DEFINING VALUE ADDING ATTRIBUTES OF HOME ENERGY ASSESSMENT

REPORT-AUTHORING TOOLS

A Thesis in
Architectural Engineering

by
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ABSTRACT

The residential building sector is accountable for more than 21% of energy consumption in the US. A significant number of single family homes in the US were built prior to the development of energy standards, and new homes are typically not built with best available energy systems. Energy audits of homes can reveal potential opportunities to save energy and are becoming more commonplace. Challenges facing the retrofit of homes and adoption of energy conservation measures include the lack of trained auditors, the time investments required, the invasive nature of in-home audits, and the lack of resources to finance significant home upgrades. The National Energy Leadership Corps (NELC) is an education and research program designed to prepare students to engage homeowners in home energy assessments. The process results in the creation of a report characterizing home energy use and providing energy efficiency improvement recommendations and resources to homeowners. The time required for entry-level students to prepare this report is a significant limiting factor in this process. This research examines the factors impacting the design and use of an automated tool to support the generation of home assessment reports. The design of the report content and presentation style is examined to inform the design of a web-based tool to support report authoring and presentation to homeowners. Iterations of use, improvements, and evaluation of the tool are used to demonstrate key value adding attributes of the tool leading to: (1) reduced time required to prepare reports, (2) support the on-going learning of users about home energy efficiency measures and the selection of measures (3) support continuous interaction of homeowners and the assessors, (4) enable entry-level users to prepare reports. The results of this research provide a foundation for the design of scalable information technology tools to broadly support the home energy assessment process and the encouragement of actions by homeowners.
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CHAPTER ONE INTRODUCTION

Concerns about saving energy have significantly increased in the recent years as a result of rising energy costs, climate change, and increasing interest in energy independence. According to the U.S. Energy Information Administration (EIA), buildings are responsible for consuming more than 40% of energy and, rather surprisingly, more than half of this consumption is dedicated to the residential sector. EIA data demonstrates that residential sector has used 20.87% of total US annual energy consumption in 2015.

![Figure 1-1. Energy Flow (2013), quadrillion BTU. Source: U.S. Energy Information Administration (EIA)]](image)

Significant effort has been placed in both creating energy efficient new homes and retrofitting of existing homes. Retrofitting of old homes can potentially save up to 40% on average energy use in each home (“Annual Report of the White House Task Force on the Middle Class,” 2010). There are many programs and methods for performing energy audits and suggesting home improvements, however few have been found to be effective at motivating homeowners to act upon the recommendations that result from audits. In some cases, when action is taken, homeowners do
not observe the energy savings predicted, and have become skeptical about the value of home energy efficiency investments (Head & Hunt, 2014).

Studies have examined obstacles to effectiveness of home energy assessments. The White House Council on Environmental Quality (CEQ) suggests that costumer’s lack of access to straightforward and reliable information, lack of access to enough financing, and nationwide shortage of skilled workers and green entrepreneurs are the main barriers to a national retrofit market (Force, 2009b). Energy audits are mostly performed by technical professionals with minimal attention to reflect the voice of homeowners (Sprehn at al., 2015). In addition, many times homeowners mistrust the energy experts or energy audit contractors. This mistrust is due to the fact that in many occasions energy auditors are advertisers of specific products, providing biased or incorrect information about them (Syal et al., 2013). Lack of personalized information (Desmedt et al., 2009), recommendations that are costly and hard to implement.

The National Energy Leadership Corps (NELC) was developed in response to the challenges in the home energy efficiency process. The NELC was conceived to engage students in the process of home energy assessment, and to explore methods to offer free home energy assessments to the homeowners. The NELC, which is discussed more in Chapter 2, has trained many students in multiple locations in the six years leading up to this research and its methods have been tested in multiple locations including Pittsburgh, PA, State College, PA, and Philadelphia, PA.

One of the goals of the NELC has been to improve the process of preparing report and the design of support tools that can automate this process while also allowing customized content for each homeowner. The first attempt to create such a tool was a Microsoft Word report template and a Microsoft Excel file with data that could be copied and pasted into reports. A second tool was
created using Microsoft Office Access to integrate the report template and database content to generate a report in MS Word report that could be tailored for each case. This effort enabled the design of advanced databases and report formats, as well as permitting experimentation with the creation of reports.

This research builds upon this experience with the goal of defining a set of attributes and corresponding value-adding processes to inform the development of energy audit report authoring tools. An emphasis is placed on key value adding processes that save time, supports learning of users, supports interaction with homeowners and is easy to use by entry level users. The attributes of this tool are defined based on the experience of using the early versions of the tool, as well as outcomes of scientific literature. The specific objectives of the research are:

1. Define specific opportunities for advancement of home energy report writing through literature review

2. Define key value-adding attributes of report-writing support tools and represent these attributes in the design a prototype tool

3. Evaluate the value of attributes of the tool through its use in the energy assessment process and through review of user/expert comments

4. Define implications of this research in design of energy audit report automation that can be applied in the residential and commercial building sector.

Chapter 2 of this research provides background information on the important topics related to residential energy assessment and report writing is provided. Chapter 3 outlines the research objectives along with the steps to achieve them. Chapter 4 describes the desired attributes of an automated report tool developed by studying similar tools and methods, and introduces a prototype tool created to include these attributes. Chapter 5 evaluates the tool through its use to conduct a
series of home assessment reports by a research team, the definition of additional desirable attributes based on this experiences, and the subsequent redesign prototype tool. Chapter 6 describes the evaluation process for the second tool through a series of structured interviews with experienced users. Chapter 7 summarizes the results of this research, limitations, and suggests future research topics.
CHAPTER TWO BACKGROUND AND PROBLEM STATEMENT

This chapter provides a review of the literature related to home energy audits and energy audit report writing. The first section focuses on residential energy audit processes and reviews background and research related to energy assessment. The second explains the NELC program background and practices. The third section focuses on home energy audit report design and the research on effective methods of report delivery.

2.1. Residential Energy Audits

In recent years, rising energy costs and concerns about climate change have resulted in establishment or further development of energy audit programs, especially in the residential sector. Studies suggest that by using existing techniques and technologies in home energy audit and retrofit, there is a potential save of up to 40% in average home energy consumption (Force, 2009a).

According to ASHRAE (ASHRAE, 2011), there are three levels of effort for energy audits. Level-1 energy audit is mainly a walkthrough of a building and is geared toward identification of potential for saving energy in a building. Level-2 energy audit is based on the findings from level-1 along with additional diagnostic testing and data collection, as well as a detailed analysis of utility bills and consumption data to identify specific problem areas. Level-3 Audits include analysis and simulation of potential energy savings, and estimated return on investment for packages of energy efficiency measures.

Among various energy audit methods in the United States the most well-known energy audit programs are the Residential Energy Services Network (RESNET) and the Building...
Performance Institute, Inc. (BPI). Both programs have created means and methods of training professional energy auditors and certification processes and are described in more detail below.

2.1.1. The Residential Energy Service Network (RESNET)

RESNET has introduced three approaches to energy audit (“What is the HERS Index? | RESNET,” 2016):

**Home Energy Survey:** This approach is a visual inspection of various features of the home such as building envelope, HVAC equipment types and ages, lighting and appliances, among others. This method does not include use of special equipment to diagnose problems in a house.

**General Energy Audit:** This approach expands on the home energy survey by collecting more detailed information about performance of a house through financial analysis of energy cost as well as use of diagnostic equipment such as blower door test, combustion analyzer and infrared camera.

**Comprehensive HERS Rating:** In this approach, the information collected at a general audit are used to generate a HERS score which then allows to compare performance of a house to other similar homes.

2.1.2. The Building Performance Institute (BPI)

BPI delivers home energy audits using a house-as-a-system approach in which components of a house – insulation, HVAC systems, lighting. - are considered parts of a whole that impact each other and should not be treated separately. The BPI energy audit starts with an interview with the
owner to understand their concerns and then continues with an interior and exterior walk-through and includes use of diagnostic equipment (blower door testing, infrared imaging and so on.). BPI then uses energy simulator software to identify the highest return on investment of packages of energy efficiency recommendations ("Home Performance | BPI | Building Science Professionals," 2016).

### 2.1.3. Challenges of Current Energy Audit Delivery Programs

Although the demand for energy audit programs has risen in the past few years, many of the homeowners are hesitant to implement recommended home improvements, resulting in limited market adoption of these programs. Studies suggest that about two-third of homeowners are not willing to purchase home energy audits for their own house (Sissine, 2012). Another study demonstrates that post-audit upgrades are successful only when highly attractive financing options are available (Fuller, 2011).

Traditional energy audits are beneficial in many ways but have considerable shortcomings. They are time consuming, require skilled auditors that have been trained over a period of time and are short-lived in that their focus is on a one-time intervention as opposed to long term engagement (Riley et al., 2012).

Trust is another barrier for homeowners to consider home energy improvements. Whelton et al. (2012) found that in most cases energy auditors try to sell a product which results in homeowners hesitation and loss of trust in the recommendations. They may also have minimal trust in knowledge of the auditor and accuracy of the audit (Palmer, Walls, Gordon, & Gerarden, 2013). The Shelton Group (Head & Hunt, 2014) also revealed that in many cases, homeowners that do
make investments in energy saving home improvements do not tend to see the predicted levels of energy savings promised by home energy auditors leading to further erosion of trust in the process.

2.2. The National Energy Leadership Corps (NELC)

The NELC is an alternative method for delivery of home energy assessment in which college students are trained to deliver free assessments to homes in the local community. A training curriculum, assessment model, data collection, data storage tools, and reporting tools have been developed over the years based on outcomes of research and prior experiments (Wu, 2016). The goal of NELC home energy assessment is to develop effective practices and procedures for energy assessment that leads to more effective energy related home upgrades (Riley et al., 2012).

2.2.1. Overview of NELC program and its background

The NELC energy assessment is a hybrid form of audit that includes a structured interview with homeowners, a home walkthrough, and the use of red camera thermography. Because the program is intended to be delivered by students that are not seeking to “sell” a products, the emphasis of the NELC program is on in-person interaction with the homeowners and gaining their trust. A key strategy of the NELC is to focus on responding to unique circumstances encountered in each home and conducting surveys, walkthroughs and presentations of findings based on homeowner’s priorities and goals, cognitive style and worldview.
To address the challenges and shortcomings of current energy audit practices, NELC emphasizes customizing the reports for the homeowners based on established market segments of cautious conservatives, concerned parents, true believers, and working class realists as defined by the Shelton Group (Head & Hunt, 2014). This emphasis is also based on studies that show that when the information format is matched with individual cognitive styles, potential recall of the content and usability rating is highly improved (Blazhenkova and Kozhevnikov 2009; Sprehn et al., 2013). Key opportunities to develop trust during the home assessment process as identified by (Wu, 2016) are also integrated into the NELC process.

2.2.2. NELC strategies in response to the current energy audit challenges

Some of the main barriers of home energy audits were discussed in section 2.1.3. The NELC program strategies to address these challenges are discussed as follows.

**Issue 1: Homeowners rarely implement recommended energy improvements**

One of the most important shortcomings of current practices is unwillingness of homeowners to act after an assessment. NELC provides guidelines for student auditors for identifying recommendations based on homeowners’ personality and priorities also in conjunction with feasibility of implementation. A key distinction of the NELC is the development of recommendations homeowners are likely to implement based on a variety of factors as opposed to strictly based on financial return on investment. Recent research showed that homeowners are more willing to act upon the recommendations when the audit service is customized based on their concerns and preferences (Wu, 2016).

**Issue 2: Homeowners cannot afford to implement recommended energy improvements**
Another challenge is that many times the recommendations are not affordable for the homeowners. In the NELC program, the energy efficiency recommendations are proposed based on analysis of a mix of energy related issues, health and safety issues, as well as the budget that the homeowner states is willing to spend on energy upgrades and their worldviews. Another emphasis of the NELC is the linkage of homeowners to local, state, and national programs that can defray the capital cost of energy efficiency improvements.

**Issue 3: Homeowners do not completely understand the information in their reports**

Energy auditors tend to communicate with engineering language which makes it hard for homeowners to understand the process. In NELC, student auditors are trained to communicate with homeowners with understandable language and to provide homeowners with training materials and additional resources. Additionally, the use of understandable language for audit reports is emphasized and included in databases used to support report-writing processes.

**Issue 4: Homeowners do not trust in accuracy and reliability of the audit**

An important missing piece is the lack of trust in reliability of data. NELC program trains students to deliver energy audits for free, as opposed to selling home upgrade products. Wu (2016) also conducted detailed research on trust and developed a framework for identifying how trust can be accumulated during the process of home assessment. The results of this research have produced an increased emphasis on building trust in the NELC training design (Wu, 2016).

### 2.2.3 Process of Home Energy Assessment

In this section an overview of the NELC audit flow is provided. Students first participate in a semester long course that is developed based on the flipped classroom approach (Marks et al.,
In the class, students learn about *home as a system* principles, which means the home is a system of interactions among building components, energy systems, and occupant behaviors, and each of them affects the entire system (“Whole-House Systems Approach | Department of Energy,” 2016).


### 2.2.3.1 Initiate Contact

The NELC is promoted in targeted communities in which the NELC course is being offered, and an online form to allow interested homeowners to request an assessment. The NELC contacts interested homeowners before the assessment and send them a short online survey that includes basic information about the home, including address and location, construction year, size of the home, and number and age of residents.

