An Effort to Refine Regional Energy Assessment Methods in Support of Energy Auditors to Increase Assessment Accuracy and Consumer Confidence

O. E. Ladipo[1], G. Reichard[1], A.P. McCoy[2], A. R. Pearce[3]

[1]Building Envelope System Technologies Laboratory, Department of Building Construction, Bishop-Favrao Hall (0156), Virginia Tech, Blacksburg, VA 24061 email: tladi001@vt.edu, reichard@vt.edu

[2]Virginia Tech Center for Housing Research, Department of Building Construction, Virginia Tech Center for Housing Research (0451), Virginia Tech, Blacksburg, VA 24061 email: apmccoy@vt.edu

[3]Sustainable Facilities & Infrastructure Laboratory, Department of Building Construction, Bishop-Favrao Hall (0156), Virginia Tech, Blacksburg, VA 24061 email: apearce@vt.edu

ABSTRACT

More than 60% of occupied homes in the U.S. were constructed before 1980, often wasting up to 60% of the consumed energy due to building envelope and systems deficits. Homeowners spend billions of dollars annually on energy bills, and there is a potential to dramatically reduce this expenditure. This return can be achieved through energy retrofit solutions applied to homes. Decisions to pursue a retrofit action in a home are commonly based upon energy assessments provided by auditors, who utilize a mix of diagnostic tools, inspection strategies, evaluation practices such as the blower door test, and energy modeling simulations. Although a variety of energy assessment methods are available today to help identify the most promising retrofit opportunities, many barriers and issues still exist for homeowners to take action. One significant factor contributing to a lack of retrofit decision-making by homeowners is the reduced confidence based on the accuracy of energy assessments, which often miss the actual energy consumption by far. This study investigated the current energy assessment methods used by energy auditors in Southwest Virginia in order to reveal insights into their strengths and struggles when conducting assessments and reporting results to homeowners. Energy auditors from four companies who conduct energy assessments were shadowed on routine audits and subsequently interviewed. As a result, common strengths and struggles were identified regarding the processes of individual auditors, the larger local energy assessment community, and the national energy assessment industry in general. The findings identify opportunities for refinement on a regional basis, and areas for additional research towards improving energy assessment accuracy, increasing stakeholder confidence, and promoting more active retrofit decision-making. This study is an initial local effort to potentially create compatible solutions on a nationwide scale.

INTRODUCTION

According to United States (U.S.) Census data, approximately 61% of homes in the U.S. were constructed before 1980. Of these homes, 60% of the energy used by them for heating and cooling is lost due to leaky ducts, inefficient equipment, poor insulation and air leaks (ETO 2008). The U.S. Department of Energy reports that only 20% of the homes built before 1980 are well insulated (DOE 2011). The issues concerning the current energy performance in many older existing homes are emptying homeowner's pockets, spending a reported 118.86 billion dollars annually on energy (EIA 2005). As new technologies and consumption items continue to enter the market and are then subsequently found in homes, residential housing energy consumption is inevitably expected to continue to increase in the future.

The high number of homes built before 1980, which would benefit most from residential retrofitting, provides an opportunity not only for the homeowner, but also for other involved stakeholders in spurring small businesses such as auditors, contractors, and home builders/retrofitters. In a report prepared by the White House Council on Environmental Quality (CEQ) identifying the key barriers to the home energy retrofit market, it was proposed that home energy efficiency retrofits have the potential to reduce home energy bills by 21 billion dollars annually, ultimately paying for themselves over time (CEQ 2009). The potential business gained by auditors, contractors, and builders through retrofitting can grow similarly as the demand for retrofits increases.

New technologies and strategies are being developed and refined that can reduce the energy consumption of homes while also aiming to reduce their impact on the environment. Homes use approximately one fifth of the total energy consumed in the U.S., and this figure has been increasing steadily since 1985 (USGBC 2011). This shift in consumption could be due to other sectors being more proactive in saving energy, or an increased growth in housing compared to other sectors, such as transportation. The total energy consumed by homes in the U.S. as stated above does not yet take into account the energy used for transportation, production, and other associated processes with manufacturing of materials and equipment that is used in the residential construction industry, which would raise that fraction significantly. The various technologies, products, incentives and techniques being developed and used in today's residential energy efficiency market can reduce energy consumption by means of insulation, increased efficiency of heating and cooling systems, appliances and household plug-loads, and many other ways, all of which can lead to substantial monetary savings due to improved energy performance. With all these available resources and incentives, why are many homeowners not taking advantage of home retrofits and reaping the rewards? One possible problem could be the step prior to retrofitting the actual spaces, the diagnosis. This problem refers to the assessment results a homeowner receives from an energy audit of their home, which identifies deficiencies and areas for improvement in their homes energy performance. For example, if these assessed and/or simulated results differ significantly from the homeowner's actual energy consumption, the confidence in any retrofit suggestions and associated savings proposed by a tool or auditor may be very low. In other instances, where a discrepancy is not identified, a homeowner might draw wrong conclusions and invest in less profitable scenarios, and subsequently portray energy efficiency measurements as unreliable to a broader public as shown in numerous blogs and comments provided on sites such as GreenBuildingAdvisor.com.

