An Approach to Design a User-Friendly Set of Guidelines for Homeowners to Achieve Maximum Energy Efficiency in Existing Home Structures

by

Kerenza Marguerite Johnson

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Approved by

Tin-man Lau, Chair, Professor of Industrial Design
Bret Smith, Professor of Industrial Design
Richard Britnell, Professor of Industrial Design

Abstract

Currently in America, there is a flood of information on how to "green" homes for energy efficiency. Despite this, there is no simple approach for homeowners to "go green". As a result, homeowners are less likely to take part in greening for energy efficiency because they are intimidated and overwhelmed by complex and often contradictory information. The most obvious solution to this problem is to create an approach for greening homes that is as clear and user-friendly as possible.

The goal for this thesis is to generate criteria for the use of homeowners that enables them to green their homes with ease. These guidelines will offer the clearest approach for homeowners to create a healthier and more energy-efficient environment within their means. The purpose of this project is to design a set of guidelines that eliminates the complexity of going green. These guidelines enable homeowners to green their homes with ease all while improving their living environment.

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I would like to thank all the professors and staff at Auburn University Industrial Design. I am especially thankful to my committee. I could not have completed this thesis without all of their help and guidance.

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Table of Contents

List of Figures

List of Tables

CHAPTER 1: INTRODUCTION TO A PROBLEM

1.1 Problem Statement

Currently in America, there is a flood of information on how to green homes for energy efficiency. There is a large amount of literature and articles that offer information on how to go about greening one's home. Due to this, it is likely that the average person may overlook taking part in greening for energy efficiency because he or she becomes overwhelmed by all of the information provided and are not sure where to begin. According to Ellen Slattery of greendaily.com, there are many excuses for going green. She states that homeowners do not know where to begin, that they are overwhelmed and that they believe that it is to expensive to make changes for energy efficiency (2008). The world has taken a huge step toward going green, so why not make all this information a little easier to understand for those who do not posses the "green bug". If greening a home could to be as simple as using a caulk gun, then families might stop looking at "going green" as a lifestyle change that just is not for them. So, if this set of guidelines could show families of all incomes where to begin when greening their homes, not just to be green, but for the money saving benefits in the most clearest and simplest way possible, then more families might be willing to join in on today's Green Movement for energy efficiency.

1.2 Need for Study

Today, homeowners have thousands of resources at their disposal for going green. Living green is not only better for the environment, but it puts money back into people's pockets while cutting back on one's personal impact on the planet. However, Americans seem to be coming up with more excuses than ever. According to Ellen Slattery, a freelance writer and writer for greendaily.com, the top excuses of Americans today is that going green is too expensive and that they do not know where to begin (2008). Tate Walker, a project manager for the Energy Center of Wisconsin, a nonprofit organization dedicated to improving energy sustainability and member of Wisconsin Green Building Alliance stated, "There are more than 55 million single-family residences in the United States and they use approximately 36 percent of energy sold in this country (2005, para.1). It is also important to know "the average household consumes the equivalent of 1,092 gallons (26 barrels) of oil each year" (Walker, 2005, para.1). According to Tate Walker, project manager for the energy center of Wisconsin, using fossil fuels the way Americans do has degraded the environment, our health and multiple land resources. This fossil fuel use makes up for somewhere around 75 percent of the U.S.'s energy production portfolio (2005). This gives a more than legitimate reason to attempt to simplify the greening process.

The point of this study is to simplify the mass amount of information provided to the American public and condense it into a set of guidelines so Americans will no longer be able to use the excuse of not knowing where to begin. The objective overall is to put an end to Americans' top excuses for not going green and provide them with clear, easy and affordable instruction on greening their homes for energy efficiency. Amann, Wilson

and Ackerly, writers for the American Council for an Energy Efficient Economy say, "the wonderful thing about energy is that in addition to helping the environment, you save money. It's like contributing to a good cause and ending with money in your pocket" (2007, p. 1).

1.3 Literature Review

The website of the comprehensive program endorsed by the National Recycling Coalition called Go Green Initiative published that the world population is expanding at a rate that will leave the population in the year 2050 with only 25 percent of the resources the population had in 1950 (Go Green Initiative, 2007). Energy Literacy Advocates (ELA) is a non-partisan, non-profit, public education and advocacy group.

According to the ELA's article *Energy and the Economy:*

> Our economy is threatened because all aspects of it are intricately dependent on the steady supply of affordable energy on which we can no longer depend. From transporting workers to the workplace, to the transport of goods, to the production of petro-chemically based products like plastic, it is impossible to overestimate the degree to which our economy is driven by energy (para., 1).

A large amount of energy is consumed in America. According to John Krigger, founder of Saturn Resource Management and publisher of many books on energy conservation and energy efficiency for buildings, "More than twenty percent of that energy flows through our homes, and if you include commercial and industrial structures, our buildings account for over forty percent of our total energy consumption" (2008, p. 1). Every decision made, even those as small as the light bulbs purchased or replaced,

are affecting the planet. "The energy we use also has an environmental impact – much of the pollution we create is emitted by the construction, maintenance, and operation of those structures" (Krigger and Dorsi, 2008, p., 1)

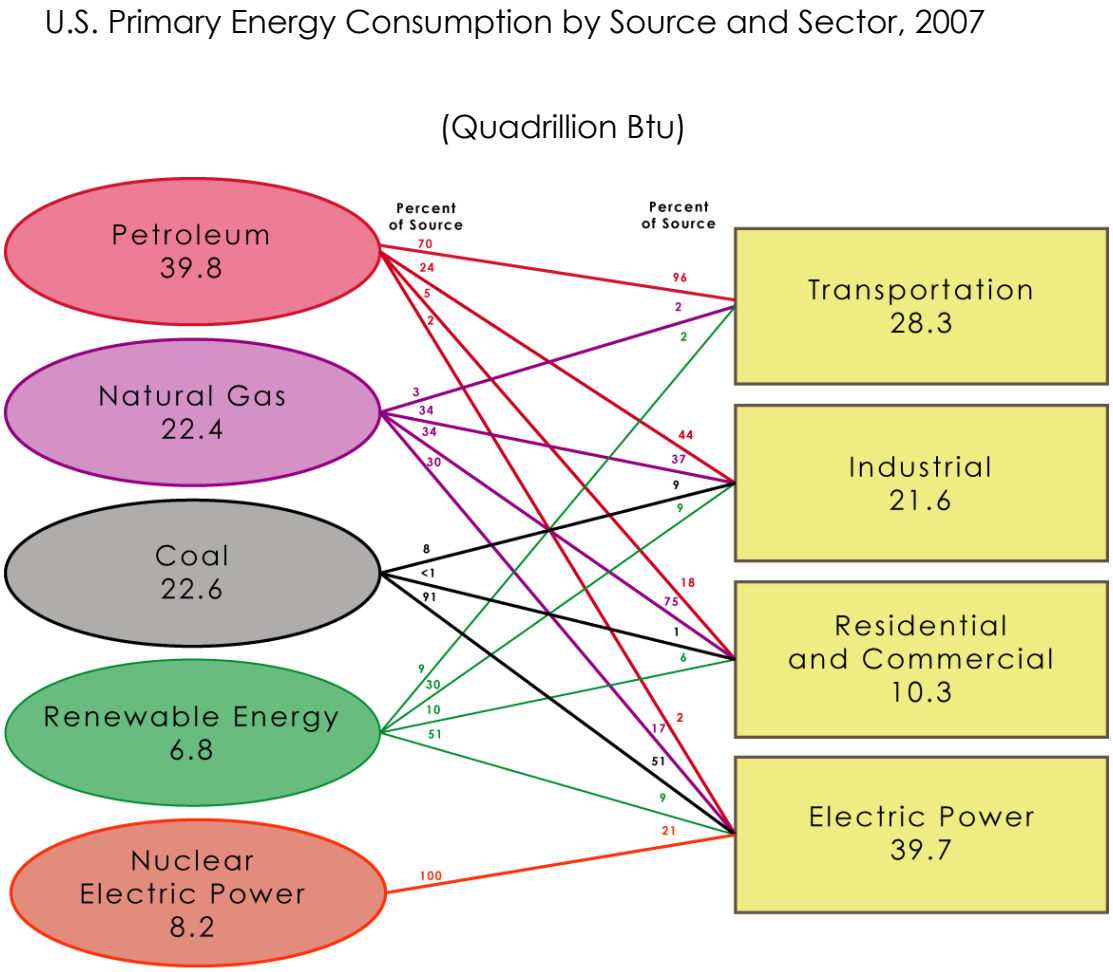


FIGURE 1: U.S. Primary Energy Consumption by Source and Sector, 2007 (EIA, 2008)

1.3.1 Defining Efficiency

Energy efficiency is the cornerstone of any green building project. David Johnston, a leader in the green building movement and founder of www.whatsworking.com and www.greenbuilding.com, along side John Gibson, a freelance writer for Fine Homebuilding magazine, wrote in their book *Green from the Ground Up*, "A well-designed green-built home consumes as little energy as possible and uses renewable sources of energy whenever possible. Lower energy use not only saves homeowners money but also has broader societal benefits, including fewer disruptions in energy supplies, better air quality, and reduced global climate change" (Johnston and Gibson, 2008, p., 1). There are four categories of energy demand: Residential, Commercial, Industrial, and Transportation. It is important to understand where a homeowner stands in reference to our energy use. Table 1 shows U.S. energy consumption by sector.

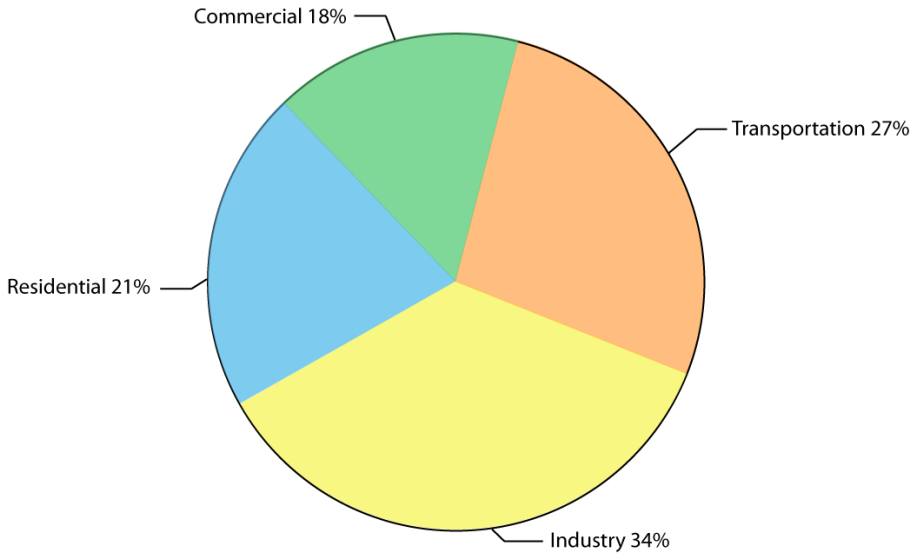


TABLE 1: U.S. Energy Consumption by Sector (Scheckel, 2005, p. 28)

"Efficiency is the production of a desired effect with a minimum amount of effort or waste" (DeGunther, 2008, p., 9). People generally understands what energy efficiency is, but what they might not know is that there are four types of efficiency. These efficiencies include: energy efficiency, financial efficiency, pollution efficiency and labor efficiency.

> According to Rik DeGunther, CEO of Efficient Homes, and energy auditing firm in Northern California (2008):
>
> Energy efficiency is generally defined as getting the most useful output from energy sources. The energy efficiency of a device is a comparison, or ratio, of the useful energy output to the total energy input. This ratio is *always* related to the particular situation (the season, timing, desired end result, and so on)
>
> Financially efficient is also termed as "cost effective". The financial efficiency of an appliance is the comparison, or ratio, of cost savings to the cost of the appliance (which included the original equipment cost plus installation costs and maintenance costs, including energy). The better the ratio of cost savings to price, the more financially efficient an investment is (p., 10).

"Pollution efficiency of an appliance is a comparison, or ratio, of the useful *output work* (the job that is being done) to the amount of pollution that is generated in the process. Labor efficiency is a comparison, or ratio, of how much work an appliance does to the amount of personal labor required to run and maintain it" (DeGunther, 2008, p., 11). If someone were strictly looking into efficiency for money savings, they would want to consider financial efficiency at the top of their list.

Financially efficient homes are cheaper to operate and have a smaller carbon footprint; those are not the only benefits of energy-efficient homes. These homes are also more valuable upon resale (Krigger and Dorsi, 2008, p., 1). Ultimately efficiency has the ability to put money back into the pocket of a homeowner, increase the home's value, and allow one to be proactive by reducing their impact on the environment.

1.3.2 Energy Literacy

America's Energy Crisis and article published by the Energy Literacy Advocates says, "A vast majority of Americans simply don't adequately understand the magnitude and urgency of our national energy crisis. They don't know that global supplies of oil will soon be insufficient to meet global energy demands" (n.d., para.1). According to energyliteracy.org's article *Energy Primer 101*, the total conventional pumping global oil supply is estimated to be 1.05 trillion barrels; assuming a steady rate of demand, the supply will be exhausted in 40 years. "If the U.S. decided to stop importing oil, at the current rate of consumption known, U.S. reserves would last between 5 to 3.5 years" (Energy Primer 101, n.d., para.10). The ultimate and most obvious solution to this is educating the American public and making them energy literate.

Not all of the energy waste and misuse is the fault of homeowners; it is a problem on many levels. A variety of energy sources are used in North America. The most common energy sources are petroleum products, natural gas, coal, nuclear, hydropower, biomass, geothermal, wind, import electricity, and solar (DeGunther, 2008, p., 18).

According to Paul Scheckel, Senior Energy Analyst at Vermont Energy Investment Corporation, "Our homes generally consume one or more primary fuels in

addition to electricity. The most common primary fuels used in homes are natural gas, liquid propane gas, and oil" (2005, p. 9). There are entire societies built on the use of fossil fuels over the past 150 years. These resources contain elements of hydrogen and carbon that generate waste, resulting in pollution (Scheckel, 2005, p. 10).

This is the kind of information that is published in news stories periodically. All of these facts simply compound and cause extreme confusion of the homeowner.

"The majority of energy sources produce power through combustion processes that require a burning chamber, oxygen, and exhaustion capacities" (DeGunther, 2008, p., 20). Combustion processes even take place in our home heating equipment, according the *Homeowner's Guide to Energy Efficiency* (2008). There are also non-combustion processes that do not exhaust pollutants; however, they require a lot of energy to manufacture. "The point is there is no such thing as a free lunch. Every energy source has pros and cons, and trying to decide how to best provide the power an economy needs is a complex problem" (DeGunther, 2008, p., 20). "Pure hydrogen is the cleanest energy source" (Scheckel, 2005, p. 9). This is also one of the most abundant elements in the universe. The only byproduct of burning pure hydrogen is water vapor. The only problem with this is that it is extremely difficult to find hydrogen on its own (Scheckel, 2005, p. 10).