### 2.2.3.2 Research

In groups of 2-3 people, the assessors conduct research on the house using web-based resources including Google Earth and Zillow to inform the planning of the assessment and additional background about the home including home’s specifications, size, age, solar orientation, number of bedrooms, and bathrooms.
2.2.3.3. Plan and Prepare

The assessors divide the tasks before getting to the targeted home. These tasks include conducting the interview and entering the data into NELC application. The application allows students to record the data collected on site, taking pictures, taking infrared pictures and taking notes.

2.2.3.4. Conduct Site Visit

The site visit consists of a 30-minute interview with the homeowner(s) and 60-minute home walkthrough. During the 30-minute scripted interview, the assessors learn about the house and assess homeowner’s confidence level, energy awareness, concerns and issues, priorities and goals. A key part of this exchange is the obtaining of a full year of electrical and heating fuel utility bills.

Walkthroughs consist of two parts: 20 minutes outside and 40 minutes inside. The exterior audit focuses on the envelope and building materials, and locations of penetrations for vents. The inside walkthrough investigates any issues detectable from the inside, such as moisture damage, leaking windows, uninsulated walls and so on. Pictures, key features, and systems, as well as potential problems are captured with both regular camera and infrared cameras (Figure 2-1). A particular emphasis is placed on exploring any issues or concerns raised during the initial interview.
2.2.3.5. Analysis

Using utility bills and other information obtained during the assessment, the assessors disaggregate utility bills to identify energy expenditures for heating, cooling, and base loads, and generate a score for the home such as Home Energy Yardstick or DOE Home Energy Score which will appear on the report. Key safety, health and energy issues are identified, and corresponding recommendations for homeowners are selected from an already developed database of issues and recommendations.

2.2.3.6. Report Generation

The data that is being collected during the assessment, pictures, and the analysis results are then used to create a report. Each report contains six pages which will be described later in more detail. A sample reports is included in Appendix A.
2.2.3.7. Presentation and Follow-Up

When possible, NELC assessors arrange for a meeting to sit with the homeowners and review the report. In the presentation, they familiarize recipients with the content and answer questions that arise. A key outcome of this presentation is the initial response of homeowners to the recommendations in the report. A survey is then presented to the homeowner to seek detailed feedback on the recommendations made and user experience in the process. The results of these surveys serve as means to identify opportunities for improvement and gather trend data about the response of homeowners to various types of recommendations. If resources permit, follow-ups are pursued to track the homeowners’ activities based on the report.

2.2.4. Comparison of NELC Home Energy Assessment to BPI Energy Audits

Wu (2016) compared the NELC home energy assessment and BPI traditional energy assessment (Figure 2-2). This comparison concludes that the main difference between the two programs is the emphasis of BPI audit on diagnosis tests, such as blower door and carbon monoxide tests, while in NELC the focus is on understanding homeowner’s preferences to develop trust and goal alignment between the homeowners and energy auditors.

As previously stated, current research builds upon the NELC approach. The tool that is developed in this research, on one hand is based on experiences gained in NELC home energy audit and on the other hand can be used toward developing more trust and delivering high quality reports in shorter amount of time.
Figure 2-2. Workflow difference between the traditional BPI energy audit and the NELC home energy audit (Wu et al., 2015).
2.2.5. NELC Home Energy Assessment Report

In traditional home energy assessments, the audit report usually is developed by a singular assessor based on their experience. These reports do not have a standard format across the industry and are often oriented in a technical presentation. This approach usually result in reports with too much technical information with little customization for different recipients (Sprehn, 2014).

Information can be presented in different styles and formats to influence perception of the information, as well as the response towards it. There are three primary categories of presenting information: Pictures or Object Imagery, graphic and abstract presentation or Spatial Imagery, or in words, also called “Verbal Format” (Kozhevnikov et al., 2005). Information is usually presented using a combination of these categories.

The effectiveness of the format of presenting information is closely related to one’s cognitive style (Sprehn, 2014). Cognition generally means the way a person perceives the word and their mental process of receiving and understanding the information as well as decision-making. Appropriate and personalized method of presenting information can affect the perception and comprehensiveness that is necessary for decision-making (Desmedt et al., 2009).

Sprehn (2014) designed an experiment to test the statements above in the context of energy audit reports and their effectiveness. She designed multiple reports, with varied contents, and presented them in differing styles to subject matters. The research indicates that two content elements, summary of the audit experience and summary of the audit recommendations are essential for the report success. Regarding formatting of the report “actual building photographs” and “actual numbers from energy assessment process” were evaluated as essential.

Sprehn’s study addressed a lack of human factor in the audit reports and a reliance on technical language, which not motivating enough for the homeowners to act. The research also
shows that cognitive style plays an important role in the decision-making process of home upgrades. Proper formatting of the reports plays an important role in getting information to resonate with the users (K. Sprehn, 2014). Results of this research were used to inform the design of a special format for NELC reports.

In early phases of the NELC program, a significant source of complication and time investment by students was the process to draft, obtain feedback, and ultimately deliver a professional report to homeowners. To address this challenge, a standard report was designed. Key features of this report and the value adding processes, it provides are described below.

The report is limited to six pages, to encourage recipients to read and digest without creating a perception that it will be too time consuming. The design of the Report Template is based on a series of content elements that have been deemed valuable to include and also reasonable for student participants to generate. The individual sections of the report are described below and sample pages are illustrated (Sample Report in Appendix A).

**Page 1: Cover letter** – The purpose is to introduce the report in a way that engages reader, generating interest in the content. Key features include: report header, personal opening sentence/message, and template language regarding purpose and content of report.

**Page 2: Home Facts and Owner Priorities**- This section reflects unique aspects of the home and owner priorities. Key content includes: address and basic facts, images of home, and owner priorities and goals.

**Page 3: Home Energy Summary** – The summary helps readers understand how energy is being consumed in the home by fuel type, and by cost, and how this compares to other homes of the same type. Key content: utility disaggregation, home energy score, charts showing energy distribution in home compared to average (Figure 2-3).
Page 4: Observed Health and Safety Issues and Energy Related Observations – This page presents the key health, safety, and energy-related observations made about the home during the assessment. The purpose of the Safety and Health section is to call attention to issues that could
affect occupant productivity and health which may or may not be directly related to energy. Key content includes images of descriptions and health and safety issues observed in building. The purpose of the Energy Related Observations section is to present a summary of energy related issues that have been observed in the house. Content includes images and descriptions of individual observations that most influence the recommendations.

**Page 5: Recommended Energy Efficiency Measures** (EEMs) – This section contains the top five energy efficiency recommendations based on the energy related observations. Content includes description of measure, individual recommendations descriptions, key benefits of implementation, images or info graphics and typical range of savings earned (Figure 2-4). Additional recommendations that are applicable to the home and homeowner, but not perceived as first priority, are also included in an appendix of the report.

**Page 6: Steps for Future** – Outlines opportunities for energy improvements, along with language that conveys the auditors’ appreciation of the homeowner for participating in the NELC home energy assessment.

The base language in the report acknowledges the existence of various worldviews and is modified based on known values of the recipient. The recommendations given to a homeowner with environmental concerns differ from a homeowner focused on saving money on energy bills. Priorities and goals of the recipients that have been obtained during the survey and walkthrough are also reflected in the report, resulting in a report and recommendations that are aligned with the needs of the recipients.
Our Top Recommendations

Based on our assessment of your home, we recommend the following actions for your home:

1. Add Attic Insulation - Fiberglass
   Boost your comfort and home heating performance
   • Attic insulation stops heat from escaping your home which will contribute to making your home more comfortable.
   • Installing attic insulation in your home will not only produce a quick payback but it will also reduce your utility bills.
   • Reduce your utility bills and spend less money on energy and more on the things you need for your family and home.
   **Potential Energy Reduction: 10% - 20% = $234 to $469 over 5 years**

2. Air Seal Ductwork
   Boost the efficiency of your heating/cooling unit
   • Increase your comfort in your home by ensuring that duct work is operating at optimal performance.
   • Gain more control over energy lost through leaks in your ductwork system by air sealing.
   • Save money by air sealing ducts which are likely heavily contributing to high energy bills.
   **Potential Energy Reduction: 3% - 8% = $70 to $187 over 5 years**

3. Insulate Water Piping
   Gain control over heat loss by insulating pipes
   • This easy step will increase the value of your home and your overall comfort while saving you money.
   • Save money by reducing the conduction heat losses from uninsulated distribution pipes.
   • Self installation of pipe insulation is very low cost and has a one year payback on top of yearly savings.
   **Potential Energy Reduction: 0.5% - 3% = $2 to $12 over 5 years**

4. Insulate Basement Ceiling
   Save utility bill by reducing heat loss through basement.
   • Improve the resale value of your home by comparing comfort, utility bill savings and durability to less efficient homes.
   • Earn a quick payback by insulating basement ceiling with relatively inexpensive materials.
   • Increase the comfort of your home without increasing utility bills by minimizing temperature variations within your home.
   **Potential Energy Reduction: 10% - 20% = $117 to $235 over 5 years**

5. Weatherize Door
   Keep your home comfortable and limit drafts easily
   • Taking this step will limit drafts in your home which will enhance your comfort and overall home performance.
   • Give yourself more control over the energy you pay for by weatherstripping doors to lower air leakage.
   • Increase your saving by making this easy and cost effective step to keep energy from escaping your home.
   **Potential Energy Reduction: 0.5% - 4% = $11 to $94 over 5 years**
The report is designed in a way that allows for different cognitive styles to result in improved perception of its content. The format of the report and the recommendations can be modified to address individuals that are object, special, or verbal oriented learners.

The report tool also draws upon an extensive database of energy efficiency measures with respective detailed descriptions, links and videos to support homeowners seeking to take action. While limited descriptions are included in actual reports, appendices and online report versions offer easy access to these resources.

2.3. NELC Report Generator Tool

While there is room to improve different aspects of home energy assessment, it was observed that report writing and delivery were key bottlenecks in the NELC process and could be improved through automation and information management tools. Considering that report writing in one of the most difficult steps of creating a report, and creating an automated tool for it can save considerable time and effort, the NELC team defined a project to create a tool to support the authoring and delivery of home energy assessment reports. The team created two beta versions of this tool using Microsoft office and this research is continuance and expansion of this effort. In the following sections overview of the early iterations and their shortcomings, which led to design and creation of SMARTdwell tool, is provided.
2.3.1. NELC Report Generator Tool: Version 0.1

The first reports created by the NELC team were based on a template created in Microsoft Word and required extensive copying and pasting of content from databases, and formatting of images. To improve this process, and to initiate the process of designing a fully automated process, a Microsoft Access tool was created to generate a Word report. The MS Access file has the following attributes:

1. It is connected to a Microsoft Excel document which includes all the Energy Efficiency Measures (EEM).
2. Pictures related to the EEMs are in the same folder with the Access file. When populating the report, the related pictures are inserted into the report from the previously defined path.
3. Pictures related to the different priorities that the homeowner may have while requesting a home energy assessment are also stored and integrated in the report based on the selections made in the MS Access tool.
4. The MS Access file requires choosing four sets of topics from the provided drop down menus (Figure 2-4):
   a. Cognitive style of the homeowner; which is selected from these options:
      i. Spatial
      ii. Verbal and
      iii. Object
   b. World view of the homeowner; which can be one of these options:
      i. True believer,
      ii. Working class realistic,
iii. Concerned parent, and

iv. Cautious conservative.

c. Top five priorities of the homeowner for the assessment; selected from these options:

i. Decreasing dependence on utility companies

ii. Improving the condition and value of the home

iii. Improving control of the energy used in the home

iv. Increasing the comfort of the home

v. Protecting the environment from pollution and damage

vi. Saving money on heating and energy bills

vii. Supporting local economy and jobs

viii. To be responsible and not waste energy

ix. To help reduce reliance on foreign fuels

d. Top five recommendations or EEMs that the student assessors want to present to the homeowner which is selected from a list of all the EEMs that are in the database.

5. The tool populates a report with some static text, lists five priorities with their relevant graphics, along with the top five EEMs with their associated images. The assessor should fill in the blank spaces related to energy consumption, utility bills, facility facts, health and safety issues, energy related issues and the amount of saving based on the recommendations.
2.3.2. Limitations of the NELC report writing tool version 0.1

Although the Access tool is beneficial and has multiple advantages, it has some shortcomings:

1. It is not fully automating the report writing process. The tool automatically generates some parts of the report. However, an assessor still needs to manually insert most of the necessary information.

2. The time required for generating the report is too long. Although compared to the original practice of writing a report, the current tool saves considerable time, it is not fully automated. Copying and pasting the graphics, sizing the text and graphics to fit
into provided spaces and the page limit, performing utility bill analysis, as well as creating and inserting relevant charts into the report for multiple data entries are time consuming processes. If automated, the report generation could result in considerable amount of time savings.

3. Support for learning and serving as an educational tool. The use of the tool is cumbersome and can detract from training and continuous learning of users. Features are needed that help users learn about EEMs, understand other options for priorities and goals, or how the report would look when different cognitive styles are selected. The tool also lacks a direct way of presenting all of the information that it carries.