Residential energy assessments face various issues, which in turn has contributed to homeowners reduced confidence in energy assessments and a lack of retrofit decision-making. These problems range from inefficient and inaccurate auditing practices and tools, differing opinions and perceptions from auditors, and auditors that are not properly trained (DOE 2011). Current methods in home energy assessments can lead to failures such as lower-than-expected savings, no savings at all, and in some cases even higher energy use (Shapiro 2011). Previous studies have investigated energy auditing practices and identified some common issues that contribute to inaccurate assessment results and failed retrofits (EAI and CSG 2009, Shapiro 2011). This includes factors such as a misuse or lack of appropriate tools, complicated housing characteristics, limited budgets, time-consuming assessment activities, and communication issues with homeowners.

With various difficulties being experienced by auditors and the prevalence of problematic assessment tools and practices, this leads to a lack of reliability in retrofitting and its promise of energy and monetary savings in return. The time and money spent on auditing homes also serves as a hindrance towards retrofitting, with many homeowners not wanting to invest in a process that could potentially lead to no earned value. Therefore, in order to solve these problems, one must investigate what energy assessment methods are most effective, and what can be improved that will benefit residential retrofitting processes and all involved stakeholders. Homeowners should be saving money and lowering their energy consumption. They look at their large energy bills but do not know what to do first to achieve savings. In hope of finding answers homeowners then turn to auditors. The auditor's task to accurately assess the current consumption of a home is made especially difficult due to the vast selection of assessment methods to select from, many of which being identified, or speculated, as unreliable. Reassurance and refinement in residential energy assessments is a must.

BACKGROUND

Residential Energy Audit Tools and Practices. Typically, an energy audit scenario starts with a homeowner reaching out to an auditor to assess their home's energy performance. The auditor then asks the homeowner to gather information about their home, such as various home characteristics, occupant energy use patterns, existing problems, and in some cases, annual utility bills. The auditor will use this information in assessing the home using various physical and/or a combination of virtual energy assessment tools (energy modeling tools) and practices. Some of the most common in-field tools used by auditors are Blower Door Tests, Thermal Imaging (using infrared cameras), and PerFlurocarbon Tracer Air Filtration Measurements (DOE 2011). These tools are used to detect air leaks, measure pressure differences and airtightness, and also detect areas where heat loss is occurring throughout a home.

Auditors also conduct exterior and interior inspections of a home to identify key features required when making energy assessment calculations. These features can include items such appliance models, lighting types, windows and doors types and orientations, and foundation type.

The three main groups of parameters that are to be measured during an energy audit using the previously mentioned tools and practices, include parameters involving the heat exchange through the building envelope, which includes the floors, walls, ceilings, and windows and doors; parameters involving the internal heat produced by occupant activities, lighting, and appliances; and parameters dealing with the energy supply for thermal comfort and building services, which includes HVAC systems and hot water generation/storage systems (Chen 2010). Infiltration, which is uncontrolled air leakage through the building envelope, is assessed by Blower Door Tests, and is an important influence parameter for evaluating the building envelope system performance. It affects the air exchange rates in a space, and through related heat gains and losses it directly influences heating and cooling requirements. On the other hand, the required amount of ventilation (controlled/conditioned air-exchange) that a space needs to achieve indoor air quality also impacts the heating and cooling demand in a home.