1.3.3 Green Building: Save Money, Save the Earth

When green information is available, it is almost always in the context of new homes. One might ask the question, "What makes a building green?" It is simple, really. According to the article *How Green is Your Home?* (2009*)*, an article published on

greenbuildingadvisor.com, a site sponsored by the publishers of Fine homebuilding and Environmental Building News, “green building is an approach to designing and constructing buildings to lessen their impact on the environment and to provide a healthful atmosphere for their occupants”. Really it all boils down to conserving materials, energy and the environment over the life of the structure. “All green buildings embody three broad principles: energy efficiency, conservation of natural resources, and high indoor air quality” (How Green is Your Home?, 2009, p. 14). “For Homeowners and Homebuyers” (2009) and article published by Build It Green, a membership supported non-profit organization whose mission is to promote healthy, energy- and resource-efficient homes in California, gives the simplest explanation. “In practical terms, green building is a whole systems approach to building that includes:

- Designing for livable communities
- Using sun and site to the building’s advantage for natural heating, cooling, and daylighting
- Landscaping with native, drought-resistant plants and water efficient practices
- Building quality, durable structures
- Reducing and recycling construction and demolition waste
- Insulating well and ventilating appropriately
- Incorporating durable, salvaged, recycled, and sustainably harvested materials
- Using energy-efficient and water-saving appliances, fixtures and technologies” (What is Green Building?, n.d., para.2).

There are major advantages to living and building green. The most obvious advantage to building green is saving money. "Green building construction practices and products make homes more energy efficient through proper, adequate insulation and air sealing. Efficient windows, appliance, lighting and other household equipment also help add to the saving and keep your monthly electric bills up to 65 percent lower" (For Homeowner and Homebuyers, n.d., para.2).

According the article "How Green Is Your Home?" in *Green @ Home*, an edition of *The Best of Fine Homebuilding* (2009), it is really cheaper to live in a green house. "Living in a more efficient house is like money in the bank. Green houses are also designed to save money with lower maintenance costs" (How Green Is Your Home?, 2009, p. 16).

Things as simple as the appliances purchased or the light bulbs chosen to replace the burned out ones are decisions that affect the environment. "You may not realize just how big a difference each of us can make by taking energy use into account in our household purchasing and maintenance decisions" (Amann, Wilson and Ackerly, 3). "If you replace a typical 1987, 20-cubic-foot refrigerator with an energy efficient 2007 model, you'll save more than 500 kWh and almost 1,000 pounds of CO_2 emissions per year!" (Amann, Wilson and Ackerly, 3). American homes put off almost as many emissions as the cars they drive (Figure 2). Reducing the amount of time spent in the car is no longer enough in helping reduce the effects on the environment; it is time to make changes in homes and lifestyles as well. This figure represents the emissions of American homes and cars (Figure 2).

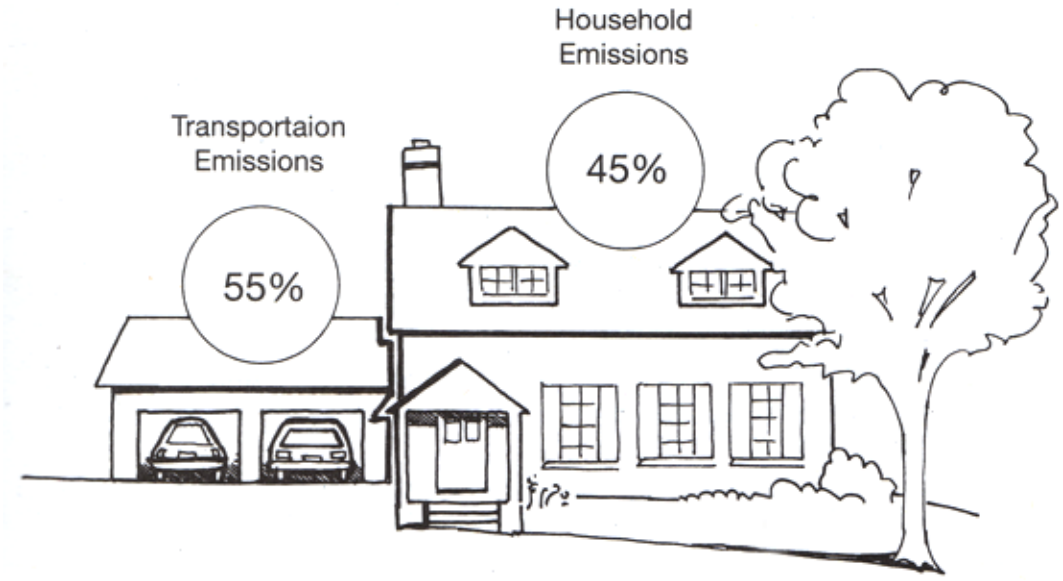


Figure 2: Household and Transportation Emission of a Single Family Household (Amann, Wilson and Ackerly, 2007, p. 3)

The typical North American home consumes somewhere around 21 percent of the energy used in this nation. In the year 2001, Americans spent around $1,493 for household heating, cooling and powering their homes (Scheckel, 2005, p. 28). It is important to know where in homes the most energy is consumed. The majority of energy consumption in a home is a result of space heating and cooling. On average, 47 percent of the total energy used in a home is used for space heating, according to Rik DeGunther, author of *Energy Efficient Homes for Dummies* (2008). Also, 21 percent of total energy consumption in homes is a result of water heating. Table 2 represents the breakdown of energy use in the typical home.

Yearly Energy Use for a Typical Home	
Purpose or Use	**Percentage of Total Energy Used**
Space Heating	47%
Water Heating	21%
Lighting	8%
Space Cooling	6%
Refrigeration	5%
Cooking	4%
Electronics	3%
Clothes washing/drying	3%
Computers	1%
Other	2%

TABLE 2: Yearly Energy Use for the Typical Home (DeGunther, 2008, p. 30)

1.3.4 The Green Advantage

Another benefit of going green includes improving the comfort of one's home and overall health, as well as playing a role in helping the environment. Good overall environmental quality has the ability of reducing the rate of respiratory disease, asthma, and allergies. Indoor air quality is also improved by choosing low emission paints and finish products.

"Chemicals emitted from building materials can be potential source of health problems if they are not properly addressed" (For Homeowners and Homebuyers, n.d., para.4). Products that might emit these chemicals are cabinetry or any other finished wood product in your home. "These products are manufactured using formaldehyde-

based adhesives. Formaldehyde can offgas into your home for years" (For Homeowners and Homebuyers, n.d., para.4). Formaldehyde is a carcinogen. Living among carcinogens in your home for years unknowingly is a devastatingly scary thought that can lead to cancer among the home's residents.

1.3.5 Green Building Materials

It is important to know that there are green alternatives to basically every material used in the home. These materials not only cause as little harm to the environment as possible, but also provide the same, if not better, benefits for one's home, health, and pocketbook. There are many green materials to choose from for the interior and exterior of a home. For example, instead of using treated lumber to frame out a house, salvaged lumber or FSC-certified lumber can be used. "FSC is an international nonprofit organization that protects forests around the globe. Lumber certified by the FSC must meet certain standards designed to protect the forests in which it was cut, as well as the people who live there" (Johnston and Gibson, 2008, p. 96).

Today a number of builders have abandoned the use of wood for a variety of new materials. AAC blocks (autoclaved aerated concrete) are one of those new materials being used in place of wood. "Blocks also take the place of wood, insulation, house wrap, and drywall – all in a single product" (Johnston and Gibson, 2008, p. 92). There are also green alternatives to roofing a home rather than the basic shingle roof. "Recycled synthetic shingles offer an alternative to materials such as cedar shingles and shakes, natural slate, clay or concrete tile, and standing-seam metal roofs" (Johnston and Gibson, 2008, p. 125). Of course, there is always the option of having a vegetated roof.

Mineral wool, cotton batt, and spray-in insulations such as blown cellulose are some of the more common alternatives to fiberglass insulation and twice as effective without the itchy side effects. "Rigid foam insulation applied to the outside of a building reduces thermal bridging and air infiltration while moving the dew point inward to reduce the risk of condensation inside wall cavities" (Johnston and Gibson, 2008, p. 222). The proper insulation choice is key to comfort and ultimate energy savings. "In general, more is better; treat code recommendations as minimums" (Johnston and Gibson, 2008, p. 207).

Aside from the materials used for the framing and exterior of the home, there are many green interior-finishing products. "Unlike carpeting, which can trap dust, animal dander, and moisture, stained concrete floors won't degrade indoor air quality" (Johnston and Gibson, 2008, p. 279). Cork floors are also becoming a very popular green option for homes because of its natural anti-bacterial qualities. There are still green carpet choices, however, such as carpeting made from natural fibers to avoid the off-gas from the bindings of other carpets and carpets made from things like recycled "pop bottles" (Johnston and Gibson, 2008, p. 307). When it comes to indoor wall finishes, low VOC paints, finishes and adhesives are the green choice. "An alternative for indoor wall finishes is natural plaster, a popular finish material available in a variety of colors that's applied to primed and sealed gypsum drywall, blue board, or other suitable substrate" (Johnston and Gibson, 2008, p. 292).

1.3.6 The Home Energy Audit

A significant reason heating and cooling a home could be costing you a fortune is that the "building envelope" may be leaking. Leaks are commonly found in the walls and structure of a home, as well as the insulation or HVAC system ductwork. In order to green a home, it is important to begin by finding out where the home is energy inefficient. The best way to do this is a home energy audit. A professional can be hired to do this, or it can be done by the homeowner. Steps on how to do a home energy audit will be addressed later.

If a homeowner chooses to have a professional come in, the test may turn out more accurate, but it is not necessary. "These contractors use sophisticated equipment, like blower doors and infrared cameras to help pinpoint air leaks and areas of inadequate insulation. Auditors that are properly certified should also test and tune-up your heating and cooling equipment, and check for duct leakage (Amann, Wilson and Ackerly, 2007, p. 16). Blower doors, duct blasters, and digital infrared cameras are all used in these home diagnostic tests. A blower door is a powerful fan that mounts onto the frame of an exterior door used to determine the air tightness and infiltration rate of the home.

A duct blaster is a similar device, attached to the duct system, that allows the professionals to determine where leaks are in the ductwork. Finally, a digital infrared camera detects thermal defects and air leakage by measuring surface temperatures of the walls and ceilings (Amann, Wilson and Ackerly, 2007, p. 18).

FIGURE 3: Infrared Camera (gettyimages.com)

With today's resources, anyone is capable of doing a DIY energy audit. With a simple but diligent walk through, one can spot many problems**.** According to the U.S. Department of Energy, "a home energy audit is the first step to assess how much energy your home consumes and to evaluate what measure you can take to make your home more energy efficient". An energy audit is not just about heating and cooling systems; it can also help a homeowner to see ways to conserve hot water and electricity.

1.3.7 Conclusion

There are steps that everyone can take to help the earth and make their homes more energy efficient havens. All it takes to get people on board with the idea of "going green" is to educate them. The reason there is no passion is because there is a lack of knowledge and understanding. The lack of clear and credible information is the reason

there is a lack of knowledge. This study is to create a simplified set of steps people can take to green their homes that does away with the excuse "I don't know where to begin".

1.4 Objectives of Study

- To create a clearly organized set of steps to guide homeowners when greening an existing home for energy efficiency.
- To improve the homes and lives of homeowners.
- To create an appreciation of the environment through education and understanding.
- To provide a method for homeowners to systematically lower the statistical figures of household emissions and waste.
- To create the most user-friendly set of guidelines possible that prioritizes the steps to take when greening a home.
- To create an approach to greening a home that can be later modified as the green market progresses.
- To identify cost benefits.

1.5 Definition of Terms

Efficiency - The production of a desired effect with minimum amount of effort or waste (DeGunther, 2008, p. 9).

Energy efficiency –Generally defined as getting the most useful output from energy sources (DeGunther, 2008, p. 10).

Financial efficiency - Also termed as cost effectiveness, the comparison, or ratio, or cost savings to the cost of the appliance (DeGunther, 2008, p. 11).

Pollution efficiency – A comparison, or ratio, of the useful output work to the amount of pollution that is generated in the process (DeGunther, 2008, p. 11).

Output work – A job being done by a product, appliance or person (DeGunther, 2008, p. 11).

Labor efficiency – A comparison, or ratio, of how much work an appliance does to the amount of labor done by a person required to run and maintain it (DeGunther, 2008, p. 11).

Green building – An approach to designing and constructing buildings to lessen their impact on the environment and to provide a healthful atmosphere for their occupants (How Green Is Your Home?, 2009).

Carcinogen – Any element or substance that promotes the incidence of cancer.

AAC blocks – Autoclaved aerated concrete blocks that "take the place of wood, insulation, housewrap, and drywall – all in a single product" (Johnston and Gibson, 2008, p. 92).

Vegetated roof – A roof of a building that is covered with vegetation and soil.

HVAC – Abbreviation for "heating, ventilation, and air conditioning (Harris, 1993, p. 433).

Blower door – A powerful fan that mounts into the frame of an exterior door and pulls air out of the house in order to lower the inside air pressure. While operating, the auditor can determine infiltration rate and better identify specific leaks around the house (Amann, Wilson and Ackerly, 2007, p. 18).

Duct blaster – A fan attached to one entry into the duct system while all other registers are temporarily sealed off. While under pressure, the instrument can detect how much air is leaking from the ductwork (Amann, Wilson and Ackerly, 2007, p. 18).

Digital infrared camera - Infrared cameras measure surface temperatures – "the camera "sees" variation in heat instead of light, and expresses warmer areas with warmer colors" (Amann, Wilson and Ackerly, 2007, p. 18).

U-value – (thermal transmittance; air-to-air heat transmission coefficient) A figure determined by experimentation, for a certain wall, floor or roof in certain situation telling how many BTU per hour will pass through one square foot of the wall when the air temperature on one side is one degree Fahrenheit higher than the air temperature on the other (National Association of Women in Construction, 1996, p. 573).

BTU- British Thermal Units

Sash – Any framework of a window; may be movable or fixed; may slide in a vertical plane (as in a double-hung window) or may be pivoted (as in casement window) (Harris, 1993, p. 714).

Frame - The fixed, nonoperable frame of a window designed to receive and hold the sash or casement and all necessary hardware (Harris, 1993, p. 909).

Jamb - A vertical member at either side of a door frame, window frame, or door lining (Harris, 1993, p. 458).

R-value – The resistance to heat flow. The higher the "R" value, the more effective the insulation (National Association of Women in Construction, 1996, p. 462).

Chimney Effect – Accounts for the way hot air rises. In a closed room, the temperature at the ceiling is always higher than that on the floor (DeGunther, 2008, p. 197).

Weatherstripping – A strip of wood, metal, neoprene, or other material applied to an exterior door or window so as to cover or seal the joint made by it with the sill, casings or threshold, in order to exclude rain, snow, cold air, etc. (Harris, 1993, p. 901).

Standby losses – Appliance or electronic device appears to be off, but is still using power because it remains plugged in (Amann, Wilson and Acklery, 2007, p. 205)

1.6 Assumptions of Study

Several assumptions have been made following the preliminary research. These assumptions are the opinions of the author.

Assumption #1: An approach to greening a home for energy efficiency may no longer feel overwhelming to homeowners who are interested in going green but are overwhelmed by the excessive amount of information provided today.