4. The report results in a static home energy assessment process. The report generated using the access tool is a static report which serves as a finish point to the process of the home energy assessment. Interaction with the homeowner is limited to presenting the report with limited options for tracking how users are doing with the recommendations or issues elaborated in the report. The only way to continue working with the homeowners is through sending surveys to them and asking them where they stand in regards to the reports, which is neither the most efficient way nor results in a high response rate.

This research aims to define the desired attributes of a new report writing tool based on the experience with the old NELC report writing tool, preserving its advantages and addressing the discussed shortcoming, then create and test the tool. This process will be discussed more in chapters 3 and 4.
2.4. Information technology supporting report-writing

The use of information technology to support report writing is increasing prevalent. Tools include data entry using tablets, cloud-based data management, and web-based report design coupled with custom report designed for target audiences and purposes.

![IPad Application as a platform of data entry](image)

Figure 2-6. IPad Application as a platform of data entry

An example of this approach is offered by the approach of the IT firm Inspect2Go which serves a variety of customers with the management of data collected through inspections of homes, cars, and other applications (website). While the goal of this research is focused on improving data
management for report writing, the full integration of on-site data collection through a tablet application and cloud-based management is not addressed. However, the report writing tool design and the experience of the NELC program designers in the creation of a tablet application to support data collection during home energy assessments (Figure 2-5) are considered inputs to this research. Specifically, the databases of house facts and survey responses used to create reports is fully aligned with the NELC on-site data collection tablet application.

2.5. Chapter Summary

Chapter 2 presents an overview of the literature of home energy audits and existing methods. The second section focused on introducing the NELC program and its comparison with the existing methods. The third section presented the NELC home energy assessment report and version 0.1 of the report writing tool.

This chapter articulates the need for further research investment in the home energy assessment delivery process. This research will address the creation of a home energy assessment report writing support tool based on the experience of using early versions. Key improvements pursued include: (1) reducing the time that is required for creating a report, (2) supporting learning of users, (3) supporting ongoing interaction with homeowners and (4) enabling the creation of reports by entry-level users. In the following chapters the process of building on the outcomes of study of background and designing a new tool is described.
CHAPTER THREE METHODOLOGY

Chapter 3 presents a framework to build on previous research and create and test a web-based report writing tool to be used in the process of home energy assessment. The research objectives are defined based on the results of literature review and the experiences of NELC home energy audit. The process of meeting the objectives and the evaluation criteria are discussed.

3.1. Research Objectives

The goal of NELC research team is to deliver low-cost/free energy assessments to the homeowners and encourage homeowners to act upon recommended energy upgrades. This goal of this research is to build on the previous efforts of NELC research and experience and develop a set of attributes that can be used to design, create and evaluate a tool which automates the process of generating home energy assessment reports. Attributes of this tool are evaluated based on their success in saving time, support of ongoing learning of users, improving interaction with the homeowners and support of entry-level users in creating reports.

The objectives of this research are illustrated in figure 3.1 and described below.

Objective 1: Define specific opportunities for advancement of home energy report writing through literature review to inform the design of automated tools for generating reports.

Through an extensive literature review, the current body of knowledge about the necessity of home energy audits, different types of energy audit and delivery methods and the strengths and weaknesses of the current approaches are studied. In addition existing methods used to support the authoring of home energy audit reporting, and potential technologies that could support the
generation of reports are reviewed and shortcomings of current approaches are identified to be used in creating a new home energy assessment report writing tool.

**Objective 2:** Define key value-adding attributes of report-writing support tools and represent these attributes in the design a prototype tool to support energy audit and assessment reporting process for volunteer energy assessors who possess minimal experience in energy auditing and report authoring.

Based on the attributes identified in literature, and current understanding of valuable report content, a prototype tool is created in a web-based environment. Key features of the tool enable a blend of custom, static, data-driven, and calculated content. Additionally, the design of databases of energy efficiency measures, images, and health and safety recommendations are designed in a way that supports entry-level users. Entry-level users are a target group of this study since the tool is created and tested in an educational environment is used by students who are trained in a semester-long course as oppose to professional auditors who may have been trained over the course of a few years and through huge investments. A functional version of the tool is created that is capable of producing web-based and PDF reports in a series of test assessments used to evaluate the tools and its key attributes.

**Objective 3:** Evaluate the value of attributes of the tool through its use in the energy assessment process and through review of user/expert comments and make recommendations for improvements.

A series of home assessments are conducted to evaluate the tool. These are carried out by volunteer students who have participated in a semester long course about NELC home energy assessment, are familiar with the report and its generating required information. 30 assessments are performed to identify key value adding features of the tool and potential improvements. This
process is concluded when key attributes of the tool have been evaluated for their capability to reduce the time required to generate reports, support entry-level users in report generations, and enable continuous education of users. A refined version of the report writing tool is then developed to enable new features to be added found that were determined to be vital to the use tool. The new features are then evaluated by experienced users of the original tool through a structured interview process.

![Research Objectives](image)

**Objective 4:** Define implications of this research in design of energy audit report automation that can be applied in the residential and commercial building sector.

Based on research results, recommendations are provided for the design of scalable tools to support home energy assessment programs and the collection of data from multiple homes as well as tracking of user interaction with the tool. Recommendations for the overall approach and key attributes of this tool that can be applied to other types and scale of buildings are provided.
3.2. Research Steps

The steps to achieve the goals and objectives of this research are shown in figure 3-2. The figure shows how each step is aligned with an objective and presents the relationship between previous NELC research, current work and future questions. Each step then consists of one or more procedures. In this section, steps and their required procedures are explained in further detail.

**Step 1: Review research on content and impacts of report formatting**

Step one involves following procedures:

A. Perform an extensive literature review on energy assessments in general and previous research by NELC team to get familiar with home energy audits types and processes

B. Become familiar with the NELC home energy assessment process through training and participating in a home energy assessment including the delivery of a report to client

**Step 2: Evaluate design and creation of basic tool to generate reports using MS Access and MS Word template**

A. Review past research that has been conducted on the content and format of home energy audit reports by generating NELC home energy assessment reports using the old tool

B. Understand the design concepts and features including a prototype tool for report generation using MS Access and an MS Word template
Step 3: Develop a set of value-adding attributes of tool through its use in preparing reports

A. Generate a number of reports (five) using the basic MS Access tool to gain experience with variable types of content and attributes of the tool.

B. Address the opportunities for advancement of report writing process based on the experiences if working with the previous iterations of report-writing tool.

C. Define the most beneficial values for the tool that are aligned with core goals of NELC project and are defined based on past experiences and studies of background research.

D. Define goals, objectives and research question with a focus on defining value-adding attributes of tools to inform the design of future tools.

E. Develop a set of specific attributes for the tool based on the defined goals, objectives and values.


**Figure 3-2. Research Steps.**

**Step 4: Design of online tool to support report preparation (PDF and online)**

A. Develop graphic presentations of attributes reflection on a MS Word report that had already been created using the early MS Access tool.

B. Comment on each of the sections of the Microsoft Word version of report and emphasizing on the values and goals in each section and the information that each section should convey.

C. Create a graphic mock-up of the report including layouts, images, styles, and content.
D. Design and create graphic mock-ups for all the section of the report writing tool in the form of screen designs using graphic software such as Adobe Photoshop, Adobe Indesign, and develop annotations to describe functionality.

E. Work with web development subcontractor to develop a beta version of the online tool.

**Step 5: Evaluation of online tool through its use by students in preparing reports**

A. Use the new tool in multiple home energy assessments and evaluate its effectiveness in addressing the values and target end points through empirical study of these assessments.

B. Identify potential improvements and additional features to include in a revised version of the tool including a new set of attributes describing key functions of the tool.

**Step 6: Refinement of tool to enable key value-adding functionality**

A. Create upgraded graphic mock-ups for both report and report writing tool to specify changes and improvement.

B. Work with web development subcontractor to implement changes in the online tool.

**Step 7: Evaluation of tool through evaluation of experienced auditors**

A. Develop a set of structured interview questions to ask from at least 3 of the past users of NELC report writing tools.

B. Perform a demonstration of the tool for each interviewee.
C. Receive feedback and evaluate the attributes of the tool based on the evaluation criteria.

**Step 8: Define evidence-based list of tool attributes to inform future versions**

A. Define the key attributes that are successfully implemented in the tool based on field use and review of the tool by experienced users

B. Explain limitations of the current tool and the unsuccessful attributes

**Step 9: Suggest scalable version of tool for broader adoption**

A. Make recommendations for future research and apply the findings to other sectors including commercial building energy auditing.

### 3.3. Evaluation Process

The objective of this research is to define a set of value-adding attributes that can be used to design, create and evaluate a home energy assessment report writing tool. To evaluate the attributes, they are measured based on their success in adding value to the home energy assessment process. The most beneficial values for this research and the evaluation criteria are defined in this section.
3.3.1. Value Adding Attributes of Energy Assessment Report Writing Tool

Value adding attributes are defined by their role in providing continuous benefit to the process of creating, editing, and delivery of content in home energy assessment report. An automated report writing tool can add a variety of value to the process of home energy assessment. Four key values are identified for this research which are in line with the goal of delivering free or low-cost customized home energy assessment to the community with the help of volunteer student auditors. These values are explained as follow:

3.3.1.1. Reduce time required to prepare report

Creating the report is one of the most challenging steps of home energy assessment process. Report writing can be highly time-consuming especially for an entry-level student can be even higher. In addition, if the time required to prepare a report can be reduced, the assessors can dedicate more time to deliver additional home energy assessments in their community.

3.3.1.2. Ongoing Learning of Users

One of the shortcomings of the traditional home energy audit methods is that the homeowners do not understand the process and do not learn from it and this results in low amount of acting upon recommendations of the report. In the NELC, a goal is to teach homeowners about energy efficiency and engage them with the process. In addition, the tool can be a source of information for entry-level student auditors who are being exposed to the process for the first times. Examples of opportunities for users to gain additional knowledge include:
a. Energy Efficiency Measures that are well described and accessible in a database that can be browsed.

b. Reference of users to additional information and resources

c. Collection of feedback so assessors can improve their performance

d. Facilitation of interaction between homeowner and assessor and the exchange the information that is beneficial for both.

e. Collecting information about homeowner’s actions to inform the types of recommendations that are typically acted upon in variable conditions.

3.3.1.3. Enhanced interaction with homeowners

There are opportunities in a long-term relationship with the homeowners that can result in their higher motivation to follow the recommendations and upgrade their home from an energy standpoint. The use of online methods to deliver reports and interactive features can provide a platform for the NELC team and the homeowners to interact over a longer period of time.

3.3.1.4. Support preparation of report by entry level users

A goal of the NELC program is to deliver home energy assessment with the help of volunteer students. The report writing tool should support this users and reduce the expertise that are required to make a report. Types of expertise expected to be reduced are written communication skills, the identification of appropriate energy efficiency measures, and the authoring of custom reports that reflect unique circumstances of homeowners.
3.3.2. Tool Evaluation Criteria

For this research, value of a specific attribute of the report writing tool is demonstrated through use in creating reports or review by experienced users. Four evaluation criteria are defined based on the defined values of the tool and are described below. Each of them includes an explanation of the conditions in which the criteria are met. These criteria will be used to evaluate the functionality of the tool and its capability to (1) reduce time required prepare reports, (2) support report preparation by entry-level users, (3) contribute to ongoing learning of users, and (4) support the ongoing learning of users, and demonstrate observable value to the report writing process. Each of these desirable outcomes and the criteria used to evaluate the tool are described below in a way that identifies how the attributes of the tool can:

1. **Contribute in reducing time required to prepare report**: Time savings will be evaluated based on the reduction of steps required to prepare reports and examples of manual processes that are now automated. The primary source of data derived from comparing the previous tool described in literature to the prototype tool.

2. **Contribute to ongoing learning of users**: The support of ongoing learning by users will be evaluated by examining the features of the tool that create opportunities for users to access additional knowledge during the assessment process and use of the report over time. While learning will not be measured directly, the success of these attributed will be evaluated based on improvements on accessibility of information, and expansion of the types of information included in the tool.

3. **Contributes to enhanced interaction with homeowners**: The tool will be evaluated based the creation of specific opportunities to support exchanges between
assessors and homeowners either online or in person, and that can support efforts to build a long-time relationships with homeowners.

4. **Support preparation of report by entry level users**: The support of entry-level users will be evaluated through the identification of tool attributes that reduce expertise required.

**3.3.3. Tool Evaluation Process**

The attributes of the tool is developed and evaluated in two phases:

**Phase 1**: Preliminary attributes are defined and implemented in a web-based platform. This trial version is used in 30 assessments and the value of key features is assessed based on observations of the tools use and the feedback from the students who use the tool. For example, time saving is assessed by the research team by comparing the time required to prepare reports compared to the time needed in the early version of the tool. In addition, students are asked if the amount of time that they spend to create a report is reduced through the use of the tool. NELC advisor also observes and measures students’ productivity in creating high quality reports. For example the number of opportunities to obtain feedback on the report and make improvements.

Contributions to learning of users is evaluated based on increasing the accessibility of information that can contribute to learning. For example, the ability of students and homeowners to access full descriptions of EEM data as opposed to summary descriptions, and the ability to link homeowners with additional resources.

Contributions to ongoing interaction are evaluated based on the ability to take time to present reports in multiple formats (hard copy, email PDF, web version) and the ability to easily
update (and track updates) in reports to represent lessons and observations made through exchanges.