Typically, an energy audit is conducted on a home often with only limited knowledge of what the main issues are in respect to energy performance. Building characteristics, influence parameters, and occasionally some knowledge about the cost and consumption patterns of energy use by the occupants are provided to the auditors and are consequently used to assess the energy performance and deficiencies of the home. This is done under the constraints of limited time, resources, and budget. The results of the audit are subsequently communicated to the homeowner, who will use that information, to decide whether or not to retrofit certain elements of their home. The cost to perform an energy audit varies as it depends on a number of factors, including the tools and practices used, the size of the dwelling, and the overall time spent conducting the audit. In some areas around the country funding is available to support energy audits through government and local energy programs and incentives.

Energy Simulation (Modeling). Several simulation models and tools have been developed and are currently in use that aim to assess an entire home’s energy performance, and some also provide recommendations for retrofit improvements in a more or less uniform way. The accuracy of the recommendations can vary based on several factors such as the inputs included and parameters evaluated.

Computer based energy modeling audit tools are commonly used off-site in conjunction with on-site tests performed. These tools are intended to help with the decision making process when it comes to improving a home’s energy efficiency. Two important aspects that these calculators must take into account when providing assessments for retrofit decision-making are the homes physical characteristics and occupant use patterns. Capturing this information within these tools can be complex, and can in turn contribute to unreliable results. Occupant use patterns are more important for user specific decision-making, and can perhaps be omitted for performance based, or purely asset based, ratings and evaluations. It has been concluded from various studies that including occupant use behavior in a simulation tool, and energy assessments in general, can significantly increase the accuracy of an assessment, as well as increase the motivation for homeowners to seek an energy assessment on their home (Clevenger and Haymaker 2006); (Ingle, Moezzi et al. 2012); (Durak 2011). Asset based modeling tools such as EPS Score, a modeling tool currently piloted in energy block programs in Southwest VA, or assessments that include a minimal amount of occupant use behavior data, can cause key assessment criteria to be overlooked or distorted. This is an important consideration when selecting assessment tools to make sure a misuse is avoided, specifically when asset based modeling tools are utilized to make user specific retrofit decisions. In a report prepared for the DOE, common traits and factors that appear to influence the success of home energy retrofit decisions based on energy assessment results were investigated. One of the conclusions made from the study was that current energy assessment tools and practices are not designed to detect behavioral patterns (Lancaster, Lutzenhiser et al. 2012).

Other recent studies have investigated and debated the accuracy of various energy modeling tools such as Home Energy Saver, REM/Rate, and TREAT (SENTECH 2010, Parker, Mills et al. 2012). It was concluded that many energy modeling tools do not accurately capture data important to producing accurate assessment results.

Increasing the accuracy of energy assessments while also reducing and/or eliminating many of the common problems with energy assessments is the research task that needs to be addressed. Investigating what is available, what works, and possible solutions for improvements are the first necessary steps in this process.

STUDY GOALS & OBJECTIVES

The purpose of this study was to investigate current energy assessment tools and practices being used prevalently today, with a regional focus on Southwest VA to exclude climate diversity issues. The goal was to identify ways in which energy assessments in this region can be improved and become more effective and can lead to increased retrofit decision-making. A literature analysis has identified a need for improved accuracy in energy assessment tools and practices to communicate more reliable results and recommendations to homeowners and retrofitters. There are an abundance of available tools and practices that can be used for home energy assessments, and many others being developed, but very few have proven to provide utmost confidence in their accuracy leading to retrofit actions.

This study involved two main objectives: first, to identify key issues in current industry energy assessment methods, and second, to identify the strengths and struggles experienced with various energy assessment tools and practices used by local energy auditors. The objectives combined the use of three methodologies, which included an initial literature analysis, followed by shadowing energy auditors on routine energy assessments, and finally conducting semi-structured interviews with the same auditors thereafter.

METHODOLOGY

Literature Analysis. A literature analysis has been conducted to compile a comprehensive list of research studies representing the status quo on issues around assessment tools and practices.

Shadowing. Shadowing is an observational technique used to collect qualitative data. It involves following and observing a subject performing particular tasks and/or their day-to-day activities to gather data for research analysis. Data collection techniques associated with shadowing can also involve note-taking, informal questions and answers, as well as in-depth informal observation. Informal observation is an observational approach that is less structured, allowing the observer considerable freedom in what information they choose to gather from informants and how they wish to proceed with it (Robson 2002).

