

## GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES HOME ENERGY AUDITING

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### Abstract

Home energy auditing is an important process that is the preliminary step in solving energy deficiency issues within houses. Energy auditing is essential for identifying wasted energy in homes. Educating homeowners on the energy efficiency of their home is important to reduce their energy bill but to also protect the environment. A home energy audit can provide the homeowner with the necessary information to maximize the energy efficiency of their house while minimizing the costs for energy. This paper defines home energy auditing, discusses some techniques used, and the requirements needed to become a certified energy auditor.

**Keywords:** Energy audit, energy efficiency, environment, thermal imaging, Certified Energy Auditor (CEA)

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### I. INTRODUCTION

Environmental problems expand into a range of pollutants, hazards, and ecosystem degradation. [7] Energy supply issues are related to global warming, air pollution, acid precipitation, ozone depletion, forest destruction, and emission of radioactive substances. All evidence shows that the future will be negatively impacted if humans continue to neglect the environment. Simple measures can be taken in energy conservation such as: shutting off lights, turning off running water, or riding a bicycle. Energy efficiency is slightly different from energy conservation because it involves the use of technology with less energy to perform the same function. For example, installing a compact fluorescent light bulb uses less energy than an incandescent light bulb but produces the same amount of light. [6] Energy auditing is an example of practices that support energy efficiency because there are several tests that can be performed in order to find the optimal use of energy in a space.

Increasing energy bills, inconsistent room temperatures, or condensation on walls or windows are signs it may be time for a home energy audit. Home energy auditing is defined as “the first step to assess how much energy your home consumes and to evaluate what measures you can take to make your home more energy efficient.” [11] By understanding the process of energy auditing, it is important to first know where energy comes from and how it impacts a person’s life. According to the typical American household, most of the energy does not come from lights but rather heating and cooling followed by the washing and drying of clothes. [12] Figure 1 shows that almost half the energy used in a home is due to heating and cooling and only 7% belongs to lighting.

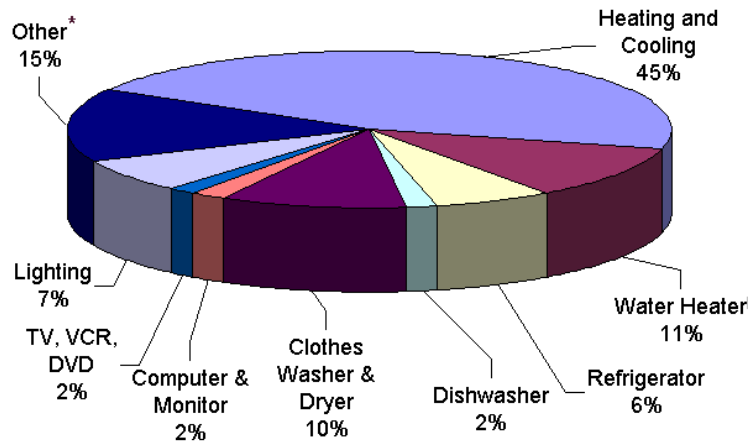


Figure 1 – Energy usage of a typical American home.

There are numerous steps that can be taken in order to save money and improve the safety in your home. An examination of your home can be something you do yourself or by hiring a professional energy auditor who will have suitable tools to get precise measurements. Simple fixes can be upgrading the HVAC system to regulate air flow or improve lighting levels which will reduce costs while creating a comfortable atmosphere. [8] Energy auditing is meant to pinpoint the hidden issues where your home is less energy efficient and provide cost effective solutions. The process of energy auditing starts with a walk-through analysis of the home and performing tests and taking measurements. [8] These tests are used to check the air filtration system, air leakage, or heating and cooling issues. Air leaks can be the biggest waste of energy because they often go undetected for long periods of time. [8]

Homeowners have the option of two different types of energy audits; home energy survey or a general energy audit. The home energy survey is a visual inspection of the house to assess the energy performance. [9] The building envelope features such as windows, doors, insulation and ducts are inspected as well as heating, cooling air ventilation, visible moisture issues, and visible health and safety issues. [9] The auditors will analyze the electric and gas billing in order to understand the home's energy usage and ask question to learn the occupants' behavior. How many people live in the home? How many rooms are in use? What is the thermostat setting for summer and winter? What is the hot water usage? [9] The inspection and interview process by the auditor are the first step to a home energy audit. The general energy audit goes further than a home energy survey by using diagnostic tests to find air leaks, potential safety issues, or inefficiency of insulation in walls and ceilings. [9] There are a variety of techniques and equipment used in order to find problematic energy efficiency within a home.