Support for entry-level users is evaluated based on the ease of use experienced by users compared to previous version of the tool and improvements in the level of guidance the tools provides for users. For example the ability of users to access advice on the relevance of EEM’s in particular situations, or the ability for to improve the solicitation of feedback and updating of report based on feedback.

**Phase 2:** Based upon the user feedback collected in phase 1 of evaluation, a second set of attributes are developed to create the second version of the online report. This version and its attributes are then evaluated using structured interviews with experienced NELC student auditors. These students have experience of using at least one of the earlier iterations of the NELC report writing tool and can compare the newest version to the previous one.

In both stages of evaluation, an attribute is considered valuable for the research if it meets at least one of the stated evaluation criteria. If an attribute does not meet any of these criteria it may still be valuable but will not directly contribute to this research.
Figure 3-3. Research System Architecture.
3.4. Chapter Summary

Chapter 3 presents the objectives of this study and explains the framework that this research has used to build on past research and experiences in order to create a web-based report writing tool in two phases. It also defines methods of evaluating the tool in each phase and the criteria for evaluation of the tool’s success in meeting research goals.
CHAPTER FOUR REPORT GENERATOR TOOL DESIGN

The concept of a web-based home assessment report generator, was derived from initial efforts to train entry level individuals how to produce professional reports for homeowners. The point of departure for this research is to build upon a rudimentary tool developed in MS Access in which some elements of the report generation were automated and which also enabled the inclusion of database-driving content in a standard MS Word template. Difficulties were experienced using the Microsoft Access tool and additional features were identified could potentially benefit users of the tool. Based on these experiences a number of attributes are defined and developed which are presented in this chapter and used to develop specifications for a new tool that features web-based access. The first version of the online tool was then created and is described.

4.1. Preliminary attributes of the new report writing tool

To develop set of tool attributes, firstly the main four values for the tool were defined which are contribution of the tool in saving time, ongoing learning of its users, continuous interaction with homeowners and support of entry-level users. In addition, using of the early iterations of the tool provides insight on the features that a tool needs to have and the requirements that it should address which were then translated into suggestions for a future tool. Each suggestion was then prioritized based on perceived value and the phase they expected to be needed in the process of development and subsequent testing. Based on this approach, six attributes (table 4.1.) were selected as the preliminary features to be included in version 1 of the online tool hereafter referred to as the SMARTdwell website.
4.1.1. Table of preliminary attributes for SMARTdwell

Six fields are used to fully describe each of the desired attributes of the tool: Name, Description, Benefits, Challenges/ Limitations, Direct Recipient of Value and target goal. Table 4.1 is developed to describe each attribute and its features.

**Name**: Reflects on the name that is used for the attribute.

**Description**: Briefly describes each attribute and the improvement it addresses.

**Background and Benefits**: Explains the existing situation and lists one or two of the main value-adding processes associated with implementing an attribute

**Challenges/ Limitations**: Lists potential challenges that are impeding the development of the attribute or limitations that the attribute may cause after being implemented

**Direct recipient of value**: Reflects on the party or parties who benefit from implementation of an attribute.

**Target Goal**: Lists the values identified in Chapter 3 that each specific attribute is expected to helping to achieve.
<table>
<thead>
<tr>
<th>#</th>
<th>Name of Attribute</th>
<th>Description of Attribute</th>
<th>Background and benefits of the Attribute</th>
<th>Challenges/ Limitations of the Attribute</th>
<th>Direct Recipient of Value</th>
<th>Target Goal</th>
</tr>
</thead>
</table>
| 1 | Single port of entering information for generating the report | The ability for the users to enter all of the information regarding the report on the website and generate reports as a PDF | • The information will not be scattered and will be easier to manage | You may not generate before entering the required data | Assessor | • Saving time  
• Support Entry Level User |
| 2 | Generating commonly formatted reports | Reports are generated based on a common template designed for readability and usability and visually similar | • Users do not need to spend time formatting reports  
• Clearly formatted and homogenous reports supports branding of NELC | Users cannot modify the template based on their personal preferences | Assessor/ Homeowner | • Improve interaction with homeowner  
• Support Entry Level User |
| 3 | Accounting for static, dynamic and database-driven language | To derive from different databases, use static prepared content and allow for case based data entry | • Select custom language can be added to report  
• Database language can speed authoring of common sections / EEM descriptions  
• Static language can be refined and not recreated | Keeping a constant tone throughout the report with transitions between custom and static language | Assessor/ Homeowner | • Support Entry Level User  
• Enhanced interaction with homeowners |
| 4 | Multiple user online access to data | Ability to login to SMARTdwell and see/modify all the reports and have access to information collected during assessments | • Previous reports will be available as a resource for future reports  
• Reports can be monitored and if required modified by multiple users to help save time and improve the quality of the reports | Reports might be modified by mistake or by unexperienced users | Assessor | • Continuous learning  
• Support Entry Level User |
| 5 | Upload image function | The function for users to upload the images directly to SMARTdwell website and remove if necessary | • Images will be gathered all in the same place with other information  
• Saves time by reducing time to find images and insert into reports | • One may accidentally delete a picture.  
• Coherent captions of images need to be written by report author | Assessor | • Saving Time  
• Support Entry Level User |
| 6 | Integration of User Guide | To provide a brief explanation for all of the fields of entry in SMARTdwell website | • External user guide was time consuming to access.  
• Users with minimal knowledge can follow the steps/guidance provided in each field of entry | Users may require variable or more extensive support based on variable levels of experience | Assessor | • Saving time  
• Support Entry Level User |

Table 4-1. Preliminary Attributes of the new NELC report writing tool
4.1.2. Attribute explanation

Each of the 6 preliminary attributes that are briefly presented in Table 4.1. are explained in the following sections.

4.1.2.1. Single port of entering information for generating the report

The online tool allows for the users to enter all the data that they collect through research or during the walkthrough in a single platform. The users are able to manage different sources of information and time is saved in the process of gathering and organizing data in a report. As new information is added or information is update, a new report can be generated to represent the changes.

4.1.2.2. Generating commonly formatted reports

The reports are generated using a pre-designed template that is designed to address numerous goals related to formatting, readability and usability. This attribute results in time-saving and a homogenous template that supports branding of NELC, and also supports entry-level users in the creation and authoring of standardized professional reports.

4.1.2.3. Accounting for static, dynamic and database-driven language

Three categories of content are needed to create each report: Static, dynamic and database-driven. Each are described below.
Static language is a text or graphic that is deemed valuable in every report. For example, explaining the organization of the report, goals of the NELC program. Static language may still evolve over time in the tool, but can largely alleviate the need for authoring some sections of the report.

Dynamic language is unique per each report and provides opportunities to customize reports for each recipient. It includes a personal greeting and thank you from the assessor, graphics related to the specific house being assessed and information that the assessor enters based on that specific case, as well as images and captions of health, safety and energy issues observed during the walkthrough, and energy consumption and energy bill data.

Database-driven language refers to content that is selected from pull-down menus and that is selected for inclusion by the report author. The two main types of database driven data are Energy Efficiency Measure language and health and safety language that make up the main recommendations being presented to homeowners, and that can also be presented using variable language and styles depending on homeowner world view and learning style. Additionally, graphics or figures in the report that are responsive to specific world views and learning styles can be drawn from databases.

While these types of languages are a common feature for many tools or websites, their incorporation in the NELC report writing tool to address specific goals of this program is a unique attribute of this tool. For example, the blending of dynamic and static language in targeted sections of the report, and the design of database content that is responsive to and variable based on world view. This attribute both minimizes and focuses authoring of unique content, and also enables development of variable versions of reports that respond to priorities and world view.
4.1.2.4. *Multiple user online access to data*

An important attribute of the online tool is the ability to enable a hierarchy of login access where assessors can navigate through previously created reports and a database that maintains all the reports in one place. This attribute supports the author in enabling feedback on a report in progress, as well as the ability to view and learn from past reports from other authors. This feature also enables the ability for homeowners to eventually access their data and report for their individual home, but not others’, to ensure privacy.

4.1.2.5. *Upload image function*

Image management is also a key feature of the tool, as images of the home (digital and infrared) of specific issues play a key role in communicating the results of the assessment. This needs an upload image function enabling the assessors to associate images with the report, and store all the images in one place.

4.1.2.6. *Integration of User Guide*

The explanation of each section needs to be provided to make it easy for entry level users to learn how to work with the tool or remember to deal with the entry fields that they have forgotten about. Specific content includes reminders about how to author custom content, and criteria for creating professional reports.
4.2. Communication of attributes with web developers

With the preliminary attributes and requirements of the online tool defined, a process of specification and communication was used to provide transfer the desired attributed to the web development team at SMARTdwell. Communication with the web developers happened in two ways: 1. Verbal or written 2. Graphical.

Early stages of discussions were mostly verbal, but included examples of basic Access tool and samples of early versions of report. After developers created a platform to represent information in the old tools (Microsoft Access and IPad application), graphical mock-ups of all of the pages of the new website were created. This was helpful in showing how the website should look, and what features it needs to include. Based on the requirements, a number of graphic mock-ups were developed for both the tool interface and the report.
Figure 4-1. Status tab mock up and comments

Figure 4-1 illustrates how the screen design and features of the tool were communicated to the web development team. The main communicated features include the following items:

**Specify pages:** Primary pages are specified based on the type of data being entered and can be navigated through a row of link buttons. These include “Application” for information gathered from the initial application for an assessment (address, year constructed, point of contact, etc); “Survey” for information gathered through the survey of homeowners; “Exterior” for capturing general condition of exterior of the home, “Interior” for doing the same for the house’s interior parts, “Utility” to include any information about energy usage and type of fuel in the house,
“Status” to include pictures of the house as well as observations about health, safety and energy related issues, “EEMs” to specify a homeowner cognitive style and worldview and recommend energy related measurements and finally “Report” to include audit information and generate the reports.

**Specify page sections:** Each page of the new tool was divided into main sections and the sections are spelled out, for example in Figure 4.1 “Pictures”, “Status”, “Home Energy Yardstick Score”, etc.

**Specify the information under each section:** All the information that needs to show be entered directly or selected from menus in each section is specified in detail and both graphically and verbally.

**Required programming features:** Specific programming functions requirements such as Upload Image or Add Home buttons are explained.

**Specify data source for each entry:** It is explained whether the data is entered manually (Dynamic language), derived from a database (Database-driven language) or if it is implemented in the tool data sources (Static language). In addition, if the users are to select from a drop-down menu, the information to appear in the drop-down menu is communicated.

**Explain where and how the data appear in report:** Generally, explains where data is coming from and where in report it should appear and how it is related to other information.

As the web development team iterated on the creation and presentation of the tool in progress, the communication continued to address some of the bugs and technical problems of the website. The communication continued until the 1st version of the SMARTdwell tool was ready to be used in the actual home energy assessments.
4.3. SMARTdwell report writing tool; Version I

In this section, an overview of the SMARTdwell report writing tool is provided. The tool is intended to be used by student assessors who have collected all the information that they need for the report. Meanwhile, they will receive training in the NELC course about how to use the tool to generate a report.

To access the SMARTdwell, the users need to enter their username and passwords which an admin had already provided them with. The login page has NELC logo to provide a hint for the users (Figure 4-2).

![Figure 4-2. SMARTdwell login page](image)

After login, the users see a list of homes with brief information about each. They may open up a previously created report or add a new home. After starting the report, the tool has multiple tabs where users input their information. The information is either collected on site, or is been researched ahead of the assessment. The users fill multiple required and optional fields in Application tab regarding to general facts about the home (Figure 4-3). At each step, users should
save their work before going to the next tab. The survey tab represents the questions from the survey that the assessors have asked and entered to the IPad application during the walkthrough.

Figure 4-3. Application tab in the SMARTdwell website
The survey collects information about the home, homeowners and their expectation of the process (Figure 4-4). None of the fields are required, however, since some parts of this section, such as Home Energy Section, will show up directly into the report, students are advised to fill these sections.
Exterior and Interior tabs represent the sections from the IPad application where students collect information on site about the observations that they have come across during the walkthrough of the home. The next, which is the Utility tab, requires entering a yearlong cost of any type of energy source at a house. While an external Excel calculator is used to disaggregate utility information and calculates the range of energy saving per each EEM, the yearly energy consumption shows up in the report and therefore it is a required information to be entered in the utility tab.

Most of the direct report writing happens in the Status tab (Figure 4-5). Students then upload the graphic result of “Home Energy Score” calculation, enter the score, and write a description about the score. They also upload a pie chart representing “Annual Energy Spending” of the home that they have generated using the NELC Excel calculator. Next, they reflect on health and safety issues observed in the house and upload pictures to guide the homeowner to the location that the issue has been seen. The same, applies to energy related issues. For each category of issue, the first few will show up on the main report and the rest will go to the appendix.
Figure 4-5. Status tab in the SMARTdwell website
In the EEM tab, students select the entries from multiple drop down menus. Cognitive style of report recipient, their priorities and goals and the EEMs are all essential information for generating a report under the EEM tab (Figure 4-6). The top 5 recommendations will show up in the main report. However, an extended list with additional EEMs, will appear in the appendix.

Figure 4-6. EEM tab in the SMARTdwell website
The last tab before generating the report, is the Report tab, where auditors enter their names and emails, and write a few sentences that welcomes the homeowner and grabs their attention to continue reading the report (Figure 4-7). Finally, in the Generate tab, the student auditors can generate PDF versions of the report. They have the option to generate a 6-page report, a report with all the appendices, and a report with all the EEMs. A sample of a full report can be found in the appendix.

