of questions (Questions 7 to 9) concerns safety and protection measures and is presented here as an example. Other sets of the same type of questions are included in the survey for energy conservation measures (Questions 10 to 12), energy efficiency measures (Questions 13 to 15), and energy generation measures (Questions 16 to 18). These questions can be found in the full version of the survey in Appendix D.

Question 7: Please list your top three safety and protection measures that you have NOT already done but would be the most useful in your home. You do not need to fill in all the blanks.

Measure 1:
Measure 2:
Measure 3:

Question 8: We would like you to answer five questions with reference to safety and protection measures (please drag the bars on the diagram below for each question accordingly):

_____ *1) What is the state of your home now? For instance, is your home not at all safe (0%), completely safe (100%) or somewhere in between?*

_____ *2) Compared to others who live around you, how do you think their homes compare to yours with regard to safety? For instance, do you think their homes are not at all safe (0%), completely safe (100%), or somewhere in between?*

_____ *3) What state would you ideally like your home to be at? For instance, would you like your home to be 100% safe, or would you be satisfied if it was mostly but not completely safe (e.g., 75%)?*

_____ *4) What state do people who are important to you think your home should be at?*

_____ *5) If you wanted to improve this aspect of your home, by yourself or with the help of someone else, how easy do you think it would be? For instance, if you thought it would be too difficult, you would say 0%, and if you thought it would be very easy, you would say 100%.*

Question 9: Please indicate which of the following safety and protection measures you have already taken in your home.

	Implemented	Not implemented	Don't know
Install a Carbon Monoxide detector	❍	❍	❍
Have your water heater, boiler and/or furnace regularly checked by a professional	❍	❍	❍
Check and replace your smoke detector batteries	❍	❍	❍
Control moisture sources in your house, and have a professional checked for moisture issues, if any	❍	❍	❍
Do not operate unvented combustion appliances, such as portable space heater or stove, in a closed living space	❍	❍	❍

These questions allow switching to a more specific assessment of homeowners' knowledge and motivations about the four general types of behaviors that are the focus of the energy audits: safety and protection measures, energy conservation behaviors, energy efficiency measures, and energy generation measures. Energy monitoring systems also belong to the spectrum of measures considered in this research but are addressed in a separated question. By providing feedback to the homeowners about their energy consumption, energy monitoring systems are considered as tools to facilitate and motivate the implementation of the other types of measures previously mentioned.

Each type of behaviors leads to three questions: the first one assesses homeowners' knowledge about measures or behaviors of each type that would be the most useful to save energy or increase the safety of their home; the second question addresses the influence of different types of motives (personal goal, descriptive norms, injunctive norms) on homeowner propensity to take some measures of a specific type; the third question asks homeowners what measures of each type they have already done.

Measures the homeowners report to not have done can then be compared to the measures they listed as useful for their home. Homeowners may be more likely to follow the measures they consider as useful for their home and that they listed in the survey. Yet these measures may not be the most effective for their home and may not be the ones that the auditors would recommend. More effort will probably be required from the auditors to convince the homeowners of the effectiveness of measures they have not listed in the survey. The auditors should follow up on the measures homeowners reported to not have done but that they did not list as measures that could be useful for their home. This discrepancy may be due to, for example, a lack of information or a lack of motivation for the said measures.

Motivation for the four different behaviors is assessed by using a self-discrepancy model of motivation (Higgins 1987). Homeowners are first asked their perceptions of the actual state of their home. Then they are asked to provide their evaluation of three elements of comparison: how their home compare to others' homes, how they would ideally like their home to be, how important others think their home should be. These questions lead to the determination of:

- homeowners' satisfaction by comparing their reported actual state and ideal state of their home
- homeowners' social motivation from the influence of descriptive norms by comparing the reported actual state of their home and their perception of others' homes
- homeowners' social motivation from the influence of injunctive norms by comparing their reported actual state and standards of what important other think they should do

Homeowners are also asked the difficulty they perceive with doing the four types of behaviors. All of these questions allow assessing whether the auditors may get resistance to change on type of measures they are likely to recommend. They inform the auditors about the type of measures the homeowners are willing to do so that the auditors can provide some help to do them if needed or stretch homeowners to behaviors they are not willing to do.

Asking homeowners which measures of the four types they have already done gives the auditors a measure of homeowners' current energy-related behavior pattern which can be an indicator of their energy consciousness. According to the Shelton Group's segmentation methodology, people are better defined by the energy efficiency improvements or conservation behaviors they have already done than their knowledge of actions they need to do or are motivated to do. Including this type of questions in the survey addresses the gap between what people think and what they actually do. Moreover the evaluation of the measures already undertaken by the homeowners can help focus the attention of the auditors on specific types of measures and behaviors that the homeowners have little or not undertaken. Provided that the homeowners demonstrate some motivation for them, these specific types of measures can form a reservoir of opportunities for home energy savings in which the auditor can tap.

The first versions of the survey only asked homeowners to list efficiency improvements and conservation behaviors they believed were needed to save energy in their homes. These versions of the survey included some follow-up questions to assess if homeowners needed help or motivation to do the behaviors they already knew about. The first testing of the survey at Menno Haven revealed that homeowners had very little knowledge about energy efficiency and conservation. A clear written description of the difference between conservation behaviors and home efficiency improvements was also needed to facilitate participants' understanding of the questions. The second time the survey was tested, at Kiski, the homeowners were able to list behaviors but they did not necessarily distinguish between what they had done from what they could do. It did reveal the extent to which they thought about the behaviors but the open-ended nature of the question made the use of it as an assessment of knowledge questionable. Moreover, the time taken to complete this section of the survey did not have the payback desired. Thus, based upon these two rounds of testing, those questions were modified. The survey still includes open-ended questions to have homeowners specify conservation and efficiency measures, but no follow-up questions on homeowner's motivation and ability to take the measures they listed. The survey also includes safety and protection measures, as well as energy generation measures to address the full

spectrum of recommendation auditors can make and raise homeowners' awareness for all type of measures. The assessment of homeowners' motivation and ability is specific to a certain type of behaviors, and not to the only behaviors the homeowners listed. Each type of measures is clearly described.

Question 19: Energy monitoring systems are devices that can visualize, manage and/or monitor the household's energy use of certain products or of the whole house. We would like you to answer three questions about energy monitoring systems.

	Yes	No
1) Do you have an energy monitoring system?	❍	❍
2) Would you like to have an energy monitoring system?	❍	❍
3) If you wanted to have an energy monitoring system, would you know how to get one?	❍	❍

This question addresses whether homeowners have an energy monitoring systems, their motivation and perceived capacity to get one.

Questions 20 to 25 assess basic demographic information that can inform some of the dimensions measured in the survey. None of these questions is scored. They provide some qualitative information about the ownership status and the household composition of the audit customers.

Question 20: What is your gender? If more than one respondent, check all that apply.

Male
Female

Question 21: Do you own or rent your home?

Own
Rent
Do not own, live rent-free

This question assesses the ownership status of the participants. This factor may have an impact on participants' likelihood to take specific types of measures. For example, renters may have a more limited power of decision for efficiency home improvements.

Question 22: How long have you lived in your current home?

This question can be an indicator of the extent to which individuals value their home if they have lived in the same home for many years. It can also indicate if individuals just moved in and therefore may be at a point of decision to perform major work in their home.

Question 23: Do you anticipate moving out of your current residence in the near future?

Yes, within a year
Yes, within three years
No
Not applicable, I don't own my home

This question assesses how long people plan to stay in their home. If individuals intend to sell their homes in a near future, they may be less willing to consider upgrades that have a longer payback. On the other hand, if individuals intend to stay in their home a longer time, they may be more willing to consider long-term investments. Though this item refers to individuals' motivation, it has not been included into the scoring system.

Question 24: How many people in each of the following age categories live six months or more per year in your household?

0 to 5 years old
6 to 13 years old
14 to 24 years old
25 to 64 years old
65+ years old

This question assesses the composition of the household which can have a potential impact on the household energy usage pattern.

Question 25: What is the highest level of school you have completed or the highest degree you have received?

Less than high school degree
High school degree
Some college but no degree
Associate degree
Bachelor degree
Graduate degree

This question assesses the education level of members of the household which may be useful for expectations about the literacy level of the homeowners and how to adapt the technical information conveyed.

Questions 26 to 29 are aimed at obtaining participants' consent to share the results of the survey with the energy auditors and combine these results with the information collected by energy auditors during their home inspection. These questions ensure maintaining the privacy and confidentiality of the results of the survey. The address of the homeowner is also collected to identify the respondent of the survey and match the resulting assessment scorecard to a specific homeowner.

Question 26: The information in this survey could improve the feedback you receive from the energy auditors. May we share your information with the energy auditors?

Yes
No

Question 27: Combining the results of this survey with the information gathered by the energy auditors during the inspection of your house could improve the feedback you receive from them. May the energy auditors share their information about your house with us?

Yes
No

Question 28: May we contact you to talk about the results of the present survey?

Yes
No

Question 29: If you said yes to any of the three previous questions, please provide us with your name and address. This information will not be used for any other purposes.

Name
Address
Address 2
City
State
Zip Code
Country

Questions 30 to 34 are aimed at obtaining participants' feedback about the length, difficulty and clarity of the survey, as well as whether participants felt comfortable with answering the survey.

Question 30: We would appreciate your feedback on the survey you just filled out. Do you have any comment about the survey?

Question 31: Did you feel comfortable answering this survey?

Yes
Somewhat
No

Question 32: Did you meet some difficulties with filling out this survey?

No difficulty
Some difficulties
Many difficulties

Question 33: How would you judge the length of the survey?

Too long
About right
Too short

Question 34: How would you judge the overall clarity of the questions of the survey?

Clear
Somewhat clear
Not Clear

4.6 Scoring of the Survey

After the assessment tool was administered to the residents of Kiski School, a rating system was developed by Dr. Swim with the help of the researcher to analyze participants' answers and convert them into qualitative and quantitative characterization data to define the homeowners' profile. The results were then summarized into an assessment scorecard intended to be provided to the energy auditors. The scales used to rate the quantitative data aimed to translate these data into a clear and easily understandable

format to facilitate their interpretation by the auditors. The rating system was implemented in SPSS. It was then further refined by the researcher to match the modifications made to the survey.

Participants' answers to the survey could be directly downloaded from Qualtrics to SPSS. The use of SPSS allowed the researcher to easily code participants' answers using the scales defined to rate the questions of the survey. The scoring system that was used for the final version of the survey is presented in Appendix E.

4.7 Presenting the Information about the Homeowners to the Auditors

Participants' answers to the survey are rated using the scoring system presented above and summarized into an assessment scorecard. The purpose of the scorecard is to present the survey results in a more practical format compared to directly submitting participants' answers to the auditors. A template was developed by the researcher in parallel with the scoring system. The scorecard is intended to be given to the energy auditors before the home assessment. An exemplar of the assessment scorecard is presented in Appendix G.

The assessment scorecard first presents a general overview of the homeowner demographic information and IMBS profile. The demographic section, presented in Figure 4-3 includes some specific information about the respondent, such as gender and highest completed level of school, the composition of the household, the ownership status of the residents, and the time they anticipate staying in their current residence. Information is then provided about the objectives, issues and home improvements that motivated the homeowners to request an audit, as well as home improvements plans or dreams the homeowner has which may represent an opportunity to carry out other energy-efficiency measures.

Your customer: Mr. XXX	Male Has a bachelor degree Owner of the house Has lived there for 3 years Does not anticipate moving out in the near future
Home occupants (live six months or more per year in this home):	2 occupants between 25 and 64 years old 2 occupants between 0 and 5 years old

Figure 4-3: Demographic section of the homeowner scorecard

The homeowners' level of information, motivation, and behavioral skills with regard to the performance of energy-saving measures, their motivation and perceived skills to take some measures of four specific types (safety and protection, energy conservation, energy efficiency, and energy generation) are presented in a graphical form. The measures of these different types the homeowners reported to have already implemented are also listed. The percentages of the total measures included in the survey the measures taken by the homeowners represent are indicated. This information is presented as in Table 4-2. This information can help focus the attention of the auditors on measures the homeowners have not taken yet.

Table 4-2: Overview of the measures the homeowner has already implemented as presented in the scorecard

Measure Types	**Percentage of measures already implemented**	**Measures already implemented**
Safety and Protection	80	Install a CO detector Check and replace smoke detector batteries Control moisture sources in your house, and have a professional checked for moisture issues, if any Do not operate unvented combustion appliances in a closed living space
Energy Conservation	20	Set thermostat to energy-saving settings (68F in winter and 78F in summer)
Energy Efficiency	50	Seal drafts, add weather-stripping around windows and doors, caulk cracks Replace the heating system with a more efficient one Install a higher efficiency or tankless water heater Purchase some higher efficiency/ENERGY STAR qualified appliances
Energy Monitoring	0	*Note: The homeowner has an energy monitoring system: 100%* *The homeowner does not have an energy monitoring system: 0%*
Energy Generation	0	

The Information, Motivation and Behavioral Skills components are then detailed into three separate sections. The Knowledge/Awareness section first presents the safety, energy conservation, energy efficiency and energy generation measures that the homeowners perceived as needed to save energy at home and ensure that their home and equipment are safe. They are compared to measures the homeowners reported to not have done yet. The auditor is less likely to get some resistance from the homeowner for the measures they considered as being useful for their home. Individual follow-up with the homeowner would be required for the measures the homeowners have not done yet but have not listed as being useful for their homes. The Knowledge/Awareness section then presents the homeowners' knowledge score. This score reflects homeowners' accuracy in their perception of energy use. A low score may indicate a lack of knowledge. It may also reflect excessive or low expectations from the homeowners about the potential of energy efficiency or conservation measures. The Knowledge/Awareness section informs the auditors about the homeowners' knowledge about measures that can be done to save energy at home. It also presents the necessity for the energy auditors to address potential misperceptions from the homeowners about energy efficiency and conservation measures.

The Motivation section breaks down homeowners' overall motivation score to save energy at home into the array of motives introduced in the survey as illustrated in Table 4-3. It allows the auditors to weight the influence of personal and principled motives on homeowners' general motivation to save energy, and the influence of specific motives within these two categories.

Table 4-3: Homeowner's motives for saving energy as presented in the scorecard

Personal Motives	**Homeowner's Score**	**Maximum Points Possible**
Save money on utility bills	10	10
Get more control over personal energy consumption and costs	7.5	10
Increase comfort in home	10	10
Keep up or improve the home condition	10	10
Improve the value of the home	10	10
Increase personal independence from energy companies	2.5	10
Average Personal Motives	**8.33**	**10**
Principled Motives	**Homeowner's Score**	**Maximum Points Possible**
Protect the environment	5	10
Decrease personal contribution to climate change/global warming	5	10
Make the world better for future generations	5	10
Be responsible and not waste	7.5	10
Help reduce the country's reliance on foreign fuels	5	10
Average Principled Motives	**5.5**	**10**

The section also summarizes in several graphics:

- homeowners' perceived dissatisfaction with the performance of their homes with reference to the four general types of behaviors considered (safety, conservation , efficiency, and generation),
- how they think they are doing compared to their neighbors,
- whether they think they ought to do more.

An exemplar of these graphics is presented in Figure 4-4 for energy efficiency measures. Thus auditor can assess whether they are likely to get some resistance on specific type of behaviors due to the fact that homeowners are satisfied with the current state of their home and do not feel any pressure to improve it. This information also allows auditors to know which types of measures and behaviors would be better perceived by homeowners because they would feel personally and morally incentivized to adopt them.

Energy Efficiency

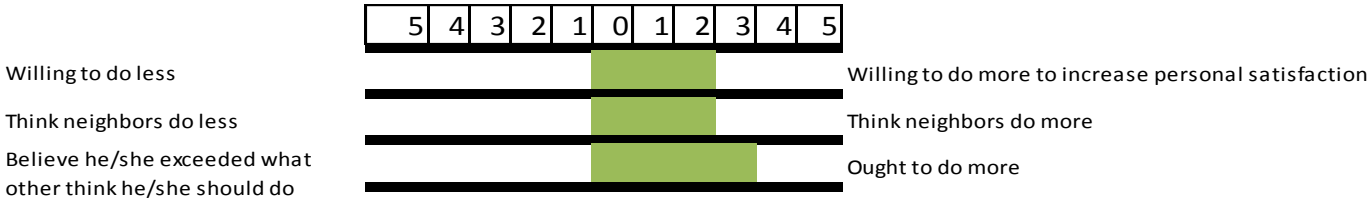


Figure 4-4: Homeowners' motivation towards a specific type of measures, here energy efficiency as presented in the scorecard

The Behavioral Skills section breaks down homeowners' overall perceived self-efficacy score to perform energy efficiency measures and conservation behaviors into their scores to each specific skill listed in the survey. It also reports homeowners' perceived capacity to change the current state of their home with reference to the four different types of energy-related behaviors. An exemplar of the graph presenting this information is presented in Figure 4-5.

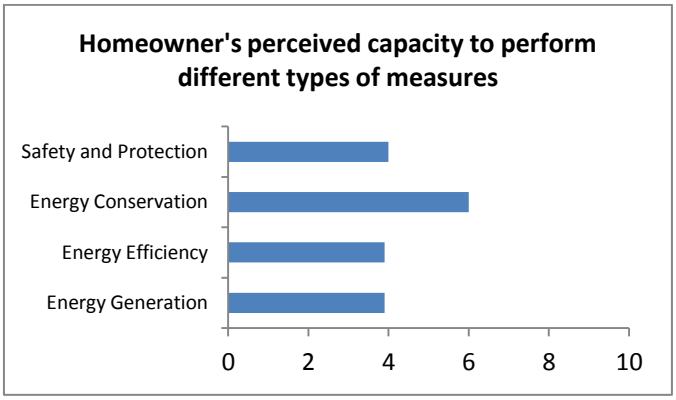


Figure 4-5: Homeowners' perceived capacity to perform four types of measures as presented in the scorecard

The combination of the Knowledge/Awareness, Motivation and Behavioral Skills sections informs the auditor about actions and action types the homeowners are willing and able to do, and perceive as needed

to save energy in their homes. It also informs the auditors about potential resistance and barriers they can expect from the homeowners to some actions they are likely to recommend. Getting homeowners to agree to actions they perceive as needed and they are willing to do can take homeowners in the desired direction of behavior changes and make them more likely to agree to other behaviors they would not have accepted upfront. Lastly the assessment scorecard reports homeowners' willingness to have an energy monitoring system and their perceived ability to get one.

To facilitate the understanding of the assessment scorecard, each section includes a brief description of its content and ways the auditors can use it for their interventions. These descriptions aim to compensate, to some extent, for the lack of training of the auditors about ways to use the information unearthed by the survey. Yet some training would be required to take more advantage of the survey's results for the auditors' preparation.

4.8 Conclusion

This chapter introduced the objectives of the homeowner assessment tool, its development process and integration in the energy audit practice.

The survey was initially tested as part of its development phase through small scale community-based audits. The immediate feedback collected from the participants, as well as inputs from the marketing firm Shelton Group, helped narrow down the number of questions and make the tool more user-friendly for the homeowners. The final version of the survey that resulted from progressive modifications was presented in this chapter. This version was then tested in its actual setting with the Mark Group energy audit customers. To prepare for this next testing, a scoring system was developed to convert homeowners' answers into individual IMBS profiles. An assessment scorecard was also created to summarize the results of the survey and present them to the auditors.

Chapter 5
Administration and Evaluation of the Assessment Tool

5.1 Introduction

This chapter describes the process by which the assessment tool was tested and evaluated in the Spring of 2012. The tool was administered to customers of the energy auditing firm Mark Group. The participants' answers were scored and summarized into assessment scorecards that were provided to the energy auditors before the home inspection. Focus groups were conducted with the Mark Group and Envinity energy auditors to collect their feedback about the relevance and usability of the information included in the homeowner assessment scorecard. The tool was also administered to individuals of the Penn State Center for Sustainability staff and listserv. A statistical analysis was performed on the responses to evaluate the internal reliability of the questions.

5.2 Implementation of the Assessment Tool in Mark Group's Energy Audit Process in the Spring of 2012

5.2.1 Mark Group Energy Audit Process

The energy auditing firm Mark Group agreed to collaborate with Penn State for the administration of the assessment tool in the Spring of 2012. Mark Group is an energy auditing/contractor firm located in the Navy Yard in Philadelphia and serving customers in Pennsylvania, New-Jersey and Delaware. In addition to its retail business, the company works through social and government contracts, and corporate programs. Its work mostly focuses on single-family buildings. Mark Group's main contractor services include air sealing, insulation, low-e storm windows, solar PV, solar hot water systems, energy-efficient lighting retrofits, and HVAC upgrades. Energy audits are a means of generating sales.

Mark Group offers two different types of home energy evaluations:

1) Home assessments
2) Comprehensive audits.

The most popular type (90% of the home energy evaluations done by the company) is a home energy assessment. It includes:

- Top to bottom energy analysis of the house with a focus on convective and conductive energy losses occurring through the building envelope;
- Use of infrared thermal imaging;
- Health and safety tests including carbon monoxide and/or natural gas leak detection, heating system draft test, visual inspection for moisture, mold, and/or asbestos.
- Determination and prioritization of a scope of work.

This type of evaluation does not include a blower door test. Following the assessment, the auditor creates a proposal detailing the scope of work to be done and the associated costs. Home energy assessments are offered free of charge and typically take 60 to 90 minutes in duration.

The second type of home energy evaluation offered by Mark Group is a comprehensive energy audit. It includes all the components of a home energy assessment as well as:

- Blower door test
- Assessment of the efficiency of the heating system
- Assessment of the efficiency of the lighting systems and appliances.

A comprehensive diagnostic report is sent to the customer after the audit with energy consumption savings and a financial modeling projection of the recommended measures. This financial modeling projection is either based on the estimation of energy savings from typical measures done by the Department of Energy and the Environmental Protection Agency, or computed by the use of basic energy simulation tools. In general, neither the audits nor the assessments provide behavioral recommendations. The cost to perform an energy audit is $400 or more. This cost goes down to $150 for homeowners participating in the government-funded Energy Works Program.

The Mark Group's customers request an audit either by sending an inquiry through the company's website, in which case a person from the Mark Group calls the customer, or by directly calling the Mark Group's office. The questions asked and the information provided by the Mark Group audit coordinator to the homeowners during the intake phone call are presented in Table 5-1.

Table 5-1: Information collected/provided by the audit coordinator during the intake phone call

Collected homeowner information	**Reasons**
Sources of leads	This information is used for marketing purposes.
Homeowners' motivation for calling the Mark Group. Homeowners' concerns with their home.	The audit coordinator can make some suggestions and describe what an audit/assessment can do to address the sources of the problems.
Information provided to the homeowners	
Recommendations for either an audit or an assessment.	
Average cost range of the measures installed by the Mark Group.	The audit coordinator makes sure that the homeowners can afford the Mark Group's services.
Energy audit/assessment procedure	
Instructions to prepare the house for the assessment/audit	
Answers to homeowners' additional questions concerning the audit/assessment	

A confirmation email with the date and time of the audit is sent to the homeowner once the audit has been scheduled. Some of the audits/assessments are declined at the end of the phone call. The Mark Group receives seventy leads per week, on average. Sixty-five percent of these leads, on average, result in the schedule of an audit or an assessment.

The audit/assessment involves both an interior and exterior walk-through, and starts with a conversation with the homeowner. The outline of this opening conversation is presented in Table 5-2.

Table 5-2: Outline of the initial conversation between the auditor and the homeowners

Auditor introduces the Mark Group and its services
Auditor inquires about homeowners' specific concerns and reasons for calling the Mark Group
Auditor presents some building science background
Auditor presents objectives and expected outcomes of the audit
Auditor presents the audit procedure
Auditor introduces the audit report that the homeowner will receive after the audit
Auditor offers for the homeowner to shadow the audit
Auditor asks homeowner to have a tour of the house
Auditor introduces referrals

The assessment/audit ends with a conversation with the homeowner. The auditor presents the issues found, such as the air leak locations. The auditor then introduces the retrofits that can be done, their effects and which parts of the house should be insulated and air sealed in priority. The auditor documents some of his/her findings with pictures taken during the walk-through. He/She then explains how the Mark Group will proceed to fix the detected issues.

There is currently no field data collection form and no script to guide the conversation of the auditor with the homeowners. The Mark Group is working on the development of a web-based portal accessible on tablet to allow the auditors to manage their planning, enter information about their customers and their houses, collect field data, share observations with the homeowners, present the company services and generate a proposal.

A proposal/report is emailed to the customers within a day after the home inspection. The auditor usually calls the homeowners one or two days after the proposal submission to offer to review the proposal and help the homeowners prioritize the listed measures. These follow-up activities are aimed at

assisting the homeowners in their decision making process and facilitating the implementation of the retrofit measures. Thirty-five percent of the audits/assessments lead to the installation of upgrades. The Mark Group looks to increase the uptake of energy conservation measures by generating a proposal and closing the sale at the end of the assessment/audit instead of coming back to the homeowners a few days later. If the homeowners were excited by the recommendations provided, they could directly agree to move forward while still having the possibility to make their decision later.

The Mark Group energy audit process is summarized in Figure 5-1. This process offered some opportunities for the implementation of the assessment tool. The use of the tool can benefit the auditors in their array of interactions with the homeowners. For instance, it can make the opening conversation with the homeowners more effective by focusing the attention of the auditors on certain issues or objectives they can then explore in detail.

The timeframe between the intake phone call and the appointment was one week, on average, though this duration varied greatly from two days to several weeks. The tool could be administered to the homeowners during this period. It was decided that the assessment tool would be administered to customers of both types of energy evaluations to maximize the number of answers; a question in the survey differentiated them for the purpose of the analysis. In case the number of responses would have been too large for the researcher to proceed, the assessment tool would have been administered in priority to the homeowners who requested a home energy assessment. Indeed, the objectives of this research were to make the interaction between the auditor and the homeowners, and the time the auditor spends on site, more effective. These objectives should be more important in the case of short energy assessments because the auditor interaction time with the homeowners is limited. Hence the importance of focusing this interaction on a small number of recommendations and making it more effective by learning about the customers prior to the audit. In this case, the auditors can address the measures that will best catch the homeowners' interest and motivation, and therefore may be more likely to be implemented. Furthermore,

the Mark Group is interested in making the free assessments more effective because comprehensive audits are costly for them to perform.