Shadowing can help the researcher to gain a sense of what actually happens rather than what should happen (Gill 2011). It is a useful data collection technique, specifically towards institutional ethnography, which is an exploration of people's social relations that structure their everyday lives and can be used to help increase efficiency and productivity (Quinlan 2011). Quinlan also discussed the Hawthorne effect, that is, by virtue of being observed, what is being observed changes. In shadowing, disruption of the normal flow of activities is how the Hawthorne effect is most commonly experienced. Because of this, keeping the right distance, ensuring participants are comfortable with the observer's presence, and being careful not to disrupt the process will allow for collecting the most useful data.

The shadowing results of different audit sessions were then comparatively analyzed and evaluated to identify prevalent issues of current auditing practices.

Semi-Structured Interviews. A series of interviews took place as part of this research study. The style of interviewing that was used was a semi-structured modus. A semi-structured interview involves having predetermined questions and topics, although the interviewer has no formal structure or outline for asking these questions. Other unplanned questions may be asked if the conversation leads into a direction that deems appropriate for the study. When interviewing participants about their personal experiences and emotive topics, "providing a non-judgmental and confidential environment, where participants can talk about their experiences in an open and unhurried manner with someone who is genuinely interested in what they have to say, can be of mutual benefit to both researchers and participants" (Lowes and Paul 2006).

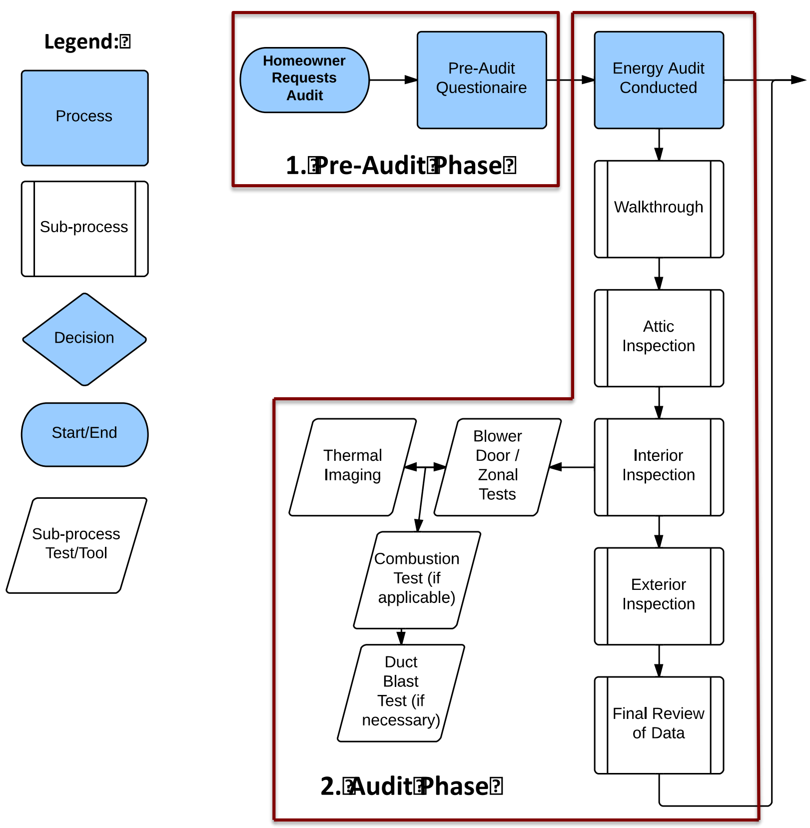
This particular style of interviewing was used for this study in an effort to gain more insightful and honest responses from interviewees due to the unrestricted nature of the interview process and conversation. The style of interview was communicated to the interviewee before the interview began, letting them know of the nature of the conversation and the freedom to stray from specific questions and topics as appropriate. Institutional Review Board (IRB) approval of questions for this study was obtained before interviews began to ensure all questions were ethically correct.

RESULTS

The results produced by both, the shadowing and the interviews were comparatively analyzed and then synthesized to produce a list of core issues of energy auditing practices. Participants of the shadowing and interview phases were then presented with the results and validated for the core findings.

Study Participants. A total of four local companies, who primarily conduct energy audits, or some select energy auditing services, were identified as potential participants for this study. Three of these four candidates were invited to participate and agreed to be shadowed and interviewed for this study. Of these three, two were energy audit companies (Company A and Company C), and one was a home inspection company (Company B). The companies were chosen based on proximity and the different perspectives they could provide based on company sizes, and services they perform.

Results of the Shadowing. Each participating company was first shadowed on a typical energy audit as performed by their auditors. This process also allowed for experiencing an unbiased view of what actually occurs during an audit. Detailed process maps of each company's typical audit process were created based on the observed activities during shadowing. An example of a process map is shown in Figure 1.