![Figure 4-7. Report tab in the SMARTdwell website](image)

### 4.4. Chapter Summary

Chapter 4 presented the preliminary attributes defined to create the first version of the web-based report writing tool. A total of six attributes were defined at this stage and were used to create
specifications for the online tool. The tool was then described in detail in this chapter. Evaluation of the tool and developing its second version are described in chapter 5.
CHAPTER FIVE EVALUATION THROUGH USING AND REVISION OF THE TOOL

Chapter five will provide a detailed comparison between the new and old NELC report writing tools. It will also describe the processes through which the tool has been tested, and provides the results and feedback which resulted in revisions made to the online tool.

5.1. Use of tool to write reports

The primary technique used to evaluate the report writing tool was to put it to use as a part of the NELC program at Penn State. This process included training of students to complete home energy assessments, and the use of the report writing tool to author reports that were provided to homeowners.

5.1.1. Training of auditors

Students that tested the tool participated in a semester long class in which they learned about the NELC program, basic energy assessments methods, and the first version of SMARTdwell website. At the end of the semester, students formed groups and each group performed an energy assessment under supervision of the teacher and more experienced assessors.

At the end of the semester, six of successful students were selected for a NELC internship experience, which included a number of home energy assessments along with making suggestion to improve the tool and working on some of the improvements.
5.1.2. Use of tool to author 30 reports

NELC interns completed 30 home energy assessments in the State College area and used the SMARTdwell platform to generate the reports. The team had weekly meetings where they discussed their experience with the process, including the report generator tool. Key observations were made during this process:

**Time saving**: An immediate reduction in the time required to prepare reports was observed. As the exact time spent preparing reports was not feasibly measured across student teams, a spot survey of users was conducted periodically. Feedback from students indicated that while the times required to prepare the report still varied between homes and students, the average time per report was four hours which indicates a cut in half, compared to approximately eight hours per report using the MS Access tool.

**Improved Quality**: Multiple factors contributed to an increase in quality compared to early iterations of NELC report writing tools. Firstly, formatting issues were decreased as a result of a standard format. Secondly, the dynamic language was kept to a minimal and mostly replaced with data-base driven language. In addition, since the time required for creating the reports was cut, the students had time to share report and discuss recommendations, and incorporate feedback into their reports. Therefore, dynamic languages and choices for database-driven languages was being discussed and checked resulting in a report that contained no or minimal mistakes.

**Evaluation of key attributes**: Through repeated use of the tool, the features of the tool could be evaluated by multiple users. This enabled an evaluation of each of the key tool attributes that were defined for the initial version of the tool. This evaluation will be discussed in the following section.
5.2. Evaluation of each attribute

After performing 30 assessments using the first version of SMARTdwell website, each of the six primary attributes of the tool were evaluated to measure if they have met their target goals (Table 5-1). The evaluation happened through observation and study of performance of student using the new tool as well as brief weekly review sessions in which students provided feedback about the tool. In many cases, users were able to compare the tool to the MS Access tool, since all six of them had experience of working with both the original tool during the training class and the new one during the test period.

5.2.1. Single port of entering information for generating the report

Based on the feedback, the report writing process was cut more than 50% mainly due to the fact that all of the information needed to be uploaded on the website as oppose to multiple MS Excel and Word files that needed to be tracked and shared. This feature also made report writing easier for entry level users who no longer needed to manage information in multiple files.

5.2.2. Generating commonly formatted reports

The users stated that one of the biggest challenges of working with MS Access tool was that it was time consuming and “impossible” to attain a proper format, especially after inserting pictures. Users evaluated this attribute highly valuable especially for saving time and supporting entry level users. They also “confirmed that this format is in line with all the previous NELC research” on effective report delivery.
5.2.3. Accounting for static, dynamic and data-base driven language

This attribute also saved a lot time for writing the report due to the fact that a lot of the report content was already generated. Users needed only to select a number of items from drop-down menus and databases and add dynamic text only in a few instances. This feature made report writing easier for the users, especially entry level users. This attribute is also beneficial for interacting with homeowners based on the ability to select types of database language targeting specific world views, are proven useful in previous research.

5.2.4. Multiple user online access to data

Users of SMARTdwell report writing tool stated that managing their previous reports was hard using the old tool. The new format was useful for them since they were able to easily find their old reports. They also used this feature to look through other people's reports and learn about the content. Therefore this attribute supported the process of obtaining feedback on reports and collective learning by and from other members of the team.

5.2.5. Upload image function

The ability to upload images, that were then auto-formatted, was a significant time saving feature. Students were satisfied with the time saved and ease of working with image upload function.
5.2.6. Integration of User Guide

Based on feedback, the most important value of this feature was that it made the process of report writing a lot easier, especially for entry level users. Also, as a result of this feature, the users rarely needed to go back to training materials on the report writing process.

<table>
<thead>
<tr>
<th>#</th>
<th>Name of Attribute</th>
<th>Saves time</th>
<th>Supports ongoing learning of users</th>
<th>Supports interaction with homeowners</th>
<th>Supports entry level user</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single port of entering information for generating the report</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Generating commonly formatted reports</td>
<td>✔</td>
<td>_</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>3</td>
<td>Accounting for static, dynamic and database-driven language</td>
<td>✔</td>
<td>_</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4</td>
<td>Multiple user online access to data</td>
<td>_</td>
<td>✔</td>
<td>_</td>
<td>✔</td>
</tr>
<tr>
<td>5</td>
<td>Upload image function</td>
<td>✔</td>
<td>_</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>6</td>
<td>Integration of User Guide</td>
<td>✔</td>
<td>_</td>
<td>_</td>
<td>_</td>
</tr>
</tbody>
</table>

Table 5-1. Evaluation of Primary Attributes of the NELC Report Writing Tool

5.3. Key upgrades needed

Based on the evaluations a number of upgrades were deemed necessary. Also, some of the initial features of the tool not implemented in the first version were added. With the experience of using the tool completed, a new list of tool attributes was developed, titled secondary attributes. The same table format that was explained in section 4.1.1 was used to introduce and describe the attributes (Table 5-1). The attributes were also communicated to the SMARTdwell development team through graphical representation of screen designs and written specifications.
5.3.1. Admin Function for EEM Database

This attribute is intended to provide a platform that allows for the assessors to make changes to the EEM database and add, remove or modify EEMs as opposed to an import process from CSV file of EEM data. All the information related to an EEM can be entered in a single page without the need to going back and forth between different software and locations. This ability is in contrary with what that had been used in the MS Access -a complicated MS Excel spreadsheet- and the early version of SMARTdwell –where only website admin had access to make changes to the database. This feature also streamlines the process to edit and add new EEM’s based on new technologies and more specific conditions.

5.3.2. EEM browser and its integration with the report

This attribute is intended to allow users to navigate through the EEMs and add the appropriate ones to the report in a queue while browsing. This function improves the access to the EEM database for both energy assessors and homeowners. The assessor can navigate through the EEMs to find the most relevant ones to a specific case, and homeowners may use it to learn about new EEMs and add them to their own queue if they want.
<table>
<thead>
<tr>
<th>Name of Attribute</th>
<th>Description of Attribute</th>
<th>Background and benefits of the Attribute</th>
<th>Challenges/ Limitations of the Attribute</th>
<th>Direct Recipient of Value</th>
<th>Target Goal</th>
<th>How the Attribute Meets Target Objectives</th>
</tr>
</thead>
</table>
| Admin Function for EEM Database | The tool allows users to add new EEMs or modify the existing ones directly in the online tool | Enables users to more easily modify EEMs or add new ones | EEM’s grow with new Tech. and can require detailed descriptions and specifics. An ever-growing database is needed | Assessor/Homeowner | • Saving time  
• Improve interaction with homeowner | • If needed, it is easy to create new EEMs or modify the existing ones  
• Students can receive feedback from homeowners and communicate with admins to improve EEMs if needed |
| EEM browser and its integration with the report | Enables the assessor to navigate through EEM database and add the relevant ones to his/her report. | • Users can easily add new EEMs to the report  
• Navigating through EEMs improve knowledge of the audience about all the information in the database | | Assessor/Homeowner | • Saving Time  
• Support Entry Level User | • It is very easy to navigate through EEMs, narrow-down the options and add proper EEMs to the To-do lists  
• Entry level users get familiar with the EEMs and get an idea of what they can recommend. |
| Health and Safety (H&S) Database and Admin Function for it | The health and safety database allows H&S comments and feedback in reports to be data-driven. Admin function enables new H&S feedback and recommendations to be added. | • Users can select relevant H&S issue from the database and add to the report  
• H&S recommendations require detailed descriptions to be specific. An ever-growing database is needed | | Assessor | • Saving time  
• Support Entry Level User | • Dynamic language is replaced with database-driven language which is quicker and easier to use. Also, modifying or adding new issues is simple.  
• Entry level users can select from a list of available issues and the list gives them ideas about the issues that they can talk about |
| Report Content Editing and Administration | Distinctions were made between Static, dynamic and Database-driven language. Admin enables editing of all, users can edit dynamic | • Dynamic language is easily customized  
• The database-driven language can be customized based on worldview and learning style | Reports need to balance customized language stock language to reduce writing time. | Assessor | • Improve interaction with homeowner | • Modifying static or database-driven language in the report based on different personalities or goals is simple |

Table 5-2a. Secondary Attributes of the new NELC report writing tool
<table>
<thead>
<tr>
<th>Name of Attribute</th>
<th>Description of Attribute</th>
<th>Background and benefits of the Attribute</th>
<th>Challenges/ Limitations of the Attribute</th>
<th>Direct Recipient of Value</th>
<th>Target Goal</th>
<th>How the Attribute Meets Target Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive EEM “To-do” list</td>
<td>Users and homeowners can easily edit the “to-do” list of EEMs in the online tool including adding new EEMs directly from the EEM browser and indicating EEMs that are “completed” or “Not Likely”</td>
<td>• Users can easily draft, obtain feedback, and modify EEM recommendations • Homeowners can interact with their queue</td>
<td>• EEM list can be perceived as a static and one-time intervention as opposed to an ongoing effort.</td>
<td>Assessor/ Homeowner</td>
<td>• Saving time • Improve interaction with homeowner • Support Entry Level User</td>
<td>• Reordering the recommendation or moving them from to-do list to other lists is simple and quick • Homeowners have the option to modify the report based on what sounds feasible and interesting for them. • It is easy for entry level users to modify the report based on feedback from advisors or homeowners</td>
</tr>
<tr>
<td>Activity log for interactive “To-Do” list</td>
<td>All transactions of EEM content and “To-do” list are logged, including additions to list, changes in order/priority, and tags for “completed” or “not likely”</td>
<td>• Recorded interactions can assess homeowner response to initial EEM list • Recorded interactions can track progress and implementation of EEM’s • Log can provide data on patterns of EEM implementation across demographics of homeowners</td>
<td>The tracking of EEM implementation is a key metric of success, but is challenging to track. ReVEaling patterns of EEM implementation or rejection can help improve process over time</td>
<td>Assessor</td>
<td>• Continuous Learning • Enhanced interaction with homeowners</td>
<td>• Tracking how homeowners are acting upon the recommendations provides insight for future assessments • This attribute provides a platform to communicate with homeowners and see how they are doing on their own modified list or congratulate them when they mark something completed.</td>
</tr>
<tr>
<td>Provide access to additional EEM information and links to resources</td>
<td>External links to websites such as YouTube or Google Shop are provided in EEM browser</td>
<td>• Improve accessibility of additional information • Improve accessibility to products and resources that can enable action</td>
<td>Videos and locally available services are helpful but challenging to keep current</td>
<td>Homeowner</td>
<td>• Continuous Learning • Support entry level users</td>
<td>• Both students and homeowners have access to additional information that is provided for each EEM and can use them as sources to learn more • Entry level users have the chance to get fully familiar with what they are recommending themselves</td>
</tr>
<tr>
<td>Online Report provided in addition to the ability to generate a pdf</td>
<td>The reports can be generated either in online format or pdf</td>
<td>• More responsive to how some recipients prefer to receive/use report. • Report can be more dynamic and more easily modified. • Creates more capabilities to interact with homeowners • Enables updating the report based on newer versions or newer EEMs</td>
<td></td>
<td>Assessor / Homeowner</td>
<td>• Saving time • Continuous interaction</td>
<td>• Time is saved for printing out the report and making sure the formatting is correct. • Homeowners can modify the report in addition to the NELC team.</td>
</tr>
</tbody>
</table>

Table 5-2b. Secondary Attributes of the new NELC report writing tool- Cont.
5.3.3. Health and Safety (H&S) Database and Admin Function

This attribute provides a database for health and safety issues which assessors can use while writing the report by looking through the list and select the common issues applicable to their case, and enable database-driven language to be inserted in the report containing important recommendations for homeowners. Similar to the EEM browser, users also have the option to add a new health and safety issue or delete/modify an existing entry.

5.3.4. Report Content Editing and Administration

Building on the attribute “accounting for Static, dynamic and Database-driven languages” which was implemented in the early version of the tool, in the new tool it should be more flexible and provide the ability to edit all types of languages if needed. Users should be able to make changes in the static or database-driven text and images along with dynamic content.