5.2.2 Administration of the Assessment Tool

In the months of February and March 2012, the assessment tool was administered for three weeks to the Mark Group customers. During the intake phone call, the audit coordinator introduced the survey to the customers after they decided to schedule an audit or a free assessment, and asked them if they were willing to take the survey. The survey was presented as a collaborative research project between the Mark Group and the Penn State University to learn what homeowners know about energy efficiency and enhance the quality of the energy audits for the homeowners. The email addresses and dates of the audit of the homeowners who accepted were then sent to the researcher. She was in charge of emailing the link to the survey using Qualtrics to keep track of the people who responded to the survey. The email was sent the same day or the day after the customers scheduled their audit to allow them the maximum amount of time to fill out the survey. One or two reminders were sent when people had not filled out the survey depending on the amount of time that was left before their audit.

The researcher programmed the scoring of the survey in SPSS. As soon as a customer filled out the survey, his/her answers were downloaded on SPSS and automatically scored using this program. The results were then manually summarized into the assessment scorecard. The scorecard was sent to the audit coordinator who forwarded it to the auditor in charge of the audit for this customer. The scorecard was typically submitted to the auditor within one day of the homeowner completing the survey. The integration of the survey in Mark Group audit process is also presented in Figure 5-1.

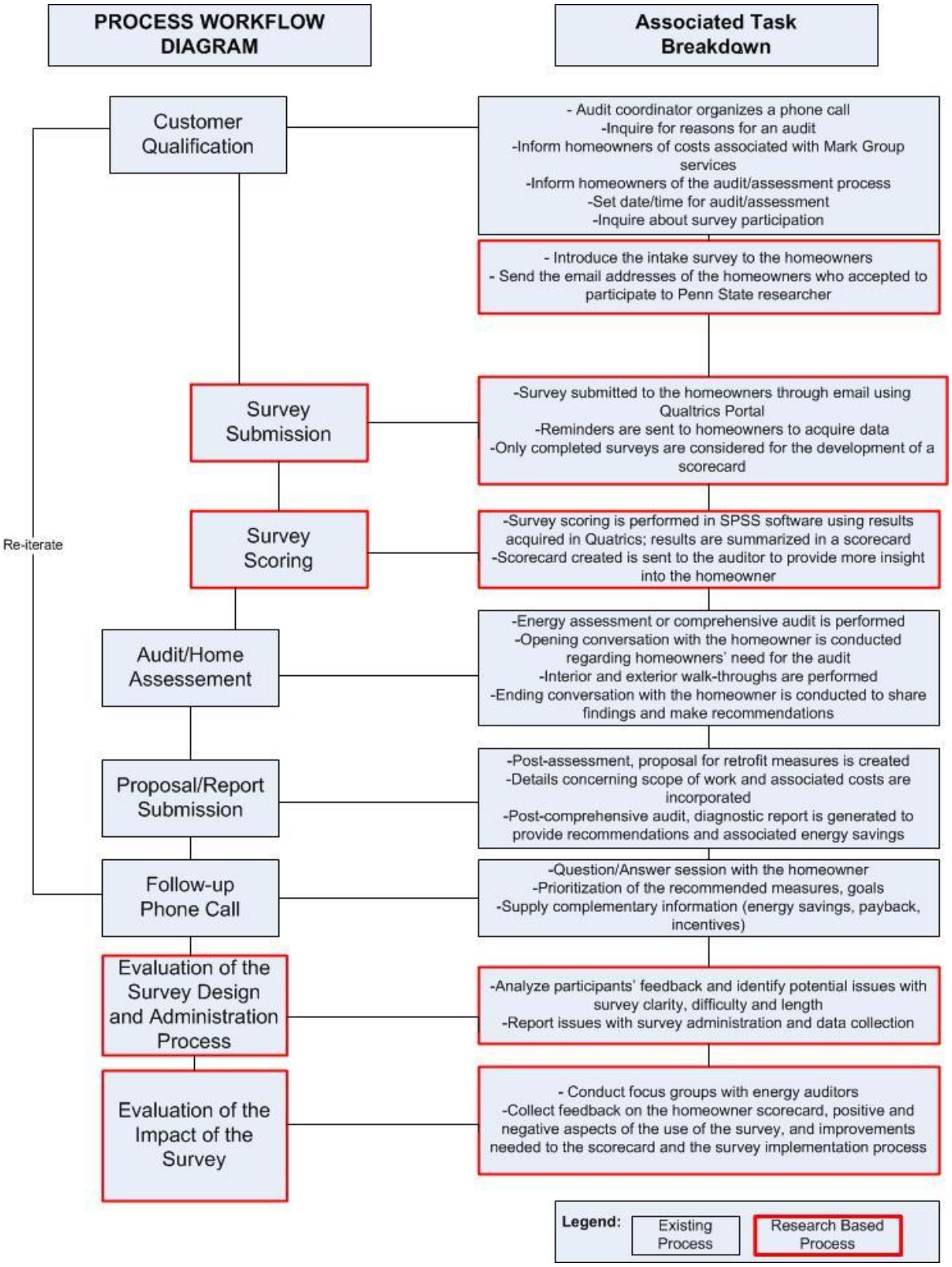


Figure 5-1: Integration of the survey in Mark Group audit process

5.2.3 Methods for the Evaluation of the Assessment Tool

The assessment tool had to be evaluated for its impact on the homeowners' experience with the energy audit and its ability to assist energy auditors in their interventions and interactions with the homeowners.

The effect of the auditor pre-knowledge about the homeowners' profile on their interventions and interactions with the homeowners was first evaluated through a focus group of the Mark Group auditors. This method allowed the researcher to collect insights for the evaluation and revision of the assessment tool less likely to be revealed by a survey or individual interviews of the energy auditors. However, the number of questions that could be asked to the auditors was limited. Four auditors and the audit coordinator, who was in charge of the intake, participated in the focus group. All of the auditors had between one and two and a half years of experience as energy auditors. They had been exposed to both comprehensive/BPI type of audits and walk-through assessments. The focus group took place four weeks after the launch of the survey on the occasion of a weekly auditor meeting. Due to the lack of homeowners' responses to the survey, only two auditors had been exposed to the scorecard for their audits and only one of them was present for the focus group. The researcher sent some exemplars of the scorecard to all the auditors two days before the focus group to ensure that the auditors could familiarize themselves with the scorecards in case they had not been exposed to it for their audits. However, the auditors did not have the time to review these exemplars. Therefore, only one auditor present during the focus group and the audit coordinator had seen the scorecards before the day of the focus group.

The focus group was forty-five minutes long. Due to time constraints for its preparation, no external facilitator was recruited to manage the discussion. This task was the responsibility of the researcher who was also in charge of taking notes. These conditions introduced a potential for bias in the questions asked during the focus group and the answers of the auditors. The researcher, however, tried to encourage both positive and negative feedback. The discussion was recorded. A questionnaire was developed to guide the

discussion with the energy auditors and organize the data collection process by setting a list of specific issues to evaluate. These issues were:

- the perceived usefulness of the information included in the homeowner scorecard,
- the ways this information could be used by the auditors for the design of their interventions,
- the outcomes of the tool on the auditors' interaction with their customers,
- the improvements needed in the administration of the tool and the design of the homeowner scorecard to better integrate the assessment of homeowners' characteristics in the energy audit practice.

The questionnaire that was developed in anticipation of the focus group can be found in Appendix H for reference.

However, since the auditors' experience with the homeowner scorecard was limited due to the lack of homeowners' responses to the survey, few insights were collected on each individual item of the scorecard to determine their specific usefulness and whether they should be kept. The discussion mostly addressed the general benefits of such an approach, where homeowners' behavioral characteristics are assessed during the intake, for the audit/contractor business and the homeowner-auditor relationship. The focus group also revealed additional benefits of the assessment tool for the homeowners.

Another focus group of two Envinity energy auditors was conducted, following the Mark Group focus group, to collect additional feedback on the scorecard. Since the auditors did not have any experience using the scorecard, the researcher sent them two exemplars of it five days before the discussion. More feedback was collected during this interview on the usefulness of the different items of the scorecard and the way they were presented. The information collected from the Envinity auditors also completed the insights from the Mark Group auditors and confirmed the main conclusions drawn from these focus groups.

A follow-up survey was initially planned to be sent to the homeowners who filled out the intake survey and some homeowners who did not participate in the intake survey for the purpose of evaluating the impact of the assessment tool on the homeowners' experience with the audit. However, the Mark Group already had its own customer feedback survey and did not want to impact their follow-up business model by using the survey developed by the researcher.

5.3 Researcher's Observations and Lessons Learned

Observations were made by the researcher throughout the administration process to assess the usability of the survey and determine challenges with its administration and the management of the collected data. The issues and lessons learned detailed in this section require some attention for future administration of the assessment tool.

5.3.1 Survey Administration

Upon the Mark Group request, the email with the link to the intake survey was sent by the researcher to the homeowners who accepted to participate. The involvement of the researcher in the sending of the survey required additional coordination and communication with the auditing firm. A good communication between the researcher and the audit coordinator who was in charge of the intake phone call was established. This communication allowed the researcher to send the link to the survey in a timely manner. However, the process could be even more efficient if it was entirely done internally by the auditing firm. The average time between the intake phone call and the appointment with the energy auditor was one week. This period was fairly short to get a response from the homeowners and limited the sending of reminders. Some audits were scheduled the day after the intake phone call which did not let enough time to send the survey and process the answers. Integrating the link to the survey in a confirmation email sent by the auditing firm the same day, after the schedule of the audit, could accelerate the data collection. It took between fifteen and twenty minutes for the participants to fill out the survey entirely, which matched what was advertised. The duration was provided by Qualtrics.

5.3.2 Scoring of the Survey and Development of the Assessment Scorecard

Proper identification of the participants was necessary to match the responses to the survey with the Mark Group customers and provide the assessment scorecard to the auditor in charge of the audit of those participants' homes. No problems with participant identification were encountered, since the respondents went to the end of the survey and provided their contact information, or were identified through Qualtrics. As people may not fill out the survey to the point where they are asked to provide their contact information, it is important to have another way to identify the respondents. Administering the survey via Qualtrics allowed the researcher to match the survey with the name and email address to whom the survey was sent.

Depending on the number of questions completed, a homeowner assessment scorecard could be created for the partially filled surveys. When the number of completed questions was very small (less than 10), as it was the case for one participant who only completed the first five questions, it was difficult to judge if creating a homeowner scorecard was worth it. Prioritizing the questions based on their usefulness could help determine which questions would need to be answered to make the scorecard valuable.

While the scoring of the responses was automated, the transcription of the results into the assessment scorecard was not. It took the researcher thirty to forty minutes on average to score one survey and translate the results into a homeowner scorecard using the Word template created. This process is fairly labor-intensive and would need to be accelerated if the survey was distributed to a greater number of audit customers. The use of SPSS facilitated the development of a code to score the survey. However, this software does not make it possible to automate the creation of the scorecard. It is likely that this process could be automated using a spreadsheet embedded in a website or a database. The format of the homeowner assessment scorecard offered the possibility to have it uploaded on a tablet used by energy auditors for their assessment.

5.4 Evaluation of Survey Participation

Few responses were collected from the administration of the survey to the Mark Group customers. Fourteen customers agreed to take the survey when asked during the intake phone call and received the email with the survey link. Five customers filled out the survey entirely; two customers filled it out partially. All the respondents had requested a free home energy assessment.

A reason for the small number of responses may be the length of the survey which was advertised to be twenty minute long. Yet five out of the seven participants who took the survey completed all the questions and six participants judged the length of the survey "about right" and the average amount of time it took them to complete it was twenty minutes and twenty seconds. Therefore people may have been discouraged by the anticipated length of the survey before taking it but they were not discouraged by the length of the survey while taking it. Another possibility to explain this small number of responses is that people may not have been motivated to fill out the survey. Few customers agreed to take the survey when asked by the Mark Group during the intake phone call. In the future, the auditing firms will need to better encourage their customers to complete the survey. Some recommendations on this point are provided in Chapter 6. An alternative may be to modify the process for assessing the homeowners' characteristics so as to increase the response rate. Some recommendations on this point are provided in the conclusion of this chapter.

Since little data was collected from this round of survey administration, no rigorous statistical analysis could be conducted. The sample of participants was not large enough to rigorously test the internal reliability of the scales used in the intake survey. Additional responses were collected for the purpose of the reliability analyses that will be described in a next section. Moreover the follow-up survey could not be launched which impeded the evaluation of the assessment tool's impact on the outcomes of the audit for the homeowners. Even if the follow-up survey had been launched, the sample of homeowners who would have taken both the intake and follow-up surveys would need to be larger to ensure the external validity of the findings. Therefore, the evaluation of the survey was limited to the collection of qualitative

data from the auditors on the perceived usefulness and benefits of the assessment tool and homeowner scorecard. Feedback was also collected from survey's participants on its design.

5.5 Feedback from the Energy Auditors

This section reports and organizes the feedback received from the Mark Group and Envinity energy auditors. General feedback on the benefits of the scorecard and the usability of the presented information was consistent between both groups of auditors. The feedback from the Mark Group auditors addressed in more details the benefits of the assessment tool for the homeowner-auditor relationship. Envinity auditors examined in more details the relevance of the collected information.

The assessment tool and homeowner scorecard were perceived as useful by both the Mark Group and Envinity energy auditors for their interventions and follow-up conversations with their customers. The Mark Group and Envinity are both energy auditing/contractor firms. The benefits of the assessment tool and the homeowner scorecard were evaluated from a sales perspective.

5.5.1 Homeowners' Concerns and Objectives

Both groups of auditors agreed that the scorecard provided more information about their customers than what they would be able to obtain through their typical conversation with them. This information was perceived as helpful for the auditors to get a better understanding of their customers before going to clients' homes. However, Envintiy auditors pointed out that the scorecard should not be used to replace the initial conversation the auditors have with the homeowners. Though cutting the need for this conversation could save some time on the audits, the initial conversation is important to build a connection with the homeowners. Letting homeowners talk about the issues they have in their homes helps auditors establish some trust. Therefore, the purpose of using the scorecard should be to make this conversation more effective, but not to replace it.

Knowing the reasons why the homeowners requested an audit and the home improvements they have in mind was judged particularly useful by both groups of auditors. This information can assist auditors in

determining on what to focus their attention, possibly anticipating the causes of the issues described by the homeowners, identifying opportunities for providing their contractor services, and anticipating the amount of work that will need to be done. The auditors want to make sure that they address the homeowners' primary reasons for requesting an audit and do not miss any opportunities to address home improvements for which the homeowners show some interest. The scorecard can aid auditors in fine-tuning the way they present their services to the homeowners based on client needs and objectives. However, asking homeowners their reasons for requesting an audit is already part of the intake phone call and is not unique to the assessment tool. On the other hand, the auditors admitted that the assessment of the behavioral factors was a unique advantage of the scorecard because these factors are more difficult for them to assess and are influential for their sales strategies. For example, knowing that the homeowners are able and would like to do the work by themselves is important to the auditors as it may reduce the chances that they call the auditing firm to install the retrofits.

5.5.2 Homeowner Knowledge Assessment

Envinity auditors were skeptical about the relevance of the homeowner knowledge score and questioned the procedure used to determine it. This procedure involves that participants give a range of savings they would expect to see on their energy bill through the implementation of different energy efficiency and conservation measures. These savings vary greatly with the home design and occupancy which makes the validity of this question as a measure of knowledge questionable. According to Envinity auditors, the homeowners' knowledge score would not be judged as relevant unless the auditors were sure that this score was correct and meaningful. Both groups of auditors agreed that knowing the extent to which their customers are knowledgeable about energy efficiency would not change the way they would conduct their assessment. However, this type of information would enable the auditing firm to dispatch the auditors so as to match their experience with the experience of their customers. For instance, the company would preferably send an auditor with a strong and diversified building experience to a customer very knowledgeable about energy efficiency.

5.5.3 Homeowner Motivation Assessment

The assessment of homeowners' motives to save energy was judged useful by the auditors as it is more thorough than what they would usually be able to determine during their visit. Knowing homeowners' motives to save energy will not change the nature of the recommendations the auditors will make, but the way they will frame these recommendations to the homeowners. From the auditors' point of view, asking homeowners their top three motives to save energy would be, however, more useful than asking them to rate different types of motives. Indeed, homeowners may be tempted to rate multiple motives high. In this case, this information will not be as useful for the auditors, since they will not be able to frame their message in a specific way.

Figures 5-2 and 5-3 give two examples of the scorecard graphs providing some information about the homeowners' motivation. The graph in Figure 5-2 presents the influence of three types of norms (personal norm, descriptive norm, and injunctive norm) on homeowners' motivation towards a specific category of measures, here energy generation. Similar graphs are included in the scorecard for safety measures, energy conservation behaviors, and energy efficiency measures. The homeowners' overall motivation towards the four categories of measures resulting from the influence of the three types of norms is summarized in the graph presented in Figure 5-3. These types of graphs were judged very useful as they can help auditors know what measures to target.

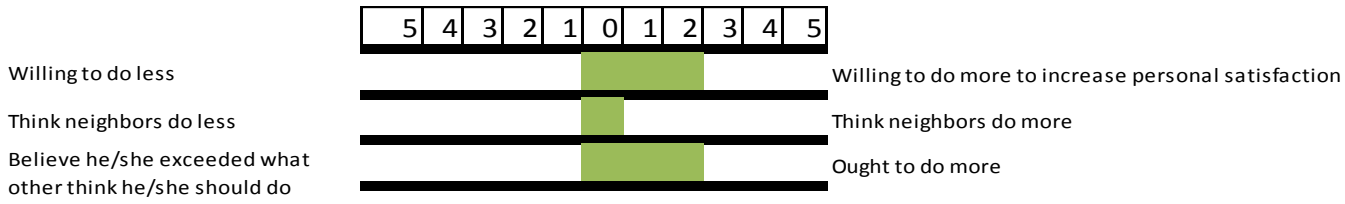


Figure 5-2: Example of graphs from the scorecard displaying homeowners' motivation towards a specific type of measures, here energy generation

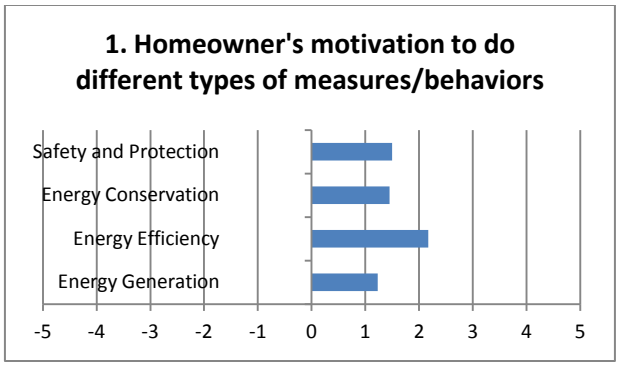


Figure 5-3: Graph of the scorecard summarizing homeowners' motivation towards four different types of measures

5.5.4 Homeowner Behavioral Skill Assessment

The behavioral skills section was judged useful overall, though it could be further refined. Most of the feedback on this section came from Envinity auditors. They encourage homeowners to implement low-cost energy measures themselves, such as replacing incandescent light bulbs with compact fluorescent ones. Therefore, knowing that homeowners like and are confident in their ability to do improvements to their homes by themselves would give the auditors a sense of whether the homeowners would be receptive to this type of measures. It was suggested that the survey could ask whether the homeowners would be ready to raise a loan to finance the upgrades. This factor is important for the auditors to address because they lose customers and opportunities for major retrofit work due to the homeowners' rejection of a loan as a way to finance the upgrades. This observation is consistent with the findings of Zundel and Stiess study (2011) where a negative attitude toward loan was found as a major barrier against comprehensive energy retrofits. Additionally the homeowners' willingness to adopt energy efficiency upgrades independently of the existence of financial incentives was mentioned as a factor of interest. The auditors would also be interested in knowing if the homeowners have already a handy man or a contractor to do the work as it may reduce the likelihood that they will hire the auditing firm for the installation work. Though interesting for the auditors, the behavioral skills section will not have a large impact on the

audit itself. The feedback of the auditors on this section suggests that this information would be more applicable to the auditors' follow-up.

5.5.5 Categorization of the Energy-Related Measures

The three categories of energy conservation, energy efficiency and energy generation cover the different energy-saving measures the auditors would typically address. Both groups of auditors do not typically analyzed conservation behaviors. The auditors mostly focus on the measures for which they can sell their contractor services. Their feedback suggests that the knowledge of homeowners' perception of energy conservation behaviors might not have a great impact on the audits, unless the homeowners' interest in energy conservation behaviors can be coupled with other home improvements to facilitate these behaviors.

The categorization of energy-saving measures, used by Envinity could help further refine the one used in the survey that was described in Chapter 4. Envinity auditors use this categorization to define a path for the implementation of the measures and prioritize their recommendations to the homeowners. This categorization is as follows:

- "Light" measures (plug load management), including no-cost measures (conservation behaviors), low-cost measures (e.g. lighting upgrades, aerators, low-flow shower heads) that the auditors typically address and get the homeowners to do themselves, and some high-cost measures such as the replacement of appliances (e.g. refrigerator, dishwasher) that will be only recommended if they can be justified economically. "Light" measures are cost-effective measures with a low upfront cost and a rapid return on investment.
- Efficiency measures, which can be broken up into two main types of measures: mechanical systems upgrades and building envelope improvements. Improvements to the building envelope should be addressed first. Once fixed, they can help downsize the mechanical systems. These measures require a higher investment but generate higher savings.

- Renewable energy systems (mostly solar)

This categorization of energy-saving measures is very similar to the one used in the survey. Safety measures are not mentioned in this categorization but are systematically addressed by energy auditors.

Both energy auditing firms do not offer energy monitoring systems. Therefore, they are currently not directly concerned by the homeowners' perception of these systems. However, the auditors would be interested in knowing if the demand for energy monitoring systems grows, in which case they would consider including them in their services.

5.5.6 Assessment of Homeowners Current Energy-Related Behavior Pattern

The specific measures used to determine the homeowners' achievement, expressed as a percentage, in safety, conservation, efficiency, and generation should not be weighed the same but as a function of their importance from the energy auditors' standpoint. For example, the auditors would give more weight to the fact that the homeowner switched the washer temperature settings from hot to cold than they would to the fact that they set the temperature of the water heater to 120F. The first behavior is more likely to denote some true energy consciousness from the homeowners than the second would do, since the homeowners may not have realized that someone set the temperature of their water heater to 120F for them.

5.5.7 Additional Feedback on the Content of the Scorecard

An additional piece of information Envinity auditors would like to see in the scorecard is the homeowners' occupation. This information can help them adapt their communication in a way that will best speak to the homeowners.

5.5.8 Perceiving Homeowners' Commitment

An important outcome of the homeowner scorecard from the Mark Group auditors was that it was a good indicator of the homeowners' commitment to the pursuit of energy-saving measures. By taking the

time to fill out the survey and share personal information with the auditors, the homeowners demonstrate their interest in energy efficiency and their motivation to work with the auditing firm. This comment was supported by the actual experience of the Mark Group auditors with some of the homeowners who filled out the survey. It is also confirmed by the responses of the homeowners who took the survey. The researcher noticed that the Mark Group customers who filled out the survey had overall a good knowledge of the measures they could take to save energy at home as well as the savings they could expect from the implementation of these measures.

5.5.9 Building a Trustful Relationship with the Homeowners

The Mark Group auditors agreed that the assessment tool and the associated homeowner scorecard could contribute to building trust with their customers. By sending them the survey, the auditing firm can show its customers that it cares about its clients and wants to better address the problems they have in their homes. Using this information and discussing it with their customers can help the auditors build a trustful relationship with their customers. This outcome is important in a context where the auditing firm may have to compete with other contractors also contacted by the homeowners to perform the retrofit work.

5.5.10 Preparing the Homeowners and Managing their Expectations

The benefits of the survey for the homeowners themselves had already been observed when the tool was administered to residents of Kiski School. The feedback of the homeowners made it salient that the survey raised their curiosity about the audit process and energy efficiency solutions. Similar benefits of the survey for the homeowners were also mentioned by the Mark Group auditors. They noticed that home energy efficiency was a vague concept to some of their customers. The survey may provide a way for the homeowners to quantify this concept of energy efficiency, their knowledge, motivation and skills to pursue energy efficiency measures. It can give them an understanding of where they stand on their path to energy efficiency through the actions they have already accomplished and the actions they would like to take.

In this research, the scorecard was not designed to be distributed to the homeowners. More research on ways to design the scorecard would be needed to present this type of information to the homeowners. However, the process of filling the survey in itself can induce them to think about the concept of energy efficiency in a quantitative manner. By doing so, the survey can prepare the homeowners to the audit and make them think about their motives and objectives to pursue energy-saving measures. As a consequence, the homeowners are likely to be more responsive at the time of their audit to a message of the auditors addressing the same motives and objectives.

This effect of preparing the homeowners for their audit and helping them identify their needs, their objectives and motives for energy retrofits, which are sometimes unclear for them, is precisely the intent of the intake process. Therefore, the assessment tool offers an opportunity to improve that process.

5.5.11 Improvements Needed to Facilitate the Implementation of the Survey

To improve the usability of the information collected about the homeowners, a summary of the scorecard should be made available to the auditors on their tablets. This summary should include key information the auditors need to know about their customers that they could consult before their appointment. The full version of the scorecard should be kept available for reference. It would give the auditors more details about their customers if needed.

Based on the feedback from Envinity auditors, the most relevant information that should be kept in this summary was:

- Demographic information
- Reasons for which the homeowners requested an audit and home improvements they are interested in
- List of measures they have already done and measures they think would be useful for their homes
- The top three motives of the homeowners for saving energy

- The homeowners' motivation with regard to safety, conservation, efficiency and generation measures.