Assumption #2: If homeowners are provided with a clearly organized series of steps that they can take to reduce their environmental impact of their home along with cost benefit information, they will act on it.

Assumption #3: By educating homeowners about the environment, they will be motivated to take action.

Assumption #4: Homeowners motivated to use these guidelines for their homes will result in appreciation of positive action and encourage other homeowners to take part in saving the earth by doing the same.

Assumption #5: This set of guidelines will change the "I am only one person" excuse by giving a simple plan to going green.

Assumption #6: It is assumed that the published literature and government statistics are legitimate.

1.7 Scope and Limits

The research collected was limited to the United States, Canada and the United Kingdom. Some areas of the world may not have access to the types of materials and technology discussed in this project.

The purpose of this study is to create an approach to greening homes by simplifying information already provided, proving that greening a home is attainable and achievable. It may be that not all people see these guidelines as simple or understandable. This thesis will be a guide. Every home is different, but the guidelines will be tailored to suit as many homes as is possible.

1.8 Procedures and Methods

The goal of this study is to provide a set of guidelines that inspire people to use them to green their home due to its easy-to-follow clear economic benefits in manageable

steps and to ensure that all households, no matter the income, have access to and capability of changes they can make to their homes to ensure a sustainable, healthy and comfortable environment. Here are the procedures and methods used in the development of this thesis:

- Identify and evaluate housing statistics.
- Gain a working knowledge of green processes and materials within the home.
- Gain a working knowledge of green and efficient products to be incorporated into the home.
- Identify different green home trends.
- Establish economic viability.

1.9 Anticipated Outcome

The goal for this thesis is to generate criteria for the use of homeowners that enable them to green their homes with ease. These communicate the simple steps that can be taken to go green. These findings should prove that people want to green their homes, but do not know where to begin. The public would like to have an easy approach to take positive steps to improve their living environment, not only for their health, but for the Earth as well.

People generally claim to know more about the environment than they actually do. By using these guidelines, they can be educated while making positive choices, which they will hopefully instill in their families for the benefit of the future population. As was mentioned earlier, knowledge is power. If homeowners become confident in

their choices and knowledge, then they will be more likely to encourage the generations of the future to make environmentally conscious choices as well.

This study will encourage and inspire homeowners to apply these methods to their home to not only put money back into their pockets but to lessen their impact on the environment. The homeowners will realize there are simple steps that can be taken to reduce their carbon footprint. These changes will result in savings and reduced energy dependence.

The final solution will be a set of guidelines for greening existing homes. These guidelines will provide the simplest steps for making homes environmentally friendly and financially beneficial. These guidelines, once applied, will result in energy efficiency for homeowners, as well as reducing their carbon footprint. These guidelines provide an action plan for every homeowner.

As a result of the application of the guidelines, smart choices will be made. The benefits of these choices will be large and have a positive impact on the environment. Homeowners using these guidelines will prove to be inspiration for other homeowners, who in turn influence other families. As more families make these positive choices, they educate themselves and their children; children of today hold the key to the future.

CHAPTER 2: DESIGN RESEARCH

2.1 The "Envelope"

Whether living in a cold or hot climate, a homeowner spends somewhere around half of the money spent on energy on heating and cooling, averaging around 47 percent of total home energy. The reason for the large amount of money spent is not necessarily due to the inefficiency of a heating or cooling system, but air leaks in the "envelope" of the home. According to ENERGY STAR, the envelope of a home includes the outer walls, ceilings, windows, doors and floors (Energy Star Training Center, n.d., para. 1). The first option should be trying to lower the heating and cooling requirements of the home. "A tight, well-insulated house saves energy and allows you to get by with smaller-capacity heating and air conditioning systems, and it is also more comfortable, with smaller temperature swings" (Amann, Wilson and Ackerly, 2007, p. 15).

2.1.1 Air Leaks

There are five main heat-loss paths in a typical home. These include, but are not limited to, air movement, walls, windows, foundation and the attic (Scheckel, 2005, p. 218). "Air leaks, or drafts, can be responsible for 25 percent of the heat loss in a new house, more in older houses" (Johnston and Gibson, 2008, p. 29). According to Johnston and Gibson (2008), "Infiltration – unwanted air intake into a house – can account for 40

percent of the heating load in existing buildings" (p. 29). When air leaks are present in a home, they provide a way for unwanted moisture to infiltrate a home, putting it at a greater risk of unhealthy air, mold and deterioration.

Every home has some drafts. This is just a generality of construction. There will always be gaps and holes left in the walls, windows, floors and doors that allow unwanted air to infiltrate a home. The best way to cut down on the air leakage is a well-sealed home. "Air leakage is driven by pressure differences between indoors and outdoors" (Krigger and Dorsi, 2008, p. 72). Wind is one of the driving forces of air leaks in the home.

"Wind creates driving suction on different sides of the home. Homeowners perceive this as drafts on a windy day" (Krigger and Dorsi, 2008, p. 72). The stack effect is also another driving force of air leakage. "Stack effect takes place when warm air rises toward your ceilings and dense cold air sinks to the floor" (Krigger and Dorsi, 2008, p. 72). This tends to be more typical during cold weather as opposed to warm weather. Leaks driven by this effect are more noticeable along the floor.

It is also important to know that there are leaks that occur high in the home. These leaks are harder to detect and typically go unnoticed. They are typical among cracks in the ceiling and light fixtures. "But these high leaks in the shell are important because they are driven by air leakage elsewhere in your home" (Krigger and Dorsi, 2008, p. 72). So, if there are leaks high in a home, it is more than likely that there is an air leak in the lower level of the home. Figure 4 shows what drives air movement in a typical home.

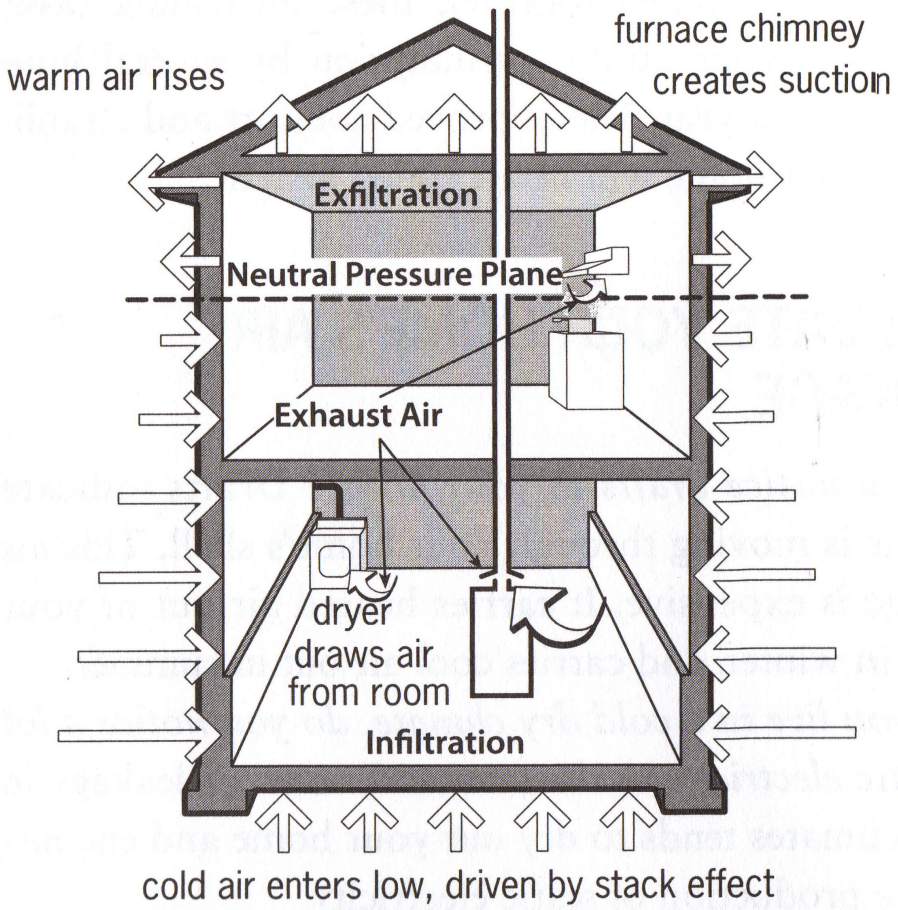


FIGURE 4: What Drives Air Movement (Krigger and Dorsi, 2008, p. 72)

Today, several steps can be taken to detect those leaks and improve upon them. Homeowners can hire a professional to come into their homes and do one of many tests to detect air loss and poor insulation. If a homeowner can afford it, a contractor such as a Home Energy Rater should be hired to use his or her diagnostic tools to measure a home's actual air leakage. As addressed earlier, these professionals use tools including infrared cameras, blower doors and duct blasters to pinpoint air leaks and areas with

inadequate insulation (Amann, Wilson and Ackerly, 2007, p. 16). They then can offer suggestions of changes and improvements to be made to the home.

Tightening up using air-sealing products that are available in a local hardware store or home supply stores can reduce the air leakage in a home. According to Paul Scheckel in his book *The Home Energy Diet* (2005), these products include:

1) "Caulk for gaps under half of an inch

2) Triple-expanding foam for larger gaps that are not near hot surfaces

3) Non-expanding foam for use around windows and doorframes

4) Backer rod, a flexible foam or rope-caulk crack filler sold in rolls, that can be used alone or with caulk

5) Foam gaskets for use behind outlet and switch plates

6) Weather-stripping in many shapes and sizes to fit window, doors and attic hatches

7) Foam board insulation or metal flashing to close large gaps

8) Metal flashing and high temperature sealant to seal chimney chases"

Avoid using fiberglass insulation to fill gaps. It is porous and does not stop air movement. Homes that will benefit the most from these air-sealing efforts are older homes. "New homes generally have a continuous vapor and/or air barrier installed during construction that will help reduce air leaks" (Scheckel, 2005, p. 243).

2.1.2 Windows and Doors

Windows and doors can have a very significant impact on the energy efficiency of a home. "They rank second only to the design of an HVAC system in complexity" (Johnston and Gibson, 2008, p. 129). Window technology has improved tremendously from just a decade ago. Windows of today incorporate materials such as "high performance glass, low-emissive coatings, insulating spacers, and improved frames with built-in thermal breaks to reduce energy loss" (Johnston and Gibson, 2008, p. 129). These types of window can make a huge energy contribution to a house.

Unless homeowners have full knowledge of how to install windows and doors, they should not attempt to do this on their own. Accuracy in installation is everything when it comes to the efficiency of the windows and doors. "Windows are always the weakest point in your home's thermal boundary. If you have single pane windows, you can cut your window energy loss in half by installing either storm windows or insulated double-pane glass" (Krigger and Dorsi, 2008, p. 101). The most efficient windows can help lower your heating and cooling costs.

It is important to choose windows with the highest R-value and lowest U-value that can be afforded by the homeowner. "A window U-factor measures heat loss and is the most important information for window comparisons in cold climates. The U-factor is the reciprocal or inverse of the R-value (U= 1/R)" (Krigger and Dorsi, 2008, p. 103). The best window choice when buying new windows is a triple pane with 2 low-emissivity (low-e) surfaces. It has a U-factor of 0.23 and an R-value of 4.3. The lower the U-factor, the better.

On an energy performance-rating sticker, there are five main things included. These are the U-factor, solar heat gain coefficient, visible light transmittance, air leakage and condensation resistance. It is important to understand what each of these represents when purchasing windows. The solar heat gain coefficient represents the amount of heat transmitted through the glass. Visible light transmittance is sort of like sunglasses. "The lower the number the darker things will appear through the glass" (Johnston and Gibson, 2008, p. 132). And air leakage and condensation resistance represent the obvious.

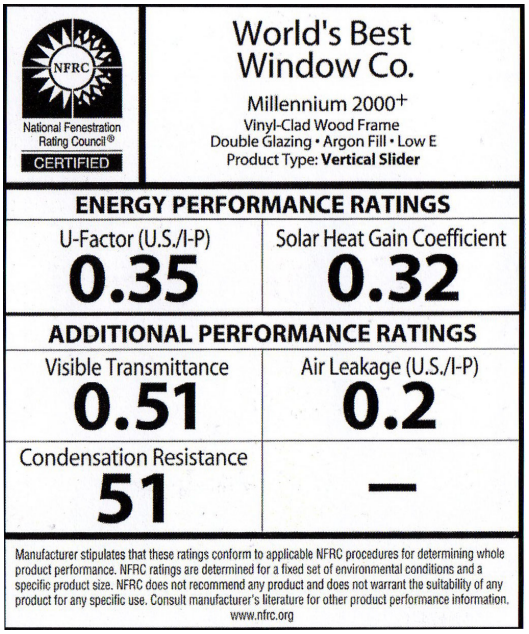


FIGURE 5: Rating Windows for Performance (Johnston and Gibson, 2008, p. 132)

For a window to posses a U-factor less than 0.30, it must possess some, if not all, of these features:

- "Double-pane or triple-pane glass: more panes of glass help slow heat *transmission* through the window. Some manufacturers use plastic fills as interior panes for these multi-pane windows.

- Low-e coating on one or more of the panes: low-e coatings reduce heat flow by slowing the rate at which heat is emitted from the glass. A low-e coating is made up of a transparent layer of metal just a few molecules thick that is applied to one of the inside layers of double- or triple-pane glass.
- Argon gas filling: argon gas is installed between the panes of insulated glass units. It is a slightly better insulator than air.
- Warm edge spacers: these reduce thermal bridging at the edge of the insulated glass unit.
- Insulated frames: these slow heat flow through the edges of the sash" (Krigger and Dorsi, 2008, p. 103).

Old windows can have benefits too. They are typically constructed of either aluminum or knot-free soft lumber. "These materials are hard to beat in terms of functionality and durability" (Krigger and Dorsi, 2008, p. 104). These windows may be unattractive or require a bit of maintenance, but if they are not leaking, there is no need to replace them. Windows are expensive to replace. Installation runs somewhere around $30 to $80 a square foot (Krigger and Dorsi, 2008, p. 104). Only several failed attempts of trying to air-tighten windows should result in window replacement. The first option should be other methods, such as caulking, adding storm windows, or weather-stripping (Amann, Wilson and Ackerly, 2007, p. 32).

U-FACTORS FOR WINDOW-FRAME MATERIALS	
FRAME MATERIAL	U-FACTOR
Aluminum (no thermal break)	1.9 to 2.2
Aluminum (with thermal break)	1.0
Aluminum-clad wood/reinforced vinyl	0.4 to 0.6
Wood and vinyl	0.3 to 0.5
Insulated vinyl/insulated fiberglass	0.2 to 0.3

TABLE 3: U-Factors for Window-Frame Materials (Johnston and Gibson, 2008, p. 135)

Old doors are not as efficient as old windows can be. Doors can be very expensive to replace as well. Door sweeps should be installed on older doors to reduce airflow underneath. Sliding glass doors can also be improved by placing insulated quilted shades over the doors. "Doors offer many non-energy benefits such as security, weatherproofing, and aesthetics" (Krigger and Dorsi, 2008, p. 112).

Doors, especially entry doors, "are more ornamental than energy efficient" (Johnston and Gibson, 2008, p. 149). However, the efficiency and R-value can be increased by something as simple as adding a storm door and weather-stripping. When choosing an entry door, an insulated steel or fiberglass door should be considered. These are much more energy-efficient than solid wood doors.