## II. TECHNIQUES OF ENERGY AUDITING

### *Thermographic Inspection:*

One of the most important tests to perform is a thermographic inspection which allows the auditor to see where the heat is in the space and where it is escaping. [8] Thermography measures "surface temperatures of walls, roofs, ceilings, floors, and other part of a building's envelope to detect heat loss, air leakage, moisture buildup, and to locate hidden infrastructure." [14] A thermographic inspection uses a camera to measure the temperature variations and find the problematic areas. Through a series of images or recordings ranging from white (warm areas) to black (cool areas), the auditor can determine the state of the insulation. In Figure 2, the dark areas shown represent heat loss for this interior space. Interior scans are more accurate than exterior surveys due to the reduced air movement making it easier to detect temperature differences and because "warm air escaping from a building does not always move through the walls in a straight line." [16] A few types of infrared scanning devices are spot radiometer, thermal line scanner, or a thermal imaging camera. [16] The simplest device is the spot radiometer which measures radiation one spot at a time, showing the exact temperature of the spot. [16] A thermal line scanner shows radiant

temperature, over a picture of the area, along a line. [16] A thermal imaging camera is the most accurate device because it provides details in a 2-dimensional thermal picture of the heat leakage. [16] Technological advancements have even made it possible to utilize drones in order to capture thermal imaging. Aerial thermography is expensive but simple to operate with easy to read data. [3] Using infrared cameras at low speeds, drones are able to take clear images of fire prone areas where heat is escaping from the exterior. [3] The use of a drone is more popular for larger properties so that every angle of the structure can be considered when looking for problem areas. This could reduce or eliminate the need for people to perform these tests in high risk areas. [3]

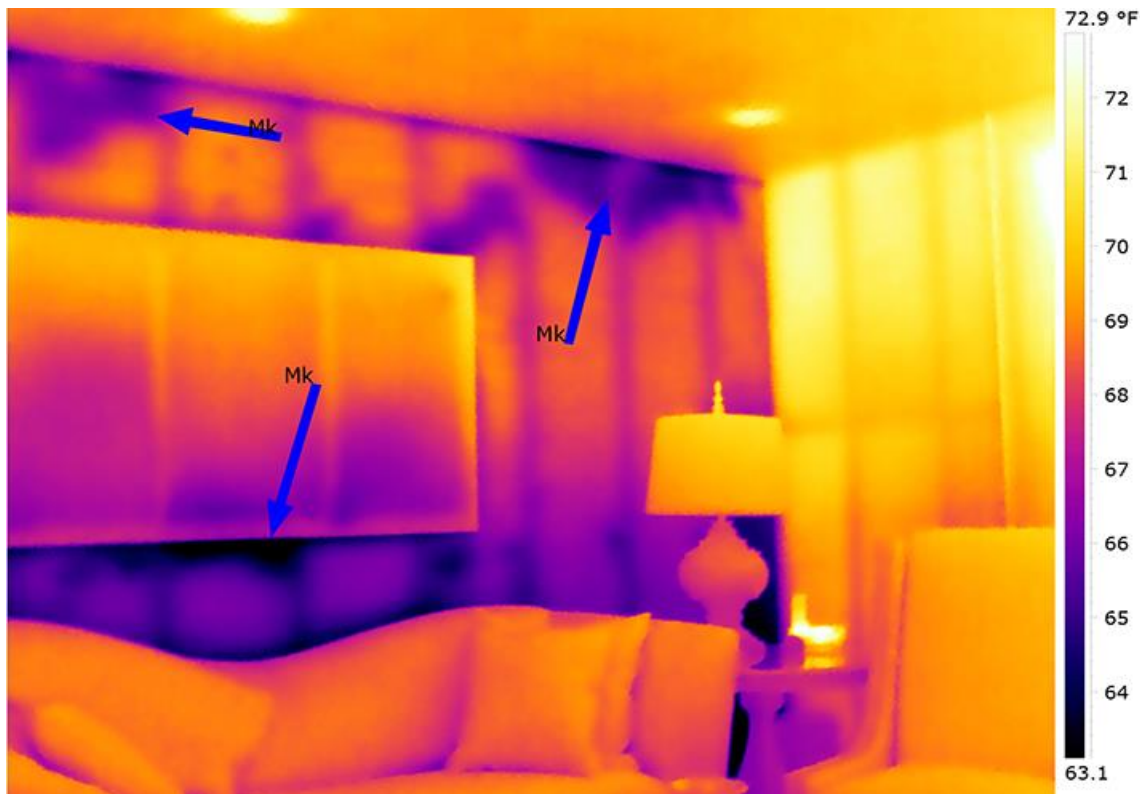


Figure 2 – The dark spots show where heat is leaking in poor insulated areas.