This information can directly affect auditors' approach at the time of their visit.

A suggestion as to the scorecard format was to transform the table giving homeowners' rating of different motives to save energy into a bar chart. An example is presented in Figure 5-4. This format would visually help auditors rapidly assess the motives the homeowners weigh more. The two tables "current energy usage pattern" and "knowledge awareness" could be combined into a single table listing the different measures by type to improve the readability of the information. A suggestion for this table is presented in Table 5-3 for the safety and conservation measure types. For each type, the percentage of measures already implemented could be indicated. For each line item, check boxes could specify whether the homeowners have taken the measure or not, and whether they thought it would be useful for their home. This format would help auditors process this information more rapidly.

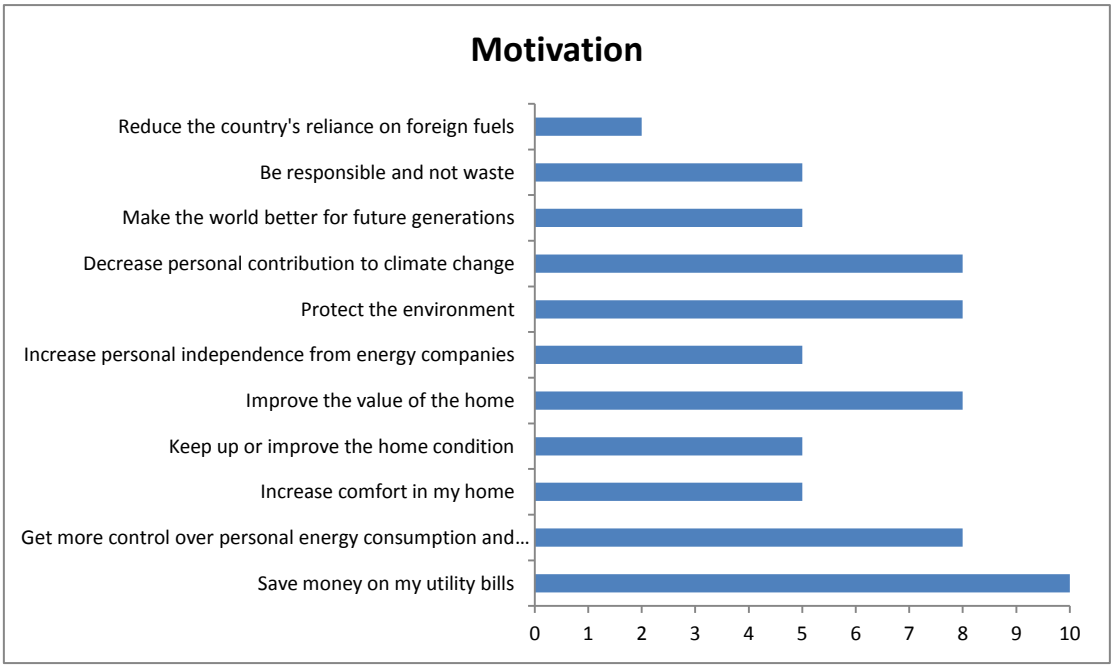


Figure 5-4: Suggestion for a bar chart presenting homeowners' motivations in the scorecard

Table 5-3: Suggestion of table for the homeowner scorecard

Measure Type	Percentage of measures implemented	Measures	Implemented	Homeowner thinks this measure would be useful	Additional measures homeowner thinks would be useful
Safety	60%	Check and replace smoke detector batteries	X		Have a radon inspection
		Do not operate unvented combustion appliances			
		Install a CO detector		X	
		Have water heater, boiler and/or furnace regularly checked by a professional	X		
		Control moisture sources in the house, if any	X		
Conservation	40%	Unplug or tunr off power strip for the electronic devices			Have short showers rather than baths
		Set the water temperature of the water heater to 120F	X		
		Set thermostat to energy-saving settings		X	
		Change the washer temperature settings	X		
		Line dry			

5.5.12 Future Potential for the Assessment Tool

The Mark Group seeks to understand why their customers do not move forward with the installation of energy efficiency upgrades. This problem is particularly striking when the suggested upgrades perfectly address the issues the customers have in their homes, fit into their budget, and the process for the implementation of these measures has been clearly defined to them. Though the company has a follow-up survey, they do not usually receive feedback about the reasons why clients do not pursue the installation of the retrofits. With more data, the survey could possibly unearth some patterns among customers based on the characteristics assessed that would help auditors predict if a person is less likely to follow through the implementation of the retrofits. This information would allow auditors to adjust their time and effort in their follow-up process based on the homeowners' likelihood to take action.

The follow-up survey that has been developed in this research could also provide some insights on this question. However, homeowners may not be willing to answer this survey or give genuine answers to it if they do not intent to call the auditing firm to install the recommended measures.

5.6 Feedback of the Participants on the Design of the Tool

Feedback from the respondents on the difficulty of the survey, its length, the clarity of the questions, and whether the respondents felt comfortable with answering the survey, was collected through questions included at the end of the survey. Descriptive statistics for these questions are provided in Tables 5-4 and 5-5. Little feedback was collected when the survey was distributed to the Mark Group customers due to the small amount of responses.

Table 5-4: Feedback of the Mark Group customers on the design of the survey

Number of respondents	Did you feel comfortable answering this survey?			
7	Yes	Somewhat	No	No answer
	5	1	0	1

Number of respondents	Did you meet some difficulties with filling out this survey?			
7	No difficulty	Some difficulties	Many difficulties	No answer
	3	3	0	1

Number of respondents	How would you judge the length of the survey?			
7	Too long	About right	Too short	No answer
	0	6	0	1

Number of respondents	How would you judge the overall clarity of the questions of the survey?			
7	Clear	Somewhat clear	Not clear	No answer
	4	2	0	1

The survey was also administered to the Penn State Center For Sustainability staff and members of the CFS listserv to collect enough data to run a statistical analysis and evaluate the internal consistency of the questions of the survey. This analysis is described in the next section. Forty-five people filled out the survey entirely. The sample of participants included homeowners and renters from the State College area. They were not customers of an energy auditing firm. They were asked to participate in the survey in order to test it and improve it. The first question of the survey (type of audit requested) was modified to account for the fact that participants had not scheduled an audit. Additional feedback on the design of the survey was collected from these participants through the questions included at the end of the survey. Some respondents provided detail feedback through the open-ended question included in the survey.

Table 5-5: Feedback of the respondents from the CFS staff and listserv

Number of respondents	Did you feel comfortable answering this survey?			
45	Yes	Somewhat	No	No answer
	37	6	2	0

Number of respondents	Did you meet some difficulties with filling out this survey?			
45	No difficulty	Some difficulties	Many difficulties	No answer
	19	25	1	0

Number of respondents	How would you judge the length of the survey?			
45	Too long	About right	Too short	No answer
	9	36	0	0

Number of respondents	How would you judge the overall clarity of the questions of the survey?			
45	Clear	Somewhat clear	Not clear	No answer
	27	16	1	0

It can be inferred from the feedback of both samples that the clarity of the questions still needs to be improved. Initial feedback from the marketing firm Shelton Group and the Mark Group director of training indicated that the set of questions asking people to assess the current state of their home and three reference states (neighbors' home, ideal home, and the state the home should be at in others' opinion) remained difficult. For example, people do not necessarily know how their neighbors' homes compare to theirs in terms of energy performance or safety because they do not talk with their neighbors about these questions. Though these questions can give auditors a representation of the homeowners' motivation to perform specific types of measures, their usefulness is limited if the auditors do not allude to the state of neighbors' homes during their interventions. It is also unlikely that the auditors will address injunctive norms, that is, the homeowners' beliefs about what their friends or family think they should do.

Some respondents found that their most accurate answers could not fit in the available categories for the answer options. For example, a "partially implemented" option would be needed for the question asking individuals which energy-efficiency measures they have already taken. Participants should also have the possibility to say if they have taken a more stringent or slightly different measure, such as setting the thermostat down to 60F at night and to 64F during the day, instead of 68F all day as it is stated in the survey. The question asking the savings generated through different energy-related measures should precise which climate the respondent should consider, as the savings generated by some of the measures (e.g. replacement of the heating system) may be different for a home located in a cold climate and a home located in a hot climate. The difference between energy conservation and energy efficiency measures was

not clear to some of the participants. Using examples would improve their understanding of these two categories of energy-related measures.

When asked what safety and protection measures would be the most useful for their homes, some participants listed measures such as door locks or security systems that are not in the scope of an energy audit. The definition of safety and protection measures included in the survey should therefore be fine-tuned. This may be difficult without using examples. A suggestion made by an Envinity energy auditor was to say that some of these measures can help protect the occupants against CO contamination, as this may speak more to the respondents.

The survey still appears challenging for people to answer. Initial feedback collected from Kiski residents indicated that the questions of the survey were very thorough, which makes them difficult for participants to answer. At the same time, their difficulty forced the residents to think about the energy performance of their home and the concept of energy efficiency. Though the difficulty of the questions may have a negative effect by discouraging people from filling out the survey, it may also have a positive effect of raising homeowners' curiosity with regard to energy efficiency, as the feedback of Kiski residents suggested. The survey should be pilot tested again in a "think aloud" format to see where people struggle and get specific feedback on each question so that modifications can be made. More feedback should be collected from people expert in survey development. Overall people were comfortable answering the survey.

5.7 Reliability Test on the Scales

The survey was administered to individuals of the Penn State Center for Sustainability staff and listserv. Their responses were combined with the ones from Mark Group customers and a statistical analysis was run on this group of responses. Only the surveys which were filled out entirely were taken into account. Fifty-one responses were therefore used for the analysis. The purpose of the statistical

analysis was to evaluate the internal reliability of the scales used in the survey to measure the different constructs, including information, motivation and perceived skills.

The reliability of the questions of the survey was assessed using the internal consistency method. This approach to reliability is used when a multiple-item measure is given on just one occasion, as it was the case for the survey.

The Cronbach's alpha coefficient was computed using SPSS to evaluate the reliability of the scales measured in the questions. A high alpha value indicates a high correlation among the items of the scale. An alpha value above 0.7 is considered to reflect a reliable assessment. High correlations imply that high score on one item is associated with high scores on other items. The "Cronbach's alpha if item deleted" represents the internal reliability of the scale if this item were to be removed from the scale. It reflects how well the item correlates to the underlying construct of the section. Items that do not support the reliability of the construct measured by the scale should be considered separately or removed from the survey in future iterations.

In addition to the internal reliability tests, a principle component factor analysis with promax rotation was used to determine how the items of the questions group together to form factors. These factors should represent the underlying scales measured by the questions. If a question has been conceptually designed to measure a single scale, only one factor should hypothetically be identified in the question. Otherwise the question does not perfectly reflect the underlying scale.

In a principle component factor analysis, the retained factors are those which account for a large proportion of the variance of the items. The variances extracted by the factors are called the eigenvalues. While there are different criteria to determine the number of factors to retain, the one considered here is a graphical method called the scree test. The scree plot is a plot of the eigenvalues of the factors that were extracted. The use of the scree plot is explained in the next sub-section with the example of the motivation scale. Because the sample size is small, the factor analyses should be considered exploratory.

The scales that were tested included:

- Homeowners' general motivation for saving energy (Question 4)
- Homeowners' perceived general behavioral skills to implement energy-saving measures (Question 5)
- Homeowners' behavioral skills to adopt specific types of energy-related measures: safety, conservation, efficiency, and generation (Questions 8, 11, 14, 17, item 5)
- Homeowners' knowledge of the energy saved through the implementation of various energy efficiency and conservation measures (Question 6)

5.7.1 General Motivation Scale

A reliability analysis was conducted to test the internal consistency of the general motives for saving energy. The calculation of the Cronbach's alpha for all the items gives a value of 0.836 which indicates that the general motivation scale of the survey is reliable.

Table 5-6 below gives the Cronbach's alpha values of the scale if one item is deleted. The alpha value of the scale is higher (0.845) when the item "Save money on my utility bill" is removed. The mean for this item is 4.75 and the standard deviation is the lowest of all the items: 0.560, as indicated in Table 5-7. There is much uniformity in the responses, which is consistent with the results of other studies stating that saving money is by far the primary driver for homeowners to save energy (Shelton Group 2011). A large proportion of participants "strongly agree" with this item (41 out of 51) whereas answers were more diversified for other items. The participants who do not strongly agree (10 out of 51) either "agree" (7 out of 10) or "neither agree nor disagree" (3 out of 10) to this item, but none of them went in the opposite direction ("strongly disagree"). This item therefore does not serve as a good way to differentiate among homeowners.

Table 5-6: Cronbach's alpha values if item deleted for the general motivation scale

	Cronbach's Alpha if Item Deleted
Save money on my utility bills.	.845
Get more control over my personal energy consumption and costs.	.817
Increase the comfort in my home.	.828
Keep-up or improve the condition of my home.	.826
Improve the value of my home.	.826
Do what I can to increase my personal independence from energy companies.	.828
Do my part to help protect the environment.	.821
Do my part to decrease my contribution to climate change/global warming.	.813
Do my part to help make the world better for future generations.	.801
Be responsible and not waste.	.823
Do my part to help reduce our country's reliance on foreign fuels.	.807

Table 5-7: Descriptive statistics for the general motivation scale

	N	Minimum	Maximum	Mean	Std. Deviation
Save money on my utility bills.	51	3	5	4.75	.560
Get more control over my personal energy consumption and costs.	51	3	5	4.43	.700
Increase the comfort in my home.	50	2	5	4.18	.800
Keep-up or improve the condition of my home.	51	2	5	4.20	.825
Improve the value of my home.	51	1	5	4.10	1.044
Do what I can to increase my personal independence from energy companies.	51	2	5	3.96	.979
Do my part to help protect the environment.	51	1	5	4.25	.868
Do my part to decrease my contribution to climate change/global warming.	51	1	5	4.06	1.066
Do my part to help make the world better for future generations.	51	1	5	4.00	1.000
Be responsible and not waste.	51	1	5	4.33	.792
Do my part to help reduce our country's reliance on foreign fuels.	51	1	5	3.67	1.178
Valid N (listwise)	50				

The items of the scale were assumed to form two subscales representing two measures of motivation: personal motivations and principled motivations. Principle component factor analyses were conducted to test whether the general motivation for saving energy formed the two subscales. The scree plot method was used to determine the number of factors to retain. The place where the smooth decrease of eigenvalues appears to level off to the right of the plot marks the number of factors that should be retained (to the left of this point). An examination of the scree plot in Figure 5-5 reveals a two factor structure. The first factor, accounting for 39% of the variance as per Table 5-8, was composed of principled motivations for energy use (e.g. protect the environment, decrease contribution to climate change/global warming, and reduce country's reliance on foreign fuels), except for the item "Do what I can to increase my personal independence from energy companies" which is a personal motivation. The second, accounting for 22% of the variance as per Table 5-8, was composed of personal motivations for energy use (e.g. save money, increase comfort in my home, improve the condition of my home). The items composing the two factors are presented in Table 5-9. Reliability analyses support using these two separate measures of motivation. The Cronbach's alpha values for the two subscales were 0.878 for the principled motivations and 0.763 for the personal motivations.

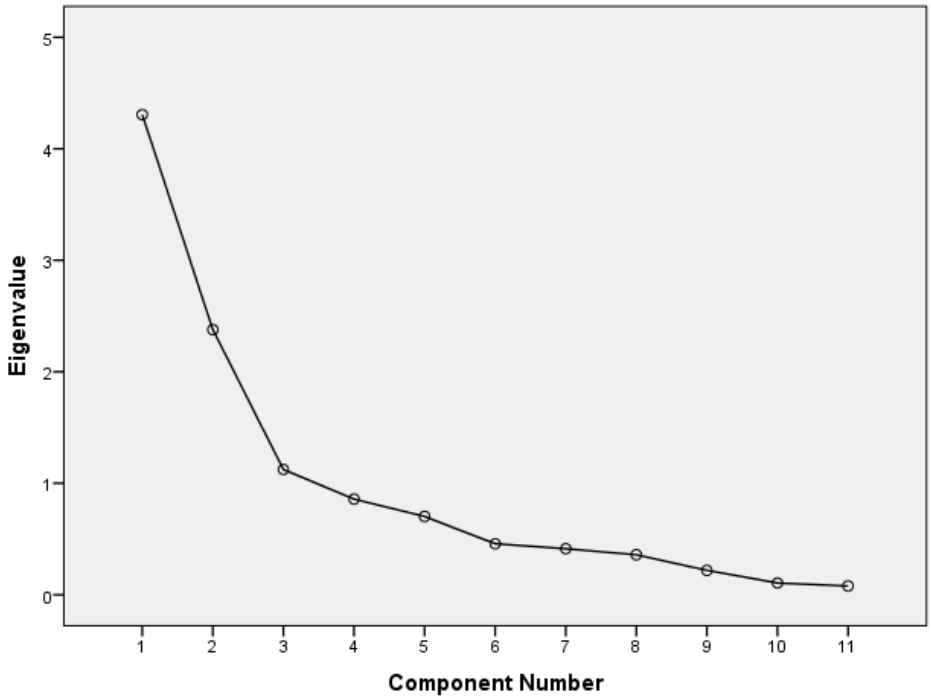


Figure 5-5: Scree plot for the general motivation scale

Table 5-8: Total variance explained for the factor analysis of the general motivation scale

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.307	39.151	39.151	4.307	39.151	39.151	4.004
2	2.377	21.614	60.765	2.377	21.614	60.765	3.125
3	1.123	10.212	70.976				
4	.858	7.802	78.778				
5	.702	6.386	85.164				
6	.457	4.157	89.321				
7	.413	3.755	93.076				
8	.359	3.263	96.339				
9	.219	1.990	98.329				
10	.105	.958	99.287				
11	.078	.713	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 5-9: Pattern matrix for the factor analysis of the general motivation scale

	Component	
	1	2
Do my part to decrease my contribution to climate change/global warming.	.933	
Do my part to help make the world better for future generations.	.922	
Do my part to help protect the environment.	.842	
Be responsible and not waste.	.789	
Do my part to help reduce our country's reliance on foreign fuels.	.615	.307
Do what I can to increase my personal independence from energy companies.	.440	
Improve the value of my home.		.872
Keep-up or improve the condition of my home.		.817
Increase the comfort in my home.		.791
Save money on my utility bills.		.577
Get more control over my personal energy consumption and costs.	.365	.529

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

5.7.2 General Behavioral Skills Scale

Principle component factor analyses were conducted to test whether the items to measure perceived behavioral skills formed a single factor. An examination of the scree plots suggested that there were several dimensions to this scale. Furthermore, reliability analyses of the scale suggested that there was not a strong internal consistency across the items (Cronbach's alpha = 0.523). The reliability analyses did suggest that a scale with an adequate reliability could be created after removing two items ("ability to change my lifestyle" and "ability to pay for improvements to my home"). Table 5-10 gives the alpha value of the scale when the item "ability to change my lifestyle has been removed (0.640). When the items "ability to pay for improvements to my home" is also removed the Cronbach's alpha value of the scale is 0.707 as per Table 5-11. Feedback from the energy auditors suggested that other items could be added to this scale, such as the willingness to raise a loan to finance the upgrades. Therefore, the behavioral skills scale should be revised to include additional items and the reliability of the new scale should be tested again.

Table 5-10: Alpha values without item for the behavioral skills scale

	Cronbach's Alpha if Item Deleted
I like making improvements to my home by myself.	.251
I am confident in my ability to make improvements to my home by myself.	.304
I am confident in my ability to find others to make improvements to my home.	.471
I am confident in my ability to pay for improvements to my home.	.572
I am confident in my ability to take the time to do home improvements.	.462
I am confident in my ability to change my lifestyle in such a way that would save energy.	.640

Table 5-11: Alpha values without item for the behavioral skills scale after the item "ability to change my lifestyle" has been removed from the scale

	Cronbach's Alpha if Item Deleted
I like making improvements to my home by myself.	.408
I am confident in my ability to make improvements to my home by myself.	.423
I am confident in my ability to find others to make improvements to my home.	.624
I am confident in my ability to pay for improvements to my home.	.707
I am confident in my ability to take the time to do home improvements.	.651

5.7.3 Behavioral skills with reference to specific categories of behaviors

The four items representing perceived behavioral skills for the specific categories of behaviors (safety, conservation, efficiency, and generation) were considered individually in the scoring of the surveys. Principle component factor analyses were conducted to test whether these items could form one scale, as an alternative measure of behavioral skills. An examination of the scree plot in Figure 5-6 suggested that there was a single factor. Furthermore, reliability analyses of the items suggested that one scale could represent perceived behavioral skills to do these behaviors (Cronbach's alpha = 0.776). Therefore, these items could be combined in the future in the scoring of the surveys.

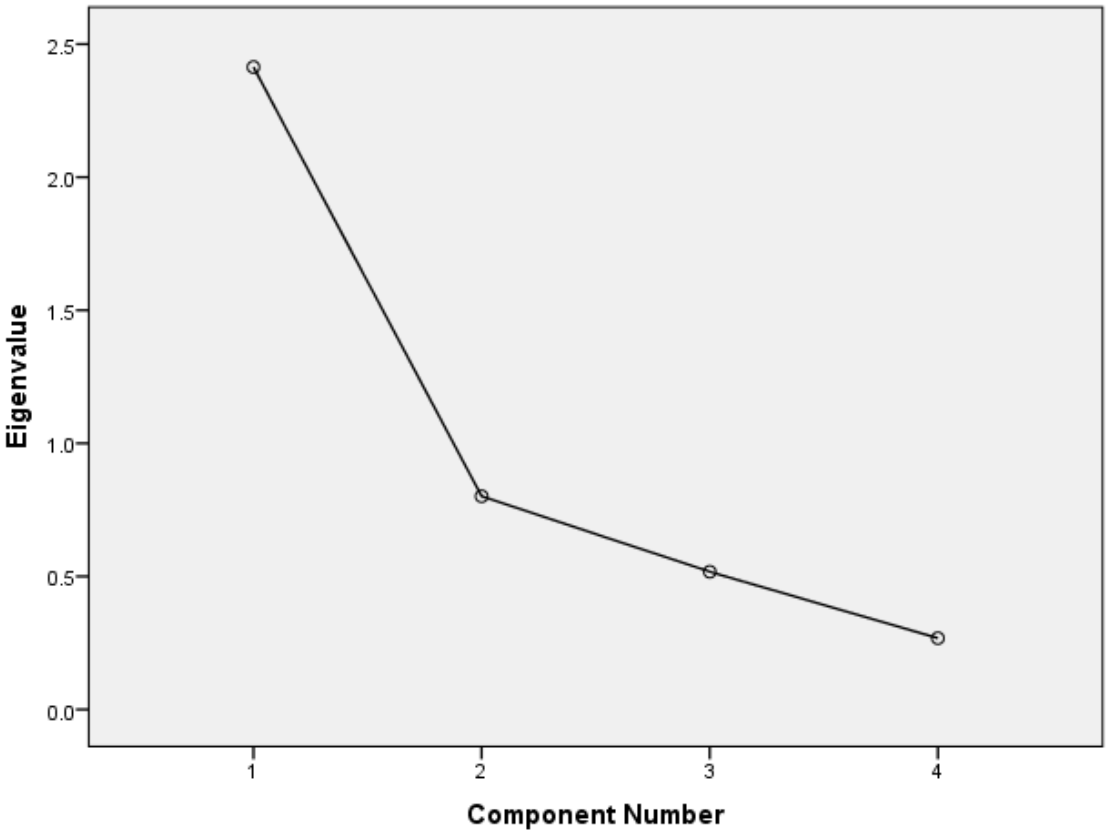


Figure 5-6: Scree plot for the scale measuring behavioral skills with reference to specific behaviors

5.7.4 Knowledge Scale

Reliability analyses were conducted to test the internal consistency across the items used to assess homeowners' knowledge of the energy saved through an array of measures.

The items were first grouped according to the actual percentage of savings they generate (items saving less than 5%, items saving between 5% and 9%, items saving between 10% and 19%, and items saving more than 30%, though this latter category had only one measure). Reliability analyses were conducted for each category to evaluate the internal consistency between items within the same percentage savings category (Cronbach's alpha for behaviors saving less than 5% = 0.811, correlation between the two behaviors saving between 5% and 9% = 0.364, Cronbach's alpha for behaviors saving between 10% and 19% = 0.637). These analyses suggested that individuals' estimates on the more energy intense behaviors (between 5% and 9% and between 10% and 19%) were not highly related to each other.

The scale was transformed in a dichotomous scale where individuals' answers were scored 0 when they equaled the right answer and scored 1 when they equaled a wrong answer. Principle component factor analyses were conducted to test whether the items to measure homeowners' knowledge using this dichotomous scale formed a single factor. An examination of the scree plot suggested that there were several dimensions to this scale corresponding to the different items. Furthermore, reliability analyses of the dichotomous scale suggested that there was not a strong internal consistency across the items (Cronbach's alpha = 0.446). However, reliability analyses conducted on all the items of the polychotomous scale did suggest that individuals' perception of the energy saving potential of the different measures, that is, whether individuals had high or low expectations for the energy saved through the different measures, was consistent across items (Cronbach's alpha = 0.871).

The scale does not give a good measure of individuals' accuracy in their estimate of the energy saving potential of different measures which was its primary purpose. Envinity energy auditors questioned the

use of this question as a measure of knowledge. Several factors can influence the estimated energy savings resulting from the implementation of energy efficiency and conservation measures, including the climate and the behavior of the occupants. Therefore, several "right" answers may exist which may increase the variability of the answers. Another way to assess homeowners' knowledge should be determined. This question does, however, provide a measure of individuals' pattern in their expectations of the energy they can save through different measures.

5.8 Conclusion

This chapter introduced the process by which the survey was implemented in the audit process of the Mark Group auditing firm. Key values of the survey and challenges with its design and implementation were identified through the researcher's observations, the feedback of the auditors and the feedback of the participants.

5.8.1 Key Values of the Survey

The scorecard was perceived as useful by the Mark Group and Envinity energy auditors. The homeowners' characteristics assessed are influential for the auditors' sale strategies. They can assist them in targeting their recommendations and discussion with the homeowners.