5.3.5. Interactive EEM queue and “To-do” list

This attribute allows the assessors and homeowners to add and remove EEM’s on the “to-do” list of priority recommendations, as well as an additional list of applicable EEM recommendations provided in the appendix of the report. It also enables broader categorization of EEMs and the ability to change the category of an EEM from “To-do List”, to “Completed” or “Not likely”. This feature allows both assessors and homeowners to easily reorder the EEMs if desired, and creates an opportunity for feedback and interaction with homeowners as they respond to and edit the recommendations created in their report.
5.3.6. *Activity log for interactive “To-Do” list*

This attribute allows for the assessors to track of all the changes that are made to the EEM queue. It is intended to be used to see how homeowners react to the recommendations when they are first presented, and how/if they keep changing and reordering the recommendations over time. This feature is critical to a key metric of home energy assessments and audits, in that is tracks actions taken by homeowners, which is ultimately the primary goal of the assessment process.

5.3.7. *Provide access to additional EEM information and links to additional resources*

The online platform for presenting reports is intended to enable the links to redirect users to resources. This attribute can serve both report writers, teaching them about the EEMs in case they need more information for writing the report, and homeowners to understand the recommendations better or to find a source to purchase relevant items.

5.3.8. *Online Report provided in addition to the ability to generate a PDF*

The report which used to be delivered in PDF or print version can now be accessed online. This feature enables an alternative method to deliver reports and the ability for homeowners to browse through EEM browser and interact with their queue (described below). The ability to create a PDF report for emailing and print versions or the report are also preserved.
5.4. SMARTdwell report writing tool; Version II

This section describes the second version of SMARTdwell report writing tool, which has the secondary set of attributes implemented. To minimize repetition, the elements of the web-based tool that are similar to the early version were not explained.

5.4.1. Architecture of SMARTdwell website

Figure 5-1 provides an overview of the architecture of SMARTdwell website, version II. Dashed lines, represent NELC IPad application and cloud data integration with the web interface that are not pursued yet but are allowed for. The Web Interface draws its data from 4 sources that are shown in the figure 5-1, which are EEM Database, Health and Safety Database, Static Content and the Client Record. The EEM database information is presented in the form of EEM queue and its changes are tracked using EEM action log. All of this information can potentially be stored on the cloud and be accessed later if needed. The information on the online web interface regarding each report is presented to the homeowner in the form of an online interactive report which can be printed as a PDF as well.
5.4.2. Overview of the tool, version II

The new address to access to the SMARTdwell website is nelc.smartdwell.com where users are asked to enter their usernames and passwords to enter the site. There are now three tabs in the home page: Homes, Admin and EEM Browser. The Homes tab looks similar to Version I, Admin tab is significantly updated and EEM Browser is a completely new tab.

For each of the homes under the Homes section, 12 tabs are available. Each contains information regarding the home. Tabs “Application”, “Survey”, “Exterior”, “Interior”, “Status” and
“Report” contain general information of the house and are identical to the old version of SMARTdwell.

One of the biggest differences between the old and the new versions of SMARTdwell is that in the new version, the EEMs are not selected from a drop-down menu. Instead, they will be added from the EEM Browser tab. In this section, the user can navigate through all the EEMs or filter them based on their category. They also can search a specific keyword and have all the EEMs that include the keyword listed. For example, they can search the word “Light” and the EEMs list, will be limited to five that include the word light in their title. Once encountering the right EEMs, the user can press the “Add to my To-do List” and it will be added to the queue of the EEMs (Figure 5-2).

EEM browser can be accessed in three ways. First, it is available when an assessor is working on a report. They can navigate through it and as explained, add one to the to-do list. Second, homeowners can see it in their online report platform. Here, the function of the browser is the same as report writing platform. Third, the EEM Browser can be navigated without being linked to an actual report, making it an online resource for training purposes.

In the EEM Browser, all the information about a specific EEM is shown in the same place. Users may also access the external links and resources related to an EEM and be directed to other websites. This feature is also a new feature of SMARTdwell (Figure 5-2).
In the report writing section, a new “Wrap-up” tab has been added. It includes a homeowner survey that needs to be filled out after the report is delivered to the homeowner. It assesses the level of satisfaction with the process and level of trust between homeowners and the auditors (Figure 5-3).
Figure 5-3. Wrap-up tab in the SMARTdwell website, Version II

Another new feature of the website that responds to the new specifications is the “Queue Log” which shows a log of all the actions that have taken place on the EEMs. This tab tracks the action of both users and homeowners. It helps the NELC team to track how homeowners have reacted to the recommendations, which EEMs are more likely to be added to their to-do list or be removed from their report (Figure 5-4).
One other new feature of the website is the online report. The homeowners receive a link to their online report to review and in some instances modify it. The online report has multiple tabs representing different sections of the report. The recipient may also scroll down through the whole report (Figure 5-5).

An important feature of the online report is the “To-do List” tab where one can change the order of EEMs by simply dragging them or move them to Completed list or Not Likely list. It is also possible to reverse the action and move something from Completed or Not Likely list to To-do list. All of the actions are in this interactive to-do list captured in the queue log (Figure 5-6).
Apart from the report writing and online report sections, SMARTdwell has an admin section which houses all the information and databases. The admin section existed in the first version, but was not as complete nor user friendly as the second version. The two main databases of the tool which are Energy Efficiency Measures and Safety and Health Concerns are all accessed through the Admin tab. Admin users can also modify and/or add new information to the databases (Figure 5-7).
Chapter 5 described the initial evaluation of version 1.0 of the web-based report generator including use of the tool to produce 30 home assessment reports, and the evaluation of each of the key tool attributes defined in Chapter 4. It also describes the additional attributes and features identified for version 2.0 of the tool, and how these features were communicated and implemented to create version 2.0. Chapter 6 described the evaluation of version 2.0 of the online report writing tool.

Figure 5-7. EEM database in the SMARTdwell website, Version II
CHAPTER SIX EVALUATION OF UPDATED TOOL

This research evaluates the tool in two phases. The first phase was described in Chapter five and that is the evaluation of the tool by students in 30 home energy assessments. The goal in student evaluation was to evaluate some of the initial productivity improvements and some of the other measurable gains, such as ability of the tool to save time. Chapter 6 describes the evaluation of the new features of the tool that were added after evaluation of the first phase. It allows evaluation of the new features and attributes in terms of the four key criteria defined in chapter 3: how they contribute to saving time, ongoing learning of users, improving interaction with homeowners and ease of use for users with minimal energy audit experience.

The importance of the second phase of evaluation is to assess the new features that are added to the tool after the first phase. Unlike phase 1, where the tool was used in the process, the second phase involves presenting the tool to seasoned energy assessors who have experience using the first version, to seek their feedback on the new features in version 2.0. The goal of this process is to directly assess how this version of the tool is improved compared to the last version, therefore presenting it to people who have used the previous version was determined to be the best approach. In addition, using the new tool in a number of assessments required time and investments that were not feasible in this study.
6.1. Interview Design and Format

6.1.1. Interview Type

According to Cohen et al. (2006), there are five types of interviews: Structured Interviews, Semi-Structured Interviews, Unstructured Interviews, Informal Interviews and Focus Groups. Each of these types are briefly explained as follows:

1. A structured interview is an interview with a rigorous set of questions, which does not allow the interviewee to be distracted.

2. A semi-structured interview is similar to a structured interview in that the questions are planned beforehand but is more open and allows for the discussion of new ideas during the interview.

3. An unstructured Interview does not have prearranged questions.

4. In an informal interview the interviewer talks casually with the subjects and collects the required data.

5. In a focus group data is collected through a group interview process with semi-structured questions.

A structured interview is used in this study in order to perform the evaluation process since it allows us to present the features in a uniform way. This type of interview produces consistent data that can be compared across a number of respondents resulting in efficient and useful data collection. Structured interviews are also beneficial in making sure everything is covered in the interview. In this research, it is used to first guide the users through the new attributes of the tool and then ask for their opinion about each of them.
6.1.2. Development of Interview Questions

The structured interview in this study is designed to address three requirements: addressing attributes, addressing value streams and is designed in a way that is not too much time consuming.

Each interview started with a demonstration of new features of the SMARTdwell website. Then the interviewee answered questions about nine of the attributes of the tool. For each attribute, four to five questions were asked. The interviews were performed online and all video recorded for further analysis. While the respondent was asked the questions, the relevant section of the SMARTdwell website was shared on the screen and the interview had the time to ask questions and digest the information before responding.

For all of the attributes, the first 4 questions are consistent; respondents are asked if the goals of saving time, educating of the users, the continuous interaction and support entry level users are met by the specific feature in question. Question 5 is designed to capture other possible benefits associated with each attribute. There is also a final, open-ended question, asking if the interviewee sees other benefits or have any concerns about the attribute. The questions are discussed in more detail as follows:

*Question 1: Does “the attribute” contribute in reducing time required to prepare report?*

This question intends to assess if the new tool has made the process more efficient and weather it has been helpful in reducing the time that is required for writing the report.

*Question 2: Does “the attribute” contribute to ongoing learning of users?*

In NELC home energy assessments, not only it is important to come up with a list of recommendations for the homeowners to act upon, but to “support” them to take action. Although the early version of the report writing tool had databases of information, there was limitations in connecting the report recipients to additional information or expanding on the recommendations.
With the new web-based environment this problem is solved and there is opportunity to connect users with useful resources. In addition, with multiple databases implemented in the SMARTdwell website, the assessors who use the tool to write the reports are exposed to a lot of useful information that they can use and will be exposed to which may result in further education. Question 2 intends to assess whether the tool has been successful in achieving this target.

*Question 3: Does “the attribute” supports a continuous interaction between NELC team and the homeowners?*

One of the goals in NELC is to support a continuous interaction of homeowners with the provided information and with the NELC team. The interaction does not intend to finish by handing the homeowners a report. In the new tool, homeowners can interact with information and the auditors have the ability to check-in with someone or see how they have used their report. Question 3 tends to measure how much each attribute of the tool can support having a relationship with homeowners over time.

*Question 4: Does “the attribute” support preparation of report by entry level users?*

An initial goal for the NELC program has been to support users with no or minimal energy audit experience, to be able to follow the process of home energy assessment concluded by a report. Many of the attributes implemented in the SMARTdwell website tends to make it easier for these users to generate the report.

*Question 5: Does “the attribute” has other benefits such as accuracy, customization ability etc.?*

Some attributes may have a benefit beyond the four explained. In some cases, the attribute can improve accuracy or provide the ability to easily customize the report. Question 5 intends to assess other probable benefits that are associated with the attributes.
Last Question: Are there any other benefits that you perceive from the capability of the tool to incorporate this “attribute”?

To capture anything that might have been missed in the previous questions, a 5th open-ended question is designed that allows for the interviewees to unload other reactions, ideas and thoughts about how each feature of the tool is improved compared to the previous version or how the feature is limited.

6.2. Interview Process and Results

6.2.1. Selection criteria for interviewees

Since the intention was to compare the tool with the previous NELC report writing tools, people with full experience were highly valuable for this study. The interviewees have used the previous tool extensively and are familiar with performing the assessment all the way to delivering of the report. Within these criteria, three people were selected and each one went through a 90 minute interview.

6.2.2. Interview Respondents

As already stated, the three respondents are previous NELC users who have completed the course, participated in a number of NELC assessment and report writing activities, and are familiar or have used SMARTdwell Version I to write reports. Respondent 1 has 4 years of experience with NELC program and more than 1.5-year experience of working with SMARTdwell Version 1.
Respondent 2 has been involved in various NELC projects for a year and about 6 month of experience working with SMARTdwell. Respondent 3 has been intermittently involved with the NELC program over the course of 2 years but has never worked directly with the NELC tool.

6.2.3. Interview Responses

Table 5-2 represents the results of the interviews for evaluating attributes of the second version of the SMARTdwell report writing tool. In the table, the responses are graphically represented with ⚫ for disagree, ◯ for neutral and ● for agree.

The columns represent the attributes and each of them has four small sections with numbers 1-4. These numbers represent the question number that is been asked in the interview. The rows of the table present the respondents and the table is filled with their responses to questions 1 to 4. The results show the average of the responses. In order for an attribute to be marked as positively evaluated, it needs two or more positive responses.

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<td>Respondent 1</td>
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<td>Respondent 2</td>
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<td>Respondent 3</td>
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〇 Disagree
◎ Neutral
● Agree

Question 1: Does “the attribute” contribute in reducing time required to prepare report?

Question 1: Does “the attribute” contribute to ongoing learning of users?

Question 3: Does “the attribute” support a continuous interaction between NELC team and the homeowners?

Question 1: Does “the attribute” support preparation of report by entry level users?
Table 6-1. Evaluation Results of the SMARTdwell Report Writing Tool, Version II

Evaluation of each attribute based on the responses, will be discussed in the following sections.

6.2.3.1. Admin Function for EEM Database

The respondents were unanimous that this attribute saves time compared to the old excel database which was hard and confusing to work with. Respondent 3 made the point that not only it saves time, but it creates more uniformity in the process.

Regarding ongoing learning of users, respondent 1 was not sure if it is effective while the two others believed that the attribute helps learning processes. Respondent 3 stated that the fact that the database is an expanding list it means that it provides the ability for people to contribute to the list and also to see what other items are available from other people. This translates into a learning opportunity since users not only can input some items and learn while doing so, but they also have access to what other people have entered.