#### **Blower Door Test:**

This test is typically performed with a thermographic scan to “exaggerate air leaking through defects in the building shell.” [16] A blower test measures the amount of air leaks and hot spots in the house. During a blower test, a powerful fan is mounted to the door to provide controlled air flow. “When air pressure and air flow are controlled and measured, they can provide data about how airtight a building is.” [10] By pushing air through the cracks and holes, air leaks can easily be identified. Most homeowners assume that poorly sealed doors and windows are the source for air leaks. However, it is more important to inspect basements or attics because the difference in air pressure between interior and exterior is greater at ground level and higher levels. [10] Auditors will check basement rim joists, holes in plumbing under tubs and showers, cracks between finish flooring and baseboards, utility chases, plumbing vent-pipe penetrations, kitchen soffits, fireplace surrounds, recessed can lights, and cracks between partition top plates and drywall. [10] Figure 3 shows the results of a blower door by a thermographic scan that portrays the dark purple spots as the poor insulated areas with air leaks.



Figure 3 – Forced air is blown out of the house in the leaks and cracks of the exterior.

#### **PFT Tracer Gas:**

Similar to the blower door test is the Perfluorocarbon (PFT) air infiltration measurement technique. This type of technique is used to measure the atmospheric pressure, weather, wind velocity, and other activities that affect air infiltration rates over time. [8] PFT is a type of tracer gas that is used to directly measure the air exchange rates in homes. “The air exchange rate is required in order to calculate the emission rate of indoor pollutants from measured indoor concentrations.” [13] Other methods for measuring air exchange rate are, “real time injections of tracer gases or real time monitoring of tracer concentrations.” [13] These techniques, however, require expensive instruments and highly trained personnel to be on site, which is why the PFT method is the most common and most cost efficient. There are many PFT gases that can be used as tracer gas sources. The most common tracer gas methods are constant injection rate and decay rate methods. [13] The constant injection rate method, also referred to as the passive tracer method, involves the placement of multiple emission sources of one or more tracer gases in a room in the house. [13] This will measure the concentration of the gas over a period of time that ranges from hours to days. [13] The decay rate method involves the injection of a tracer gas which measures the decay in real time over a few hours. [13] This method does not require trained technicians onsite and only measures the air exchange rate over a short time. This technique would be typically used for a smaller structure while the constant injection method would be used for larger scale structures. Figure 4 shows the process of releasing the gas, within a controlled environment, into the air to detect the location of the leaks. The PFT technique is also used to determine the infiltration rates of other gases, like radon. [15] By placing the devices in the soil next to the foundation, below the basement floor, and in the house, it is possible to detect a potential radon hazard. [15] Essentially, an emitter is placed in a room of a house in order to inspect for air leaks. The emitter then sends out an odorless, colorless, safe PFT tracer gas. Then a receiver measures the concentration of the gas which then determines the air tightness within the room. This process is used to measure the air exchange rate over a period of time.