The taxonomy of energy-related measures used in the survey goes beyond the categories of measures generally considered by the energy auditors of these two firms. It includes other types of measures, such as energy conservation behaviors or feedback mechanisms, which may not be typically addressed across auditing firms but can increase the potential of the auditors' interventions. Thus, the survey can focus the attention of the auditors on other measures that homeowners may be interested in, but not able or motivated to do, and for which the intervention of the auditors can provide some assistance. For example, the installation of lighting controls and programmable thermostats can facilitate the adoption of conservation behaviors for homeowners interested in these behaviors but not motivated to commit to them.

The auditors' feedback revealed additional benefits of the tool. The survey may have the unintended value of reflecting homeowners' commitment to the pursuit of energy-saving measures. A response to the survey may be the indicator of an informed customer and a good lead. However, this outcome should be verified by measuring the uptake rate of energy-saving measures. The survey may also have a potential educational value for the homeowners. It can improve their understanding of the energy efficiency concept, help them assess their own interest in various types of energy-related measures, and set their expectations for the energy audit.

5.8.2 Challenges with the Survey

Some questions of the survey can be fine-tuned or reconsidered. The questions of the survey measuring homeowners' knowledge and general behavioral skills to implement energy-saving measures did not provide a reliable assessment of their underlying constructs. Other items should be added to the behavioral skills question and tested again to ensure their internal consistency. The items that do not support the internal consistency of the scale, such as the ability to pay or the ability to change one's lifestyle to save energy, can still be considered separately. Another question to measure homeowners' knowledge needs to be determined. Also, the different categories of behaviors (safety, conservation, efficiency and generation) needs to be better explained, for instance by providing examples.

The main challenge with the implementation of the survey that came out from this round of testing was the low response rate from Mark Group customers. The length of the survey, which was advertised as twenty minute long, may have discouraged homeowners from filling it out. The short timeframe between the intake phone call and the date of the audit limited the time allowed to homeowners to fill out the survey and restricted the sending of reminders. Some surveys were partially completed which limited the value of translating the answers into a scorecard. Furthermore, the difficulty of the questions experienced by the participants may also impact the response rate.

5.8.3 Alternative Model for the Assessment of Homeowners' Behavioral Characteristics

The low participation rate in the survey among the Mark Group's customers has been identified as a major challenge with the model used to assess homeowners' knowledge, motivation and behavioral skills. The use of a web-based survey, though convenient, poses the risk to not get this information due to the short period of time between the intake phone call and the audit, and the lack of homeowners' motivation to fill the survey out. Assessing this data during the intake phone call and at the time of the audit can be an alternative model to the use of a web-based survey that may increase the number of responses. Feedback of the energy auditors on the scorecard helped identify what information in the homeowners' profile was the most influential for their approach to the homeowners. This information included:

- Demographic information
- Homeowners' reasons for requesting an audit and home improvements they are interested in
- List of measures they have already done and measures they think would be useful for their homes
- The top three motives of the homeowners for saving energy
- The homeowners' motivation with regard to safety, conservation, efficiency and generation measures.

If it is not already the case, demographic information, homeowners' reasons for requesting an audit, and home improvements the homeowners are interested in could be asked during the intake phone call. The other questions could be either adapted to the intake phone call or answered by the homeowner at the time of the auditor's visit. In this latter case, the information will not assist the auditors' in their opening conversation with the homeowners. But it may still inform the recommendations the auditors will tackle at the end of their assessment and the follow-up conversations the auditors will have with the homeowners. Moreover, the collected data could still be entered in a database to track the profile of the homeowners who are more likely to pursue energy efficiency retrofits. Future research should examine

the value of splitting the assessment of homeowners' behavioral characteristics between the intake phone call and the audit.

Chapter 6
Summary and Guidelines for the Integration of the Assessment Tool in Energy Audit Practice

6.1 Introduction

This chapter presents some guidelines for future development and integration of an assessment tool of homeowners' characteristics into the energy audit process. These guidelines integrate the lessons learned from this research. The issues that were encountered are described along with future work needed to address them.

6.2 Rationale for the Development of an Assessment Tool of Homeowners' Characteristics

Energy auditors can assist homeowners in improving the energy performance of their homes and addressing comfort issues through the analysis of their energy consumption and the recommendations of specific efficiency measures. These recommendations are mostly based on the physical characteristics of the homes assessed during the audit. However, though homeowners are provided with cost-effective energy efficiency measures adapted to their homes and a clear path to implement them, they often do not move forward with the implementation of these measures. This observation generates the need to better understand the homeowners and the rationale behind their decision making.

The home design and energy performance may dictate the type of retrofits that need to be done. But the actual intervention and communication of the auditors should be adapted to the homeowners and the behavioral factors influencing their decisions. Since these factors vary greatly among individuals, their assessment should be embedded in the energy audit process. The premise of this research is that a holistic approach for home energy audits, where the auditors' interventions and recommendations are based on both the home design and the characteristics of the occupants, is likely to increase the uptake of energy-saving measures.

The development of a tool for energy auditing firms to gather some characteristics about their customers is a first step towards the integration of these characteristics in energy audit practice. This tool was developed in the form of an intake survey intended to be administered to energy audit customers once they have scheduled an audit.

6.3 Homeowners' Characteristics Assessed

The Information, Motivation, and Behavioral Skills model was used as a framework to organize the assessment of homeowners' characteristics. The application of this model to the adoption of energy-saving measures determined the dimensions of the homeowners' profile the intake survey should assess. These dimensions are:

- Their knowledge about energy efficiency measures and conservation behaviors
- Their motivation to save energy at home and adopt specific types of measures typically recommended by energy auditors
- Their perceived behavioral skills to perform energy-related improvements to their homes and adopt conservation behaviors.

Based upon this assessment, the auditors can tailor their feedback to the homeowners so as to foster the implementation of energy-saving measures. For instance, auditors can address potential lack of information of the homeowners about actions they can take to save energy at home. Knowledge of homeowners' motives to save energy can help the auditors target their recommendations and frame them in a way that aligns with these motives. Auditors can also provide assistance to overcome potential barriers experienced by the homeowners for the implementation of energy-saving measures.

In addition to these behavioral characteristics, the survey collects some demographic information about the homeowners, such as the household composition or the time people intend to stay in their current residence. This demographic information can have an influence on the households' energy consumption and decision to invest in energy efficiency improvements.

6.4 Guidelines for the Integration of the Tool in Audit Practice

6.4.1 Design of the Tool

Being part of the intake process, the assessment tool is an important element in the establishment of homeowners' trust in the auditor work. Therefore, it has to be carefully designed to avoid discouraging customers or generating some reticence from them due to the feeling of being judged. The survey has to be clear and of an appropriate length, and avoid any phrasing that would have a negative effect on participants' mindset.

The testing of the survey revealed that it was not perceived as intrusive by the homeowners. The length of the current survey was perceived as acceptable by most of the homeowners who took it. However, some participants experienced difficulties answering the survey. The questions are very thorough and make the survey challenging to answer. The difficulty of the survey forces the participants to think about energy efficiency which has the positive effect of raising their curiosity towards an energy audit. In its current form, the survey can unearth homeowners who are very knowledgeable and motivated about energy efficiency. A completed survey may be an indicator of an informed customer and a good lead for the auditing firm. However, homeowners who are less familiar with this topic may feel overwhelmed by the questions and discouraged from filling out the survey. Therefore, to ensure that the survey reaches different types of audit customers, the questions should be revised to be understood by a larger audience. The survey should be pilot tested again in a "think aloud" format to see where participants struggle and get specific feedback on each question so that modifications can be made.

Feedback received from energy auditors on the current version of the scorecard and statistical analyses performed on the homeowners' responses showed the necessity to reconsider some questions of the survey in future revisions of the tool. The assessment of homeowners' knowledge about the impact of different energy-saving measures is questionable. Exploratory reliability analyses on the question used in the survey for this assessment indicated that it does not provide a reliable measure. The assessment of homeowners' motives to save energy could be limited to asking their top three motives to save energy.

The exemplars of measures listed in the survey to assess homeowners' achievements in terms of safety, conservation, efficiency, and generation should be re-evaluated based on the weight the auditors give them in their assessments. The assessment of homeowners' behavioral skills could be further refined to integrate other barriers and facilitators such as the homeowners' attitude towards a loan. Some items used for this assessment, such as the homeowners' ability to pay for home improvements or to change their lifestyle to save energy, do not support the internal consistency of the entire scale measuring homeowners' skills and should be considered separately.

6.4.2 Integration of the Tool in the Intake Process of Energy Audit Customers

The specific steps in the energy audit process and the form of the different interactions with the customers may vary between energy auditing firms. Administering the tool early in the process lets more opportunities to use the information collected. This research proposed to integrate the assessment tool in the customer intake process. It can complement other information requested from the homeowners for the schedule of an audit. The information collected by the survey is provided to the auditors ahead of the audit so as to let them some time to react to this information and use it to prepare their interventions. Collecting this type of information early can be even more beneficial for energy audit/contractor firms willing to streamline their process by presenting an audit report or a proposal to the homeowners at the end of the home inspection.

The assessment tool was developed in the form of a web-based survey which provides a scalable, time- and cost-saving method of administration. However, since this method tends to be less invasive than face-to-face or phone interviews, homeowners need to be strongly encouraged to fill out the survey. This is also important to ensure that the survey is completed in a timely manner before the visit of the auditor. The survey should be introduced during the intake phone call and the survey link should be sent the same day in a confirmation email with the date of the audit. Homeowners may be discouraged by a twenty minute long survey. Therefore, the message introducing the survey must be carefully framed to raise homeowners' interest and motivation. As a suggestion, the questionnaire can be presented as a pre-audit

survey that, if homeowners take the time to fill it out, will help the auditors be more effective during their visit and make the best use of the homeowners' time.

The survey was developed on Qualtrics. This software can be used to create a panel with the names and email addresses of the homeowners and email them the link to the survey. This method has two main advantages. First, it ensures the proper identification of the respondents which is crucial to match them with their responses and create a scorecard for their specific profile. When using a panel, the name of the participants, instead of their IP address, appears on Qualtrics with their answers. Second, this method allows tracking whether the respondents have answered the survey or even looked at it, and managing the sending of reminders accordingly. If an alternative method is used to send the survey, it should ensure proper tracking of the data.

6.4.3 Presentation of the Homeowners' Profile to the Auditors

Once a customer has filled out the survey, his/her answers can be downloaded on the Statistical Package for the Social Sciences (SPSS) where they can be analyzed. A scoring system has been developed and coded on SPSS to convert people's answers into qualitative and quantitative data used to define the homeowners' profile. This data is then summarized into an assessment scorecard that is provided to the energy auditor in charge of the home assessment. The assessment scorecard aims to present participants' answers in a clear and actionable format for the auditors.

The use of SPSS facilitates the development of a code to automatically score participants' answers and convert them into the format in which they will be reported. However, the actual action of carrying forward the data from SPSS on the scorecard cannot be automated on SPSS. As a result, the entire process of scoring the survey and creating the scorecard is labor-intensive. This process should be automated in more extensive applications in the future. It is likely that this could be done by using a spreadsheet embedded in a website or a database.

The scorecard is a six page pdf document. It can be uploaded on a tablet if the auditors use this type of electronic tool for their assessments. To increase the usability of the collected information, an at-a-glance summary of the scorecard presenting key information about the homeowners should be made available to the auditors. Thus, the auditors could rapidly consult this summary before their visit. The full version of the scorecard would still be available for reference. Key information currently assessed by the survey that the summary should include has been identified based on the feedback of two groups of energy auditors. This information includes:

- demographic information
- the reasons why the homeowners requested an audit,
- home improvements and equipment upgrades the homeowners consider doing or think would be useful for their home
- measures the homeowners have already implemented
- homeowners' top three motives to save energy
- homeowners' motivation towards safety, energy conservation, energy efficiency and energy generation measures.

These items have a direct impact on the auditors' approach at the time of the audit. They give the auditors a starting point for their conversation with the homeowners and set some priorities in their home assessment. Collaborative work with energy auditors of different firms would be needed to generalize the importance of these items for audit practices.

Once the auditors are familiar with the scorecard, there is no need to include some background information on the content of the scorecard as it is currently the case. Some modifications can also be made to the format of the different sections to condense the information presented and help the auditors process that information more rapidly.

The interpretation and use of the homeowner scorecard has been left up to the energy auditors. Their experience may have an influence on their ability to effectively utilize the information included in the scorecard when providing feedback to the homeowners. The possibility to train the auditors in coaching techniques and strategies for behavior changes should be considered. It could then be tested if the combination of both the training and the use of the assessment scorecard can improve the likelihood that homeowners will pursue energy efficiency measures.

6.5 Evaluating the Assessment Tool

The development of an assessment tool of homeowners' characteristics is an ongoing process. The success of the tool will depend upon the ability to make adjustments to it in order to improve it. Evaluating the outcomes of the tool is necessary in order to determine the needed improvements.

This evaluation should be made by measuring the short-term and long-term success of energy audits informed by the assessment tool on homeowners' actions. Additionally, the evaluation of the tool should focus on measuring changes in behavioral determinants of homeowners' actions following the audit. This latter measure can increase the understanding of why the use of the assessment tool to assist the auditors in their interaction with the homeowners was successful or not. For example, it may be found that the tool did not have the expected short-term effects on the homeowners because the use of the tool did not help auditors address some of the barriers experienced by the homeowners.

The following paragraphs provide some recommendations for the evaluation of the tool. Indicators of short-term and long-term success of energy audits on homeowners' behaviors and decisions, as well as behavioral determinants of homeowners' actions, are proposed. An instrument to measure these factors has been created. A procedure to implement this instrument and evaluate the outcomes of the tool has also been developed. Due to limitations of data collection processes achievable with the energy auditing firm the researcher worked with, this evaluation could not be conducted.

6.5.1 Process for the Evaluation

A web-based follow-up survey was created for the purpose of evaluating the outcomes of the tool on the success of energy audits. This follow-up survey should be administered to both groups of homeowners who have received an audit after they filled out the intake survey and those who have not participated in the intake survey. The former group of homeowners would form a treatment group. Their answers to the intake survey would be provided to the auditors. The homeowners who did not fill out the intake survey would form a control group. The follow-up survey was designed to measure some behavioral factors influencing the homeowners' decision to pursue energy-saving recommendations and some indicators of short-term success of energy audits on homeowners' actions. Long-term success of energy audits can be measured through the actual uptake of energy efficiency measures.

The evaluation of these factors can be then compared between the control group and the treatment group. This comparison would determine whether the auditors' interaction with the homeowners improved due to the intake survey and the auditors' pre-knowledge of homeowners' information, motivation and skills with regard to the adoption of energy efficiency measures. The audits received by the treatment and control groups should be conducted in parallel and by the same auditors to avoid any time effect or differences due to the experience and skill sets of the energy auditors.

The follow-up survey should be sent to the homeowners at least three weeks after they received the visit of the auditors. This duration can be adjusted. Allocating more time between the audit and the follow-up survey can increase the likelihood that homeowners have determined the energy-saving recommendations they want to pursue and have already taken some steps towards their completion.

6.5.2 Factors Measured for the Evaluation of the Assessment Tool

The information collected by the assessment tool aims to help auditors tailor their recommendations to the homeowners' goals and motives, and address potential barriers for the implementation of these recommendations. Improvements in the auditors' communication can be evaluated by measuring

homeowners' determinants of actions and the outcomes of the audit. The determinants of actions assessed by the follow-up survey are: homeowners' perceived self-efficacy to take energy-saving measures, their satisfaction with the audit, their trust in the auditor and their future intention dealing with recommended energy-saving measures. These factors have been identified through the literature review and discussion with energy auditors as factors influencing the likelihood that the homeowners pursue energy-saving measures on the long-term. The follow-up survey also assesses potential short-term success of the audit through steps the homeowners may have taken towards the implementation of the recommended measures. The variables assessed by the follow-up survey are detailed in table 6-1 below.

Table 6-1: Variables assessed by the follow-up survey

Behavioral factors
Homeowner's perceived self-efficacy to do efficiency improvements to his/her home and adopt energy conservation behaviors: - Ability to make home improvements by oneself or with the help of others - Ability to pay for home improvements - Ability to take the time to do home improvements - Ability to change one's lifestyle to save energy at home
Homeowner's intention to do energy efficiency upgrades and retrofits
Homeowner's satisfaction with the energy audit and increased motivation: - Satisfaction with the feedback received from the energy auditor - Perceived relevance of the auditor communication to personal goals, motives and needs - Perceived benefits of the measures recommended by the energy auditor - Company referral
Homeowner's satisfaction with the energy audit and increased knowledge: - Homeowner spread the word about what he/she learned during the audit
Homeowner's trust in the auditor: - Perceived ability of the auditor - Perceived benevolence of the auditor - Perceived integrity of the auditor
Indicators of short-term success of energy audits
- Homeowner agreed with other members of the household on how to do the efficiency upgrades - Homeowner secured some funds to pay for the upgrades - Homeowner contacted a contractor to do the work or bought some materials to do the work himself/herself - Homeowner scheduled an appointment with a contractor to do the work - Homeowner implemented the upgrades

The comparative assessment of these factors between the treatment group and the control group can help evaluate the impact of the assessment tool on the homeowners' likelihood to follow through the recommendations of the auditors. This evaluation can then be completed by measuring the ratio of homeowners who implemented some of the measures recommended by the energy auditors. This measurement requires a longer timeframe.

The entire follow-up survey, including the introduction and informed consent form, can be found in Appendix H along with the scoring system used to rate participants' responses. The objectives of the question are also detailed in Appendix. The survey was estimated to be 10 minute long. It was kept short to increase the chance that the homeowners would fill it out without any incentive to do it.

6.5.3 Analysis of the Results of the Follow-up Survey

The results of the follow-up survey can be downloaded on the SPSS software. A scoring system was developed to give a quantitative measure of the different assessed factors.

A comparative analysis can be run on the results of the follow-up survey between the treatment group and the control group to measure the outcomes of the audits using the assessment tool on the different factors presented in the previous section. This analysis involves testing significant differences between the means of the results from the treatment group and the control group. This technique is called the analysis of variance (ANOVA). Variances are compared in order to test statistical differences between means. The ANOVA test partitions the total variance into two components: one component is due to within-group variability (individual differences and experimental error) that cannot be readily explained; the other component is due to difference in the means between groups or between-group variability. Means between the treatment and the control groups are significantly different, that is, the effect of the assessment tool is significant, if the variance due to between-group variability is higher than the variance due to within-group variability.

Some of the behavioral factors measured in the follow-up survey, including homeowners' perceived self-efficacy, satisfaction with the energy audit, and trust in the auditor, are measured through several variables. For example, homeowners' trust in the auditor is divided into three elements of trustworthiness: ability, benevolence and integrity (Mayer et al. 1995). In this case, the type of test used to analyze the effect of the assessment tool on the behavioral factors is a multivariate analysis of variance (MANOVA). The MANOVA test allows to assess the effect of one independent variable (here whether the homeowner took the pre-audit survey and his/her results were communicated to the auditor) on several dependent variables theoretically assessing one behavioral factor. The MANOVA allows to examine the effect of the independent variable in the same way as the univariate ANOVA.

This comparative analysis can unearth factors that the use of the assessment tool and the auditors' pre-knowledge of homeowners' information, motivation and skills did not address. Recommendations can then be made to address these issues. For instance, the assessment tool can be modified to provide additional information about the homeowners, or the auditors can be trained to use the information provided in a different way.

6.6 Conclusion

This chapter introduced some guidelines for the integration of the tool in the energy audit process. Issues with the current version of the tool and recommendations for future work were presented. Recommendations were specifically formulated for the design of the tool, its administration, the management of the collected data and their presentation to the auditors. An evaluation plan for the tool was developed. This evaluation should be carried out to guide the revision of the tool and identify other criteria for the tool development.

Chapter 7
Conclusion

7.1 Summary of Work

The main goal of this research was to formalize and integrate the assessment of homeowners' knowledge, motivation, and behavioral skills with regard to the adoption of energy-saving measures in the intake process of energy audits.

The Information, Motivation and Behavioral Skills (IMBS) model of behavioral change was used to understand the predictors of the homeowners' uptake of energy-saving measures and determine the homeowners' characteristics to be assessed. A survey tool was developed to integrate the collection of these characteristics in the process of energy audits. A scoring system and a homeowner scorecard were created to convert the results of the survey into individuals' IMBS profile and present it to the auditors before the home inspection. The survey and the scorecard were tested with customers of an energy auditing firm. Feedback from the energy auditors and the survey participants was collected to evaluate the value of the survey and identify challenges with the survey implementation. The different steps in the research process and a summary of the achievements are presented below.

7.1.1 Development of a Survey Tool to Assess Homeowners' Knowledge, Motivation and Behavioral Skills

A review of the literature on determinants of pro-environmental behaviors, field observations made by the researcher, and interviews with professional auditors helped define the dimensions of the homeowners' profile matching the theoretical components of the IMBS model used as a conceptual framework for this research. These dimensions are:

- Homeowners' beliefs about the extent to which different actions can save energy and their knowledge about measures and behaviors that would be the most useful to save energy in their home.

- Homeowners' objectives and motives for saving energy. Different types of motives are considered, including a) personal motives versus principled motives, and b) a variety of types of norms (personal norms, community standards, and descriptive norms).
- Homeowners' perceived capacity to engage in energy-efficiency actions. These include a) their general skills for changing their behaviors and doing efficiency improvements to their home, and b) behavioral specific skills.

An assessment tool of these characteristics was developed in the form of a web-based survey including thirty-four questions. This survey was designed to be used by energy auditors during the intake process of their customers. The survey was pilot tested as part of its development process with fourteen energy audit customers to collect their immediate feedback and review it accordingly. Inputs from the marketing firm Shelton Group also contributed to revising the tool to make it more user-friendly for the participants and ensure the quality of the information collected.

7.1.2 Development of the Homeowner Assessment Scorecard

A scoring system was developed on SPSS to rate participants' answers to the survey and translate them into qualitative and quantitative data to describe the IMBS profile of the homeowners. A template of a homeowner scorecard was developed to summarize this data and present it to the auditors.

7.1.3 Implementation of the Survey in the Intake Process of an Energy Auditing Firm and Evaluation of the Survey

The survey was then administered during the intake process of the Mark Group audit customers. Participants' answers were scored and summarized into an assessment scorecard using the previously developed template. The assessment scorecard was provided to the auditors prior to their home inspection.

A focus group of the Mark Group auditors was organized at the end of the test period. Feedback was collected from the auditors on the benefits of the assessment tool and the use of the information provided

about the homeowner during the audit process. Additional feedback was collected from two Envinity auditors on the usefulness of the information collected by the assessment tool. Through the process of administering the tool and processing participants' answers, some observations were made by the researcher. These observations require some attention for future iteration of the tool. Feedback was also collected from survey participants through questions included at the end of the survey.

Feedback from the auditors and the survey participants, and observation from the researcher were reported in Chapter 5 of this thesis. Recommendations that integrate the lessons learned from this research were made for the integration of the tool in energy audit practices.

7.2 Key Findings from the Auditors Feedback

The assessment of the homeowners' IMBS profile provides auditors with actionable information they can use for their assessment. More specifically, this information can help the auditors:

- Anticipate and prioritize the scope of the assessment based on the reasons why the homeowners requested an audit
- Determine homeowners' base-line knowledge of measures they can take to save energy at home, their motives to save energy and their skills to do energy efficient improvements to their homes or adopt energy conservation behaviors.
- Target specific measures and behaviors that are more likely to be considered by the homeowners such as measures for which the homeowners reported having plans for, reasons why the homeowners requested an audit, measures the homeowners have already thought about, measures the homeowners are willing and able to do.
- Fine-tune the way they can present their contractor services based on the homeowners' needs, objectives and interests.

Additional benefits of the assessment tool for the auditing business and the homeowners themselves were brought up by the energy auditors. One auditor suggested that a completed survey demonstrated a

strong commitment to the pursuit of energy conservation and energy efficiency measures. By taking the time to fill out the survey and share personal information with the auditors, the homeowners show their interest in energy efficiency and their motivation to work with the auditing firm. It was also suggested that the survey in itself could inspire the homeowners' confidence in the auditors' work by reinforcing the idea that the auditors want to better address their needs, priorities, and preferences. The more the auditors know about their customers, the easier it will be for them to build a trustful relationship with their customers.

The survey was also perceived to be helpful in raising homeowners' curiosity and manage their expectations towards the energy audit. It can give them a concrete idea of the concept of energy efficiency which will prepare them for the audit. Through the process of filling out the survey, the homeowners can assess for themselves their needs, motives and objectives in terms of home energy improvements. Consequently, the homeowners are likely to be more responsive at the time of the audit to a message of the auditors addressing these same needs, motives and objectives.

7.3 Contributions

The intent of this research is to improve the effectiveness of home energy audits and increase the homeowners' implementation percentage of energy-saving recommendations by fostering considerations made for the characteristics of the homeowners in the audit process.

This research contributed to identifying the behavioral factors that should be assessed in homeowners and evaluated the use of an Information, Motivation, and Behavioral Skills framework for organizing this assessment. This research also contributed to the developing a tool and a process to integrate the assessment of these factors during the intake phase of energy audit customers. A homeowner scorecard was also created and tested as a preliminary means to communicate the homeowner profile to auditors.

7.4 Limitations

One of the objectives of the assessment tool is to improve the auditors' interaction with the homeowners. However, the impact of the tool on the homeowners' experience with the auditors was not measured due to limitations of data collection process achievable with the selected auditing firm. The lack of retrofit uptake data for the homeowners who participated in the survey also limited the evaluation of the impact of the tool on the effectiveness of the audit.

Due to the research time frame, the survey was tested on a small number of homeowners. The researcher did not have control over the sampling selection, and consequently the respondent-related variables that served the evaluation of the design of the survey. The assessment tool should be tested with a larger sample of homeowners to reliably assess its design and its impact on homeowners' experience of the audit. The tool should also be tested with a greater number of auditors and in other environments to reliably assess its applicability.