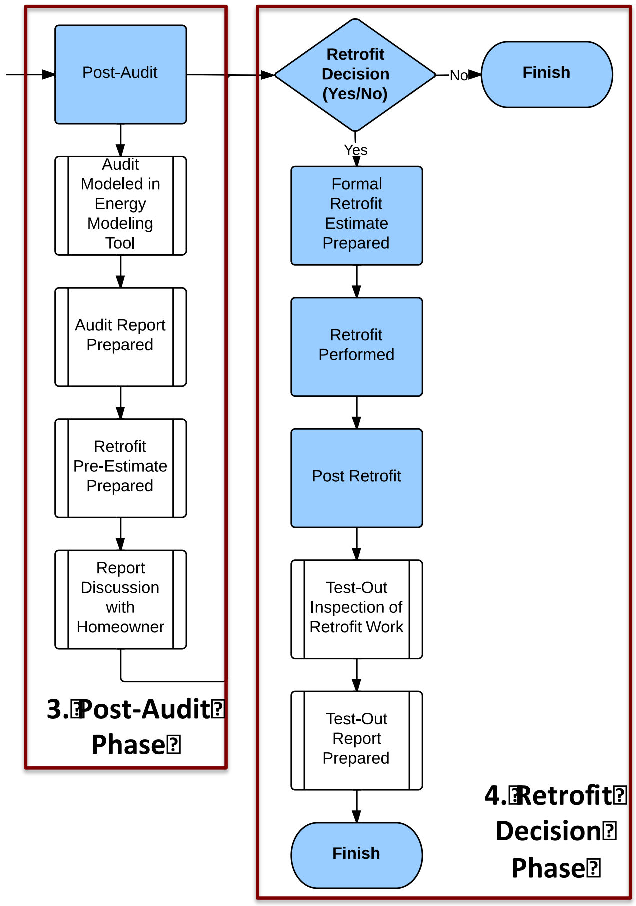


Figure 1. Example of an energy audit process map created for Company A based on shadowing activity – depicts the four different phases experienced.

The process maps provided an overview of the typical tools and tests used and performed when conducting and audit, as well as the processes they underwent pre and post audit. Four main phases were identified for each energy auditing company, which consisted of the Pre-Audit Phase, the Audit Phase, Post-Audit Phase, and the Retrofit Decision Phase. Some typical tools utilized during the majority of the shadowing observations included a blower door, infrared camera, fan flow, moisture meter, temperature sensors, gas leak detectors, and carbon monoxide detectors. EPS Score was one of the energy modeling tools used by Companies A and C as required by a local, government funded incentive program. The companies use this tool in addition to other modeling tools, for which they have obtained licenses and routinely utilize for their assessments.

Results of the Interviews. Once the shadowing phase was completed and the processes of each company were observed and documented, questions were asked to each of the participating energy auditors in the form of a semi- structured interview. Two auditors were interviewed from Company A as well as the company owner, and two auditors were interviewed from Company C. The home inspector from Company

B was not available for a follow-up interview within the allotted time frame of this study. The interview questions addressed topics such as their personal views, opinions, difficulties, and strengths when performing audits. Questions were also posed towards their opinions of their company's processes, the local energy auditing community, and the energy auditing industry in general. A total of four energy auditors were interviewed, and one of the company owners was also interviewed. Interviews were conducted privately in one-on-one sessions, which lasted between 30 minutes to one hour. As the format for the interview sessions was semi-structured, some questions that were not on the original interview guideline were asked as the conversation lead in a way that was appropriate for the study. Common perceptions were synthesized from all interviews and shadowing events to identify the main strengths and struggles faced in the local energy auditing industry, and will be discussed below.