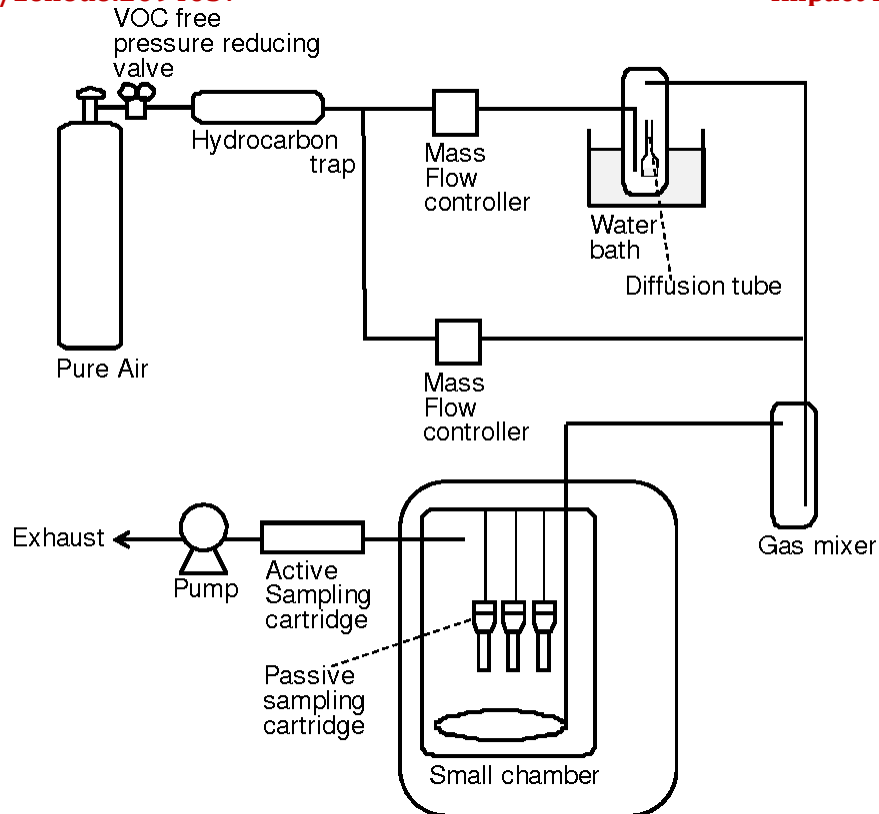


Figure 4 – System of measurement for the PFT tracer gas rate.

### III. CERTIFICATION REQUIREMENTS FOR ENERGY AUDITORS:

There are several organizations available that provide training, education, and certification to become an energy auditor. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) is an organization that provides certification to become an energy auditor. [1] One certification offered by ASHRAE is the Building Energy Assessment Professional (BEAP) certification which fulfills the definition of a qualified energy auditor. [3] Requirements for this certification include an application fee and scheduling an exam. [3] The Residential Energy Auditor (REA) certification program is designed for professionals with energy auditing experience who want to expand their knowledge into specifically residential energy use. [5] Applicants must complete one of criteria listed in table 1 below, as well as attend one of the Association of Energy Engineers' (AEE) preparatory REA training seminars, submit a REA application, and pass an open book exam. [5]

*Table 1 - Applicants must meet one of these criteria to be considered for the REA certification program.*

| Education  |     | Work Experience              |
|--|-----|------------------------------|
| 4-year engineering/architectural degree OR Professional Engineer (PE) OR Registered Architect (RA) | AND | 3+ years related experience  |
| 4-year unrelated degree  | AND | 4+ years related experience  |
| 2-year associate degree  | AND | 5+ years related experience  |
| Current Status of Certified Energy Manager (CEM®)  | AND | 3+ years related experience  |
| NONE   | AND | 10+ years related experience |

To become a Certified Energy Auditor (CEA), the eligibility requirements are a little more complex. These requirements involve completing a minimum of two hours of safety training and participating in five commercial audits, both within the last three years. [4] Two of the audits are required to be a minimum of 10,000 square feet and two different types of buildings. [4] Applicants must also meet at least one of the criteria listed in table 2 below, as well as attend a CEA preparatory training seminar, submit a CEA certification application, and pass an open exam. [4]

*Table 2 - Applicants must meet one of these criteria to be considered for the CEA certification program.*

| Education & Experience  |
|---|
| 2-year Technical degree or 4-year degree from an accredited university or college OR        |
| Currently working as a residential energy auditor with 3+ years of verifiable experience OR |
| US Military Veteran with 3+ years of verifiable relevant technical experience OR            |
| Current status of Certified Energy Manager (CEM) or Certified Energy Auditor (CEA)          |

Both of these certification programs are among the many that are accredited by the AEE. [4] The Residential Energy Services Network (RESNET) created national training and certification standards for the Home Energy Rating System (HERS) which helps calculate energy efficiency in homes. [9] “To calculate the HERS score of a home, a certified RESNET home energy rater will do a home energy rating and compare the data against a similar home.” [12] The score ranges from 0 to 150 and the lower the number, the more energy efficient the house is. [12] To become an Energy Smart Contractor through RESNET, the applicant must complete eight hours of training, pass a 50-question exam and sign up with a Contractor Education and Qualification Provider (CEQ). [9]

#### IV. CONCLUSION

The environment is being negatively affected by human behavior which is causing a strain on energy conservation. Adopting simple measures can increase energy efficiency. Energy auditing is just one approach to identifying the areas of wasted energy within the house. It is important to know that the energy audit does not actually decrease energy usage, the energy saving strategies must be applied. Every house is different because of different environments and learning about energy auditing can make it easier to adapt to these environments. By using these techniques and tests, it becomes possible to reduce wasted energy in the home and therefore reducing the amount of pollution. Energy auditing is the first step to saving money, energy, and making your home more comfortable. The different ways for energy auditing certification include education, training, and work experience. Organizations like ASHRAE and RESNET provide programs that vary in requirements depending on the level of certification desired. These certifications ensure the best possible auditor professional to locate the areas of the home that can maximize energy efficiency which will build a better environment.

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