Another limitation comes from the way the focus groups of auditors were conducted. The ideal design for a focus group would have required the assistance of a facilitator other than the researcher to avoid any potential for bias in the feedback of the auditors.

7.5 Recommendations for Future Research

The followings are some options and considerations for future research aimed at improving the assessment tool and its implementation, the process by which the tool is evaluated, and the presentation and the use of the collected homeowner data.

Improvements to the assessment tool and its implementation

- Pilot test the survey again in a "think aloud" format to see where people struggle and get specific feedback on each question. This feedback will help modify the questions of the survey to make them more accessible to a larger audience and improve the quality of the data collected.

- Examine alternative models for the assessment of homeowners' characteristics to increase the response rate. Key information to be assessed prior to the audit can be determined and integrated into the intake call. The value of collecting information about homeowners' knowledge, motivation, and skills at the time of the assessment to inform the auditors' feedback to the homeowners should be determined.

Evaluation of the tool

- Evaluate the impact of the assessment tool and the information provided to the auditor on the homeowners' experience with the energy auditor and success of the audit. This evaluation can be performed through the measurements of homeowners' behavioral determinants of actions (assessed at the end of the audit) and uptake of energy-saving measures (assessed several months after the audit).

Future potential for the presentation and the use of the homeowner data

- Fine-tune the way the homeowner profile is presented to the auditors. More research is necessary to narrow down the information the auditors should know about the homeowners before their visit. Different formats to present that information could also be explored to improve the usability of this information for the auditors.
- Examine the existence of patterns in the collected homeowner data indicating a higher likelihood that the homeowners will pursue energy efficiency measures. This study can contribute to increasing the profitability of the audits for the auditing businesses by helping auditors adjust their time and effort to the potential of success of their interventions.
- Conduct research on the necessity and the effectiveness of training the auditors to use the information collected about the homeowners through the use of behavioral techniques. Study how the factors assessed by the survey interface with the information, resources, motivational tools, and behavioral recommendations by the auditors.

- Conduct research on effective ways to present the results of the survey to the homeowners and evaluate the impact that this could have on homeowners' attitude and behavior with regard to the audit.
- Examine possible connections between a better characterization of the homeowners and more accurate homeowners-dependent inputs into building energy models. The homeowner data collected can inform the behavioral assumptions embedded in energy simulation tools and, as a result, improve the overall accuracy of the energy models.

APPENDIX A
IRB Submission Form

Institutional Review Board (IRB)

The Office for Research Protections

The 330 Building, Suite 205

University Park, PA 16802 | 814-865-1775 | ORProtections@psu.edu

Submitted by: Nathalie Mohr

Date Submitted: November 9, 2011 3:36:18 PM

IRB#: 38207

PI: Nathalie Mohr

Review Type: Exemption

Protocol Subclass: Social Science

Approval Expiration: -pending-

Class Project: No

Study Title

1>Study Title

Pre-Assessment Survey for Home Energy Evaluations

2>Type of eSubmission

New

Home Department for Study

3>Department where research is being conducted or if a student study, the department overseeing this research study.
Architectural Engineering

Review Level

4>What level of review do you expect this research to need? NOTE: The final determination of the review level will be determined by the IRB Administrative Office.
Choose from one of the following:
Exemption

5>Exempt Review Categories:

Choose one or more of the following categories that apply to your research. You may choose more than one category but your research must meet one of the following categories to be considered for expedited review.

[X] Category 2: Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observations of public behavior unless:

Basic Information: Association with Other Studies

6>Is this research study associated with other IRB-approved studies, e.g., this study is an extension study of an ongoing study or this study will use data or tissue from another ongoing study?
No

7>Where will this research study take place? Choose all that apply.

[X] University Park
[X] Other Site(s)

8>Specify the building, and room at University Park where this research study will take place. If not yet known, indicate as such.

310 Sackett Building

You have indicated that the research study location will include an outside laboratory or other non-PSU site(s).

9>List each site and provide contact information [name & address] for each site.

1) Survey data will be collected on the web;

or

2) Faculty housing at
The Kiski School
1888 Brett Lane
Saltsburg, PA 15681

or

3) Menno Haven retirement community
2075 Scotland Avenue
Chambersburg, PA 17201-1499

10>Do any of these sites have an IRB?

No

If you answer "No" to the above question, provide a letter of agreement/permission from an individual in a decision making position indicating their willingness to participate in the research study.

11>Does this research study involve any of the following centers?

[X] None of these centers are involved in this study

12>Describe the facilities available to conduct the research for the duration of the study.

The facilities available to conduct the research for the duration of the study are the Center for Sustainability office in 310 Sackett Building (University Park)

13>Is this study being conducted as part of a class requirement? For additional information regarding the difference between a research study and a class requirement, see IRB Policy I – "Student Class Assignments/Projects" located at http://www.research.psu.edu/policies/research-protections/irb/irb-policy-1.

No

Personnel

14>Personnel List

PSU User ID	Name	Department Affiliation	Role in this study	Added
nim5109	Mohr, Nathalie	Architectural Engineering	Principal Investigator	101620 10/23/2011
jks4	Swim, Janet Kay	Psychology	Advisor	101620 10/23/2011
mgw12	Whelton, Michael G	Architectural Engineering	Advisor	101620 10/23/2011

Mohr, Nathalie (Principal Investigator)

PSU User ID: nim5109	**Phone:** 1 857 204 8459
Email: nim5109@psu.edu	**Alt:**
Email Notifications: Yes	**Pager:**
PSU Person Type: Graduate Student	**Fax:**

Dept: Architectural Engineering

Address 1: 306B DUNHAM HALL

Address 2:

Mail Stop:

City, State, Zip: UNIVERSITY PARK, PA 16802

Procedures: Nathalie Mohr will administer the paper-based version of the survey, collect the results of the survey, analyze the results of the survey, and write the final report for this study.

Experience: Nathalie Mohr has experience in the conduct of research in the field of energy audits. She has already shadowed home energy audits.

Swim, Janet Kay (Advisor)

PSU User ID: jks4	**Phone:** 814 863 1730
Email: jks4@psu.edu	**Alt:**
Email Notifications: Yes	**Pager:**
PSU Person Type: Faculty	**Fax:**

Dept: Psychology

Address 1: 515 Moore Building

Address 2:

Mail Stop:

City, State, Zip: University Park, PA 16802

Procedures: Lead the study

Experience: High level of experience

Dr Swim has already led different research studies at the Pennsylvania State University involving the development and implementation of surveys.

Whelton, Michael G (Advisor)	
PSU User ID: mgw12	**Phone:** 865 3369
Email: mgw12@psu.edu	**Alt:**
Email Notifications: Yes	**Pager:**
PSU Person Type: Research Associate	**Fax:**
Dept: Architectural Engineering	
Address 1: 0104 ENGINEERING UNIT A	
Address 2:	
Mail Stop:	
City, State, Zip: UNIVERSITY PARK, PA 16802	
Procedures: Participating in the constructing of the survey and interpretation of the results.	
Experience: The survey is to improve home audits and Whelton has experience doing home audits.	

Funding Source

15>Is this research study funded? Funding could include the sponsor providing drugs or devices for the study.

Yes

NOTE: If the study is funded or funding is pending, submit a copy of the grant proposal or statement of work for review.

16>Sponsor List

Sponsor Name

National Renewable Energy Laboratory

- **Sponsor Name**

National Renewable Energy Laboratory

Sponsor address or other contact information

1617 Cole Boulevard
Golden, CO 80401-3305
Contact Name: Michael Gestwick

17>Is the funding awarded through a subcontract?

No

18>Is the sponsor providing drug, device, etc, free of charge?

No

19>Does this research study involve prospectively providing treatment or therapy to participants?

No

Conflict of Interest

20>Do any of the investigator(s), key personnel, and/or their spouses or dependent children have a financial or business interest(s) as defined by PSU Policy RA20, "Individual Conflict of Interest," associated with this research? NOTE: There is no de minimus in human participant research studies (i.e., all amount must be reported).

No

Exemption Questions (Prescreening)

21>Does this research study involve prisoners?

No

22>Does this research study involve the use of deception?

No

23>Does this research study involve any FDA regulated drug, biologic or medical device?

No

24>Does this research study involve the use of protected health information covered under the Health Insurance Portability & Accountability Act (HIPAA)?

No

Exemption Questions

25>Maximum number of participants/samples/records to be enrolled.

500

26>Age range – Check all that apply:

[X] 18 – 25 years
[X] 26 – 40 years
[X] 41 – 65 years
[X] 65 + years

27>Describe the steps that will be used to identify and/or contact prospective participants. If applicable, explain how you have access to lists or records of potential participants.

We are working with two auditing firms (Envinity in State College, PA, and Mark Group, in Philadelphia, PA). The prospective participants are customers of these two energy auditing firms. The auditing firms will ask their clients if they are willing to participate in our survey as part of their intake process.

During this recruitment process, the researcher will identify himself/herself as a Penn State researcher, and will inform the participants that the study is being conducted for research purposes.

28>Choose the types of recruitment materials that will be used.

[X] Telephone Script (Verbal)
[X] In-person Script (Verbal)
[X] Email

29>When and where will participants be approached to obtain informed consent/assent? If participants could be non-English speaking, explain how consent/assent will be obtained. If consent/assent will not be obtained, explain why consent/assent will not be obtained.

The participants will be approached to obtain informed consent at the time they take the survey.

During the consent process, the researcher will: identify himself/herself as a Penn State researcher, will inform the participants that the study is being conducted for research purposes, will provide a description of the procedures that the participant will do as part of the study, will state that participation is voluntary, will state participants may end their participation at any time, and that participants may choose to not answer specific questions.

For the web-based survey, the informed consent form will appear at the beginning of the survey. Participants will be asked to read the consent form and give their agreement to take the survey by clicking on a button that will direct them to the questions of the survey. In the case where participants do not agree to take the survey, they will be asked to click on another button that will make them leave the survey.

In person, participants, will be handed the consent form before the survey begins. Their agreement to take the survey will be acknowledgment of consent.

On the phone, the consent form will be read to participants. Their agreement to take the survey will be acknowledgment of consent. Their consent will be documented by reporting their acknowledgment at the bottom of the informed consent form.

The participants will be asked whether they agree on taking a survey twice. If they agree, the same consent form will be used for the second survey.

Participants will be English speaking.

30>Provide the background information and rationale for performing the study.

A challenge for energy reduction in homes is that homeowners do not always follow through on recommendations given to them. The intake process is a place where information about homeowners can be gathered. This information might help tailor auditor feedback to increase the likelihood that homeowners follow recommendations.

31>Summarize the study's key objectives, aims or goals.

This study is aimed at testing a diagnostic tool for energy auditors to assess their customers' characteristics prior to conducting an energy evaluation. This diagnostic tool consists of a questionnaire on homeowners' knowledge about their energy consumption and measures they can take to save energy at home (i.e. information), their motivation and motives to take those measures, and their perceived self-efficacy to take those measures (i.e., behavioral skills). The questionnaire will be implemented and tested for its length, clarity and to make sure that it is well accepted by the homeowners. The purpose of this study is to make sure that the Information, Motivation and Behavioral Skills model of behavior change used as a framework for this diagnostic tool provides a viable way to understand customers. Based on the information collected with this tool, energy auditors will be able to characterize their clients and tailor their approach to meet their clients' values, expectations, needs and objectives, and address potential barriers that impede the implementation of energy efficiency upgrades or conservation behaviors in their clients' home.

32>Describe the major inclusion and exclusion criteria.

Participants must be over 18 and speak English.

33>Summarize the study's procedures by providing a step-by-step process of what participants will be asked to do.

Participants will be first asked verbally or in an email if they agree to take two surveys as part of the energy evaluation they will have scheduled with the energy auditing firm. Participants will be informed that the first survey will occur before the energy evaluation and the second survey will occur after they get feedback from the energy auditor.

If they agree, the link to the first web-based survey will be sent to them a few days before the energy auditor's visit. The email will introduce the survey and its objectives. By clicking on the link, participants will be sent to a page of introduction for the survey followed by the consent form. If the participants agree to take the survey, they will be asked to click on a button that will send them to the survey's questions. If the participants do not agree to take the survey, they will be asked to click on another button that will make them leave the survey. The link to the second web-based survey will be sent a few days after participants receive feedback from energy auditors. The same procedure as for the first survey will allow the participants to agree or decline to take the survey.

For in-person surveys, the participant will be asked verbally if they agree to take a survey as part of the energy evaluation they are about to receive. During the evaluation, the survey will be described, consent obtained, and the homeowner will complete the survey. We will come back a few days after participants receive feedback from energy auditors to administer the second survey

in the same way.

On the phone, the participant will be asked verbally if they agree to take a survey as part of the energy evaluation they will have scheduled with the energy auditing firm. The consent form and survey will then be read to participants and they will provide their responses. We will call participants back a few days after participants receive feedback from energy auditors to administer the survey in the same way.

34>Indicate the type(s) of compensation that will be offered. Choose all that apply.

[X] Compensation will NOT be offered

35>Will any type of recordings (audio, video or digital) or photographs be made during this study?

No

36>Will any data collection for this study be conducted on the Internet or via email (e.g., on-line surveys, blogs or chat room observations, on-line interviews, email surveys)?

Yes

37>Does this study involve any foreseeable risks and/or discomforts to participants – physical, psychological, social, legal or other?

Yes

38>Describe the risks and/or discomforts.

This study does not involve any risk for the participants. It can involve a slight discomfort from answering demographic questions and questions related to personal energy usage habits.

39>Will data be stored securely and accessible only to the research personnel listed on this application?

Yes

40>Describe how data confidentiality will be maintained.

For the web-based and telephone survey, the data confidentiality will be maintained in the following manner:
The survey program we are using (Qualtrics) indicates that they have "SAS 70 certification and meets the rigorous privacy standards imposed on health care records by the Health Insurance Portability and Accountability Act (HIPPA)". All Qualtrics accounts are hidden behind passwords and all data is protected with real-time data replication. Only the select members of the Pennsylvania State University will have access to these data. Those select members are: Dr Janet Swim, professor of psychology; Michael Whelton, research director at the Center for Sustainability; and Nathalie Mohr, graduate student in Architectural Engineering. The data will be stored and secured on a password protected secure server. The data will be reported without the names of the participants attached. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

For the in-person survey, the data confidentiality will be maintained in the following manner: The paper versions of the survey will be kept in a cabinet in a locked room. Only the select members of the Pennsylvania State University will have access to these data. Those select members are: Dr Janet Swim, professor of psychology; Michael Whelton, research director at the Center for Sustainability; and Nathalie Mohr, graduate student in Architectural Engineering. The data will be stored and secured on a password protected secure server. The data will be reported without the names of the participants attached. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Document Upload

CONSENT FORMS

Document 1001 Received 10/19/2011 14:20:01 - Adult Form Implied Informed Consent Form for Web-Based Survey

Document 1002 Received 10/19/2011 14:20:52 - Adult Form Implied Informed Consent Form for Face-to-Face and Phone Survey

CORRESPONDENCE

Document 1001 Received 10/23/2011 12:15:10 - Other Kiski School Letter of Agreement

DATA COLLECTION INSTRUMENTS

Document 1001 Received 10/19/2011 14:43:39 - Supportive document for the survey questions

Document 1002 Received 10/19/2011 14:44:46 - Survey

RECRUITMENT

Document 1001 Received 10/19/2011 14:06:23 - Recruitment Materials Telephone Script

Document 1002 Received 10/19/2011 14:06:56 - Recruitment Materials In-Person Script

Document 1003 Received 10/19/2011 14:07:20 - Recruitment Materials Email

REVIEW - REQUEST INFO

Document 1001 Received 10/26/2011 01:54:28 PM - Returned for Additional Information

Document 1002 Received 11/14/2011 12:42:30 PM - Returned for Additional Information

SUBMISSION FORMS

Document 1001 Received 10/18/2011 05:35:49 PM - Grant Proposal --Task Order

Document 1002 Received 10/18/2011 05:36:23 PM - Grant Proposal --Research Plan - Task Order

Document 1003 Received 11/14/2011 12:33:31 PM - Application Auto-generated by eSubmission Approval

APPENDIX B
Introduction of the Homeowner Survey Tool

The survey started with a short introduction including some information about the purpose of the survey, the expected amount of time the survey took, and the confidentiality of the results. It aimed to motivate individuals to take the survey by emphasizing that their participation would increase the effectiveness and value of the energy audit they would receive.

« We are researchers from the Pennsylvania State University and we are collaborating with the Mark Group on a survey research project. This survey aims to help us understand what you know about energy efficiency, your needs and your goals so as to enhance the quality of energy assessments and recommendations. By taking the time to fill out this survey, you will help us make the intervention of the energy auditor more effective and valuable for you.

Your participation in this survey is voluntary. It will take you about 20 minutes to complete the survey. You must be 18 years or older to participate. You do not have to answer any questions you do not want to answer. We will keep your results confidential and only share them if you agree. Please note that you cannot use your browser's back button when taking the survey. As you proceed through the survey pages, you will not be able to go back to change your answers. Thank you for your participation. »

APPENDIX C
Informed Consent Form for the Homeowner Survey Tool

Implied Informed Consent Form for Social Science Research
The Pennsylvania State University

Title of Project: Pre-Assessment Survey for Home Energy Evaluations

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1. **Purpose of the Study:** The purpose of this research study is to understand what home owners or renters know about energy efficiency, their needs and their goals so as to enhance the quality of home energy evaluations and recommendations.

2. **Procedures to be followed:** After reading the consent form, you will be asked some questions about your objectives in terms of home energy improvements, your knowledge about how energy is used in your home, your knowledge of measures you can take to save energy in your home, your willingness and ability to take those measures. You will also be asked to provide some demographic information. At the end of the survey, you will be asked to provide your name and address so that we can contact you to talk about the results of the present survey. We will share your information with the energy auditor you contacted if you agree to it.

3. **Discomfort and Risks:** There are no risks in participating in this research beyond those experienced in everyday life. Some of the questions are personal and might cause discomfort.

4. **Benefits:** This survey will provide important information on how residential energy evaluations can be improved and how auditors can better help householders save energy. It will improve your personal experience with an evaluation of energy use and energy-saving opportunities in your home.

5. **Duration:** It will take about 20 minutes to complete the survey.

6. **Statement of Confidentiality:** Your participation in this research is confidential. Your confidentiality will be kept to the degree permitted by the technology being used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties. However, the survey program we are using (Qualtrics) indicates that they have "SAS 70 certification and meets the rigorous privacy standards imposed on health care records by the Health Insurance Portability and Accountability Act (HIPPA)". All Qualtrics accounts are hidden behind passwords and all data is protected with real-time data replication. Only the energy auditing firm you contacted and select members of the Pennsylvania State University will know if you participated. The data will be stored and secured on a password protected secure server. The Office of Research Protection and the Social Science Institutional Review Board may review records related to this project. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

7. **Right to Ask Questions:** Please contact Janet Swim at (814) 863 1730 with questions or concerns about this study.

8. **Voluntary Participation:** Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Completion and submission of the survey implies that you have read the information in this form and consent to take part in the research. Please print off this form to keep for your records.

This informed consent form was reviewed and approved by the Institutional Review Board at The Pennsylvania State University on 11/21/2011. It will expire on 10/25/2016.

APPENDIX D
Homeowner Pre-Audit Survey

Below are the questions of the homeowner assessment tool that was administered to people who scheduled an audit. The questions are those of the final version of the survey that was used with the Mark Group customers in spring 2012. The skip patterns that were implemented on Qualtrics are highlighted in blue.

Q1 Which of the following best describes your situation?

- ❍ I requested a free home energy assessment
- ❍ I requested a home energy audit
- ❍ I requested neither a free home energy assessment nor a home energy audit

Answer If Which of the following best describe your situation? I requested a free home energy assessment Is Selected

Q2 What are the reasons for which you requested a home energy assessment?

Answer If Which of the following best describe your situation? I requested a home energy audit Is Selected

Q2 (alternative) What are the reasons for which you requested a home energy audit?

Q3 Do you have any plans or dreams for home improvements for the upcoming year? If so, what are they?

Q4 Below is a list of reasons people give for wanting to save energy in their home. Please indicate the extent to which you agree that these reasons apply to you.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Save money on my utility bills.	❍	❍	❍	❍	❍
Get more control over my personal energy consumption and costs.	❍	❍	❍	❍	❍
Increase the comfort in my home.	❍	❍	❍	❍	❍
Keep-up or improve the condition of my home.	❍	❍	❍	❍	❍
Improve the value of my home.	❍	❍	❍	❍	❍
Do what I can to increase my personal independence from energy companies.	❍	❍	❍	❍	❍
Do my part to help protect the environment.	❍	❍	❍	❍	❍
Do my part to decrease my contribution to climate change/global warming.	❍	❍	❍	❍	❍
Do my part to help make the world	❍	❍	❍	❍	❍

better for future generations.					
Be responsible and not waste.	❍	❍	❍	❍	❍
Do my part to help reduce our country's reliance on foreign fuels.	❍	❍	❍	❍	❍

Q5 To what extent do the following statements describe you (or if applicable, someone else in your household)?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I like making improvements to my home by myself.	❍	❍	❍	❍	❍
I am confident in my ability to make improvements to my home by myself.	❍	❍	❍	❍	❍
I am confident in my ability to find others to make improvements to my home.	❍	❍	❍	❍	❍
I am confident in my ability to pay for improvements to my home.	❍	❍	❍	❍	❍
I am confident in my ability to take the time to do home improvements.	❍	❍	❍	❍	❍
I am confident in my ability to change my lifestyle in such a way that would save energy.	❍	❍	❍	❍	❍

Q6 Please indicate how much money you think can be saved on a typical monthly utility bill by each of the measures noted below. This is not about the savings that would be achieved if the measure was implemented into your home but in general how much can be saved by each measure (Check one percentage for each).

	Nothing	<5%	Between 5 and 9%	Between 10 and 19%	Between 20 and 29%	30% +	Don't know
Turn down thermostat from 72F to 68F in winter, and turn up thermostat from 73F to 78F in summer	❍	❍	❍	❍	❍	❍	❍
Unplug or turn off the power strip for the electronic devices (computer/TV(s)/DVD(s)/VCR(s)/Xbox/Wii) when not in use	❍	❍	❍	❍	❍	❍	❍
Turn down water heater thermostat from 140F to 120F	❍	❍	❍	❍	❍	❍	❍
Change the washer temperature settings from "hot wash, warm rinse" to "cold wash, cold rinse"	❍	❍	❍	❍	❍	❍	❍
Line dry when possible instead of using the clothes dryer	❍	❍	❍	❍	❍	❍	❍
Seal drafts, add weather-stripping around leaky windows and doors, caulk cracks	❍	❍	❍	❍	❍	❍	❍
Insulate an uninsulated or under insulated attic up to R-49, i.e. 16 inches of fiberglass or 15 inches of cellulose (Department Of Energy recommendation for Pennsylvania)	❍	❍	❍	❍	❍	❍	❍
Replace single-pane windows with high-efficiency/ENERGY STAR qualified windows	❍	❍	❍	❍	❍	❍	❍
Replace most incandescent light bulbs with compact fluorescent light bulbs or Light Emitting Diode (LED) bulbs	❍	❍	❍	❍	❍	❍	❍
Replace the heating system with a more efficient one (92% efficient)	❍	❍	❍	❍	❍	❍	❍
Install a higher-efficiency (0.7 energy factor) or tankless water heater	❍	❍	❍	❍	❍	❍	❍
Purchase higher-efficiency/ENERGY STAR qualified appliances (dishwasher, clothes washer, clothes dryer, refrigerator)	❍	❍	❍	❍	❍	❍	❍

Installing aerating low-flow faucets and shower heads	❍	❍	❍	❍	❍	❍	❍
Install a geothermal heat pump to replace a conventional heating system	❍	❍	❍	❍	❍	❍	❍

In the next four sets of questions, we would like you to think about four types of recommendations that are typically made after the energy evaluations of homes. The four types of recommendations are: 1) Safety and protection, 2) Energy conservation, 3) Energy efficiency, 4) Energy generation

For the first set of questions please think about Safety and Protection measures: Measures that ensure that home and equipment operation do not pose any risk to the health and well-being of members of the household. These measures are mostly aimed at addressing indoor air quality issues and fire risks.

Q7 Please list your top three safety and protection measures that you have NOT already done but would be the most useful in your home. You do not need to fill in all the blanks.

Measure 1:

Measure 2:

Measure 3:

Q8 We would like you to answer five questions with reference to safety and protection measures (please drag the bars on the diagram below for each question accordingly):

_____ 1) What is the state of your home now? For instance, is your home not at all safe (0%), completely safe (100%) or somewhere in between?

_____ 2) Compared to others who live around you, how do you think their homes compare to yours with regard to safety? For instance, do you think their homes are not at all safe (0%), completely safe (100%), or somewhere in between?

_____ 3) What state would you ideally like your home to be at? For instance, would you like your home to be 100% safe, or would you be satisfied if it was mostly but not completely safe (e.g., 75%)?

_____ 4) What state do people who are important to you think your home should be at?

_____ 5) If you wanted to improve this aspect of your home, by yourself or with the help of someone else, how easy do you think it would be? For instance, if you thought it would be too difficult, you would say 0%, and if you thought it would be very easy, you would say 100%.

Q9 Please indicate which of the following safety and protection measures you have already taken in your home.

	Implemented	Not implemented	Don't know
Install a Carbon Monoxide detector	❍	❍	❍
Have your water heater, boiler and/or furnace regularly checked by a professional	❍	❍	❍
Check and replace your smoke detector batteries	❍	❍	❍
Control moisture sources in your house, and have a professional checked for moisture issues, if any	❍	❍	❍
Do not operate unvented combustion appliances, such as portable space heater or stove, in a closed living space	❍	❍	❍

For the next set of questions please think about Energy Conservation behaviors: Everyday behaviors homeowners can change to restrict the use of existing energy equipment or use this equipment more effectively.

Q10 Please list your top three everyday conservation behaviors that you have NOT already done or are NOT already doing but would be the most useful to conserve energy. You do not need to fill in all the blanks.