2.1.3 Roofing

"The right roof is essential to designing an environmentally friendly and energy-efficient home" (Energy Efficient Roof Shingles, 2009, para.1). There are many options when it comes to roofing a home. One of the worst things that can be done when it comes to living green is to install 15-year non-recycled shingles. This type of roof releases toxic gases into the air when heated by the sun.

Recycled asphalt shingles are a great option. "These shingles often have a 50-year lifespan instead of 15, so you won't have to replace them as often" (Energy Efficient Roof Shingles, 2009, para.2). Metal roofing is also another energy efficient choice. This choice is more energy efficient than shingles. "Metal does not have the kind of heat-absorption qualities shingles have, so it will absorb and radiate less heat into your home" (Energy Efficient Roof Shingles, 2009, para.3). The materials metal roofing is made of guarantee a lead-free roof.

Clay and slate roofs are also energy-efficient choices. These are natural materials that can be disposed of without causing pollution. Slate can last up to 100 hundred years with little or no maintenance. One of the greenest choices for roofing is a vegetated roof or "living roof". These roofs "involve a protected membrane that provides a base for irrigated soil and vegetation" (Energy Efficient Roof Shingles, 2009, para.8). Several European countries have subsidized this type of roofing installation because of how effectively it cools a home.

There is absolutely no need in replacing a roof unless it is in dire need of repair or replacement. However, when it comes time to replace the roof, some of the new energy

efficient roofing options should be considered. ENERGY STAR-qualified roofing is the ultimate choice. This particular roofing reflects the sun's rays. According to ENERGY STAR's website, "This can lower roof surface temperature by up to 100F, decreasing the amount of heat transferred into a building" (Roof Products, n.d., para.1). These products can also reduce the amount of air conditioning needed. "Energy Star qualified roof products can help reduce the amount of air conditioning needed in buildings, and can reduce peak cooling demand by 10-15 percent" (Roof Products, n.d., para.2).

2.1.4 Insulation

The purpose of insulation is to keep a home warm in the winter and cool in the summer. "Insulation is your primary defense against heat loss through the house envelope" (Amann, Wilson and Ackerly, 2007, p. 23). Insulation, if properly installed, also helps to keep heating and cooling costs down. "When correctly installed with air sealing, each type of insulation can deliver comfort and lower energy bills during the hottest and coldest times of the year" (Air Seal and Insulate with ENERGY STAR, n.d., para. 8).

"Heat losses through the wall, roof and floor together amount to over 45 percent of all the heat a typical house loses" (Amann, Wilson and Ackerly, 2007, p. 23). Adding insulation to an existing home is difficult, but can be done. The greatest savings can be achieved by attic insulation. If the insulation in an attic is level with or below the floor joists, more insulation should be added. The best option would be adding loose fill or unfaced fiberglass batts (Amann, Wilson and Ackerly, 2007, p. 25).

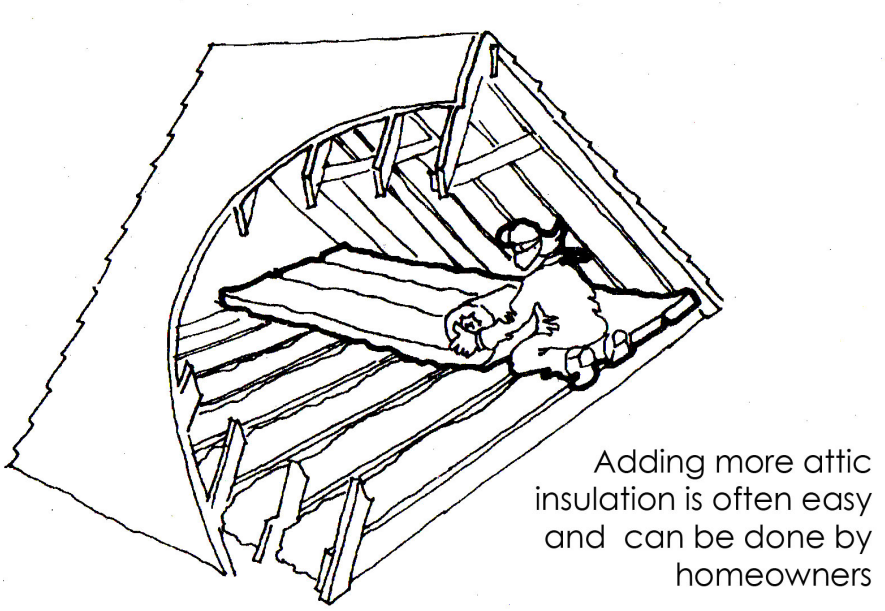


FIGURE 6: Homeowners Adding Insulation (Amann, Wilson and Ackerly, 2007, p. 26)

"Floor and foundation insulation is mandatory for efficient homes in cold climates, and a worthwhile addition to super-efficient homes in warm climates" (Krigger and Dorsi, 2008, p. 81). The best insulation for attics is the commonly used blown cellulose. Most of today's homes do not have enough insulation. "This has happened because energy prices have been low for many years, allowing our building codes to neglect energy conservation" (Krigger and Dorsi, 2008, p. 82).

There are several common types of insulation, as well as some newer green options. The most commonly used insulations include "fiberglass (in both batt and blown forms), cellulose, rigid foam board, and spray foam" (Air Seal and Insulate with ENERGY STAR, n.d., para.5). An important thing to understand about insulation is its

R-value. R-value is the insulation's ability to resist heat flow. The higher the R-value, the better and more efficient the insulation is. "The recommended insulation level for most attics is R-38" (Air Seal and Insulate with ENERGY STAR, n.d., para.8). This is only the minimum recommended R-value. To ensure even more efficiency from your insulation, choose an R-value above the recommended value (Table 4).

Typical R-Value Versus Recommeneded R-Values				
Type of home	**Attic**	**Walls**	**Floor**	**Bsmt. walls**
Typical existing older home	15	9	2	0
Recommended in cold climate	50	30	30	20
Recommended in moderate climate	50	21	30	12
Recommended in warm climate	50	21	19	12
The ideal home with super-insulated details	60	40	40	40

TABLE 4: Typical R- Values Versus Recommended R-Values (Krigger and Dorsi, 2008, p. 82)

The bottom line is this: The insulations levels of a home (attic, walls and foundation) should be determined in order to determine how well a home is actually insulated. "If your wall cavities are not already full, have a professional insulator install dense-packed insulation to fill the cavities" (Krigger and Dorsi, 2008, p. 100). Attic insulation should have an R-value of 40 or more. Crawl spaces should have insulation at the foundation wall or floor (Krigger and Dorsi, 2008, p. 100).

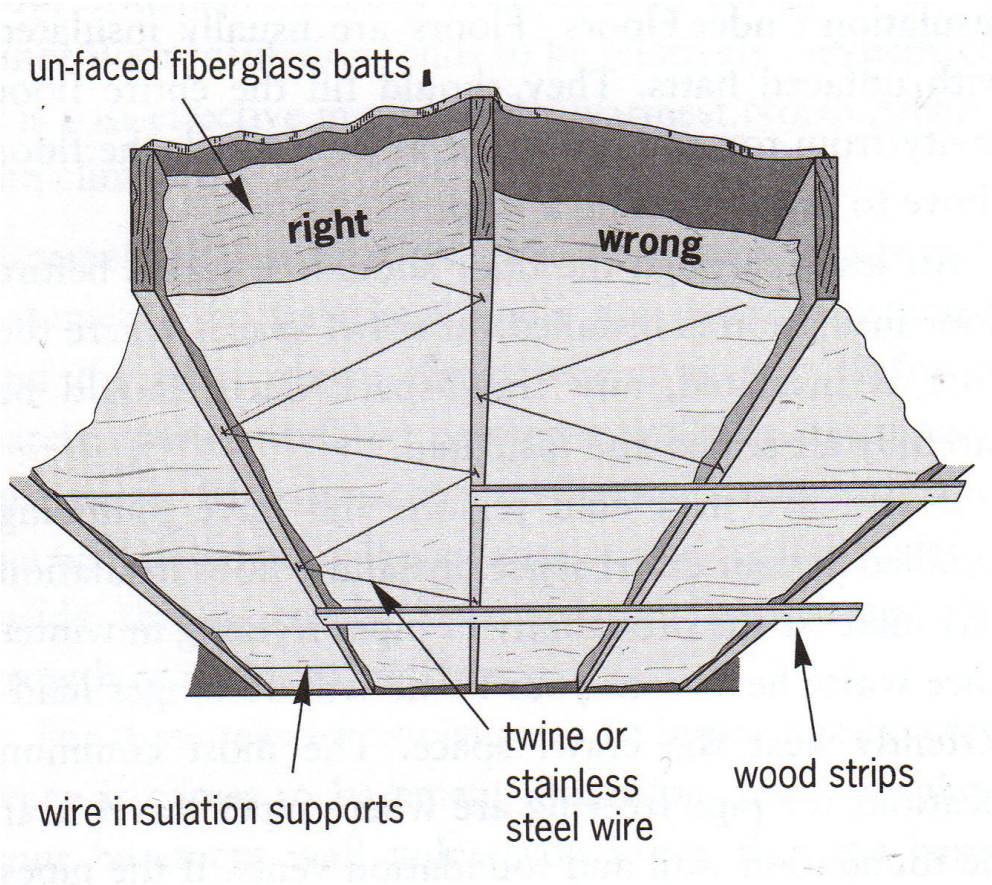


FIGURE 7: Insulating the Floor Above a Crawl Space (Krigger and Dorsi, 2008, p. 100)

2.1.5 Ventilation and Air Quality

All houses exchange indoor and outdoor air for two reasons. Houses always have leaks of some kind, no matter the size. "These might include larger gaps around pipes, vents, and chimneys, and smaller cracks at places such as the join between the window frame and the wall" (Amann, Wilson and Ackerly, 2007, p. 46). Another reason includes pressure differences in the air inside and outside of a home. "Air works hard to move

from regions of high air pressure (warmer temperatures) to ones with lower air pressure (colder temperatures)" (Amann, Wilson and Ackerly, 2007, p. 46).

"Most homes don't do a good job when it comes to ventilation" and fall victim to the chimney effect (DeGunther, 2008, p. 199). The chimney effect, pictured in Figure 8, is when hot air rises to the ceiling and the cooler air stays along the floor. There are a few small tips that can optimize ventilation in a home. It is a good idea to install fans in a home. This will allow homeowners to achieve the highest efficiency at the lowest operating and equipment cost (DeGunther, 2008, p. 199).

It is hardest to achieve a home that has efficient ventilation in both the winter and summer. In the summer, homeowners look to banish the heat in their homes. In winter, homeowners look to retain heat within their homes. Currently, most homes are more efficient in one season or another, not both.

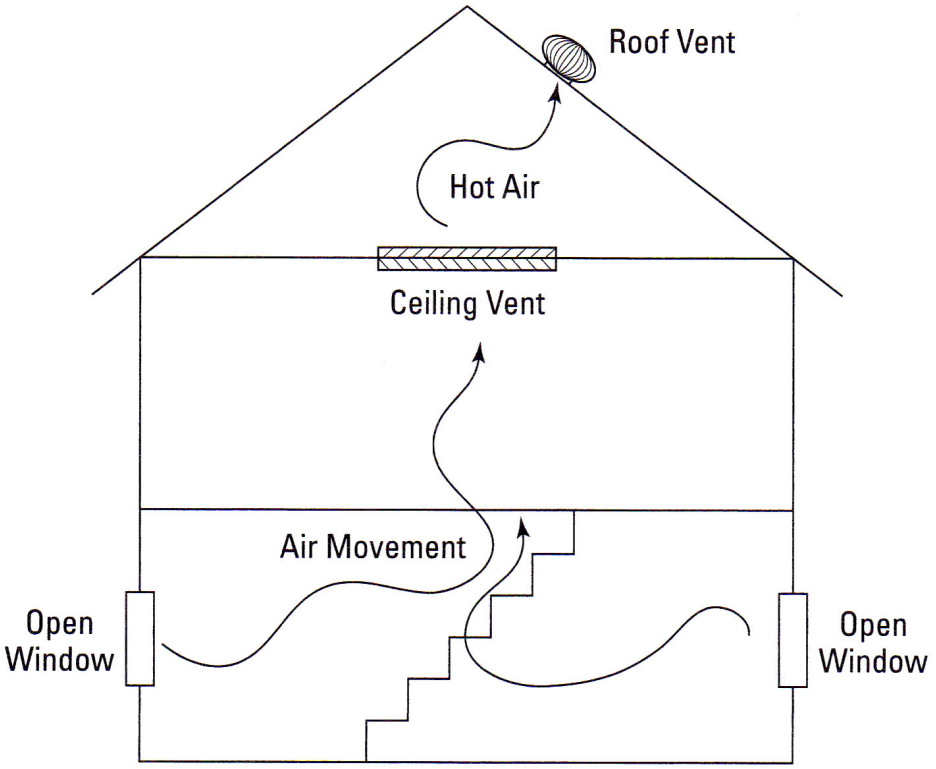


FIGURE 8: The Chimney Effect Moving Air through a House (DeGunther, 2008, p. 198)

Window fans and ceiling fans are the two best options. "One small window fan mounted properly can do the same work a s a number of large fans scattered about the house" (DeGunther, 2008, p. 202). A window fan should be mounted, upstairs if possible, and downwind of the home. "Ceiling fans can accomplish two things: convective cooling and reversing or enhancing the chimney effect" (DeGunther, 2008, p. 203).

It is important for the attic to have an attic vent, roof vent or gable vent, possibly with a vent fan to allows the attic to breathe properly. These fans turn on automatically when the attic gets too hot. "The most efficient of the attic vents is the rooftop vent" (DeGunther, 2008, p. 205).

"The best way to condition your home's air is to keep a fresh supply of outside air moving through" (DeGunther, 2008, p. 210). However, sometimes the windows just cannot be opened due to weather or extreme low or high temperatures. The only solution for continuously fresh air is an air filter. "Active air filters work on much the same principle as water filters: they filter the air as it comes into your home" (DeGunther, 2008, p. 210).

The most recommended and most effective air filter is a mechanical filtration system with HEPA filters (DeGunther, 2008, p. 211). When trying to get the most out of an air filter, there is something that should be kept in mind. It must be changed; if not, it becomes a breeding ground for the pollutants it is collecting. One might also want to consider the amount of noise that is generated by an air filter. Choose one that is not so loud that the noise will put up a roadblock for its use.

According to Rik DeGunther (2008), author of *Energy Efficient Homes for Dummies*, there are also a few natural ways to improve the air quality of a home. He suggests growing houseplants and changing vacuum cleaner bags regularly. Plants like spider plants and elephant ears absorb carbon monoxide and formaldehyde. However, if these plants are poorly maintained, they can provide breeding grounds for bugs inside homes (DeGunther, 2008, p. 212).