Respondent 2 agreed that having the EEM database improves continuous interaction with homeowners, stating that after delivery of the report, the homeowners may discuss the results and the reports which may result in updating or improving some sections of the database, and this process presents an interaction between the two entities. However, respondents 1 and 3 disagreed arguing that this makes the information more accessible but does not necessarily take the interaction to new level.

The respondents were unanimous about the attribute supporting preparation of report by entry level users. Respondent 3 stated that in contrast to the old method, this new function has a
more interactive and consolidated source of information providing an improvement over surfing through the spreadsheets and manually formatting word reports.

There was finally a fifth question asking if this attribute improves the accuracy of the report which all the respondents were positive about, although two of them expressed concerned that this attribute allows for the users to add some degree of personalization to the reports, for example they may put together an EEM thinking about just a specific homeowner. In that regard, there should be some level of supervision over changes that take place in the database.

In conclusion, the interviewees decided that the attribute saves time, supports ongoing learning, supports entry level users and improves accuracy but does not contribute in enhancing interaction with the homeowners.

6.2.3.2. EEM Browser and its integration with report

Respondents all agreed that this attribute saves time compared to the old tool. One of them stated that not having to navigate through an excel file and multiple tabs, not only is time saving, but also results in a higher level of accuracy. Similarly, they all agreed that it contributes to ongoing learning of users due to the fact that navigating through different EEMs exposes a lot of useful information to both homeowners and assessors.

Regarding contribution of the tool to enhanced interaction of Homeowners with NELC team, respondent 1 was not sure that this is helpful, while the two others agreed that it is effective. Respondent 3 however, challenged the word interaction saying that it means exchange. The tool is more interactive in accessing the information that homeowners need, but as far as being able to directly have specific questions asked by homeowners that the NELC team answers, it does not
necessarily achieve that. Yet the interface is more interactive than it was before and therefore it serves the goals to some extent.

Finally, all the interviewees agreed that the feature supports entry level users in writing report especially through familiarizing them with a lot of content and by having a user-friendly interface.

Therefore, based on the evaluations, the EEM browser and its integration with the report, saves time required for writing the reports, contributes to ongoing learning of users, improves interaction of different entities and supports entry level users.

6.2.3.3. Health and Safety (H&S) Database and Admin Function for it

All the respondents unanimously agreed that having a health and safety database reduced the time that is required to prepare the report as well as contributing to ongoing learning of the users especially the report writer. On the contrary, none of them could find a direct relation between this attribute and enhancing interaction with the homeowners, especially because the homeowners don’t directly have access to this part of the tool and cannot directly input on it. Finally, all of the respondents found a relationship between the tool and supporting entry level users.

Thus, the attribute is considered successful in saving time, ongoing learning of users and supporting entry level users, but is not effective in enhancing the interaction with homeowners.
6.2.3.4. Report content editing and administration

This attribute was the least favorite of all eight among the respondents. Regarding saving time, while respondents 1 and 2 decided that it saves time stating that it is now easy to edit the content if needed, respondent 3 didn't find it relevant.

The respondents were not sure or rejected the effect of the tool on learning of the users.

The responses to question 3 was the same as question 1: Interviewees 1 and 2 decided that the attribute enhances interaction with the homeowners since it allows for the content to be customized and modified for each type of homeowner. Adversely, respondent 3 did not find this attribute directly relevant to enhancing interaction with the homeowners stating that it allows some degrees of flexibility in terms of being able to expand information that is available and the options that allow to choose from, however it does not open a line of communication between the homeowners and does not respond to any of their questions.

The exact same responses were received for question 4 which evaluates the relation of the attribute and supporting of entry level users. Respondents 1 and 2 found it relevant while respondent 3 gave a negative respond reasoning that the entry level users are more interested in achieving completion. They are not thinking about improving the tool therefore the attribute does not directly affect them.

Based on the responses, report content editing and administration attribute does not necessarily saves time, improve interaction with homeowners or support entry level users and is not contributing to ongoing learning of users.
6.2.3.5. The interactive EEM To-do list

All respondents agreed that this feature saves time required for writing the report. Many times, a change in the order of the EEMs is required and with this attribute the process of having to go back and change something is expedited.

Regarding the question about ongoing learning of users, interviewee 1 responded negatively stating that you need to have the knowledge to be able to make changes in the order of recommendations and this function itself does not contribute in ongoing learning. In return, the responses from the others was positive to this question. Respondent 3 believes that this attribute affects learning of homeowners since they need to do some research before they can make changes in the list and they would learn in this process.

The respondents were all strongly positive that the interactive EEM To-do list improves interaction between homeowners and the users. They all had the same opinion for support of entry level users as well.

In conclusion, this attribute was evaluated as one of the best ones in the tool which saves time, improves interaction with homeowners and supports entry level users. It may also be effective in ongoing learning of users.

6.2.3.6. Providing additional information and links to resources

Interviewees 1 and 2 believe that additional information and links to resources contributes to saving the time that is required to prepare the report while the 3rd one does not find this attribute directly relevant. However, all 3 of them strongly agree that this attribute supports ongoing learning since it provides the option to check on external information. Same as question 1, respondents 1
and 2 believe that the attribute enhances interaction since the homeowners may spend some time checking on the links and then get back to the NELC team with questions. Respondent 3, however, didn’t find this one relevant either. And finally, they all agreed that the attribute assists entry level users with writing the report especially since they may not be fully familiar with what they are recommending themselves. Therefore, having the ability of quickly looking it up helps them to learn and write reports.

### 6.2.3.7. Activity log for interactive “To-Do” list

Activity log was one of the more controversial attributes of the new tool. Regarding saving time, respondents 1 and 2 did not provide a positive feedback to the attribute. Respondent 2 stated that using the to-do list may even makes the users more confused and therefore is more time consuming than time saving. On the other side, interviewee 3 responded positively to this question reasoning that seeing how homeowners interact with recommendations, can assist report writers with writing the new reports.

Respondent 1 and 3 assessed the attribute positively in regards to ongoing learning of users. While respondent 2 gave a negative respond saying that it is not possible to see the original list and what has been the original top 5 recommendations or it is very time consuming to figure that out.

All three of the respondents were unanimous about effectiveness of the attribute in enhancing interaction. This was not the case for supporting entry level users where respondent 2 was not sure about effectiveness of the EEM and respondents 1 and 3 were against it stating that one will be confused and overwhelmed by seeing all the changes to the EEM list.
6.2.3.8. Online Report provided in addition to the ability to generate a PDF

The online report feature received mostly positive feedbacks. Respondents all agreed that it saves time compared to the old tool since it is easy to edit the report if needed and one does not need to spend time printing out the reports. In contrary, 2 of the 3, responded negatively to the question about ongoing learning of users. Respondent 3 stated that probably all the learning has already happened through other attributes and this one does not add anything new to the ones before.

Responses to questions 3 and 4 was all positive. The attributes contribute to enhancing the interaction since homeowners can navigate through the website and see what else they want to do. It also supports entry level users they don’t have to worry about finalizing the report and it is generated wit click of a button.

6.3. Evaluation of all the attributes

Two sets of attributes were developed in the tool and evaluated in chapters 5 and 6. Table 6-2 summarizes all of the attribute and the role that they play. Attributes 1 through 6 are evaluated through use and attributes 7 to 14 are evaluated by interviews with experiences NELC users. Table 6-2 shows how each attribute at the end offers value to the process of home energy assessment.
The final stage of evaluation confirms that almost all the improvements made to the tool contribute to at least one of the four main goals of the research. The only attribute that was not successfully evaluated as valuable to the research is “Report content editing and administration”. One reason for that may lay in the fact that this attribute is an admin-based feature and entry-level users may never come across using that. It is still a valuable feature enabling admins to modify all types of content in the reports but it does not meet the evaluation criteria. Except for this attribute,
all the others were defined as valuable and in that manner, the tool has achieved the goals and the process has been successful.
CHAPTER SEVEN CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The goal of this research is to improve the home energy audit process through the exploration of value-adding attributed of support tools that are designed to assist in the authoring and delivery of home energy audit reports. Chapter 7 summarizes the key findings of this research, the limitations of the research and provides recommendations for future research that could build upon this work.

7.1. Summary of findings

This research defined a set of value-adding attributes of home energy assessment report authoring tools through the development and experimentation with two versions of a web-based tool. The research evaluated the functionality of the tool and the value of specific attributes by using the tool to produce 30 assessment reports, and through the evaluation of a refined version of the tool by experiences users.

7.1.1 Defined criteria for tool for targeted use

A strong demand exists for automating the report generation process and the assumption that technology can help in saving time and improving the quality of the reports. This research focused on a tool designed for a specific style of home audit, referred to as an assisted audit, and also maintained an emphasis on entry-level energy assessors as a target audience. Four specific
criteria were then defined articulate the types of value sought be tool attributes and are summarized below.

**Reduce time required to author reports:** The first criterion was to create a tool that saves time that is required for writing the report. This was developed to enable the auditors to efficiently perform their task related to home energy assessment and allows them to perform more assessments during a specific window of time. Reducing the time required to create reports helps reduce the cost of creating reports, and also supports the timely and professional delivery of the report to homeowners.

**Support continuous learning by users:** The second criterion defined as creating a tool that supports ongoing learning of users. NELC introduces a tool that not only automates writing the report writing process but also is informative in its use. It helps the users to gain knowledge about home energy efficiency measures and the assessment process through the content and information that are embedded in the tool.

**Support interaction with homeowners:** The third criterion was to support interaction with homeowners. As many observations and studies suggest, one of the most important issues of the current practices of energy audit is that they are not personalized for a specific homeowner and are a one-time intervention or finish when the report is delivered. A main function of the tool is that it keeps homeowners engaged and continues interaction even after the report is delivered.

**Support entry-level users:** The fourth criterion is to support entry level users. An important characteristic of NELC program is that it delivers free assessments with the help of student volunteers. Users are not experts in energy auditing and are trained with limited resources. As such, the tool needs to support for authoring technical writing, require only basic customization, and that guides the assessment and report writing process are valuable.
7.1.2 Demonstrated value of tool to entry-level users

A considerable amount of support of entry level users took place throughout the research. The tool was tested and used by students trained in the NELC program who successfully created reports and delivered them to the homeowners. The tool also helped organize the data collection process, as well as authoring and customizing the reports. The report drafts were then evaluated by advisors and delivered to the homeowners using a specified content and format. In addition, all of the previous reports are accessible in the tool which makes it a valuable resource for future energy assessment reports.

7.1.3 Defined and tested set of value-adding attributes

Two sets of value-adding attributes of home energy assessment report writing tools were identified and tested. The first iteration of the testing demonstrated effectiveness of the tool and specific attributes in saving time and usability through its use in the creation of assessment reports that were delivered to homeowners. The second set of attributes were nuanced specialty features that were determined to be of high value, and that were tested through structured interviews with experienced users of the tool.

Observations from the evaluation demonstrates that EEM browser and its integration with the tool, admin function for EEM browser, health and safety database and its admin function, interactive EEM to-do list and online report in addition to generating a PDF file, are most effectively meet the end goals the research. Most of the other attributes such as Single port of entering information for generating the report, generating commonly formatted reports, Upload
image function and Providing access to additional EEM information and links to recourses, are also highly beneficial in serving the goals of this research. Overall, the research has been successful in developing an effective tool that meets the end goals.

7.2. Contributions of the work

This research provides a structured approach to articulate and test the value adding features of home energy assessment report authoring tools that are designed for a targeted audience of entry-level users. These efforts contribute to the future design of support tools for the growing field of energy efficiency retrofit construction.

The research provided detailed analysis of the design and the information required for creating an online energy audit tool and architecture of a database. The product of this step provides executable recommendations for future energy audit tool. In addition, concrete distinctions are made between custom content, static content and database driven contents in the format of an online tool. These are worthy of consideration in future tools. Also, the tool is capable of supporting entry level users with professional language and technical content.

The transition from PDF reports to an online environment enables the potential to significantly increase value to report authors and homeowners through providing the ability to browse through a database of energy efficiency measures, interact with a queue, link to external content, and track actions of users who reject or act upon recommendations in reports.
7.3. Limitations

To be able to develop a tool that is measurable during the available time of research, a set of boundaries were established to guide the scope of work. Among the main ones is that the tool is created, used and evaluated solely by entry level users. For it to be adopted in a large scale, which is one of the initial intentions of NELC program, it would be beneficial for the tool to be evaluated by additional professionals experienced in the home energy auditing industry.

Another limitation of this research is since some of the features of the tool, specifically integration of IPad application, cloud database, and the SMARTdwell website are not fully implemented yet. This prevents the full value of the tool to be tested as a time saving and data management instrument.

While the second version of the tool was successfully evaluated for functionality and usability, it was not tested through its use to author actual reports. Additional use of the tool in a more rigorous setting would advance conclusions drawn about its effectiveness.

7.4. Future work

This research has developed a set of attributes to create an online report writing tool. The research is not limited to the current tool. Instead, many of the features and lessons learned in this work are applicable to other scales such as commercial. Supporting entry level users, providing a database of recommendations, customizing the report based on someone’s priorities and goals are among them. Future work may build on the experience of this research and evaluate the outcomes in other sectors including commercial building energy auditing.
In addition, with minor modifications, the tool can be accessible to professional home energy auditors. While the tool is specifically designed for entry-level users, it is not limited to this use and a future research may study how the professional world are interacting with and evaluating the tool.
Appendix A- Cited Works


Cohen, D., & Crabtree, B. (2006). Qualitative research guidelines project. GEN.