Behavior 1:

Behavior 2:

Behavior 3:

Q11 We would like you to answer five questions with reference to energy conservation behaviors (please drag the bars on the diagram below for each question accordingly):

_____ 1) What is your current energy usage pattern with regard to energy conservation? For instance, do you try to conserve energy as much as you can through your everyday behaviors (100%) or not at all (0%)?

_____ 2) Compared to others who live around you, how do you think their energy usage patterns compare to yours? For instance, do you think they conserve energy much more through their everyday behaviors (100%) or not at all (0%)?

_____ 3) To what extent would you ideally like to conserve energy through your everyday behaviors?

_____ 4) To what extent do people who are important to you think you should conserve energy through your everyday actions?

_____ 5) If you wanted to improve this aspect of your lifestyle, how easy do you think it would be? For instance, if you thought it would be too difficult, you would say 0%, and if you thought it would be very easy, you would say 100%.

Q12 Please indicate which of the following energy conservation behaviors you usually do (occasionally does not count).

	Usually do	Don't do or rarely do	Don't kow
Set thermostat to energy-saving settings (68°F in winter and 78°F in summer)	❍	❍	❍
Unplug or turn off the power strip for the electronic devices (computer/TV(s)/DVD(s)/ VCR(s)/Xbox/Wii) when not in use	❍	❍	❍
Set the water temperature of the water heater to 120F	❍	❍	❍
Change the washer temperature settings from "hot wash, warm rinse" to "cold wash, cold rinse"	❍	❍	❍
Line dry	❍	❍	❍

For the next set of questions please think about Energy Efficiency measures: Home improvements or investments in appliances that would reduce homeowners' energy consumption, or have the potential to create this reduction, if used effectively.

Q13 Please list your top three improvements that you have NOT already done but would be the most useful to improve the energy efficiency of your home. You do not need to fill in all the blanks.

Improvement 1:

Improvement 2:

Improvement 3:

Q14 We would like you to answer five questions with reference to energy efficiency improvements (please drag the bars on the diagram below for each question accordingly):

_____ 1) What is the state of your home now with regard to energy efficiency? For instance, are your home and appliances very energy-efficient (100%), not energy-efficient (0%), or somewhere in between?

_____ 2) Compared to others who live around you, how do you think their homes and appliances compare to yours with regard to energy efficiency? For instance, do you think their homes and appliances are very energy-efficient (100%), not energy-efficient (0%), or somewhere in between?

_____ 3) What state would you ideally like your home to be at with regard to energy efficiency? For example would you like your home to be 100% energy-efficient or would you be satisfied if it was mostly but not completely energy-efficient (e.g., 75%)?

_____ 4) What state do people who are important to you think your home should be at with regard to energy efficiency?

_____ 5) If you wanted to improve this aspect of your home, by yourself or with the help of someone else, how easy do you think it would be? For instance, if you thought it would be very difficult, you would say 0%, and if you thought it would be very easy, you would say 100%.

Q15 Please indicate which of the following energy efficiency measures you have already implemented.

	Implemented	Not implemented	Don't know
Seal drafts, add weather-stripping around windows and doors, caulk cracks	❍	❍	❍
Insulate the attic up to R-49, i.e. 16 inches of fiberglass or 15 inches of cellulose (Department Of Energy recommendation for Pennsylvania)	❍	❍	❍
Replace the windows with high-efficiency/ENERGY STAR qualified windows	❍	❍	❍
Replace most incandescent light bulbs with compact fluorescent light bulbs or Light Emitting Diode (LED) bulbs	❍	❍	❍
Replace the heating system with a more efficient one	❍	❍	❍
Install a higher-efficiency or tankless water	❍	❍	❍

heater			
Purchase some higher-efficiency/ENERGY STAR qualified appliances	❍	❍	❍
Installing aerating low-flow faucets and shower heads	❍	❍	❍

The next questions ask about Energy Generation systems: Systems or products that allow homeowners to produce their own energy to run their home or to purchase energy produced from renewable sources.

Q16 Please list your top one energy generation measure that you have NOT already done but would be the most useful in your home.

Measure 1:

Q17 Renewable energy systems or products allow you to meet your own energy demand with on-site solar or wind systems or by purchasing electricity produced from renewable sources to your utility company. We would like you to answer five questions with reference to renewable energy systems or products (please drag the bars on the diagram below for each question accordingly):

_____ 1) What is the state of your home now with regard to renewable energy systems or products? For instance, does all the energy you use come from renewable sources (100%)? None of it (0%)? Or only a part of it?

_____ 2) Compared to others who live around you, how do you think their homes compare to yours with regard to renewable energy systems and products? For instance, do you think all the energy they use comes from renewable sources (100%), or none of it comes from renewable sources (0%)?

_____ 3) What state would you ideally like your home to be at with regard to renewable energy systems and products?

_____ 4) What state do people who are important to you think your home should be at with regard to renewable energy systems and products?

_____ 5) If you wanted to improve this aspect of your home, by yourself or with the help of someone else, how easy do you think it would be? For instance, if you thought it would be too difficult, you would say 0%, and if you thought it would be very easy, you would say 100%.

Q18 Please indicate which of the following energy generation measures you have already implemented.

	Implemented	Not implemented	Don't know
Install a solar array	❍	❍	❍
Install a solar hot water system	❍	❍	❍
Install a geothermal heat pump	❍	❍	❍
Pay a premium on my utility bill to purchase electricity produced through renewable sources such as solar or wind	❍	❍	❍

Q19 Energy monitoring systems are devices that can visualize, manage and/or monitor the household's energy use of certain products or of the whole house. We would like you to answer three questions about energy monitoring systems.

	Yes	No
1) Do you have an energy monitoring system?	❍	❍
2) Would you like to have an energy monitoring system?	❍	❍
3) If you wanted to have an energy monitoring system, would you know how to get one?	❍	❍

Q20 What is your gender? If more than one respondent, check all that apply.

❍ Male
❍ Female

Q21 Do you own or rent your home?

❍ Own
❍ Rent
❍ Do not own, live rent-free

Q22 How long have you lived in your current home?

Years

Q23 Do you anticipate moving out of your current residence in the near future?

- ❍ Yes, within a year
- ❍ Yes, within three years
- ❍ No
- ❍ Not applicable, I don't own my home.

Q24 How many people in each of the following age categories live six months or more per year in your household?

0 to 5 years old
6 to 13 years old
14 to 24 years old
25 to 64 years old
65+ years old

Q25 What is the highest level of school you have completed or the highest degree you have received?

- ❍ Less than high school degree
- ❍ High school degree
- ❍ Some college but no degree
- ❍ Associate degree
- ❍ Bachelor degree
- ❍ Graduate degree

Q26 The information in this survey could improve the feedback you receive from the energy auditors. May we share your information with the energy auditors?

- ❍ Yes
- ❍ No

Q27 Combining the results of this survey with the information gathered by the energy auditors during the inspection of your house could improve the feedback you receive from them. May the energy auditors share their information about your house with us?

- ❍ Yes
- ❍ No

Q28 May we contact you to talk about the results of the present survey?

- ❍ Yes
- ❍ No

Q29 If you said yes to any of the three previous questions, please provide us with your name and address. This information will not be used for any other purposes.

Name
Address
Address 2
City
State
Zip Code
Country

Q30 We would appreciate your feedback on the survey you just filled out. Do you have any comment about the survey?

Q31 Did you feel comfortable answering this survey?

- Yes
- Somewhat
- No

Q32 Did you meet some difficulties with filling out this survey?

- No difficulty
- Some difficulties
- Many difficulties

Q33 How would you judge the length of the survey?

- Too long
- About right
- Too short

Q34 How would you judge the overall clarity of the questions of the survey?

- Clear
- Somewhat clear
- Not Clear

APPENDIX E
Homeowner Pre-Audit Survey Scoring System

Q1 Which of the following best describes your situation?

- ❍ *I requested a free home energy assessment*
- ❍ *I requested a home energy audit*
- ❍ *I requested neither a free home energy assessment nor a home energy audit*

Scoring: Type of home energy evaluation requested by the homeowner.

This question provides some qualitative information that was directly reported in the homeowner assessment scorecard.

Q2 What are the reasons for which you requested a home energy assessment?

Q2 (alternative) What are the reasons for which you requested a home energy audit?

Scoring: Reasons why the homeowner requested a home energy evaluation.

Both questions provide some qualitative information that was directly reported in the homeowner assessment scorecard.

Q3 Do you have any plans or dreams for home improvements for the upcoming year? If so, what are they?

Scoring: Piggybacking opportunities.

This question provides some qualitative information that was directly reported in the homeowner assessment scorecard.

Q4 Below is a list of reasons people give for wanting to save energy in their home. Please indicate the extent to which you agree that these reasons apply to you.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Save money on my utility bills.	❍	❍	❍	❍	❍
Get more control over my personal energy consumption and costs.	❍	❍	❍	❍	❍
Increase the comfort in my home.	❍	❍	❍	❍	❍
Keep-up or improve the condition of my home.	❍	❍	❍	❍	❍
Improve the value of my home.	❍	❍	❍	❍	❍
Do what I can to increase my personal independence from energy companies.	❍	❍	❍	❍	❍
Do my part to help protect the environment.	❍	❍	❍	❍	❍
Do my part to decrease my contribution to climate change/global warming.	❍	❍	❍	❍	❍
Do my part to help make the world better for future generations.	❍	❍	❍	❍	❍
Be responsible and not waste.	❍	❍	❍	❍	❍
Do my part to help reduce our country's reliance on foreign fuels.	❍	❍	❍	❍	❍

Scoring: General motivation of the homeowner to save energy at home.

The personal motives (items 1 to 6) are scored the following way:

0: Strongly disagree, 2.5: Disagree, 5: Neither, 7.5: Agree, 10: Strongly agree. The score of each item ranges from 0: little personal motive to save energy (strongly disagree) to 10: high personal motives to save energy (strongly agree). The six items are averaged together to obtain a total score of homeowner's personal motives ranging from 0 to 10.

The principled motives (items 7 to 11) are scored the following way:

0: Strongly disagree, 2.5: Disagree, 5: Neither, 7.5: Agree, 10: Strongly agree. The score of each item ranges from 0: little principled motive to save energy (strongly disagree) to 10: high principled motives to save energy (strongly agree). The six items are averaged together to obtain a total score of homeowner's principled motives ranging from 0 to 10.

The score for personal motives and the score for principled motives are then averaged together to calculate the total score of the participant's motivation. This score ranges from 0 to 10.

Q5 To what extent do the following statements describe you (or if applicable, someone else in your household)?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I like making improvements to my home by myself.	❍	❍	❍	❍	❍
I am confident in my ability to make improvements to my home by myself.	❍	❍	❍	❍	❍
I am confident in my ability to find others to make improvements to my home.	❍	❍	❍	❍	❍
I am confident in my ability to pay for improvements to my home.	❍	❍	❍	❍	❍
I am confident in my ability to take the time to do home improvements.	❍	❍	❍	❍	❍
I am confident in my ability to change my lifestyle in such a way that would save energy.	❍	❍	❍	❍	❍

Scoring: Homeowner's perceived self-efficacy to do home efficiency improvements and adopt energy conservation behaviors.

The participant's perceived self-efficacy to do energy conservation behaviors and efficiency home improvements is scored the following way:

0: Strongly disagree, 2.5: Disagree, 5: Neither, 7.5: Agree, 10: Strongly agree. The score of each item ranges from 0: perceived low self-efficacy (strongly disagree) to 10: perceived high self-efficacy (strongly agree). The six items are averaged together to get the homeowner total score for general behavioral skills which ranges from 0 to 10.

Q6 Please indicate how much money you think can be saved on a typical monthly utility bill by each of the measures noted below. This is not about the savings that would be achieved if the measure was implemented into your home but in general how much can be saved by each measure (Check one percentage for each).

	Nothing	<5%	Between 5 and 9%	Between 10 and 19%	Between 20 and 29%	30% +	Don't know
Turn down thermostat from 72F to 68F in winter, and turn up thermostat from 73F to 78F in summer	❍	❍	❍	❍	❍	❍	❍
Unplug or turn off the power strip for the electronic devices (computer/TV(s)/DVD(s)/VCR(s)/Xbox/Wii) when not in use	❍	❍	❍	❍	❍	❍	❍
Turn down water heater thermostat from 140F to 120F	❍	❍	❍	❍	❍	❍	❍
Change the washer temperature settings from "hot wash, warm rinse" to "cold wash, cold rinse"	❍	❍	❍	❍	❍	❍	❍
Line dry when possible instead of using the clothes dryer	❍	❍	❍	❍	❍	❍	❍
Seal drafts, add weather-stripping around leaky windows and doors, caulk cracks	❍	❍	❍	❍	❍	❍	❍
Insulate an uninsulated or under insulated attic up to R-49, i.e. 16 inches of fiberglass or 15 inches of cellulose (Department Of Energy recommendation for Pennsylvania)	❍	❍	❍	❍	❍	❍	❍
Replace single-pane windows with high-efficiency/ENERGY STAR qualified windows	❍	❍	❍	❍	❍	❍	❍
Replace most incandescent light bulbs with compact fluorescent light bulbs or Light Emitting Diode (LED) bulbs	❍	❍	❍	❍	❍	❍	❍
Replace the heating system with a more efficient one (92% efficient)	❍	❍	❍	❍	❍	❍	❍
Install a higher-efficiency (0.7 energy factor) or tankless water heater	❍	❍	❍	❍	❍	❍	❍
Purchase higher-efficiency/ENERGY STAR qualified appliances (dishwasher, clothes washer, clothes dryer, refrigerator)	❍	❍	❍	❍	❍	❍	❍

Installing aerating low-flow faucets and shower heads	❍	❍	❍	❍	❍	❍	❍
Install a geothermal heat pump to replace a conventional heating system	❍	❍	❍	❍	❍	❍	❍

Scoring: Knowledge about the impact of energy-saving measures on households' energy consumption.

The table below shows the actual answers for each measure and behavior.

Measures/Behaviors	Nothing	< 5%	Between 5 and 9%	Between 10 and 19%	Between 20 and 29%	30% +	Don't know
Turn down thermostat from 72F to 68F in winter, and turn up thermostat from 73F to 78F in summer		X					
Unplug or turn off the power strip for the electronic devices (computer/ TV(s)/ DVD(s)/VCR(s)/Xbox/Wii) when not in use		X					
Turn down water heater thermostat from 140F to 120F		X					
Change the washer temperature settings from "hot wash, warm rinse" to "cold wash, cold rinse"		X					
Line dry when possible instead of using the clothes dryer		X					
Seal drafts, add weather-stripping around leaky windows and doors, caulk cracks				X			
Insulate an uninsulated or under insulated attic up to R-49, i.e. 16 inches of fiberglass or 15 inches of cellulose (Department Of Energy recommendation for Pennsylvania)				X			
Replace single-pane windows with high-efficiency/ENERGY STAR qualified windows				X			
Replace most incandescent light bulbs with compact fluorescent light bulbs or Light Emitting Diode (LED) bulbs			X				

Replace heating system with a more efficient one (92% efficient)				X			
Install a higher-efficiency (0.7 energy factor) or tankless water heater		X					
Purchase higher-efficiency/ENERGY STAR qualified appliances (dishwasher, clothes washer, clothes dryer, refrigerator)			X				
Installing aerating low-flow faucets and shower heads		X					
Install a geothermal heat pump to replace conventional heating system						X	

Energy conservation behaviors (items 1 to 5) save less than 5% on a typical utility bill. Energy efficiency measures (items 6 to 13) save between 5% and 19% on a typical utility bill. Energy generation measures (item 17) save more than 30% on a typical utility bill.

Participants' responses are compared with the actual responses. For example, "seal drafts, add weather-stripping around windows and doors, caulk cracks" can save "between 10% and 19% on utility bills". If participants say "seal drafts, add weather-stripping around windows and doors, caulk cracks" can save "between 10% and 19% on utility bills", they get a score of 0. If they say "between 5 and 9%", they get a score of -1 for an underestimate. If they say "less than 5%", they get a score of -2. If they say "nothing", they get a score of -3. If they say "between 20% and 29%", they get a score of +1 for an overestimate. If they say "more than 30%", they get a score of +2. The same scoring system is applied to the other measures and behaviors, using negative numbers for underestimates and positive numbers for overestimates.

The measures are grouped together based on the actual percentage of energy they save and the absolute value of their score is averaged per group. They are therefore 4 groups of measures: measures saving less than 5% for which the average score ranges between 0 and 4; measures saving between 5 and 9% for which the average score ranges between 0 and 3, measures saving between 10 and 19% for which

the average score ranges between 0 and 3, and measures saving more than 30% for which the average score ranges between 0 and 5; there is no measure that save between 20 and 29% and there is no measure that does not save anything. Then the sum of the averages of the absolute values computed for each group of measures is calculated. This total sum ranges from 0: most accurate to 15: most inaccurate.

To obtain a final score ranging from 0: most inaccurate to 10: most accurate, the final score is computed as: (15 – total sum) x 10/15. This score measures people's accuracy in their estimate of the energy they can save through different measures. It is important to notice that the participants' score to this question, which is used as a measure of the knowledge, does not only depend on whether they chose the right answer or a wrong answer, but also on the extent to which they deviated from the right answer in their response.

Behaviors can also be grouped by types: conservation, efficiency, generation. Then the number of behaviors having a negative score and the number of behaviors having a positive score are calculated for each behavior type to measure if people tend to overestimate or underestimate the savings they can do.

Q7 Please list your top three safety and protection measures that you have NOT already done but would be the most useful in your home. You do not need to fill in all the blanks.

Measure 1:
Measure 2:
Measure 3:

Scoring: Safety measures considered by the homeowner as useful for his/her home.

This question provides some qualitative information that was directly reported in the homeowner assessment scorecard as measures considered by the homeowner.

Q8 We would like you to answer five questions with reference to safety and protection measures (please drag the bars on the diagram below for each question accordingly):

_____ 1) What is the state of your home now? For instance, is your home not at all safe (0%), completely safe (100%) or somewhere in between?

_____ 2) Compared to others who live around you, how do you think their homes compare to yours with regard to safety? For instance, do you think their homes are not at all safe (0%), completely safe (100%), or somewhere in between?

_____ 3) What state would you ideally like your home to be at? For instance, would you like your home to be 100% safe, or would you be satisfied if it was mostly but not completely safe (e.g., 75%)?

_____ 4) What state do people who are important to you think your home should be at?

_____ 5) If you wanted to improve this aspect of your home, by yourself or with the help of someone else, how easy do you think it would be? For instance, if you thought it would be too difficult, you would say 0%, and if you thought it would be very easy, you would say 100%.

Scoring: Influence of personal norms, descriptive norms, and injunctive norms on the homeowner's commitment to take safety and protection measures.

- Question 8, items 1 and 2 evaluate the discrepancy between the homeowner's perception of the actual state of his/her home and others' homes as a measure of the influence of descriptive norms on homeowners' motivation to take safety and protection measures.

  "State of my current home" for safety measures ranges from 0: 0% to 10: 100% (1)

  "State of others' homes" for safety measures ranges from 0: 0% 10: 100% (2)

  The discrepancy between the actual state and the comparison group ((2) – (1)) ranges from -10 to 10 where a negative number means that individuals perceive others' homes as worse than their own homes and a positive number means that individuals perceive others' homes as better than their own homes. The higher the positive number is, the higher the influence of descriptive norms.

- Question 8, items 1 and 3 evaluate the discrepancy between the homeowner's perception of the actual state of his/her home and the ideal state of his/her home. This discrepancy represents the homeowner's personal goal to improve the state of his/her home with regard to safety and protection to increase his/her own satisfaction.

  "State of my current home" for safety measures ranges from 0: 0% to 10: 100% (1)

  "The state I would like my home to be at" for safety measures ranges from 0: 0% to 10: 100% (3)

  The discrepancy between the actual state and the ideal state ((3) – (1)) ranges from -10 to 10 where a negative number means that individuals are satisfied with their home (the current state of their house exceeds their "ideal") and a positive number means that individuals are not satisfied with their home (the current state of their house is worse than their "ideal"). The higher the positive number is, the higher the individual's dissatisfaction is and the more likely the individual will be to carry out safety measures.

- Question 8, items 1 and 4 evaluate the discrepancy between the homeowner's perception of the actual state of his/her home and standards of what others think one should do as a measure of the influence of injunctive norms on homeowners' motivation to take safety and protection measures.

  "State of my current home" for safety measures ranges from 0: 0% to 10: 100% (1)

  "The state people important to me tell me my house should be at" for safety measures ranges from 0: 0% to 10: 100% (4)

  The discrepancy between the actual state and the standards of what others think one should do ((4) – (1)) ranges from -10 to 10 where a negative number means that individuals perceive that their home is better than what is ought to be and a positive number means that individuals perceive that their home is worse than what it is ought to be. The higher the positive number is, the higher the influence of injunctive norms.

Each type of discrepancy (Others-Actual, Ideal-Actual, Ought-Actual) is then scored on a scale from -5 to 5 by computing:

Others-Actual / 2, with -5: little influence of descriptive norms, 5: high influence of descriptive norms

Ideal-Actual / 2, with -5: little dissatisfaction, 5: high dissatisfaction

Ought-Actual / 2, with -5: little influence of injunctive norms, 5: high influence of injunctive norms

The three scores are then averaged to obtain a total score for the motivation to do safety and protection measures.

Scoring: Perceived self-efficacy to do safety and protection measures.

Question 8, item 5 measures homeowners' perceived ability to do each of the four types of behaviors. The score ranges from 0 = 0%: very difficult to 10 = 100%: completely able.

Q9 Please indicate which of the following safety and protection measures you have already taken in your home.

	Implemented	Not implemented	Don't know
Install a Carbon Monoxide detector	❍	❍	❍
Have your water heater, boiler and/or furnace regularly checked by a professional	❍	❍	❍
Check and replace your smoke detector batteries	❍	❍	❍
Control moisture sources in your house, and have a professional checked for moisture issues, if any	❍	❍	❍
Do not operate unvented combustion appliances, such as portable space heater or stove, in a closed living space	❍	❍	❍

Scoring: Proportion of safety and protection measures already implemented.

Each item is rated: 20%: implemented, 0%: not implemented, 0%: don't know. The scores of all the items are added up together. The total score ranges from 0%: no safety measures implemented, to 100%: 5 safety measures already implemented.

Q10 Please list your top three everyday conservation behaviors that you have NOT already done or are NOT already doing but would be the most useful to conserve energy. You do not need to fill in all the blanks.

Behavior 1:
Behavior 2:
Behavior 3:

Scoring: Energy conservation behaviors considered by the homeowner as useful for his/her home.

This question provides some qualitative information that was directly reported in the homeowner assessment scorecard as behaviors considered by the homeowner.

Q11 We would like you to answer five questions with reference to energy conservation behaviors (please drag the bars on the diagram below for each question accordingly):

_____ 1) What is your current energy usage pattern with regard to energy conservation? For instance, do you try to conserve energy as much as you can through your everyday behaviors (100%) or not at all (0%)?

_____ 2) Compared to others who live around you, how do you think their energy usage patterns compare to yours? For instance, do you think they conserve energy much more through their everyday behaviors (100%) or not at all (0%)?

_____ 3) To what extent would you ideally like to conserve energy through your everyday behaviors?

_____ 4) To what extent do people who are important to you think you should conserve energy through your everyday actions?

_____ 5) If you wanted to improve this aspect of your lifestyle, how easy do you think it would be? For instance, if you thought it would be too difficult, you would say 0%, and if you thought it would be very easy, you would say 100%.

Scoring: Influence of personal norms, descriptive norms, and injunctive norms on the homeowner's commitment to adopt energy conservation behaviors.

This question is scored in the same manner as the equivalent question for safety and protection measures.

Scoring: Perceived self-efficacy to adopt energy conservation behaviors.

This question is scored in the same manner as the equivalent question for safety and protection measures.

Q12 Please indicate which of the following energy conservation behaviors you usually do (occasionally does not count).

	Usually do	Don't do or rarely do	Don't know
Set thermostat to energy-saving settings (68°F in winter and 78°F in summer)	❍	❍	❍
Unplug or turn off the power strip for the electronic devices (computer/TV(s)/DVD(s)/ VCR(s)/Xbox/Wii) when not in use	❍	❍	❍
Set the water temperature of the water heater to 120F	❍	❍	❍
Change the washer temperature settings from "hot wash, warm rinse" to "cold wash, cold rinse"	❍	❍	❍
Line dry	❍	❍	❍

Scoring: Proportion of energy conservation behaviors already done

Each item is rated: 20%: done, 0%: don't do or rarely do, 0%: don't know. The scores of all the items are added up together. The total score ranges from 0%: no energy conservation behaviors done, to 100%: 5 energy conservation behaviors done.

Q13 Please list your top three improvements that you have NOT already done but would be the most useful to improve the energy efficiency of your home. You do not need to fill in all the blanks.

Improvement 1:
Improvement 2:
Improvement 3:

Scoring: Energy efficiency measures considered by the homeowner as useful for his/her home.

This question provides some qualitative information that was directly reported in the homeowner assessment scorecard as measures considered by the homeowner.

Q14 We would like you to answer five questions with reference to energy efficiency improvements (please drag the bars on the diagram below for each question accordingly):

_____ 1) What is the state of your home now with regard to energy efficiency? For instance, are your home and appliances very energy-efficient (100%), not energy-efficient (0%), or somewhere in between?

_____ 2) Compared to others who live around you, how do you think their homes and appliances compare to yours with regard to energy efficiency? For instance, do you think their homes and appliances are very energy-efficient (100%), not energy-efficient (0%), or somewhere in between?

_____ 3) What state would you ideally like your home to be at with regard to energy efficiency? For example would you like your home to be 100% energy-efficient or would you be satisfied if it was mostly but not completely energy-efficient (e.g., 75%)?

_____ 4) What state do people who are important to you think your home should be at with regard to energy efficiency?

_____ 5) If you wanted to improve this aspect of your home, by yourself or with the help of someone else, how easy do you think it would be? For instance, if you thought it would be very difficult, you would say 0%, and if you thought it would be very easy, you would say 100%.