There is a threat of indoor air pollutants in every home. Some of these pollutants include excess moisture, radon and combustion products. "Moisture is one of the most important and least recognized indoor air pollutants, affecting human health and the health of the building" (Amann, Wilson and Ackerly, 2007, p. 48). When moisture collects, mold, mildew and dust mites are a result. These can be the main cause of allergies and asthma among families. "High indoor humidity can also facilitate the "off-gassing" of toxins in furniture and cleaning products" (Amann, Wilson and Ackerly, 2007, p. 48). The appropriate ventilation and air-tightness in a home can prevent this from happening.

According to the United States Environmental Protection Agency, radon is a cancer-causing natural radioactive gas that you can't see, smell or taste (Radon, 2009). It is the second leading cause of lung cancer among Americans. "Radon is a radioactive gas that is generated naturally in the soil and enters the house from the ground" (Amann, Wilson and Ackerly, 2007, p. 49). There is no way to avoid this, but homeowners should have an in-home radon detector.

Combustion products are also included in the list of major indoor air pollutants. "Gas fired appliances include furnaces, water heaters, ranges and some dryers, and produce carbon dioxide, carbon monoxide, nitrous oxides, and water vapor" (Amann, Wilson and Ackerly, 2007, p. 49). These toxic pollutants can enter the house if these appliances are not vented properly. The most dangerous of these pollutants is carbon monoxide because this poison is virtually undetectable without carbon monoxide detectors.

Many houses have the simplest ventilation systems like kitchen and bathroom fans. These systems are not very complex, but they work better than nothing at all. "As long as the fans are used regularly, at least grease, unburned hydrocarbons, and cooking odors can be eliminated in the kitchen, and very damp air exhausted from bathrooms" (Johnston and Gibson, 2008, p. 190). Even the smallest and most simple options are good options. Any ventilation, no matter how simple the option, will be beneficial to the air quality of a home.

2.1.6 Heating and Cooling

"In a green-built home, heating and cooling equipment can be smaller, less costly, and less complicated" (Johnston and Gibson, 2008, p. 173). Today's heating and cooling can consume a lot of energy. A lot of the cost can be a result of leaks in the ductwork or envelope of a home. This is why it is important to make sure all leaks in the "envelope" are sealed. To ensure this, if it can be afforded, homeowners should have a professional come in and use the tools, spoken of previously, the duct and door blasters.

It is possible to maintain a comfortable environment with less energy and cost (DeGunther, 2008, p. 107). "In 1978, Americans used 6.9 quads to heat 77 million homes. In 2001, 4.6 quads were used to heat 107 million homes, showing the huge value of more efficient building techniques and weatherization efforts in older homes" (Scheckel, 2005, p. 171).

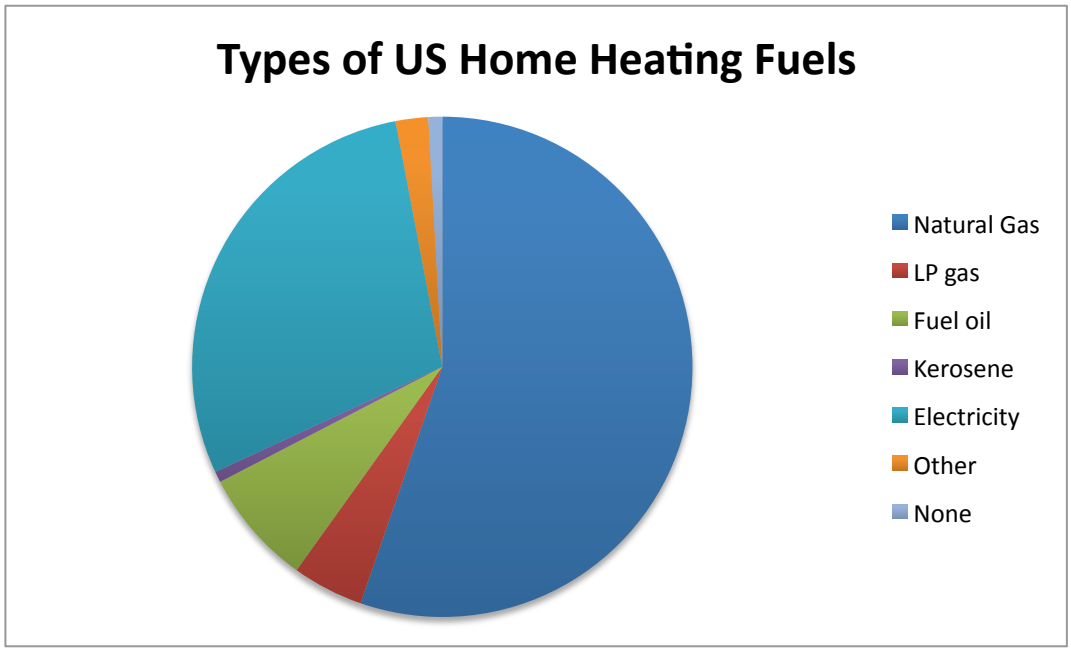


TABLE 5: Types of US home heating fuels (Scheckel, 2005, p. 172)

Four major things can affect the heating load of homes: climate, building efficiency, occupant behavior, and heating system efficiency. "Conduction, convection, and radiation, along with air leakage, all contribute to your home's heat loss" (Scheckel, 2005, p. 174). Every household has a temperature that they are most comfortable with. "According to the American Society for Heating, Refrigeration, and Air Conditioning Engineers, humans are most comfortable when the temperature is between 72° and 78°F with a relative humidity between 35 and 60 percent" (Scheckel, 2005, p. 176).

This can result in moving the thermostat up and down during the day to "save energy". There is a more simplified solution for this. A programmable, automatic setback thermostat is the best choice for a home. It has many advantages. It can be set to

a lower temperature at night for sleeping and a higher-less energy consuming temperature during the day because there is no reason to burn energy when no one is home.

The most common heating system used in today's homes is a combustion furnace. Older combustion furnaces can be a lot less effective than newer ones. The newer furnaces with AFUE (annual fuel utilization efficiency) rating of 90 to 95 percent can reduce your fuel consumption by one-third. (Krigger and Dorsi, 2008, p.130). If this is the type of heating element used in a home, it is important that occasional inspections should be carried out.

Now, after the furnace has been identified, is the time when a blower duct test should be done, in order to make sure that the heating system is working as effectively as it can. Once the tests are conducted, any leaks in the duct system should be sealed. Another option for more efficient heating is duct insulation. Insulating ductwork insulation is a simple step that can be done by just about anyone.

To do so, ductwork should be wrapped in fiberglass insulation or any other green option that a homeowner chooses. The pieces should be cut as large as possible to avoid seams. Cut carefully and precisely to avoid gaps in order to get the most out of the insulation. Overlap all seams and fasten the insulation with tape, followed by twine, wire or plastic cable ties (Krigger and Dorsi, 2008, p. 136).

Radiant floor heating is a heating system that is commonly overlooked. Radiant flooring is quite possibly the most effective heating system for homes overall. "Radiant floors offer unbeatable comfort, superior energy efficiency, and the ability to use a

condensing boiler and hydronic heat pump to its full potential" (Krigger and Dorsi, 2008, p. 138).

The efficiency of air conditioning systems relies on the same principles as heating systems. It is very important to maintain and clean the outdoor and indoor air conditioning coils. To clean these, homeowners can use an air hose to blow off the coils once a year. If homeowners do not have access to an air hose, they can use an outdoor shop vacuum to clean the coils. It is also important to keep the blower and air filter cleaned as well. But before homeowners think about buying a new heating and cooling system, they should make sure that the "envelope" of their house is sealed.

There are several basic types of cooling systems. These include central air conditioners, heat pumps, room air conditioners, evaporative coolers and ductless mini-split air conditioners (Figure 8).

> "Air conditioners and heat pumps use the refrigerant cycle to transfer heat between an inside unit and an outside unit. Heat pumps differ from air conditioners only in the special valve that allow the cycle to reverse, providing either warm or cool air to the inside" (Amann, Wilson and Ackerly, 2007, p. 108).

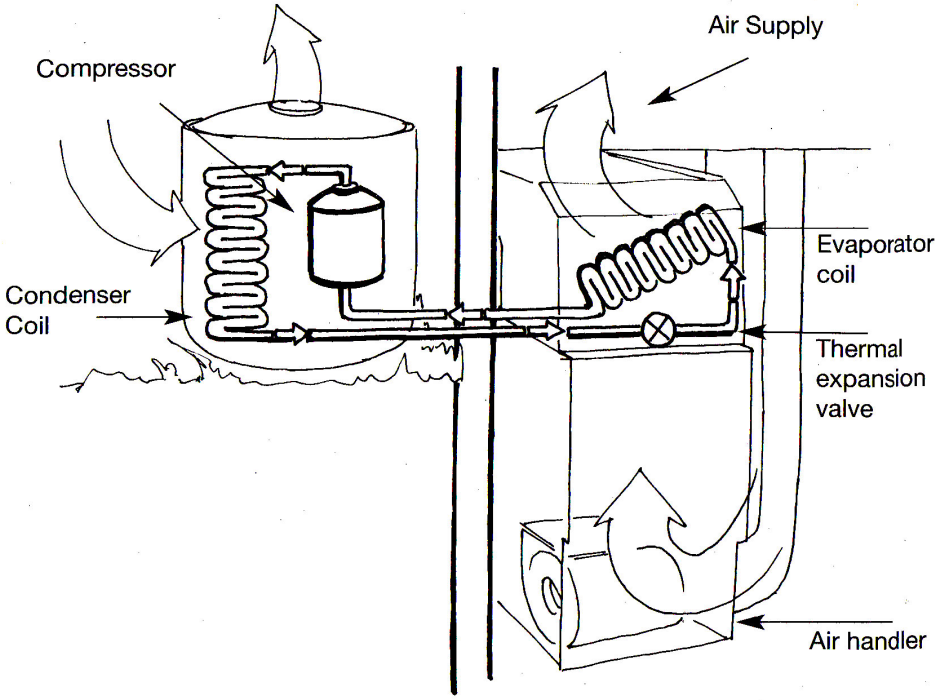


FIGURE 9: Air Conditioners and Heat Pump Refrigerant Cycle Use to Transfer Heat Between Inside and Outside Units (Amann, Wilson, Ackerly 108).

No matter how efficient the heating and cooling system, if the "envelope" leaks, it is like throwing away money. If homeowners are considering replacing air conditioning equipment, the smallest air conditioner with the most acceptable comfort should be installed. A homeowner's first instinct when it comes to the efficiency of the heating and cooling system should be to seal the "envelope" (Krigger and Dorsi, 2008, p. 128).

2.2 The Interior

The first thing a homeowner should know is that green interior choices and finishes do not offer the same kind of payback that green "envelope" choices offer. However, choosing energy efficient light bulbs and operating home appliances more efficiently will reap some financial benefits. Even if these choices may only put a few dollars back in a homeowners' pocket, they will actively be living in a healthier and less impacting environment.

2.2.1 Interior Finishes

It is important to be aware that things as small paint choices and cleaning products can affect the health of residents in a home. "Many conventional materials – including particleboard, paint, adhesives and sealants – give off noxious chemicals that turn a well-sealed, energy efficient home into anything but a safe haven" (Johnston and Gibson, 2008, p. 287). Any product that has a strong smell several days after use or application probably is not good for the health of a home's residents.

The interior finishes are the last steps taken in making a home "green". Interior finishes include wall and floor finishes, paint and caulk, and countertops and cabinets. According to *Green from the Ground Up: A Builder's Guide* (2008), there are a few things a homeowner should take into consideration when finishing or refinishing a home. Toxicity is the first thing to consider. This includes paints and finishes that emit unhealthy fumes dangerous to all members of the household.

Durability, resource conservation, and sustainability are also key things to consider. It is very important to consider the life of the product being used. The longer

the life span, “repairs and replacement will become less frequent” (Johnston and Gibson, 2008, p. 287). When it comes to resource conservation, homeowners should choose recycled or salvaged products. Making a sustainable choice consists of choosing products that are renewable. In the end, this means fewer resources will be used to achieve the finished product.

When choosing finish products for a home, including aesthetic furnishings, the green choice would be “products made from sustainably harvested materials, which have low embodied energy and contribute to indoor air quality” (Johnston and Gibson, 2008, p. 268). There are so many products on the market today that make these choices easy for all homeowners.

2.2.2 Flooring

In the home, there are so many simple steps that can be taken to go green, including flooring. Homeowners should consider finished concrete floors. This choice conserves resources that would have been used to otherwise finish the floors with carpets or other options. Understandably though, concrete floors can be cold and uncomfortable, so homeowners should consider a choice like cork or bamboo flooring. “Bamboos are from a large family of grasses, not wood. Some can grow 4 ft. per day and are large enough in only a few years to be turned into a variety of building products” (Johnston and Gibson, 2008, p. 305).

2.2.3 Countertops

Concrete and recycled glass are green options for countertops. Solid surface countertops are the healthiest choice for a home’s occupants. These countertops are less

likely to harvest bacteria when cleaned regularly because there are no hidden pores in which the bacteria can cultivate. They are also the one of the most durable choices for the home, remembering that durability of a product is a "green" quality to look for.

2.2.4 Cabinetry

Cabinets can be one of the most toxic furnishings in a home. "Much of the standard cabinetry on the market today contains particleboard made with a urea formaldehyde binder that emits formaldehyde and other harmful chemicals" (Johnston and Gibson, 2008, p. 295). These binders can emit and offgas for years, reducing the air quality of the home and posing a health risk for residents. However, there is hope. Healthier options are showing up on the market. These include cabinets that have been stained or treated with non-toxic eco-friendly finishes.

2.2.5 Lighting

It is important to first know that since electricity became commonplace in the home, most home lighting is provide by incandescent light bulbs. These incandescent bulbs provide exceptional lighting, but they seem to provide much more heat than actual light. According to Alex Wilson, who for over fifteen years has been writing Environmental Building News for professionals interested in green building, "About 90 percent of the electricity they use is converted into heat, only 10 percent into usable light" (Wilson, 2006, p. 87). However, more energy efficient and earth friendly options appear on the market every day. Compact fluorescent lighting is a great option.

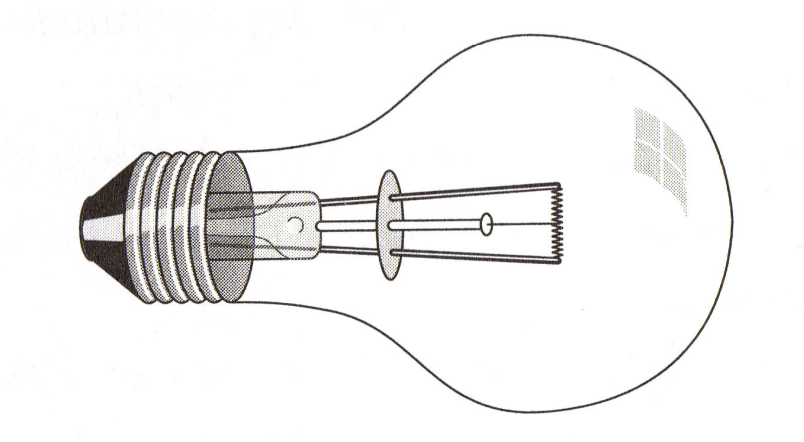


FIGURE 10: Incandescent Light Bulb (Krigger and Dorsi, 2008, p. 20)

Fluorescent lighting appeared around the1950s. When fluorescent first made its appearance on the market, it had poor lighting quality and was, at times, quite noisy. However, they "provide three to four times as much light per unit of electricity consumption as incandescent" (Wilson, 2006, p. 87). Today, fluorescents have improved drastically and are offered in a much more convenient form for the home. This form is what is referred to as compact fluorescent lamps (CFLs).