Fuller, M. C. (2011). Driving Demand for Home Energy Improvements: Motivating residential customers to invest in comprehensive upgrades that eliminate energy waste, avoid high utility bills, and spur the economy. *Lawrence Berkeley National Laboratory*. JOUR.


Kozhevnikov, M., Kosslyn, S., & Shephard, J. (2005). Spatial versus object visualizers: A new characterization of visual cognitive style. *Memory & Cognition, 33*(4), 710–726. JOUR.


intelligent decision support system for home energy retrofits. *Journal of Construction Engineering and Management, 140*(1), 4013030. JOUR.


Appendix B - NELC Report Example
Hello Homeowner A,

You are very considerate about your friendly home. We hope that our recommendations can help you improve the condition of your home and save you some money on energy bills. In addition, between rising energy costs and increasing global demand for energy, saving energy is more important and beneficial than ever! Like many other homes, yours has opportunities to reduce energy waste and improve your control of energy costs. The good news is that we have access to numerous tools and resources today to dramatically reduce the energy consumption of America’s households and each and every one of us can make an impact.

Based on our assessment and some basic assumptions, following our recommendations could save you $90-$200 annually on energy costs!

Important note: Our calculations are only estimates. A more detailed analysis by a professional energy auditor can help to develop a detailed plan for investments in improving the energy and health of your home.

We hope that our visit and this report will help you move forward on a path to energy independence. The measures presented in this report should help you make tangible progress towards more comfort, safety, and energy cost savings at home.

Thank you! On behalf of a generation of students that are working hard to ensure a better future, thank you for participating in the National Energy Leadership Corps program. It was a pleasure working with you on your home energy assessment. Please contact us with questions you may have.

National Energy Leadership Corps

"Treat the earth well: it was not given to you by your parents, it was loaned to you by your children."

Chief Seattle, Suquamish Tribe

www.NELC.psu.edu
Chaislain Residence

Location

State College, PA - Pennsylvania

House Facts

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Photos of Your Home

![Photo 1](image1)
![Photo 2](image2)
![Photo 3](image3)
![Photo 4](image4)

Your Priorities and Goals

These are reasons that motivate you to save energy:

- Saving money on your heating and electricity bills
- Improving the condition and value of you home
- To be responsible and not waste energy
- Supporting your local economy and jobs
- Protecting the environment from pollution and damage
Home Energy Profile

Current Estimated Energy Costs

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<td>$450</td>
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</tbody>
</table>

Your Energy Independence Status (your assessment): 5

Home Energy Score: 9/10

Your high score is a result of your home’s size and the energy you use.

This score represents the relative efficiency of your home compared to others of similar size, and is based on your energy consumption, number of occupants, and the features of your home.

Your Annual Energy Spending

Confidence and Commitments

Your confidence in making home improvements

<table>
<thead>
<tr>
<th></th>
<th>low confidence</th>
<th>high confidence</th>
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</thead>
<tbody>
<tr>
<td>Change your habits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do-it-yourself projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investing in upgrades</td>
<td></td>
<td></td>
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<tr>
<td>Time to make improvements</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Safety and Health Concerns

The pressure tank was mentioned to check by professional before. Extra attention to leaking or an inspection of pressure tank are recommended.

Ungrounded outlets

You expressed concern about some of your outlets that you feel are not grounded. Ungrounded outlets are a safety hazard and are in violation of the building and national wiring codes.

We highly recommend you to fix them to prevent future hazards.

Energy Related Issues and Recommended Solutions

- The ceiling of your basement has no insulation. This ends up in a lot of unwanted heat exchange between your basement and your first floor.
- There are evidences of leaks in the ducts in your basement. You are conditioning the air in an unfinished area resulting in losing a lot of energy.
- Think layers of insulation in the attic area. This is one of the most important reasons for heat loss at your home.
- Hot water pipes in your basement is not insulated and are considerably warm. This means that you are losing energy through them.
- The insulation is removed at some parts of your attic. Since heat rises, it's very important to have proper insulation in the attic.
- There are gaps around your entrance door resulting in heat exchange between inside and outside of your house.
Our Top Recommendations

Based on our assessment of your home, we recommend the following actions for your home:

1. Add Attic Insulation - Fiberglass
   Boost your comfort and home heating performance
   • Attic insulation stops heat from escaping your home which will contribute to making your home more comfortable.
   • Installing attic insulation in your home will not only produce a quick payback but it will also reduce your utility bills.
   • Reduce your utility bills and spend less money on energy and more on the things you need for your family and home.
   
   Potential Energy Reduction: 10% - 20% = $234 to $469 over 5 years

2. Air Seal Ductwork
   Boost the efficiency of your heating/cooling unit
   • Increase your comfort in your home by ensuring that duct work is operating at optimal performance.
   • Gain more control over energy lost through leaks in your ductwork system by air sealing.
   • Save money by air sealing ducts which are likely heavily contributing to high energy bills.

   Potential Energy Reduction: 3% - 8% = $70 to $187 over 5 years

3. Insulate Water Piping
   Gain control over heat loss by insulating pipes
   • This easy step will increase the value of your home and your overall comfort while saving you money.
   • Save money by reducing the conduction heat losses from uninsulated distribution pipes.
   • Still installation of pipe insulation is very low cost and has a one year payback on top of yearly savings.

   Potential Energy Reduction: 0.5% - 3% = $2 to $12 over 5 years

4. Insulate Basement Ceiling
   Save utility bill by reducing heat loss through basement.
   • Improve the resale value of your home by comparing comfort, utility bill savings and durability to less efficient homes.
   • Earn a quick payback by insulating basement ceiling with relatively inexpensive materials.
   • Increase the comfort of your home without increasing utility bills by minimizing temperature variations within your home.

   Potential Energy Reduction: 10% - 20% = $117 to $235 over 5 years

5. Weatherize Door
   Keep your home comfortable and limit drafts easily
   • Taking this step will limit drafts in your home which will enhance your comfort and overall home performance.
   • Give yourself more control over the energy you pay for by weatherstripping doors to lower air leakage.
   • Increase your saving by making this easy and cost effective step to keep energy from escaping your home.

   Potential Energy Reduction: 0.5% - 4% = $11 to $94 over 5 years
Congratulations! Taking the time to investigate energy saving opportunities in your home is a great first step. In doing so, you are now more informed about the status of your home, and can begin to make plans and take actions that will save energy and money. Some tips to get started are below.

**Based on our assessment and some basic assumptions, following our recommendations could save you $90-$200 annually on energy costs!**

You have an opportunity! You are currently wasting energy and money due to the conditions in your home. The actions described in this report will help you reduce your exposure to risks due to energy costs. These improvements will also improve the value of your home, increase your control of energy use, and also reduce health and safety risks. In the future, once you have reduced your energy needs, it will be feasible for you to obtain all the energy you need from reliable and domestic sources!

$$$ Help is available! Many of the energy efficiency improvements are supported by local, state or governmental incentives. There are also incentives from utility companies to reward certain improvements. Learning about these would be helpful in making choices. The NELC Local Energy Incentives Fact Sheet outlines some programs that might be helpful.

Energy costs are rising! Electricity and fuel costs across the nation are on the rise. The good news is that by investing in energy efficiency now, you will be saving more money each year. You will also be protecting your home and family from the risks of rising energy costs.

Do 5 things! We encourage you to take steps towards energy independence by acting on our suggestions to reduce your home energy consumption. You will soon begin to see the benefits through savings on your utility bills and a more comfortable, healthy home.
Appendix C - Interview Questions

SMARTdwell Assessment Interview Questions:

Your email address:


Your gender:
○ Male
○ Female

Your experience with NELC home energy assessment program:


Month

Your experience with previous SMARTdwell website:


Month

For each of these items please tell us about your observations of the new version of SMARTdwell website by indicating the strength of your agreement with each statement: Strongly disagree, Disagree, Agree, and Strongly Agree.

1. The admin function for EEM database:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
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</thead>
<tbody>
<tr>
<td><strong>Contributes in reducing time required to prepare report</strong></td>
<td>○</td>
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<tr>
<td><strong>Contributes to ongoing learning of users</strong></td>
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<tr>
<td><strong>Contributes to enhanced interaction with homeowners</strong></td>
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<tr>
<td><strong>Supports preparation of report by entry level users</strong></td>
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</table>
Improves accuracy of the reports

<table>
<thead>
<tr>
<th>Disagree</th>
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<th>Agree</th>
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Are there any other benefits that you perceive from the capability of the tool to have admin option for EEM database?

2. Integration between the report and database:

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
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</thead>
<tbody>
<tr>
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Are there any other benefits that you perceive from the capability of the tool to integrate between the report and database?

3. Health and Safety (H&S) Database and Admin Function for it:

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
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<table>
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<tr>
<th>Disagree</th>
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</table>
Are there any other benefits that you perceive from the capability of the tool to have Health and Safety database and implement admin function for it?

4. Report content editing and administration:

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<th></th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
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</thead>
<tbody>
<tr>
<td>Contributes in reducing time required to prepare report</td>
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<tr>
<td>Contributes to ongoing learning of users</td>
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<tr>
<td>Contributes to enhanced interaction with homeowners</td>
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</tr>
<tr>
<td>Supports preparation of report by entry level users</td>
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</table>

Are there any other benefits that you perceive from the capability of the tool to edit and administer report content?

5. The interactive EEM “To-do” list:

<table>
<thead>
<tr>
<th></th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contributes in reducing time required to prepare report</td>
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<tr>
<td>Contributes to ongoing learning of users</td>
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<tr>
<td>Contributes to enhanced interaction with homeowners</td>
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<tr>
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Are there any other benefits that you perceive from the capability of the tool to have interactive EEM “To-do” list?
6. Providing additional information and links to resources:

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<th></th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
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<tr>
<td>Supports preparation of report by entry level users</td>
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<tr>
<td>Improves Homeowner engagement</td>
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</table>

Are there any other benefits that you perceive from the capability of the tool to provide additional information and links to resources?

Are there any other benefits that you perceive from the capability of the tool to have activity log for interactive “to-do” list?

<table>
<thead>
<tr>
<th></th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
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</thead>
<tbody>
<tr>
<td>Contributes in reducing time required to prepare report</td>
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<tr>
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<tr>
<td>Supports preparation of report by entry level users</td>
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</table>

Are there any other benefits that you perceive from the capability of the tool to have activity log for interactive “to-do” list?
8. Access/Browsing capability of the EEM Database:

<table>
<thead>
<tr>
<th></th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contributes in reducing time required to prepare report</strong></td>
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<tr>
<td><strong>Contributes to ongoing learning of users</strong></td>
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<td><strong>Contributes to enhanced interaction with homeowners</strong></td>
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<td><strong>Supports preparation of report by entry level users</strong></td>
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</table>

Are there any other benefits that you perceive from the capability of the tool to access/browse the EEM database?

---

9. Online Report provided in addition to the ability to generate a pdf:

<table>
<thead>
<tr>
<th></th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
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</thead>
<tbody>
<tr>
<td><strong>Contributes in reducing time required to prepare report</strong></td>
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<tr>
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<tr>
<td><strong>Contributes to enhanced interaction with homeowners</strong></td>
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<tr>
<td><strong>Supports preparation of report by entry level users</strong></td>
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</table>

Are there any other benefits that you perceive from the capability of the tool to provide online report in addition to generate a pdf?
Please indicate the extent to which you are agree with the following statements regarding the new SMARTdwell tool:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is easy to learn and work with</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>Report generating is fast</td>
<td>○</td>
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<tr>
<td>It results in generating the final version of the report that needs no</td>
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<tr>
<td>further modification</td>
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</tbody>
</table>

Please provide us with any further feedback that you may have regarding the SMARTdwell new version:
Appendix D - IRB Approval

EXEMPTION DETERMINATION

**Date:** November 3, 2016  
**From:** Tracie Kahler, IRB Analyst  
**To:** Shahrzad Fadai

<table>
<thead>
<tr>
<th>Type of Submission:</th>
<th>Initial Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title of Study:</td>
<td>Developing a report writing tool for efficient home energy assessment report writing</td>
</tr>
<tr>
<td>Principal Investigator:</td>
<td>Shahrzad Fadai</td>
</tr>
<tr>
<td>Study ID:</td>
<td>STUDY00006118</td>
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<tr>
<td>Submission ID:</td>
<td>STUDY00006118</td>
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<tr>
<td>Funding:</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

**Documents Approved:**
- SMARTdwell Assessment Interview Questions.docx (0.01), Category: Data Collection Instrument

The Office for Research Protections determined that the proposed activity, as described in the above-referenced submission, does not require formal IRB review because the research met the criteria for exempt research according to the policies of this institution and the provisions of applicable federal regulations.

Continuing Progress Reports are **not** required for exempt research. Record of this research determined to be exempt will be maintained for five years from the date of this notification. If your research will continue beyond five years, please contact the Office for Research Protections closer to the determination end date.

Changes to exempt research only need to be submitted to the Office for Research Protections in limited circumstances described in the below-referenced Investigator Manual. If changes are being considered and there are questions about whether IRB review is needed, please contact the Office for Research Protections.

Penn State researchers are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within CATS IRB (http://irb.psu.edu).

This correspondence should be maintained with your records.