Scoring: Influence of personal norms, descriptive norms, and injunctive norms on the homeowner's commitment to do energy efficiency improvements to his/her home.

This question is scored in the same manner as the equivalent question for safety and protection measures.

Scoring: Perceived self-efficacy to do energy efficiency improvements.

This question is scored in the same manner as the equivalent question for safety and protection measures.

Q15 Please indicate which of the following energy efficiency measures you have already implemented.

	Implemented	Not implemented	Don't know
Seal drafts, add weather-stripping around windows and doors, caulk cracks	❍	❍	❍
Insulate the attic up to R-49, i.e. 16 inches of fiberglass or 15 inches of cellulose (Department Of Energy recommendation for Pennsylvania)	❍	❍	❍
Replace the windows with high-efficiency/ENERGY STAR qualified windows	❍	❍	❍
Replace most incandescent light bulbs with compact fluorescent light bulbs or Light Emitting Diode (LED) bulbs	❍	❍	❍
Replace the heating system with a more efficient one	❍	❍	❍
Install a higher-efficiency or tankless water heater	❍	❍	❍
Purchase some higher-efficiency/ENERGY STAR qualified appliances	❍	❍	❍
Installing aerating low-flow faucets and shower heads	❍	❍	❍

Scoring: Proportion of energy efficiency measures already implemented.

Each item is rated: 12.5%: implemented, 0%: not implemented, 0%: don’t know. The scores of all the items are added up together. The total score ranges from 0%: no energy efficiency measures implemented, to 100%: 8 energy efficiency measures already implemented.

Q16 Please list your top one energy generation measure that you have NOT already done but would be the most useful in your home.

Measure 1:

Scoring: Energy generation measures considered by the homeowner as useful for his/her home.

This question provides some qualitative information that was directly reported in the homeowner assessment scorecard as measures considered by the homeowner.

Q17 Renewable energy systems or products allow you to meet your own energy demand with on-site solar or wind systems or by purchasing electricity produced from renewable sources to your utility company. We would like you to answer five questions with reference to renewable energy systems or products (please drag the bars on the diagram below for each question accordingly):

_____ 1) What is the state of your home now with regard to renewable energy systems or products? For instance, does all the energy you use come from renewable sources (100%)? None of it (0%)? Or only a part of it?

_____ 2) Compared to others who live around you, how do you think their homes compare to yours with regard to renewable energy systems and products? For instance, do you think all the energy they use comes from renewable sources (100%), or none of it comes from renewable sources (0%)?

_____ 3) What state would you ideally like your home to be at with regard to renewable energy systems and products?

_____ 4) What state do people who are important to you think your home should be at with regard to renewable energy systems and products?

_____ 5) If you wanted to improve this aspect of your home, by yourself or with the help of someone else, how easy do you think it would be? For instance, if you thought it would be too difficult, you would say 0%, and if you thought it would be very easy, you would say 100%.

Scoring: Influence of personal norms, descriptive norms, and injunctive norms on the homeowner's commitment to take energy generation measures.

This question is scored in the same manner as the equivalent question for safety and protection measures.

Scoring: Perceived self-efficacy to take energy generation measures.

This question is scored in the same manner as the equivalent question for safety and protection measures.

Q18 Please indicate which of the following energy generation measures you have already implemented.

	Implemented	Not implemented	Don't know
Install a solar array	❍	❍	❍
Install a solar hot water system	❍	❍	❍
Install a geothermal heat pump	❍	❍	❍
Pay a premium on my utility bill to purchase electricity produced through renewable sources such as solar or wind	❍	❍	❍

Scoring: Proportion of energy generation measures already implemented.

For each item, score 25%: implemented, 0%: not implemented, 0%: don’t know. The scores of all the items are added up together. The total score ranges from 0%: no energy generation measures implemented, to 100%: 4 energy generation measures already implemented.

Q19 Energy monitoring systems are devices that can visualize, manage and/or monitor the household's energy use of certain products or of the whole house. We would like you to answer three questions about energy monitoring systems.

	Yes	No
1) Do you have an energy monitoring system?	❍	❍
2) Would you like to have an energy monitoring system?	❍	❍
3) If you wanted to have an energy monitoring system, would you know how to get one?	❍	❍

Scoring: Proportion of energy monitoring measures already implemented.

Item 1 is rated Yes: 100%, No: 0%.

Scoring: Homeowner's motivation and perceived self-efficacy to install an energy monitoring system.

Items 2 and 3 provide some qualitative information that was directly reported in the homeowner assessment scorecard.

Questions 20 to 29 scoring:

These questions provide some demographic information that was directly reported in the homeowner assessment scorecard. The consent of the homeowner to share his/her answers to the survey with the auditors was also reported.

Questions 30 to 34: These questions were not scored for the purpose of the homeowner assessment scorecard. They were analyzed to evaluate the design of the survey in terms of length, clarity and intrusion upon the homeowners. This analysis is described in Chapter 5.

APPENDIX F
References for the Estimation of the Percentage of Energy Saved on Typical Energy Bills from Specific Energy Conservation Measures

Measures	Percentage of energy saved	Comments/Calculations	Sources
Set thermostat to energy-saving settings (68F in winter and 78F in summer)	< 5% (3.4%)		Gardner and Stern, 2008
Unplug or turn off the power strip for the computer/TV(s)/DVD(s)/VCR(s)/Xbox/Wii when not in use	< 5% (1 to 2%)		http://www.consumerenergycenter.org/tips/summer.html
Lower the water temperature of the water heater to 120F	< 5% (0.7%)		Gardner and Stern, 2008
Change the washer temperature settings from "hot wash, warm rinse" to "cold wash, cold rinse"	< 5% (1.2 to 4%)		Gardner and Stern, 2008 http://www.consumerenergycenter.org/tips/summer.html
Line dry when possible instead of using the clothes dryer	< 5% (1.1 to 5%)		Gardner and Stern, 2008 http://www.consumerenergycenter.org/tips/summer.html
Air sealing	10%	"EPA estimates that homeowners can typically save up to 20% of heating and cooling costs (or up to 10% of total energy costs) by air sealing their homes and adding insulation in attics, floors over crawl spaces, and accessible basement rim joists. This estimate is based on energy modeling (using REM/Rate version 11.0) of cost-effective improvements made to 'typical' existing U.S. homes with a weighted composite of characteristics. The modeled results are corroborated by the field experience of professional building science contractors who have done air sealing and insulation work for more than 20 years." (Source: http://www.energystar.gov)	http://www.psnh.com/SaveEnergyMoney/For-Home/Heating-and-Cooling-Tips.aspx www.energystar.gov

Insulate the attic up to R-49	10%		www.energystar.gov
Install high-efficiency/ENERGY STAR qualified windows	15%		www.energystar.gov
Replace most incandescent light bulbs with CFL or LED	Between 5 and 9%	Lighting accounts for 11% of a typical energy bill (source: 2007 Buildings Energy Data Book, Table 4.2.1, 2005 energy cost data, cited in the DOE Energy Saver Booklet). CFL light bulbs use about 75% less energy than incandescent light bulb. So the percentage of savings on the utility bill generated by replacing incandescent light bulbs with fluorescent ones is: 11% - 11% x 25% = 8.25%	
Replace HVAC equipment with more energy efficient ones	Between 10 and 19% (11%)		www.energystar.gov http://www.consumerenergycenter.org/tips/summer.html
Install a higher-efficiency or tankless water heater	< 5%	Natural gas on-demand or tankless water heater can save up to 30% compared with a standard natural gas storage tank water heater (source: Energy Saver Booklet). Water heating accounts for 12% of total home energy use (source: 2007 Buildings Energy Data Book, Table 4.2.1, 2005 energy cost data, cited in the DOE Energy Saver Booklet). Therefore the percentage of energy saved on the energy bill by installing a tankless water heater is: 12% x 30% = 3.6% Heat pump water heaters reduce water heating costs from 30-50% (average 40%) (source: http://www.psnh.com/SaveEnergyMoney/For-Home/Water-Heating-Tips.aspx . The source for this website is the DOE website). Therefore on the total energy bill, the percentage of energy saved is: 12% x 40% = 4.8%	
Purchase higher-efficiency/ENERGY STAR qualified appliances	Between 5 and 9%	A new refrigerator with an ENERGY STAR label uses at least 20% less energy than required by current federal standards and 40% less energy than the conventional	

(dishwasher, clothes washer, refrigerator)		models sold in 2001 (source: DOE http://www.energysavers.gov/tips/refrigerators.cfm). A new dishwasher with an ENERGY STAR label uses less water and 41% less energy than required by federal standards (source: DOE http://www.energysavers.gov/tips/dishwashers.cfm). ENERGY STAR clothes washers clean clothes using 50% less energy than standard washers (source: DOE http://www.energysavers.gov/tips/laundry.cfm). Appliances account for about 17% of the household's energy consumption, with refrigerators, clothes washers, and clothes dryers at the top of the consumption list (source: DOE http://www.energysavers.gov/tips/appliances.cfm). By replacing the refrigerator, the dishwasher and the clothes washer with ENERGY STAR appliances, one can reasonably expect to save 40% on the energy used by the appliances, that is, on total energy use: 17% x 40% = 6.8%	
Install a geothermal heat pump	30% +		DOE Home Energy Saver http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12670

APPENDIX G
Exemplar of Homeowner Assessment Scorecard

Below is an exemplar of the homeowner assessment scorecard. This exemplar does not correspond to a participant's response.

HOMEOWNER SCORECARD

DEMOGRAPHICS

This section gives you an idea of the person you are likely to talk to during the home assessment. It also provides you with some information about the composition of the household, the status of the residents (owner, renter) and the time they anticipate staying in their current residence.

Your customer: Mr. XXX	Male Has a bachelor degree Owner of the house Has lived there for 3 years Does not anticipate moving out in the near future
Home occupants (live six months or more per year in this home):	2 occupants between 25 and 64 years old 2 occupants between 0 and 5 years old

MEASURES TO TARGET

This section gives some information about the objectives, issues and/or home improvements that motivated the homeowner to request an audit. It also includes possible piggybacking opportunities, that is, home improvement plans or dreams the homeowner has which may represent an opportunity to perform energy efficiency retrofits.

The homeowner requested a home energy assessment for the following reasons:

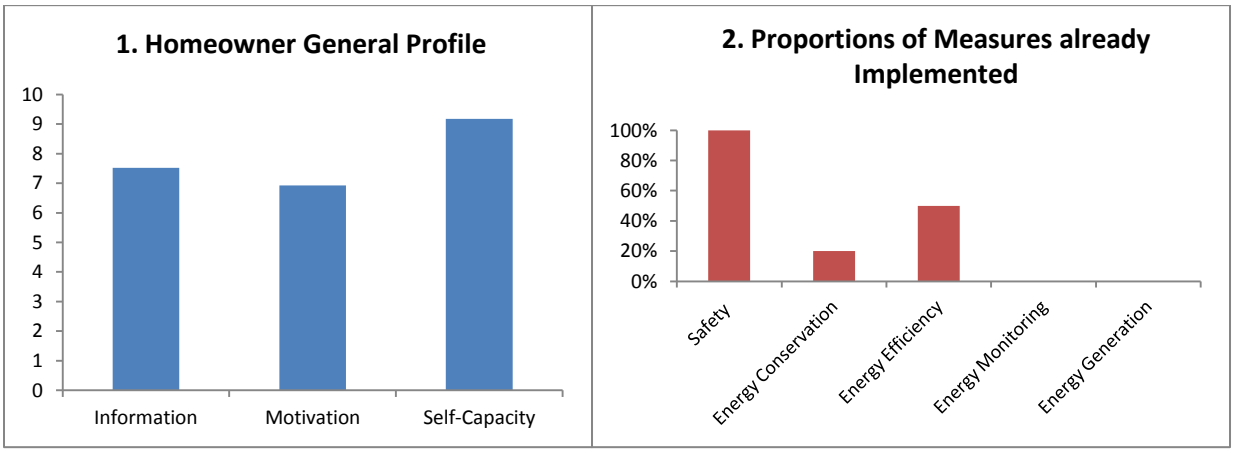
- Air conditioning costs

Piggybacking opportunities. Look for energy-saving measures that could be combined with the following home improvements that the homeowner considers doing:

- Updating a bathroom

HOMEOWNER PROFILE

*The graphs below represent 1) the homeowner's level of information about energy-saving measures and their impact on the home energy consumption, general motivation and perceived capacity to do energy-efficiency improvements or adopt energy conservation behaviors, 2) the proportions of measures of five different types that the homeowner has **already** taken relative to a list of measures typically recommended by energy auditors.*



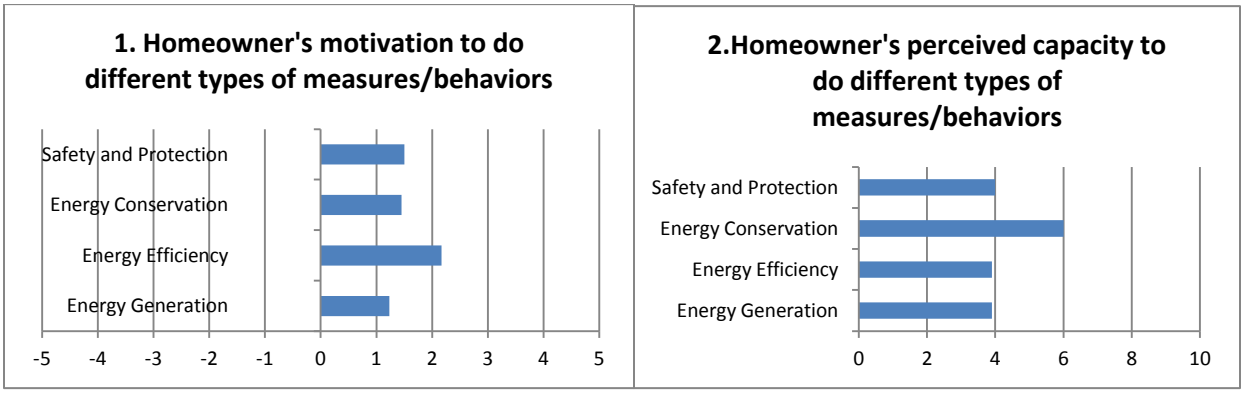
The graphs below represent the homeowner's level of 1) motivation and 2) perceived capacity to do four different types of measures/behaviors typically recommended by energy auditors.

Safety measures are measures that ensure that home and equipment operation do not pose any risk to the health and well-being of the members of the household. These measures mostly address indoor air quality and fire risks. Example: Install a CO detector.

Energy conservation behaviors are everyday behaviors homeowners can change to restrict the use of existing equipment or use this equipment more effectively. Example: Set thermostat to 68F in winter and 78F in summer.

Energy efficiency measures are home improvements or investment in appliances that can reduce households' energy consumption. Example: Seal drafts and add weather-stripping around windows and doors.

Energy generation measures are systems or products that allow homeowners to produce their own energy to run their homes. Example: Install a PV system.



CURRENT ENERGY USAGE PATTERN

*The table below describes the extent to which the homeowner has already made some progress towards better home energy performance and safety. It gives the percentage of measures of five types that the homeowner has **already** implemented relative to a list of measures typically recommended by energy auditors.*

Measure Types	**Percentage of measures already implemented**	**Measures already implemented**
Safety and Protection	100	Install a CO detector Have your water heater, boiler and/or furnace regularly checked by a professional Check and replace smoke detector batteries Control moisture sources in your house, and have a professional checked for moisture issues, if any Do not operate unvented combustion appliances in a closed living space
Energy Conservation	20	Set thermostat to energy-saving settings (68F in winter and 78F in summer)
Energy Efficiency	50	Seal drafts, add weather-stripping around windows and doors, caulk cracks Replace the heating system with a more efficient one Install a higher efficiency or tankless water heater Purchase some higher efficiency/ENERGY STAR qualified appliances
Energy Monitoring	0	*Note: The homeowner has an energy monitoring system: 100%* *The homeowner does not have an energy monitoring system: 0%*
Energy Generation	0	

KNOWLEDGE/AWARENESS

This section presents the top measures the homeowner is aware that he/she could do to save energy at home and ensure that his/her home and equipment operation are safe (column 2). Those measures are compared to the measures the homeowner reported to not have done yet among a list of safety, conservation, efficiency and generation measures (column 3). Individual follow-up with the homeowner would be needed for the measures listed in the third column, that is, measures the homeowner has not done yet, but not listed in the second column as measures the homeowner thinks he/she should do to save energy.

Measure Type	**Measures the homeowner thinks would be useful for his/her home**	**Measures not done by the homeowner yet**
Safety and Protection	Installation of additional fire alarms Installation of fire escape ladders Whole house air filtration	
Energy Conservation	Lower temperature during winter Raise temperature during summer Install low flow faucets	Unplug or turn off the power strip for the electronic devices when not in use Set the water temperature of the water heater to 120F Change the washer temperature settings from "hot wash, warm rinse" to "cold wash, cold rinse" Line dry
Energy Efficiency	Insulate the attic Insulate the walls	Insulate the attic up to R-49 Replace the windows with high-efficiency/ENERGY STAR qualified windows Replace most incandescent light bulbs with CFL or LED Install aerating low-flow faucets and shower heads
Energy Generation	Solar systems	Install a solar array Install a solar hot water system Install a geothermal heat pump Pay a premium on my utility bill to purchase electricity produced through renewable sources

Homeowner's knowledge about the amount of energy saved through the implementation of energy conservation behaviors and energy efficiency retrofits

This section reports potential misperceptions from the homeowner about the amount of energy he/she can expect to save by adopting some energy conservation and efficiency measures typically recommended by auditors. It shows whether he/she tends to overestimate or underestimate the energy savings resulting from specific types of measures.

Homeowner's Total Score	Maximal Points Possible	Information Profile
7.52	**10**	**High**

Measure Type	**Deviation from actual amount of savings**
Energy Conservation	Overestimate
Energy Efficiency	Underestimate
Energy Generation	No deviation

MOTIVATION

This section reports the homeowner's level of motivation to save energy at home and describes the type of motives, personal and/or principled, that the homeowner has to save energy. This information can help you frame the recommendations you will make to the homeowner in a way that best resonates with his/her motives.

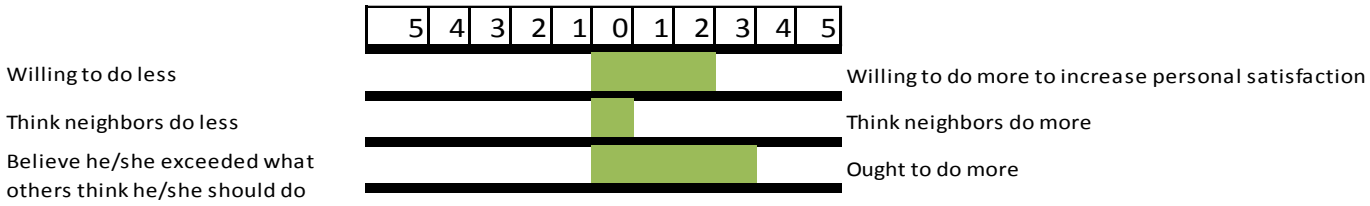
Homeowner's Total Score	Maximal Points Possible	Motivation Profile
6.92	**10**	**High**

Personal Motives	**Homeowner's Score**	**Maximum Points Possible**
Save money on utility bills	10	10
Get more control over personal energy consumption and costs	7.5	10
Increase comfort in home	10	10
Keep up or improve the home condition	10	10
Improve the value of the home	10	10
Increase personal independence from energy companies	2.5	10
Average Personal Motives	**8.33**	**10**
Principled Motives	**Homeowner's Score**	**Maximum Points Possible**
Protect the environment	5	10
Decrease personal contribution to climate change/global warming	5	10
Make the world better for future generations	5	10
Be responsible and not waste	7.5	10
Help reduce the country's reliance on foreign fuels	5	10
Average Principled Motives	**5.5**	**10**

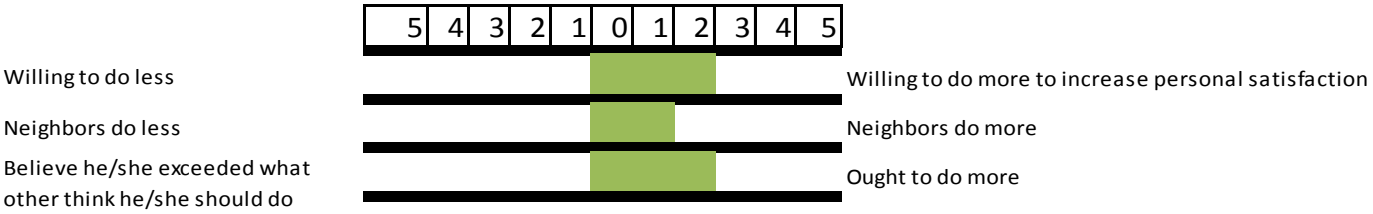
The charts below report a more specific assessment of the homeowner's motivation about the four general types of measures previously described. They provide a measure of the homeowner's perceived dissatisfaction with the state of his/her home with regard to specific types of measures, how he/she thinks is doing compared to his/her neighbors and whether he/she thinks he/she ought to do more. This information allows you to assess which types of behaviors would be better perceived by the homeowner because he or she would feel personally and morally incentivized to adopt them.

Note: Rows are left blank for items that could not be assessed.

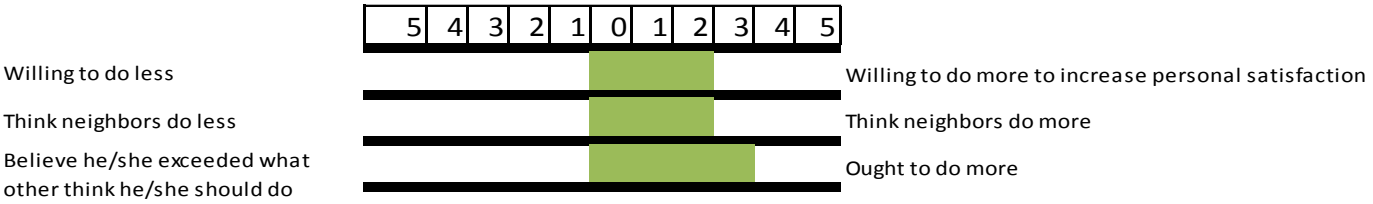
Safety and Protection



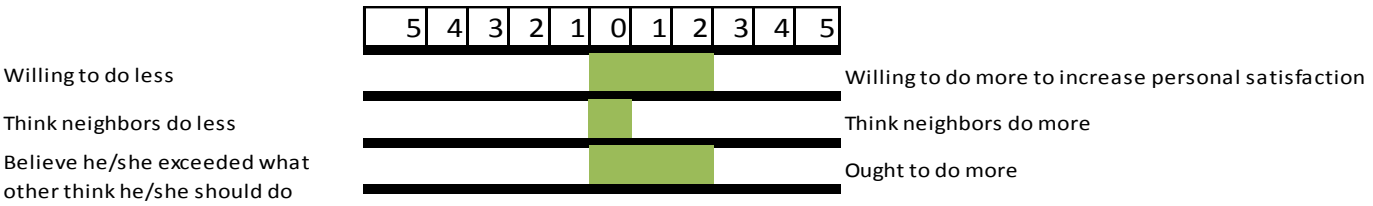
Energy Conservation



Energy Efficiency



Energy Generation



BEHAVIORAL SKILLS

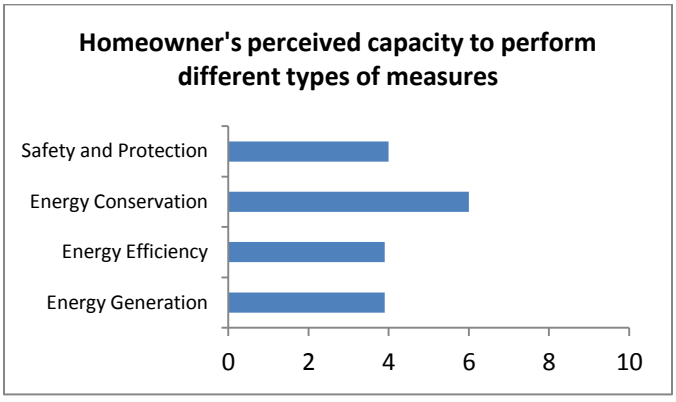
This section reports the homeowner's perception of the difficulty of improving the energy performance and safety of his/her home. It first reports homeowner's confidence in some specific skills necessary to do so. It then describes homeowner's perceived capacity to implement specific types of energy-related measures by himself/herself or with the help of a contractor. This information can help you address specific barriers that may prevent the homeowner from pursuing energy-saving recommendations.

Homeowner's perceived general capacity to adopt energy efficiency and conservation measures

Homeowner's Total Score	Maximal Points Possible	Behavioral Skills Profile
9.17	**10**	**High**

Behavioral Skills	**Homeowner's Score**	**Maximum Points Possible**
The extent to which the homeowner likes making improvements to his/her home by himself/herself	10	10
Homeowner's confidence in his/her ability to upgrade his/her home by himself/herself	10	10
Homeowner's confidence in his/her ability to upgrade his/her home with the help of a professional contractor	10	10
Homeowner's confidence in his/her ability to pay for the upgrades	7.5	10
Homeowner's confidence in his/her ability to take the time to do home improvements	7.5	10
Homeowner's confidence in his/her ability to change his/her everyday life to save energy	10	10

Homeowner's perceived capacity to change the current state of his/her home with reference to the four different types of energy-related measures and behaviors



ENERGY MONITORING SYSTEMS

The homeowner would like to have an energy monitoring system but does not know how to get one.

This person has accepted to share the information of the survey with the energy auditor.
This person has accepted that the energy auditor shares the information he will have gathered during the inspection of the home with Penn State researcher.

APPENDIX H
Questionnaire for the Focus Group of Energy Auditors

Opening questions:

- Introduce yourself
- How long have you been working at the Mark Group? Did you have previous experience as an energy auditor before that?