"Typical CFLs with flicker-free, silent, electronic ballasts last 10 times as long a incandescent lamps and use one-quarter to one-third as much electricity" (Wilson, 2006, p. 87). According to Alex Wilson, author of *Your Green Home*, homeowners may still be hesitant to buy CFLs because of the price (2006). They are more expensive, but homeowners will get their money's worth because of the lifespan of the bulbs. The only downside to CFLs is that they contain mercury, and "when they are dead, they have to be properly disposed of" (Top Green Lighting Tips, n.d., para.5).

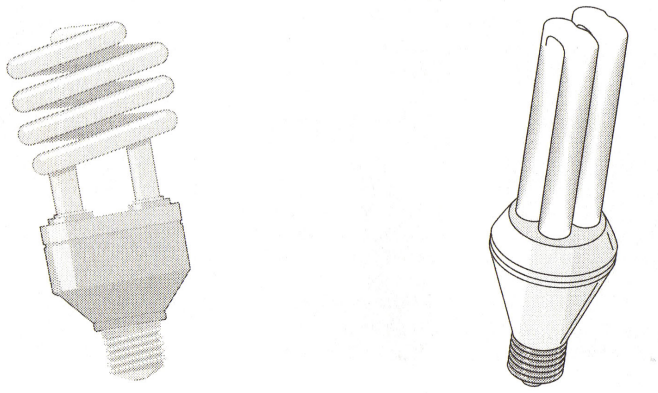


FIGURE 11: Compact Fluorescent Lamps (Krigger and Dorsi, 2008, p. 21)

The newly introduced and most green choice would be LEDs (light-emitting diodes). "LEDs are extremely long-lasting (30,000 to 50,000 hours), and their efficacy (in lumens of light output per watt of electrical consumption) has improved dramatically" (Wilson, 2006, p. 87). However, LEDs are very expensive and hard to find for general home lighting. The bottom line is this: with these options, there should be little or no incandescent lighting in a home whose homeowners have decided to go green.

Type of Lamp	Efficiency (lumens/watt)	Typical Lifespan (hours)
Incandescent	10-17	750-2500
Halogen	12-22	2000-4000
Fluorescent tube lamp	30-100	7000-24,000
Compact fluorescent lamp (CFL)	50-70	8000-10,000

TABLE 6: Comparison Among Types of Lamps (Krigger and Dorsi, 2008, p. 20)

Richard Montgomery, author of *The Home Energy Audit*, offers a few suggestions about lighting a home (1983). First, photocell lighting with an override manual switch should be used outdoors. In homes, 40-watt or 60-watt light bulbs should be used rather than 75- to 100-watts. 3-way bulbs or electronic dimmer switches should be installed where the level of light needed varies, enabling homeowners to conserve energy. "Dimmers save energy by reducing the consumption of fixtures when a low output of light is acceptable" (Krigger and Dorsi, 2008, p. 23).

Occupancy sensors are also an option to be considered by homeowners for outdoor lighting. They can offer a savings of 20 to 40 dollars a year. "Outdoor occupancy sensors offer security advantages over continuous lighting – the abruptly switched lights startle intruders and alert residents and neighbors to activity in the area" (Krigger and Dorsi, 2008, p. 22). Finally, the most obvious of all conscious changes is turning the lights off when the room is not being used (Montgomery, 1982, p. 172).

2.2.6 Cleaning Products

Once a home has been converted into a green haven, it is important to keep it clean to ensure a healthy indoor living environment. Most cleaners, however, are not healthy for the residents of a home. "Many products release VOCs (volatile organic compounds)" (Wilson, 2006, p. 145). According to Christie Matheson, a food and lifestyle writer whose work has appeared in *Glamour*, *Cooking Light*, and the *Boston Globe* Magazine, "Cleaners are one of the many things homeowners use without thinking twice. Conventional cleaners release volatile organic compounds and other

toxic chemicals that remain on the home's surface and evaporate into the air" (Matheson, 2008, p. 32).

These are the kind of toxins that contribute to a home having poor indoor air quality. "These cleaners are the second-biggest contributor - behind pesticides – to the fact that the air inside most homes is two to five times more polluted than the air outside" (Matheson, 2008, p. 32). Sadly, these toxins are not just staying inside homes; they are secretly escaping from homes into the environment. This means that homeowner's "cleaning habits" affect wildlife and vegetation in a negative way as well. "Almost 70 percent of streams sampled in a 2002 study by the U.S. Geological Survey contained chemicals from household cleaning products" (Matheson, 2008, p. 32).

There is a solution to the toxicity of household cleaning products. There are several "green living" cleaning products on the market. Also, homeowners can consider using common, environmentally safe household products. Crissy Trask, the sole proprietor of GreenMatters.com, a business started in 1999 to advance environmental education and activism online, offers, for example, products like vinegar, baking soda, salt, club soda, borax, cooking oil and lemons that are environmentally safe (Trask, 2006, p. 47). These products, standing alone or combined, make household cleaners for almost all circumstances (i.e. furniture polish, all purpose cleaners, etc.).

The ingredients of the cleaners are not the only things that help in the degradation of the environment. The packaging products that household cleaners are sold in can also be very harmful to the environment. When purchasing these cleaners, one should also consider whether or not the packaging is made from recycled materials and if it is

something that can be recycled following use. If the packaging cannot be recycled, it is wise to consider whether or not the packaging can or will be re-used.

2.3 Appliances

"Home appliances such as refrigerators, water heaters and clothes washers are major consumers of energy. 25 to 40 percent of residential energy consumption in the United States was appliance related" (Lipschutz et al, 1982, p. 138). When it comes to appliances, it is important to understand the ENERGY STAR rating system. The U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) recognized the need for environmentally friendly and energy efficient products and created the ENERGY STAR label. "This helps consumers identify energy efficient heating and cooling equipment, appliances, computers, lighting and home electronics" (Amann, Wilson and Ackerly, 2007, p. 10).

Federal law requires that there be an EnergyGuide label on most appliances (Figure 12). These labels are bright yellow with black lettering. "The main feature of the label is a line scale showing how that particular model compares in energy efficiency with other models on the market of comparable size and type" (Amann, Wilson and Ackerly, 2007, p. 11). For most appliances, the range shows annual energy consumption in kWh/year for electricity. "The most efficient models will have labels showing energy consumption, at or near the left-hand end of the range close to the words "Uses Least Energy"" (Amann, Wilson and Ackerly, 2007, p. 11).

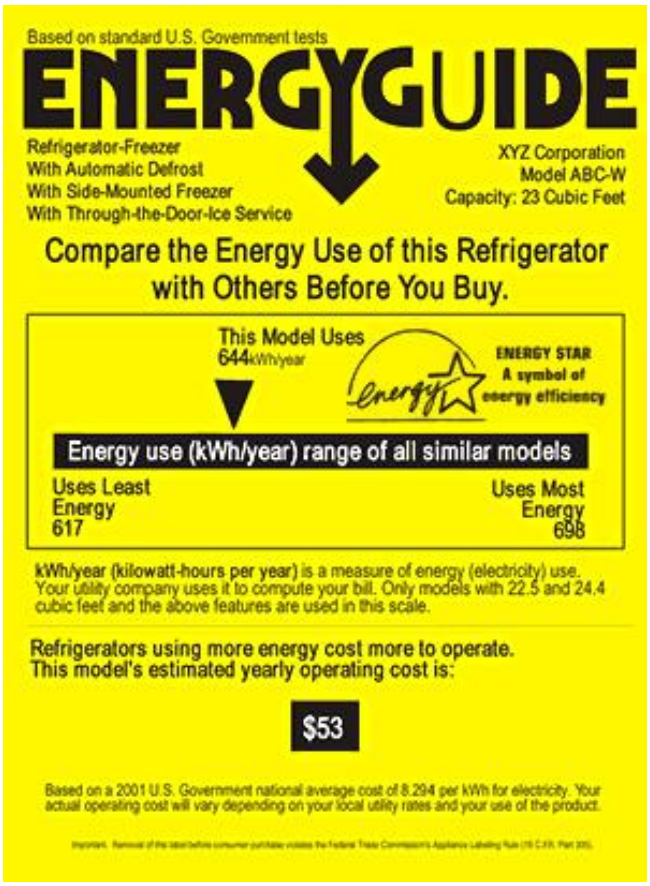


FIGURE 12: Energy Guide Label (refrigeratorefficiency.com)

2.3.1 Refrigerators and Freezers

"In most homes, the refrigerator consumes more electricity than any other appliance, accounting for 8 to 15 percent of total electrical consumption" (Krigger and Dorsi, 2008, p. 23). Before considering replacing a refrigerator, homeowners should see if making a few changes in its everyday use helps to cut back on operating costs. According to Rik DeGunther, 2008, p., "The number one way to save money with your refrigerator is to keep the coils clean" (DeGunther, 2008, p. 169). The thermostats inside the refrigerator and freezer should be adjusted to the correct temperature. The

refrigerator's thermostat should be set to read between 37° to 40°F, and the freezer should be set to 5°F (Krigger and Dorsi, 2008, p. 23).

If the refrigerator being used has an Energy Saver switch, it should be activated unless the residents of the home reside in a location where moisture poses a problem. The doors must also be kept closed. "Don't open the doors more than necessary" (Krigger and Dorsi, 2008, p. 23). If the seals on a refrigerator or freezer are worn out or ineffective, "up to 25 percent of the refrigerators energy is being wasted" (DeGunther, 2008, p. 170). If possible, change the seal. If the seal cannot be changed, try using a silicone caulk or sealant.

Efficiency of refrigerator/freezers can vary depending on the style and configuration of the doors. "Side by side refrigerator/freezers use more energy than similarly sized models with the freezer on top, even if they both carry the ENERGY STAR label" (Amann, Wilson and Ackerly, 2007, p. 150). Side-by-side refrigerators can use 10 to 30 percent more energy. These features cause weakness in the thermal insulation of the unit. Another feature that can cause energy setbacks are through-the-door icemakers and water dispensers, which increase energy consumption by 10 to 20 percent.

Refrigerator Type	Total Capacity (ft^3)	Fridge Capacity (ft^3)	Freezer Capacity (ft^3)	Energy Use (kWh/year)
Non-ENERGY STAR Models				
Top Freezer	21.9	15.5	6.4	529
Bottom Freezer	22.4	15.6	6.8	530
Side-by-Side	22.1	14.3	7.8	679
Non-ENERGY STAR Models				
Top Freezer	21.7	15.2	6.5	422
Bottom Freezer	22.4	15.6	6.8	482
Side-by-Side	22.6	14.1	8.5	584

TABLE 7: Comparison of Energy Use Across Refrigerator Types (Amann, Wilson and Ackerly, 2007, p. 151)

No matter how energy efficient, the size of the refrigerator matters. Homeowners should try to buy the smallest refrigerator/freezer that can fit their needs. "Big refrigerators always consume more due to the increased surface area and longer gaskets" (Krigger and Dorsi, 2008, p. 25). Placement of these products is also critical to its energy conservation. These units should be placed away from direct sunlight or any source of heat. This causes the refrigerator/freezer to have to work twice as hard to cool, resulting in unnecessary energy use.

It is very common for homeowners to keep old refrigerators in a garage or shop for extra storage once they have purchased a new one. Homeowners should resist this temptation. Typically, this extra refrigerator is on old one. "Older refrigerators are very inefficient and should be recycled rather than used" (Krigger and Dorsi, 2008, p. 25). An extra refrigerator can be $100 to $150 extra a year in operating costs. If a second refrigerator is something a homeowner must have, a compact ENERGY STAR refrigerator should be considered (Krigger and Dorsi, 2008, p. 25).

Buying one large refrigerator	Buying a second compact fridge	Keeping your old fridge in the basement	
New ENERGY STAR Refrigerator (25 ft)	New ENERGY STAR Refrigerator (20 ft) + New Mini-Fridge (5ft)	Your Old 1994 Refrigerator (25 ft)	New ENERGY STAR Refrigerator (20 ft)
505 kWh/year	762 kWh/year	737 kWh/year	432 kWh/year
$48 per year	$72 per year	$111 per year	

TABLE 8: Cost of Owning a Second Refrigerator

2.3.2 Dishwashers

The easiest place to start going green in the kitchen is lessening the load on the dishwasher. Many people think that the first and most obvious way to conserve energy is

washing the dishes by hand. However, washing a 12-place setting of dishes in a sink uses an average of 27 gallons of water, depending on user or style of washing, and 2.5kWh of energy to heat the water. "If you run hot water in the sink and keep it running, you are using at least 2 gallons of water for every minute you have the sink turned on" (Lars, 2007, para.2). Lars is a freelance writer for practicalenvrionmentalist.com. If it takes 10 minutes to wash the dishes, this can account for somewhere around 20 gallons of water.

The same 12-piece setting, when washed in an automatic dishwasher, will only use somewhere around 4 gallons of water and 1.5 kWh of total electrical energy (Scheckel, 2005, p. 107). An ENERGY STAR rated dishwasher uses just 4 gallons of water per load. Surprisingly, even a dishwasher that is not ENERGY STAR rated only uses upwards of 6 gallons per load (Lars, 2007). In comparison, the average cost of operation for a dishwasher for one year is under $30. Affordable operating costs and lessening the load of homeowner's responsibilities is what most people would consider a deal that is hard to refuse.

There are a few other tips offered by the American Council for an Energy Efficient Economy. Always wash only full loads. "The dishwasher uses the same amount of water whether it's half-full or completely full, so nothing will save more energy than waiting to run your dishwasher" (EFFICIENT DISHWASHING, 2007, para.5). Air dry dishes rather than using the heated dry following the wash cycle. Lastly, take it easy on the pre-rinsing. According to ENERGY STAR, "If you find you must rinse dishes first, try to get into the habit of using cold water" (EFFICIENT DISHWASHING, 2007, para.3). Or, homeowners could opt for scraping off their dishes instead of rinsing them.

2.3.3 Cooking Elements

According to the U.S. Department of Energy, cooking accounts for somewhere around three percent of the total energy used in a home (Amann, Wilson and Ackerly, 2007, p. 9). Even though this is a small amount, it is important to make sure homeowners are getting the most of the energy that is being used. As mentioned earlier, when it comes to buying a new appliance, homeowners should consider ENERGY STAR models. However, if the cooking equipment is not being used correctly, homeowners may not be getting the most efficiency out of these appliances.

APPLIANCE	TEMP.	TIME	ENERGY	COST *
Electric oven	350°F	1 hr.	2.0 kWh	19¢
Convection oven (elec.)	325°F	45 min.	1.4 kWh	13¢
Gas oven	350°F	1 hr.	.11 therm	13¢
Frying Pan	420°F	1 hr.	.9 kWh	9¢
Toaster Ovens	425°F	50 min.	.95 kWh	9¢
Crockpot	200°F	7 hrs.	.7 kWh	7¢
Microwave	High”	15 min.	.36 kWh	3¢

*Assumes 9.5¢/kWh for electricity and $1.20 therm for gas.