DISCUSSION

Some general similarities gathered in the analysis process include the certifications held by each auditor interviewed, in which all of the auditors hold at least one certification, with the exception of one of the company owners, who does not hold any certifications. A certification held by all the auditors is the Building Performance Institute (BPI) Certified Professional certification. All interviewed auditors have been conducting energy audits for between one and two years, with the exception of one auditor who has been conducting energy audits for five years, and the company owner who does not conduct energy audits, but has been operating the business for approximately five years. The auditors conduct audits primarily regionally, and only sometimes out of state. The typical types of homes they audit were built between the years 1950-1970, but they have audited older as well as newer homes. The audited homes vary in characteristics and architectural properties. Typical tools/practices used by the auditors include a variety of diagnostic tools such as a blower door, infrared camera, and combusting testing sets. Their typical clients that seek energy audits are predominantly looking to increase the comfort inside their homes and save on energy bills in the process, while others are energy efficiency enthusiasts. The most common energy related problems auditors seem to face are related to air sealing and insulation. There was discussion regarding the awareness of risk associated with retrofit recommendations and the actual results of performed retrofit work, rooted in miscommunication and/or not specific enough instructions. It was a general consensus that their clients (i.e. homeowners) often need to be "convinced" to create buy into the recommendations they provide post audit. One of the company owners identified this as what he believes to be one of the energy auditing industries biggest issues.

Common Strengths. The core findings identified in common strengths include diagnostic tools/tests, certifications, and teamwork.

Diagnostic Tools/Tests:

Many commonly utilized tools and performed tests were observed in the field and also mentioned in the interviews by each auditor. There was general favor in their value for various reasons. It was discussed how some tools are more critical for collecting raw data, while others are more for communicating and presenting information to the homeowner post audit, sometimes even during an audit, as observed during shadowing. The blower door test and an infrared camera are two tools used prevalently in the field by all the auditors as observed during shadowing. These tools were of most interest to the homeowner, and also the most known of by the homeowner, where many times the homeowner asked when those tools and tests would be performed, and were intrigued with the processes when they finally were employed. Viewing the contrast in colors presented on the infrared camera screen as the blower door was running made it easier for the auditor to translate the meaning of what the homeowner saw when looking at it in relation to the condition of their home. This served as a visual aid of sorts in the field where curiosity arose, and also in the audit reports for presenting collected and analyzed data.

Internal benefits of the tools were also discussed. The data of the blower door serves a purpose much like that of a scale, as one auditor described it. It provides numeric values, which they can be used to compare a home's pre and post retrofit state to evaluate improvements. Other tools and tests used for diagnostics such as combustion testing, efficiency tests, and carbon monoxide detectors provide an abundance of raw data not only for the energy assessments, but also for health and safety inspections. A tool mentioned by only one auditor in an interview but seen on every audit shadowed, was the digital camera. This was used to collect an abundance of photos of the interior and exterior characteristics of a home. These photos were used as data in the office to analyze and provide retrofit recommendations. The auditor that discussed this tool in the interview described the camera to act much like that of a pen and paper, but in a more efficient and accurate way.

Certifications:

As mentioned previously, all of the auditors interviewed are BPI Certified Professionals, with some auditors holding multiple other certifications related to energy auditing and building performance. It was a general consensus between all auditors, as well as the company owner, that their certifications add significant value not only to their personal knowledge, but also towards obtaining business and resources. The BPI certification was discussed as an intense course with a lot of information delivered in a short period of time that may not have been absorbed if it were not for them continuing on practicing in the profession as energy auditors. Despite this, there was general favor that the certification training helped to strengthen awareness and knowledge of energy auditing and the associated building sciences. All believed that their certifications provided themselves, as well as their associated company, with credibility, helping them to attain work where the certifications were of particular importance to clients looking for it as a credential. Their certifications also provide them with access to use certain tools they were otherwise restricted from, allowing them to expand the scope of work they can perform. The company owner mentioned that while he believes an individual can have all the knowledge the certification offers in training without becoming certified, however, without it, the credibility is missing.

Teamwork:

When shadowing auditors on local audits, they were observed individually, as well as in auditing teams of two auditors. All the auditors discussed how they favored working together in the field, rather than individually. A big part was that it reduced the time it would take collect data in the field by dividing responsibilities. This also provided opportunities for sharing knowledge and insight in the field while collecting data. This combination allowed for more attention to be applied to areas in the home being inspected due to now reduced time constraints. Less time constraints lead to a reduction in possible overlooked data that could have been omitted if they did not have another team member to converse with and prioritize the scope of work. While observing the auditors in the field, it was also apparent how much more efficient their time was being used while conducting an audit on a home together versus conducting an audit individually.

Common Struggles. The core findings identified as common struggles include the diversity in the local housing stock, lack of time, lack of incentives, communication with the homeowner and report formats, and the use of EPS Score and other energy modeling tools.