1) Design of the homeowner assessment scorecard

- Did you have difficulties with interpreting the information included in the homeowner assessment scorecard?
- What information do you think is useful in the homeowner assessment scorecard? Why?
- What information do you think is not useful in the homeowner assessment scorecard? Why?
- What information do you think is missing in the homeowner assessment scorecard?
- What do you think should be improved in the presentation of the homeowner profile (format wise)?
- Did some of you receive the assessment scorecard before the energy assessment? (if some auditors answer "yes" to the previous question) Did you try to use the information provided in the homeowner assessment scorecard? If not, why? If yes, how?

2) Use of the information provided by the homeowner scorecard

- How would you use the information included in the homeowner scorecard during your intervention?
    - How would you adapt your intervention/approach if you learnt about your customers' level of awareness/knowledge with regard to their home energy performance and energy conservation measures?

  - How would the knowledge of your customers' motives to save energy and level of motivation to pursue energy conservation measures impact your intervention or change your approach?
  - How would the knowledge of your customers' perceived ability to take energy conservation measures impact your intervention or change your approach?
  - Would the information included in the homeowner assessment scorecard help you determine what energy conservation measures to target?
  - How would the information included in the homeowner assessment scorecard help you frame your recommendations?
- Can you give some examples of situations where knowing some information about your customers ahead of your visit influenced your conversation with your customers and the way you conducted the home assessment?
- Does the homeowner scorecard overall give you a better knowledge of the homeowners you are going to talk to compared to what you would learn about them while on-site if you did not have access to the scorecard?
- Would you feel more confident when getting to your customers' house if you had access to their assessment scorecard beforehand? Why?
- Do you think that you could be more efficient during your interventions if you had access to this information about the homeowners beforehand? If yes, how?

3) Integration of the intake survey in the audit process

- What do you think should be done/improved to integrate the use of the homeowner assessment scorecard into your audit practice?

APPENDIX I
Follow-up Survey

We are researchers from the Pennsylvania State University and we are collaborating with the Mark Group on a survey research project. This survey aims to help us improve the quality of the energy assessments and recommendations. We are interested in what you have learned during the home energy assessment you received and we would like some feedback about your experience with the intervention of the energy auditor.

After reading the consent form, you will be asked your opinion about the energy assessment you received, as well as some questions about actions you could take to save energy in your home, your intention to take these actions, and you ability to do so.

Your participation in this survey is voluntary. The results from your survey will be accessible to select members of the Pennsylvania State University but only aggregate results will be made available to the Mark Group and the larger community. No personally identifiable information will be shared. It will take you about 20 minutes to complete the survey. You must be 18 years old or more to participate. You do not have to answer any questions you do not want to answer. Thank you for your participation.

Implied Informed Consent Form for Social Science Research

The Pennsylvania State University

Title of Project: Pre-Assessment Survey for Home Energy Evaluations

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1. Purpose of the Study: The purpose of this research study is to understand what home owners or renters know about energy efficiency, their needs and their goals so as to enhance the quality of home energy evaluations and recommendations.

2. Procedures to be followed: After reading the consent form, you will be asked some questions about your experience with the energy audit you received, your knowledge of measures you can take to save energy in your home, your intention and ability to take those measures. At the end of the survey, you will be asked to provide your name and address so that we can contact you to talk about the results of the present survey.

3. Discomfort and Risks: There are no risks in participating in this research beyond those experienced in everyday life. Some of the questions are personal and might cause discomfort.

4. Benefits: This survey will provide important information on how residential energy assessments can be improved and how auditors can better help householders save energy.

5. Duration: It will take about 20 minutes to complete the survey.

6. Statement of Confidentiality: Your participation in this research is confidential. Your confidentiality will be kept to the degree permitted by the technology being used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties. However, the survey

program we are using (Qualtrics) indicates that they have "SAS 70 certification and meets the rigorous privacy standards imposed on health care records by the Health Insurance Portability and Accountability Act (HIPPA)". All Qualtrics accounts are hidden behind passwords and all data is protected with real-time data replication. Only select members of the Pennsylvania State University will know if you participated. The data will be stored and secured on a password protected secure server. The Office of Research Protection and the Social Science Institutional Review Board may review records related to this project. Only aggregate results will be made available to the energy auditing firm you contacted. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

7. Right to Ask Questions: Please contact Janet Swim at (814) 863 1730 with questions or concerns about this study.

8. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Completion and submission of the survey implies that you have read the information in this form and consent to take part in the research. Please print off this form to keep for your records.

This informed consent form was reviewed and approved by the Institutional Review Board at The Pennsylvania State University on 11/21/2011. It will expire on 10/25/2016.

I consent to be in this study.

1) Yes
2) No

Question 1: Which of the following best describe your situation?

1) *I received a free home energy assessment*
2) *I received a home energy audit*
3) *None of the above*

This question allows to track what type of audits/assessments participants received as it may have an impact on their answers to this survey. This question is especially useful for the control group of homeowners who have not filled out the intake survey. The treatment group of homeowners has already answered this question in the intake survey.

Question 2: To what extent do you agree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I am satisfied with the feedback I received from the energy auditor	❍	❍	❍	❍	❍
The energy auditor seemed to understand our motives and goals for energy upgrades	❍	❍	❍	❍	❍
The energy auditor addressed the reasons for which I requested an audit	❍	❍	❍	❍	❍
The upgrades/ retrofits recommended by the energy auditor can be combined with other plans or dreams for home improvements we have for the upcoming year	❍	❍	❍	❍	❍
I believe that the auditor's recommendations will pay off over time	❍	❍	❍	❍	❍
I believe that the auditor's recommendations will improve my quality of life	❍	❍	❍	❍	❍

This question assesses:

- 1st item, "I am satisfied with the feedback I received from the energy auditor": overall statement to assess homeowner's satisfaction with the audit
- 2nd and 3rd items, "The auditor seemed to understand our motives and goals for energy upgrades" and "The auditor addressed the reasons I had for requesting an audit": address whether the auditor listened to the homeowners and personalized its communication so as to increase the relevance of the recommendations made to the homeowners' situation.
- 4th item, "The upgrades/retrofits recommended by the energy auditor can be combined with other plans or dreams of home improvements we have for the upcoming year": addresses whether the auditor took advantage of other home improvements the homeowner considered doing to suggest efficiency measures that could be combined with these home improvements as a way to motivate the homeowners.
- 5th and 6th, "I believe that the auditor's recommendations will pay off over time" and "I believe that the auditor's recommendations will increase my quality of life": address homeowner's confidence in the energy-saving recommendations made by the auditor.

Scoring: Between Group comparison

- Item 1 is scored:

  – 2: Strongly disagree, -1: Disagree, 0: Neither, +1: Agree, +2: Strongly agree.
- Items 2 and 3 are scored:

  – 2: Strongly disagree, -1: Disagree, 0: Neither, +1: Agree, +2: Strongly agree. Both scores are averaged and the average scores are compared between groups
- Item 4 is scored:

  – 2: Strongly disagree, -1: Disagree, 0: Neither, +1: Agree, +2: Strongly agree.
- Items 5 and 6 are scored:

– 2: Strongly disagree, -1: Disagree, 0: Neither, +1: Agree, +2: Strongly agree. Both scores are averaged and the average scores are compared between groups

Question 3: To what extent do you agree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
The auditor was skilled at assessing the energy performance of my home.	❍	❍	❍	❍	❍
The auditor was skilled at providing suggestions for energy-saving improvements that fit the characteristics of my household.	❍	❍	❍	❍	❍
The energy auditor is working in my best interest.	❍	❍	❍	❍	❍
The measures the auditor recommended to me will serve my best interest.	❍	❍	❍	❍	❍
The auditor's services were consistent with what the auditing firm committed to do.	❍	❍	❍	❍	❍
I am comfortable with relying on the information the auditor told me.	❍	❍	❍	❍	❍

The 6 items aim to assess homeowner's trust in the auditor using the three factors of perceived trustworthiness defined by Mayer, Davis and Schoorman (1995): ability, benevolence, and integrity. Items 1 and 2 measure homeowners' perception of the auditor's ability; items 3 and 4 measure homeowners' perception of the auditor's benevolence; items 5 and 6 measure homeowners' perception of the auditor's integrity.

Scoring: Between group comparison

- Items 1 and 2 are scored:

– 2: Strongly disagree, -1: Disagree, 0: Neither, +1: Agree, +2: Strongly agree. Both scores are averaged and the average scores are compared between both groups.

- Items 3 and 4 are scored:

  – 2: Strongly disagree, -1: Disagree, 0: Neither, +1: Agree, +2: Strongly agree. Both scores are averaged and the average scores are compared between groups.

- Items 5 and 6 are scored:

  – 2: Strongly disagree, -1: Disagree, 0: Neither, +1: Agree, +2: Strongly agree. Both scores are averaged and the average scores are compared between groups.

Reliability tests on the scales and correlation studies between the items of the scale allow to determine if the scores for the different items can be added together to give a measure of the homeowners' trust in the auditor.

Question 4: To what extent do the following statements describe you (or if applicable someone else in your household)?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I like making improvements to my home by myself.	❍	❍	❍	❍	❍
I am confident in my ability to make improvements to my home by myself.	❍	❍	❍	❍	❍
I am confident in my ability to find others to make improvements to my home.	❍	❍	❍	❍	❍
I am confident in my ability to pay for improvements to my home.	❍	❍	❍	❍	❍
I am confident in my ability to take the time to do home improvements.	❍	❍	❍	❍	❍
I am confident in my ability to change my lifestyle in such a way that would save energy.	❍	❍	❍	❍	❍

This question assesses homeowners' perceived self-efficacy to do home energy improvements and adopt energy conservation behaviors in a way similar to the pre-audit survey.

Scoring: Between Group comparison

The question is scored in the same way as in the pre-audit survey. The average scores of both groups are compared.

Question 5: How many of the upgrades/retrofits that the auditor recommended do you intend to pursue within the next 6 months?

1) *None*
2) *A few*
3) *Most*
4) *All*
5) *I don't know*

If None Is Selected, Then Skip To End of BlockIf I don't know Is Selected, Then Skip To End of Block

This question assesses the homeowners' intention to pursue the recommendations of the auditor.

Scoring: Between Group comparison

The question is scored:

0: None, 0: Don't know, 1: A few, 2: Several, 3: All. The average scores from both groups are then compared.

Question 6: Which recommendations do you intend to pursue?

This question goes with the previous question. It provides some qualitative information related to the previous question about the measures the homeowners intend to take.

Question 7: Have you (or someone else in your household if applicable) taken the following steps towards the implementation of some or all of the recommended retrofit/upgrade solutions? Check all the steps you have taken so far, whether they concern all of the measures you intend to take or only some of them.

	Yes	No
I, and other members in my household if applicable, have come to an agreement about how we will implement the upgrades/retrofits we intend to do	❍	❍
I got a loan to finance the retrofit work or applied for a rebate/incentive program or I can pay for the retrofit work by myself.	❍	❍
I have contacted some contractors likely to do the work and/or I have bought the materials needed to do the work by myself.	❍	❍
I have scheduled an appointment with a contractor to do the work.	❍	❍
I have already implemented some of the retrofit solutions by myself or with the help of a contractor	❍	❍

This question assesses short-term outcomes of the audit in terms of steps the homeowners have taken towards the completion of energy-saving upgrades.

Scoring: Between Group comparison

The scores for each statement, as defined in the table below, are added together. The averages of the sum scores are compared between both groups.

	Yes	No
I, and other members in my household if applicable, have come to an agreement about the actions I am going to take	+1	0
I have got a loan to finance the retrofit work or applied for a rebate/incentive programs or I can pay for the retrofit work by myself	+1	0
I have contacted some contractors likely to do the work and/or I have bought the materials needed to do the work by myself	+1	0
I have scheduled an appointment with a contractor to do the work	+1	0
I have already implemented some of the retrofit solutions by myself or with the help of a contractor	+1	0

Question 8: Did you talk to your family members, friends, or neighbors about what you learned through the energy analysis you received?

1) *Yes*
2) *No*

This question measures the homeowners' satisfaction and excitement about the audit.

Scoring: Between Group comparison

The question is scored: +1: Yes, 0: No. The average score from both groups are compared.

Question 9: Did you refer other people to the auditing company for which you received an audit?

1) *Yes*
2) *No*

This question also assesses the homeowners' satisfaction with the audit.

Scoring: Between Group comparison

The question is scored: +1: Yes, 0: No. The average score from both groups are compared.

The following demographic questions are not scored. They help collect demographic information about the control group to compare the sample to the treatment group for which demographic information was collected in the pre-audit survey.

Question 10: What is your gender? If more than one respondent, check all that apply.

1) *Male*
2) *Female*

Question 11: Do you own or rent your home?

1) *Own*
2) *Rent*
3) *Do not own, live rent-free*

Question 12: How long have you lived in your current home?

Years

Question 13: Do you anticipate moving out of your current residence in the near future?

1) *Yes, within a year*
2) *Yes, within three years*
3) *No*
4) *Not applicable, I don't own my home.*

Question 14: How many people in each of the following age categories live six months or more per year in your household?

1) *0 to 5 years old*
2) *6 to 13 years old*
3) *14 to 24 years old*

4) *25 to 64 years old*

5) *65+ years old*

Question 15: What is the highest level of school you have completed or the highest degree you have received?

1) *Less than high school degree*

2) *High school degree*

3) *Some college but no degree*

4) *Associate degree*

5) *Bachelor degree*

6) *Graduate degree*

Question 16: May we contact you to talk about the results of the present survey?

1) *Yes*

2) *No*

Question 17: Please provide us with your name and address.

Name

Address

Address 2

City

State

Zip Code

Country

REFERENCES

Abrahamse, W., Steg, L., Vlek, C., and Rothengatter, T. (2005). "A review of intervention studies aimed at household energy conservation." *Journal of Environmental Psychology*.

Abrahamse, W., Steg, L., Vlek, C., and Rothengatter, T. (2007). "The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents." *Journal of Environmental Psychology*, 265-276.

Adler, A. (1964). *Problems of neurosis*. Harper & Row, New-York.

Ajzen, I. (1985). "From intentions to actions: A theory of planned behavior." *Action-control: from cognition to behavior*, J. Kuhl & J. Beckmann.

Ajzen, I. (1991). "The theory of planned behavior."

Allport, G. (1955). *Becoming*. Yale University Press, New-Haven, CT.

Amann, J. (2006). "Valuation of non energy benefits to determine cost-effectiveness of whole-house retrofit programs: a literature review." American Council for an Energy-Efficient Economy.

Attari, S. Z., DeKay, M. L., Davidson, C. I., and Bruine de Bruin, W. (2010). "Public perceptions of energy consumption and savings."

Baden, S. (2011). ""Shaping the future for retrofits: what Resnet has accomplished in 2010 and where we are heading."

Bamberg, S., and Möser, G. (2007). "Twenty years after Hines, Hungerford, and Tomera: a new meta-analysis of psycho-social determinants of pro-environmental behaviour." *Journal of Environmental Psychology*.

Bandura, A. (1994). "Self-efficacy." *Encyclopedia of human behavior*, 71-81.

Black, J. S., Stern, P. C., and Elworth, J. T. (1985). "Personal and contextual influences on household energy adaptations." *Journal of Applied Psychology*.

Brown, M. A. (2001). "Market failures and barriers as a basis for clean energy policies."

Building Performance Institute. (2005). "Building Performance Institute - Technical Standards for the Building Analyst."

Carroll, E., Hatton, E., and Brown, M. (2009). "Residential energy use behavior change pilot."

Cialdini, R. B. (2007a). "Descriptive social norms as underappreciated sources of social control." *Psychometrika*.

Cialdini, R. B. (2007b). "Testimony to the Subcommittee on Research and Science Education, House Committee on Science and Technology. At the hearing on: The Contribution of the Social Sciences to the Energy Challenge."

Cialdini, R. B., Reno, R. R., and Kallgren, C. A. (1990). "A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places." *Journal of Personality and Social Psychology*, 1015-1026.

Clevenger, C. M., and Haymaker, J. (2006). "The impact of the building occupant on energy modeling simulations."

Collins, S., and Davies, J. (2011). "Changing the Market for Energy Efficiency in Whatcom County." San Fransisco.

Condelli, L., Archer, D., Aronson, E., Curbow, B., McLeod, B., Pettigrew, T. F., White, L. T., and Yates, S. (1983). "Improving utility conservation programs: outcomes, interventions, and evaluations."

Cooley, C. (1964). *Human nature and the social order*. Schocken Books, New-York.

Council on Environmental Quality. (2009). *Recovery through retrofit*.

Craig, C. S., and McCann, J. M. (1978). "Assessing communication effects on energy conservation." *Journal of Consumer Research*.

van Dam, S. S., Bakker, C. A., and van Hal, J. D. M. (2010). "Home energy monitors: impact over the medium-term." *Building Research & Information*.

Darby, S. (2006). "The effectiveness of feedback on energy consumption. A review for DEFRA of the literature on metering, billing and direct displays."

Darnton, A. (2008). "Reference report: An overview of behaviour change models and their uses."

De Young, R. (1993). "Changing behavior and making it stick: the conceptualization and management of conservation behavior." *Environment and Behavior*.

Department of Energy. (2010). "Weatherization Assistance Program - Program Overview."

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., and Vandenbergh, M. P. (2009). "Household actions can provide a behavioral wedge to rapidly reduce U.S. carbon emissions."

Feldman, S. (1987). *Energy Efficiency: Perspectives on Individual Behavior*. American Council for an Energy-Efficient Economy.

Fischer, C. (2008). "Feedback on household electricity consumption: a tool for saving energy?."

Fishbein, M. (1975). *Belief, attitude, intention, and behavior: an introduction to theory and research*.

Fisher, J., and Fisher, W. (1992). "Changing AIDS risk behavior." *Psychological Bulletin*, 455-474.

Fisher, W. A., Williams, S. S., Fisher, J. D., and Malloy, T. E. (1999). "Understanding AIDS risk behavior among sexually active urban adolescents: an empirical test of the information, motivation, behavioral skills model."

Freud, S. (1961). "The ego and the id.." *J. Strachey The standard edition of the complete psychological works of Sigmund Freud*, Hogart Press, London, 3-66.

Friedrich, K., Amann, J., Vaidyanathan, S., and Elliott, N. (2010). "Visible and concrete savings: case studies of effective behavioral approaches to improving customer energy efficiency."

Fuller, M. C., Kunkel, C., Zimring, M., Hoffman, I., Soroye, K. L., and Goldman, C. (2010). *Driving demand for home energy improvements*. Environmental Technologies Division, Lawrence Berkeley National Laboratory.

Gardner, G. T., and Stern, P. C. (2008). "The short list: The most effective actions U.S. households can take to curb climate change." *Environment Magazine*.

Geller, E. S. (1995). "Integrating behaviorism and humanism for environmental protection." *Journal of Social Issues*, 179-195.

Geller, E. S. (2002). "The challenge of increasing proenvironmental behavior." *Handbook of environmental psychology*, Wiley, New-York, 525-540.

Gonzales, M. H., Aronson, E., and Costanzo, M. A. (1988). "Using social cognition and persuasion to promote energy conservation: a quasi-experiment." *Journal of Applied Social Psychology*.

Gram-Hanssen, K. (2010). "Residential heat comfort practices: understanding users."

Gronhoj, A., and Olander, F. (2007). "A gender perspective on environmentally related family consumption." *Journal of Consumer Behavior*.

Hendron, R., and Engebrecht, C. (2010). *Building America House Simulation Protocols*. National Renewable Energy Laboratory.

Higgins, E. T. (1987). “Self-discrepancy: A theory relating self and affect.” *Psychological Review*, 94(3), 319-340.

Hines, J. M., Hungerford, H. R., and Tomera, A. N. (1986). “Analysis and synthesis of research on respsonsible environmental behaviour: a meta-analysis.” *Journal of Environmental Education*.

Hirst, E., Bronfman, B., Goeltz, R., Timble, J., Lerman, D., and Keating, K. (1983). “Evaluation of utility residential energy conservation programs: a pacific northwest example.”

Hoes, P., Hensen, J., Loomans, M., de Vries, B., and Bourgeois, D. (2009). “User behavior in whole building simulation.”

Jaffe, A. B., and Stavins, R. (1994). “The energy-efficiency gap: What does it mean?.”

Jevons, W. S. (1866). *The coal question*. Macmillan and Co., London.

Kahneman, D., Knetsch, J., and Thaler, R. (1991). “The endowment effect, loss aversion and status quo bias.” *Journal of Economic Perspectives*.

Karlin, B. (2011). “Exploring Differences Among Energy Behaviors.”

Kempton, W., Harris, C., Keith, J., and Weihl, J. (1985). “Do consumers know "What works" in energy conservation?.” *Marriage and Family Review*, (9), 115-33.

Khazzoom, J. D. (1980). “Economic implications of mandated efficiency in standards for household appliances.” *The Energy Journal*, 21-40.

Krosnick, J. A., and MacInnis, B. (2011). “National survey of American public opinion on global warming - Standford University with Ipsos and Reuters.”

Leiserowitz, A. (2007). “American opinions on global warming: summary.” Yale University School of Forestry and Environmental Studies.

Leiserowitz, A., Maibach, E., and Roser-Renouf, C. (2009). “Saving energy at home and on the road: a survey of American's energy saving behaviors, intentions, motivations, and barriers.”

Lindenberg, S. (2001). “Intrinsic motivation in a new light.” *Kyklos*, (54), 317-342.

Lindenberg, S. (2006). “Prosocial behavior, solidarity and goal-framing processes.” *Solidarity and prosocial behavior. An integration of sociological and psychological perspectives*.

Lutzenhiser, L. (1987). “Social variation and electricity consumption in San Diego California: exploratory data analysis and the California Energy Commission's electricity demand forecasting model.”

Lutzenhiser, L. (1991). “A cultural model of household energy consumption.”

Lutzenhiser, L. (1993). “Social and behavioral aspects of energy use.”

Maibach, E., Roser-Renouf, C., and Leiserowitz, A. (2008). “Communication and Marketing as Climate Change Intervention Assets: A Public Health Perspective.” *American Journal of Preventive Medicine*, 488-500.

Markowitz, P. (2010). “A community-based approach to promoting residential efficiency improvements.”

Mayer, R. C., Davis, J. H., and Schoorman, F. D. (1995). “An integrative model of organizational trust.” *The Academy of Management Review*, 20(3), 709-734.

McKenzie-Mohr, D. (2000a). “Promoting sustainable behavior: an introduction to community-based social marketing.” *Journal of Social Issues*, 543-554.

McKenzie-Mohr, D. (2000b). “Fostering sustainable behavior through community-based social marketing.”

National Renewable Energy Laboratory. (2009). “Energy Savers Booklet.”

Parnell, R., and Popovic Larsen, O. (2005). “Developing the home energy report: an everyday

householder-centred approach."
Pérez-Lombard, L., Ortiz, J., and Pout, C. (2007). "A review on buildings energy consumption information."
RESNET. (2009). "RESNET - National Average Cost of Home Energy Ratings."
RESNET. (2010). "Chapter Seven - RESNET Standards."
RESNET. (2011). *2010 RESNET Annual Report*.
Rogers, C. (1961). *On becoming a person*. Houghton Mifflin, Boston.
Ross, M. H., and Williams, R. (1976). "Energy efficiency: our most underrated energy resources." *Bulletin of the atomic scientists*, 30-38.
Schultz, P. W. (2002). "Knowledge, information, and household recycling: examining the knowledge-deficit model of behavior change." *New tools for environmental protection*, Washington DC: National Academy of Sciences, 67-82.
Schultz, P. W., and Kaiser, F. G."Promoting proenvironmental behavior." *Handbook of Environmental and Conservation Psychology*.
Seacat, J. D., and Northrup, D. (2010). "An information-motivation-behavioral skills assessment of curbside recycling behavior."
SENTECH, Inc. (2010). *Review of selected home energy auditing tools*. U.S. Department of Energy.
Shelton Group. (2011). "Consumer Perceptions (and Misconceptions) about Home Energy Efficiency."
Steg, L., and Vlek, C. (2008). "Encouraging pro-environmental behaviour: an integrative review and research agenda." *Journal of Environmental Psychology*.
Stern, P., Dietz, T., Abel, T., and Guagnano, G. (1999). "A value-belief-norm theory of support for social movements: the case of environmentalsim." *Human Ecology Review*, (6), 81-97.
Stern, P. (2000). "Toward a coherent theory of environmentally significant behavior." *Journal of Social Issues*, 407-424.
Stern, P. C. (1992). "What psychology knows about energy conservation."
Stevens, D. (2011). "Customer Energy Education."
Stevenson, F., and Leaman, A. (2010). "Evaluating housing performances in relation to human behaviour: new challenges." *Building Research and Information*.
Stobaugh, R., and Yergin, D. (1979). "Conservation: the hey energy source." *Energy future: report of the energy project at the Havard Business School*, Random House, New-York.
Train, K. (1985). "Discount rates in consumers' energy-related decisions: a review of the literature." *Energy*, 10, 1243-53.
Tversky, A., and Kahneman, D. (1981). "The framing of decisions and the psychology of choice." *Science*, 211, 453-58.
Van Raaij, W. F., and Verhallen, T. M. (1983). "A behavioral model of residential energy use." *Journal of Economic Psychology*.
Wilhite, H., Shove, E., Lutzenhiser, L., and Kempton, W. (2000). "Twenty years of energy demand management: we know more about individual behavior but how much do we really know about demand?."
Wilk, R. R., and Wilhite, H. (1987). "Why don't people weatherize their homes? An ethnographic solution." *Energy Efficiency: Perspectives on Individual Behavior*, American Council for an Energy-Efficient Economy.

Wilson, C. (2010). “Energy efficient retrofits: rational or rationalized?.”
Wilson, C., and Dowlatabadi, H. (2007). “Models of decision making and residential energy use.” Annual Review of Envrionment and Resources.
Yates, S., and Aronson, E. (1983). “A social psychology perspective on energy conservation in residential buildings.” American Psychologist.
Zundel, S., and Stiess, I. (2011). “Beyond profitability of energy-savings measures - Attitudes towards energy saving.”