TABLE 9: Energy Costs for Various Methods of Cooking (Amann, Wilson and Ackerly, 2007, p. 163)

To get the most out of a cooktop while using the least amount of energy, the pan size should be matched to the element size. “For example, a 6” pan on an 8” burner will waste over 40 percent of the heat produced by the burner” (Amann, Wilson and Ackerly, 2007, p. 163). The American Council for an Energy Efficient Economy recommends that

sturdy, flat-bottomed cookware should be purchased in order to get the most efficiency out of a cooktop. "The ideal pan has a slightly concave bottom – when it heats up, the metal expands and the bottom flattens out" (Efficient Cooking, 2007, para.2). If the pan does not have good contact with the heating element, it makes the element significantly less efficient.

The material the cookware is made out of makes a difference as well. Copper bottom pans are the best choice for efficiency. These pans heat up faster than all other pans. With copper bottom pans, "you can turn down the temperature about 25°F and cook foods just as quickly" (Efficient Cooking, 2007, para.4). It is also important to keep the stovetop clean so there is no build up to cause interference in the heat transfer between the cooking element and pan.

When cooking, the lids should always be on. "Cooking without lids can take three times as much energy" (Energy Efficient Cooking, 2004). There should also be an attempt by homeowners to reduce cooking time. To do this, begin by defrosting foods in the refrigerator prior to cooking. "Cook double portions when possible, and freeze the remainder. Less energy is required to reheat than to cook the dish over again" (Energy Efficient Cooking, 2004).

2.3.4 Washers and Dryers

Laundry and dishes make up for 5 percent of the overall energy use in homes. The best way to save energy when doing laundry is to use cold water. Today, many cold-water detergents are sold in stores to ensure the cleanest clean when using cold water. "You can easily save 25 percent on your washing costs by using cold water most of the

time – in particular, for the rinse cycle" (DeGunther, 2008, p. 166). When washing, as little water as necessary should be used in getting the job done. Also, only full loads should be washed. This makes the washing much more efficient.

CLOTHES WASHER CAPACITY	ANNUAL ENERGY USE kWh/yr	$/yr	ANNUAL WATER USE Gallons/yr	$/yr*
Less than 2.0 cubic feet	Least 113 Most 298	$10.75 $28.30	2,766 5,749	$121.70 $252.95
2.0 to 3.0 cubic feet	Least 126 Most 257	$11.95 $24.40	3,547 9,196	$156.05 $404.60
More than 3.0 cubic feet	Least 120 Most 316	$11.40 $30.00	4,323 11,116	$190.20 $489.10
Compare to non-ENERGY STAR 3.2 cubic feet	463	$44.00	13,312	$585.73

TABLE 10: Range of Energy and Water Use for ENERGY STAR Washers (Amann, Wilson and Ackerly, 2007, p. 174)

Of course, ENERGY STAR offers the most efficient washers and dryers, but the model may make a difference in the efficiency as well. Typically a front-loading washer will be more efficient than a top-loading washer. When it comes to dryers, it is very important that the dryer hose is vented outside with no kinks or tears. Also, the heating element in these dryers must be maintained. If a dryer is not drying the way it should,

there may be a hole in the dryer hose, or the heating element may be dirty or burnt out. All of these things are an easy fix.

When drying clothes, consider drying two or more loads in a row. This takes advantage of the heat from the first load and may even allow the other loads to take less time to dry. Be sure that the filter is cleaned after every load. This can hinder the clothes' drying time and poses a risk for lint fires. The clothesline is always an option to bypass the dryer. "Clothes dried outdoors smell much better, particularly if they're in direct sunlight" (DeGunther, 2008, p. 167).

2.3.5 Hot Water Heaters

"Water heating usually accounts for the third-highest consumption in American homes (after heating and cooling). In a very high-efficiency home, the water heater may be the single greatest energy consumer" (Wilson, 2006, p. 82). The most common among water heaters are the storage-type water heaters. Most of the performance of the storage model water heaters is dependent on the amount of insulation surrounding it. Elizabeth Rogers, a member of the National Resource Defense Council (NRDC), states in order to preserve the efficiency of an existing water heater, "wrap your water heater in an insulated blanket to store heat" (Rogers and Kostigen, 2007, p. 9).

It is important that the thermostats on water heater be set no higher than 120°F in order to conserve energy. Making changes such as these can enable homeowners to save up to 25 percent of the energy used in a home. "In a conventional gas storage water heater, less than 50 percent of the fuel energy reaches the point of use" (Amann, Wilson

and Ackerly, 2007, p. 128). This energy loss is called standby loss (Figure 13). This can be reduced with the use of newer, more efficient water heaters.

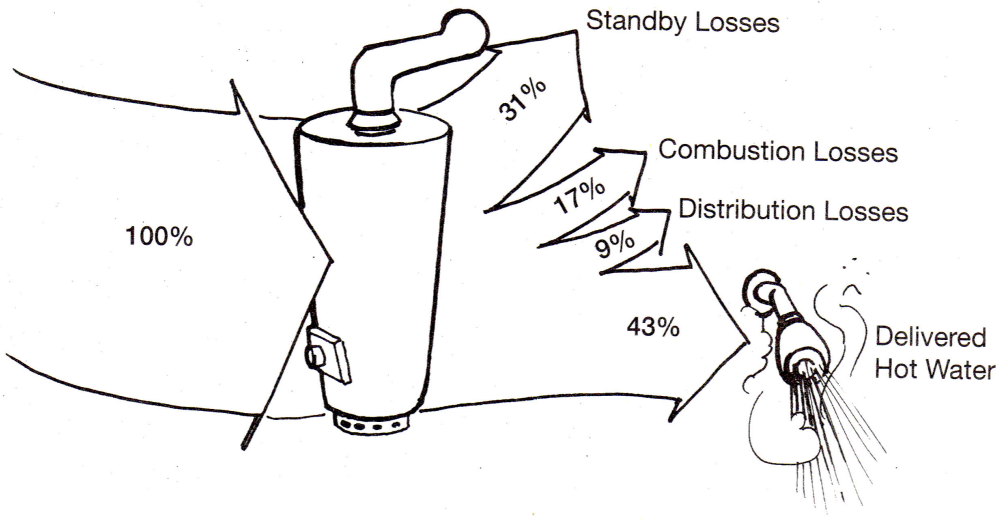


FIGURE 13: Water Heater Energy Losses (Amann, Wilson and Ackerly, 2007, p. 128)

It is also important to have the lines between the hot water heater and the fixtures insulated. If they are not, many gallons of water are being wasted each day. Although the storage model water heaters are the least efficient, this leaves room for the most improvement. For more efficient water heater choices, homeowners should consider tankless on-demand water heaters or solar water heating systems.

The most efficient and reasonable choice for a water heater in a home is a tankless on-demand water heater. "They heat water as it flows through the heater, eliminating the storage tank" (Krigger and Dorsi, 2008, p. 34). With the storage tank eliminated, standby

losses through the walls of the tank are no longer an issue. This type of water heater provides a continuous flow of hot water. However, it may only be able to serve the needs of a maximum of two fixtures or appliances at a time.

Water Heater Type	Efficiency	Cost	Yearly Energy Cost	Life (years)	Cost over 13 Years
Gas Storage	0.60	$850.00	$350	13	$5,400
High-Efficiency Gas Storage	0.65	$1,025	$323	13	$5,200
Condensing Gas Storage	0.86	$2,000	$244	13	$5,200
Oil-Fired, Free Standing	0.55	$1,400	$654	8	$11,300
Electric Storage	0.90	$750	$463	13	$6,800
High-Efficiency Elec. Storage	0.95	$820	$439	13	$6,500
Tankless Gas (no pilot)	0.80	$1,600	$262	20	$5,000
Electric Heat Pump	2.20	$1,600	$190	13	$4,100
Solar-Assisted Electric	1.20	$4,800	$175	20	$7,100

TABLE 11: Life Cycle Costs for 13-Year Operation of Different Types of Water Heaters (Amann, Wilson and Ackerly, 2007, p. 140)

Homeowners should also consider low-flow showerheads as an option to maximize efficiency. The newest low-flow showerheads by law deliver less than 2.5 gallons per minute (Krigger and Dorsi, 2008, p.29). Most families do not even notice the difference when showering. "With an old shower head that uses 5 GPM, a family of four that each takes a daily six minute shower will use about 43,000 gallons of hot water per year!" (Krigger and Dorsi, 2008, p. 29). Low-flow showerheads have the ability to cut this number in half, saving families a few hundred dollars a year.

2.4 Home Electronics

Currently, 10 to 15 percent of electricity being used in homes is being used for home electronics. "As electronics use continues to proliferate, and as new products with higher energy demands hit the market, the overall portion of the household energy budget devoted to electronics is expected to grow" (Amann, Wilson and Ackerly, 2007, p., pg.203). One would think most of the energy consumed by home electronics would be consumed by products like cells phones, iPods or cameras, all of those products with chargers. This however, is not true. These products only account for about 10 percent of the home electronics energy use.

The products making the most of home energy use, up to 90 percent, include home entertainment systems and home office equipment. When homeowners plug each of these electronics, in they typically do not think twice about them because they are relatively small in relation to all other power-hoarding electronics in the home. Even when the products are turned off, they are using what is known as standby power. Among all electronics in a home, standby power can significantly add up (Figure 13).

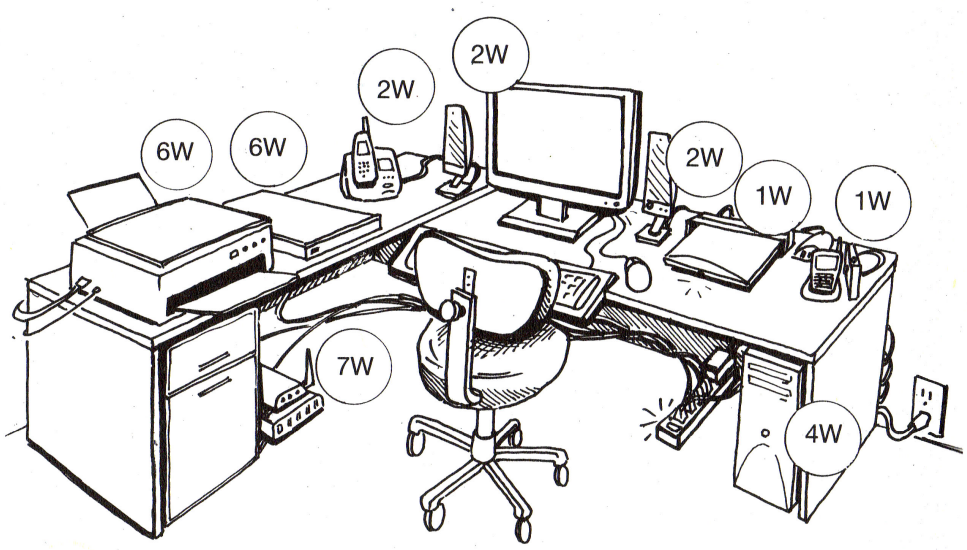


FIGURE 14: Standby Power in Small Numbers Add Up (Amann, Wilson and Ackerly, 2007, p., p. 210).

2.5 Water Consumption and Conservation

"The minimum human requirement for water is only around four gallons per day, and that's for both consumption and cleaning" (DeGunther, 2008, p. 137). With that stated, it is determined that a family of 4 uses somewhere around a maximum of 350 gallons of water a day. That is upwards of 128,000 gallons per year (DeGunther, 2008, p. 137). That is just personal use. There is use for landscaping, washing clothes, dishwashers, washing cars and even swimming pools.

The easiest way to start to cut back on water consumption in the home is by making a few changes in the everyday showering habits and dishwashing styles. There are many products on the market today that allow homeowners to conserve water. Water

fixtures, showerheads and toilets are all sold with a lower gallon per minute (gpr) rating than ever. This allows homeowners to save water and money.

Homeowners can make many changes in their everyday lifestyle practices to conserve water as well. For example, the length of a shower makes a difference when it comes to water conservation. Taking baths should be avoided all together. Homeowners should always opt for taking a shower over a bath. "You simply can't take an economical bath" (DeGunther, 2008, p. 148).

A nice option to consider is installing a graywater recycle system on shower and bath drains. These systems recycle a home's water for belowground irrigation. This is a great option for dry regions. "Graywater is usually used to mean wastewater generated from showers, bathroom sinks, and clothes washers – not including waste water from toilets, kitchen sinks, or dishwashers" (Wilson, 2006, p. 159).

A final option is harvesting rainwater (Figure 14). "Rainwater collected off roofs is another under-utilized source of water for landscape irrigation – and for other uses, including drinking water" (Wilson, 2006, p. 161). This technique that is seemingly new has really been taking place for centuries. It is simple. A barrel or bucket should be placed under the downspout of a home. Homeowners can then use this collected water for their plants.

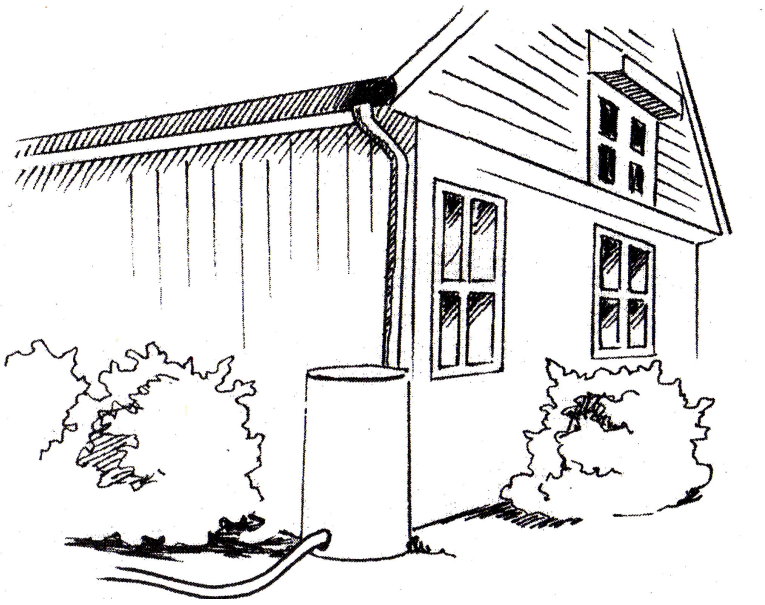


FIGURE 15: Harvesting rainwater provides a simple solution for conserving water, and a source for watering flower gardens (Wilson, 2006, p. 162).

2.6 Landscaping

"Collectively, Americans spend $25 billon on lawn care a year, according to the EPA (Environmental Protection Agency)" (Johnston and Gibson, 2008, p. 311). There can be serious benefit to a home from the money spent on landscaping. Landscaping can be an effective way to reduce heating and cooling costs in a home. " If your home is presently subject to glaring summer sun or blustery winter winds, you could see substantial savings from a well-crafted landscape" (Krigger and Dorsi, 2008, p. 57).

"Studies by the U.S. Department of Agriculture and Department of Energy illustrate how carefully positioned trees can reduce an average household's energy consumption by 20 to 25 percent, saving $300 to $400 each year" (Krigger and Dorsi,

2008, p. 57). Homeowners should take the time to review their existing landscaping to see if it improves their home's efficiency. If not, a plan should be developed that does.