Diversity in the Local Housing Stock:

Although a majority of the homes audited by the participating auditors were built between the 1950s and the 1970s, this does not conclude that there is one typical style of home they encounter. All auditors discussed how they face a wide variety of types of homes; some old, some new, some architecturally unique, while others seem “off-the-shelf”. This adds a considerable amount of difficulty to their processes in the field and back in the office when analyzing data.

The variation of homes they audit adds significant time towards collecting data in the field and analyzing the data in the office. The auditors need to know what tools to use and bring with them, which is derived from the scope of work developed for the home before an audit is conducted. This disparity experienced between the types of homes they encounter makes it difficult to use the exact same process for each home. Although there are many of the same tools and processes implemented each time on an audit, what and how they address the home with these tools and processes can be much different. Not having architectural plans to assist with calculating volumes and creating floor plans is another difficulty that relates to the diversity of homes they encounter and the extra time needed to collect that information.

Although this adds difficulty to the auditor’s processes, one auditor mentioned how this difficulty is not always a bad one to have. It was discussed how the added challenge is a good learning experience and helps with the development of an auditor in a positive manner.

Time:

Time consuming processes was a common subject that arose in the interviews in many different ways relating to different issues such as collecting data in the field while on an audit, analyzing collected data, and communicating with the homeowner. For example, a lot of time is consumed when auditing homes due to the architectural and systems variation in the homes as discussed in the previous section. Time is also affected by the tests and tools used in the field, some more critical than others for perhaps presenting recommendations to the homeowner, but maybe not so much when inputting data into an assessment analysis, or vice versa. Many of the auditors discussed that time is, what they believe, the auditing industries weakest link because it is affected by so many different aspects of energy auditing and cannot simply be addressed by one solution.

It is apparent that energy auditors are looking for faster ways to complete audits and it seems to be a constant struggle they face. The time constraints can lead to rushing and overlooked/missed critical data. This can ultimately lead to assumptions being made, and as a result, poor recommendations and a lack there of, as discussed by one of the auditors. As one auditor mentioned, their main obstacle is getting all of the desired data from an audit while still making it cost effective, because the more information that is wanted, the more time it will take to collect and process it.

Lack of Incentives:

All the auditors and the company owners expressed how the lack of incentives provided in the state of Virginia is a limitation to their work and the number of clients they receive. They believe that Virginia lacks in incentives compared to other states, and other countries, which offer more and better incentives to homeowners. It was discussed how incentives not only can encourage energy conservation, but can also spur more business for energy auditing companies. The local block grant institution, which the auditors currently work with, offers incentives to homeowners to seek an energy audit and retrofit work. Incentives can be an asset towards generating new business, but even so, it was discussed how some homeowners are still skeptical towards incentives. This skepticism is speculated to arise from past bad experiences, disappointment in expected pay-offs, and the fear of ulterior motives.

Communication with Homeowners and Report Formats:

The need to “convince” homeowners of the benefits of their retrofit recommendations was a common struggle that came up in all of the interviews. This was due to some homeowner skepticism and communication barriers encountered. This also relates to how the audit reports are presented to the homeowner. Finding ways to improve the effectiveness of how information is communicated to the homeowner is an important issue. This includes aspects such as the terminology used that may not be common knowledge, visual presentation of data, and the pay-off estimates and benefits. How one homeowner responds to the information presented to them by an energy auditor may be completely different for another homeowner, and adapting to this is a challenge they always face.

EPS Score and Energy Modeling:

The interviews revealed a general consensus for unreliability in the energy modeling tool EPS Score's results. One auditor however did mention that considering the amount of inputs required (which is low) the results were remarkably close to actual utility data he had compared it to, thus giving him confidence in the results produced by EPS Score. For the other auditors and company owner interviewed, their views were quite the contrary.

It was discussed that there was a lack in confidence in the results produced by EPS Score because of the simplicity and generalized nature of the tool, which over-valued certain savings estimates, produced problems due to inconsistent input requirements, and contained subjective and generalized inputs. One auditor described that the difficulty faced with EPS Score is due to over predicting results, which leads to homeowner dissatisfaction, and also noted that it is difficult to get the most accurate results without knowing how occupants interact in their homes and use their energy, which EPS Score completely excludes. Despite these dissatisfactions with EPS Score, there were some benefits identified for the tool, which includes providing a good report format for homeowners to easily understand, and its value in providing the "big picture" and ballpark estimates.

One energy auditor discussed how they know that EPS Score and other energy modeling tools cannot be 100% accurate, but despite that, it is always better to utilize them when conducting an energy assessment. He believes that learning the different tools and identifying the inputs and data that have the most significant effect on the results in order to increase accuracy is a learning process, which takes time and practice, something himself and his colleagues are always working to improve upon.

CONCLUSION

Energy auditors and their assessments are a key factor towards successful retrofitting homes and residential energy consumption goals. The recommendations they provide to their clients are crucial towards retrofit decision-making, and can in many ways be seen as the center of influence in the residential energy efficiency industry. The core findings of this study revealed key strengths and struggles faced by local auditors when conducting energy assessments that can contribute to decreased assessment accuracy and reluctant retrofit decision-making. In addition to the barriers identified for the region in this study, there are many comparable barriers present nationwide that are preventing active retrofit decision-making and household energy savings from reaching their potential. Investigating and identifying areas to address these barriers identified additional avenues for future research, which have the potential to translate to a nationwide scale.

Limitations to this study included the small sample size of participants and the Hawthorne Effect. Considering the small size of the local energy auditor population for the study region, and the distribution of energy auditors in each participating company, it is safe to say that a majority of the local energy auditors were included in this study. There were additional energy auditors and companies in surrounding areas who could have been included, but energy auditors in closer proximity to the research location were the preferred focus for this study. In regards to the shadowing that took place for this study, the occurrence of the Hawthorne Effect was inevitable. Every effort was made to not disrupt the normal flow of the auditors activities. But as the Hawthorne Effect describes, when one is being observed, there is always the possibility that what is being observed will change, which is out of the control of the observer.

REFRENCES

CEQ (2009). Recovery Through Retrofit. Washington, D.C., White House Council on CEQ.

Chen, S. (2010). Energy Audit of Gefle Vapen. Technology and Built Environment, University of Gävle. **Master in Energy Systems:** 67.

Clevenger, C. and J. Haymaker (2006). "The Impact of the Building Occupant on Energy Modeling Simulation." Joint International Conference on Computing and Decision Making in Civil Building Engineering, Montreal, Canada.

DOE (2011). "Energy Efficiency and Renewable Energy - Energy Savers." Retrieved September 25, 2011, from http://www.eere.energy.gov/.

Durak, T. (2011). A Framework for Simplified Residential Energy Consumption Assessment towards Developing Performance Prediction Models for Retrofit Decision-Making. Environmental Design and Planning. Blacksburg, VA, Virginia Polytechnic Institute and State University. **Philosophy**.

EAI and CSG (2009). Energy Performance Score 2008 Pilot - Findings and Recommendations Report, Energy Trust of Oregon, Inc.

EIA (2005). Table US5. Total Expenditures by Fuels Used, 2005 - Billion Dollars. R. E. C. S. E. C. a. Expenditure.

ETO (2008). Home Energy Solutions - Existing Homes. I. Energy Trust of Oregon.

Gill, R. (2011). "The shadow in organizational ethnography:moving beyond shadowing to spectating." Qualitative Research in Organizations and Management: An International Journal **6**(2): 115-133.

Ingle, A., et al. (2012). "Behavioral Perspectives on Home Energy Audits: The Role of Auditors, Labels, Reports, and Audit Tools on Homeowner Decision-Making." Sponsored by the United States Government.

Lancaster, R., et al. (2012). "Post-Retrofit Residential Assessments." Pacific Northwest National Laboratory.

Lowes, L. and G. Paul (2006). "Participants' experiences of being interviewed about an emotive topic." Journal of Advanced Nursing **55**(5): 587-595.

Parker, D., et al. (2012). "Accuracy of the Home Energy Saver Calculation Methodology." Proceedings of the 2012 ACEEE Summer Study on Energy Efficiency in Buildings.

Quinlan, E. (2011). "Conspicuous Invisibility: Shadowing as a Data Collection Strategy." Qualitative Inquiry **14**(8).

Robson, C. (2002). Real World Research: a resource for social scientists and practitioner - researchers, Blackwell Publishers Inc.

SENTECH, I. (2010). Review of Selected Home Energy Audit Tools - In Support of the Development of a National Building Performance Assessment and Rating Program. Washington, D.C., The U.S. Department of Energy, Office of Energy Efficient and Renewable Energy.

Shapiro, I. (2011). "10 common problems in Energy Audits." ASHRAE Journal **53**(2): 26-32.

USGBC (2011) Benefits of Green Home Building. LEED for Homes