In summer, shade cast by trees or other landscaping can reduce a home's air conditioning cost by up to 50 percent. These savings will be greatest in the hottest climates. The same type of landscaping can reduce your winter heating bill by creating a windbreak during cold weather (Johnston and Gibson, 2008, p. 319). This can reduce the winter heating bill by almost one-third. It will also help to reduce the draftiness of a home in winter.

In order to lower cooling costs, tall deciduous trees should be planted anywhere from 5 to 15 feet away from the southward facing side of the home. This blocks solar heat from high in the summer sky (Dorsi and Krigger, 2008). Plant trees 10 to 30 feet away from the home's west side to block low angle solar heat in the summer afternoons.

In order to lower heating costs, homeowners should plant tall evergreen trees on the north, west and east side of their homes. These trees should be planted farther away from the house than shade trees. These trees will serve as a windbreak that can reduce heating cost by one-third during winter (Dorsi and Krigger, 2008).

CHAPTER 3: DEVELOPMENT OF GUIDELINES

3.1 Introduction

This is an approach to generate a set of guidelines for the use of homeowners that allows them to transform their homes into energy efficient havens in a few simple steps. While this approach is intended for existing structures, it can also be applied to new constructions if the homeowner/homebuilder chooses. Homeowners can apply these guidelines, few or all, dependent upon preference, to their homes, enabling them to become more energy efficient and healthier for living.

Within the approach, it will be described which topics will offer the most financial benefit to the homeowner. It will illustrate changes that can be made to different areas of the home to help in reducing one's carbon footprint as well as the power bill. These guidelines will include tips for the inside and outside of the home as well as things homeowners can do to make their appliances most efficient.

It is important to understand, however, that there are topics that will not be included in this study that have already been addressed in the past. A professional should always handle abatement issues including radon and asbestos. These issues are very complex and one should never try to handle it alone.

Regardless of household type or style, this approach is intended to be suitable for as many households as are willing to participate in being proactive and going green. Each step is broken down into categories according to the homeowner's needs. If the projects and requirements are beyond the homeowner's capabilities, a professional should be contacted.

There are three steps to applying these guidelines to a home: 1) Evaluation 2) Modifications 3) Financial Return. It is important that these steps be followed in order to achieve the most significant energy savings and financial savings.

3.2 Outside

It is important to first understand that the elements assessed on the exterior home are just as, if not more important than, what is going on on the inside of the home. Without the exterior of the home being evaluated and changes being implemented accordingly, it will be almost impossible to achieve a more energy efficient home.

3.2.1 Immediate Changes

Changes that need to be made to homes, be it inside or out, fall into two categories: immediate changes and changes to be scheduled over time. Some changes are not as critical as others and can be almost unreasonable if, for example, an appliance or windows have a number of years left in them. However, sealing leaks in a home and replacing a thermostat with an automatic one are examples of changes that should be classified in the category of immediate changes.

3.2.1.a Sealing Air Leaks

Homeowners should begin by evaluating the exterior, or the "envelope" of the home, for air leaks. Air leaks can represent from 25 to 40 percent heat loss in winter and cool air loss in the summer. If all the candidates for air leakage are handled correctly, with options like caulking, weather-stripping and added insulation, it is possible that up to 25 percent of the heating and cooling bill could be cut.

Testing a home for air tightness can be simpler than one may think. However, if homeowners prefer, they can hire a professional to test for air leakage in the home. To test the home in a DIY manner, on a windy day, use a stick of incense or smoke pen to help identify the air leaks in the home. Hold the incense stick next to any windows, doors, electrical boxes and outlets, plumbing/pipe entrances, attic hatches, or any other locations where there is a possible air path to the outside. If the smoke blows horizontally, then a leak has been located. The best options for sealing these leaks are caulk, foam sealers, or weather-stripping.

It is not necessary for a leak to be located. If homeowners would just like to take precautions when it comes to air leakage, they can apply these guidelines as well. Homeowners can seal all of these places even if leaks are not evident as a preventive method.

The most common place for air leakage in the envelope of the home is the basement sill plate. This is where the frame meets the homes foundation. To stop the possibility for air leakage here, caulk should be applied where the wood frame meets the

home's foundation. Here, homeowners should also check where the joists penetrate the foundation. If there is any possibility for air leakage here, it should be caulked as well.

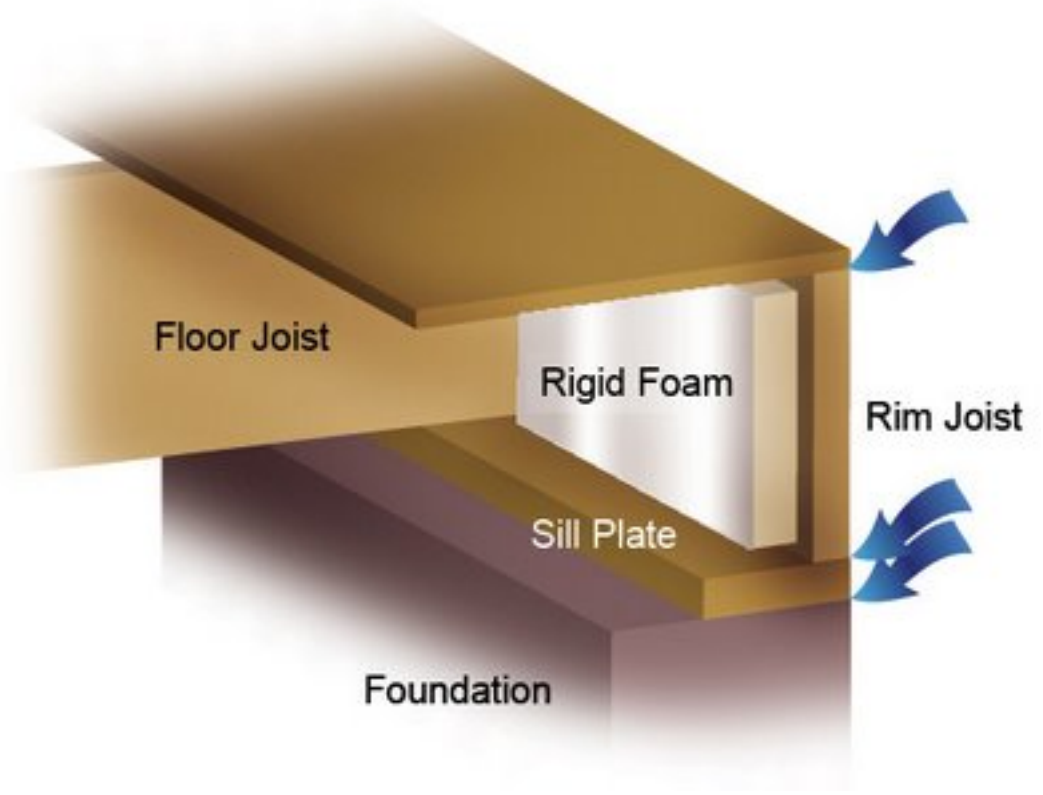


FIGURE 16: Sill Plate and Floor Joist Typical Air Leakage Entrance Areas

Exterior electrical outlets can also be an open invitation for air leakage. They can account for up to 20 percent of the air loss if they have not been sealed properly. These exterior outlets should be caulked around the edges. The exterior outlets should have a plate that has outlet covers that close in order to help eliminate air leakage. Pipe and wire entrances should be handled in a similar manner. A foam sealer may be required here, depending on the size of the gap the wires or pipes are leaving.

The next areas to be inspected by the homeowner are the windows and doors. Caulk and weather-stripping is what will be needed for leaky windows and doors. Caulk would be applied to gaps between the window and doorframes and the home structure. "An 1/8 inch opening in just two doors can let in as much as a 12 inch window opened 6 inches all winter long" (Field, 2009, para.1).

The money spent on weather stripping and caulking can be recovered in one heating season or less. For larger gaps, weather-stripping or a foam sealer should be used in place of caulk. Whether or not a hole or leaks in a joint are visible, the bead of caulk should overlap both the frame and the exterior wall in order to achieve the best seal.

The U.S. Department of Energy states weather-stripping is most effective on windows and doors as well. Weather-stripping should be applied inside the track of a double-hung or sliding window, top and sides of door. Another option for use if there are cracks when the doors close is to apply the weather-stripping fitted into the doorjamb so the door presses against it firmly. (Energy Savers Tips: Sealing Air Leaks, 2009).

Lastly, if a home has older windows that are single paned, homeowners should consider installing storm windows or even consider replacement. Installing storm windows can often be more cost effective than window replacement due to overall cost. Adding a storm window can cut heat loss in half.

The last place to check for air leaks on the outside of a home is the fireplace. If the damper is left open, it could be sucking warm or cool air out of the home. If the fireplace is not being used, consider having it sealed to prevent air loss.

3.2.2 Changes to Consider Over Time

Some changes are not critical changes, but can be reasonable options to consider implementing over time. These changes do offer a turn around, but the turn around might not be as significant due to the cost or otherwise. These changes are considered less critical for many reasons. For example, it is completely unreasonable to tear off a perfectly good roof just to replace it with a more energy-efficient one. The payoff will not be worth the money wasted on the existing roof or the money spent on a new one.

3.2.2.a Landscaping for Efficiency

A step homeowners can take to improve their energy efficiency by making changes to the exterior of the home is landscaping. Landscaping, if done strategically, can help reduce the energy bill and assist with cooling the home. Homeowners tend to overlook this option. "Studies by the U.S. Department of Agriculture and Department of Energy illustrate how carefully positioned trees can reduce an average household's energy consumption by 20 to 25 percent, saving $300 to $400 each year" (Krigger, 2008, p.57). This option is something that can be carried out gradually as the homeowner can afford it.

In order to lower cooling costs, tall deciduous trees should be planted anywhere from 5 to 15 feet away from the southward facing side of the home. This blocks solar heat from high in the summer sky (Dorsi and Krigger, 2008). Plant trees 10 to 30 feet away from the home's west side to block low angle solar heat in the summer afternoons.

In order to lower heating costs, homeowners should plant tall evergreen trees on the north, west and east side of their homes. These trees should be planted farther away

from the house than shade trees. These trees will serve as a windbreak that can reduce heating cost by one-third during winter (Dorsi and Krigger, 2008).

3.2.2.b Window, Door and Roofing Replacement

Window and door replacement also falls under the category of changes to consider over time. The payback from window and door replacement is not significant enough for it to be a priority of a homeowner. The steps mentioned in the immediate changes category can and should be taken before considering replacement. If the windows and doors have been sealed to the best of the homeowners' capabilities and still pose the problem of leaks, it is then that the windows and doors should be replaced.

If homeowners are thinking about replacing windows, they should consider double or triple pane windows. If at all possible, windows with a low-e coating are a good option, as well as insulated frames. Windows like these are the most efficient choice. When purchasing new windows, homeowners should "pay close attention to the ratings by the National Fenestration Rating Council (NFRC)" (Krigger and Dorsi, 2008, p.103).

Windows should not be purchased unless they display the NFRC label. It is important that the purchased window have a low U-factor. The U-factor is a measurement of heat loss. The lower the U-factor the better. It is not a bad idea to go ahead and spend the extra money to buy windows that have an ENERGY STAR label.

When it comes to exterior door replacement, a model with built-in insulation and weather-stripping should be chosen. A door should have an R-value of no less than R-5,

preferably R-10. Doors' efficiency is measured in R-value as opposed to the U-factor that windows are measured (Krigger and Dorsi, 2008, p.114).

Changing a roof, unless it is leaking, is not a critical move to achieving energy efficiency. If it is time to replace the roof, then it is a wise choice to choose a reflective roofing option. If it is not time to replace the roof, homeowners should do some investigating on what roof would best suit them, their region and their needs in the future.

3.3 Inside

The next step to making the home more energy efficient is evaluating the inside of the home. Here, there will also be immediate changes and changes to schedule over time. Changes on the interior of the home will be suggested in order to complete the sealing the homes for air tightness, as well as cutting back on energy and improving the health and well-being of the residents of the home.

3.3.1 Immediate Changes

The changes to be made immediately inside the home are for the most beneficial and most immediate financial returns of the homeowner. There is one major change that should be made immediately to the inside of the home for the changes on the outside to be as beneficial as possible. That is ensuring that the home has adequate insulation levels. The other changes in the home are not as vital and may not offer as much financial incentive, but definitely offer a return of a small amount of financial savings and a healthier living environment.

3.3.1.a Insulation

When beginning the evaluation process, a homeowner should first examine these two things: 1) How thick is the attic insulation? 2) How thick is the insulation in the walls? The first line of defense against energy loss for a homeowner should be attic insulation. Without proper attic insulation, all the changes that have been made to the outside of the home can be useless. This investment will offer one of the most significant returns.

For the attic, the insulation should be at a level of R-40 or more. One should first inspect the insulation to identify the type of insulation used. The three most common types used in the attic are fiberglass batts, loose-fill fiberglass, and cellulose. Fiberglass batts come in rolls that are typically yellow or pink. The R-value of this type of insulation will be printed on the face side of the insulation.

Loose-fill fiberglass looks like chopped up fiberglass batts and is sold in bales. This type will either be pink, yellow or white in color. Cellulose, which can be blown by a professional or purchased in densely packed bags and installed by the homeowner, looks similar to newspapers that have been chopped up. When determining the R-value of loose-fill or cellulose, measure the thickness and then calculate use this calculation procedure.

- **Identify** the type of Insulation and determine the R-value per inch by using Table 12.

- **Measure** the thickness if the type of insulation identified in the home was cellulose or loose-fill fiberglass.
- **Multiply** the R-value per inch by the number of inches measured in the previous step (Krigger and Dorsi, 2008, p. 83).

Building Material	R-Value per inch
Fiberglass Batts (standard)	2.6 to 3.4 (avg. 3.0)
Fiberglass Batts (high density)	3.8 to 4.3 (avg. 4.0)
Fiberglass (loose-fill open attic)	2.2 to 2.4 (avg 2.3)*
Fiberglass (dense-pack in cavity)	3.6 to 4.4 (avg 4.0)*
Cellulose (dense-pack in cavity)	3.0 to 3.4 (avg. 3.2)*
Cellulose (loose-fill in open attic)	3.2 to 3.6 (avg. 3.4)*

*Varies according to installed density

TABLE 12: R-Value of Common Insulation Materials (Krigger and Dorsi, 2008, p. 85)

If the attic of the home does not meet the recommended R-value, a minimum of R-40, then it is in the homeowner's best interest to add additional insulation in order for the insulation to be the most beneficial.

If a homeowner is unable to identify what particular type of insulation is used in his or her home, he or she should take a small piece of it to the local hardware or building supply store for help with identification. If a home does not have an open attic, typically it has an attic cavity. Insulation can be added here, but it is a difficult process that is best left to a professional.

Wall insulation is the next area that should be evaluated. This does not included interior walls of the home. “Wall insulation is one of the most underestimated and neglected energy savers for the home” (Krigger, 2008, pg. 94). Most homes to not have adequate wall insulation. The reason for this is that adding insulation to the walls is a more difficult process.

To check the level of insulation in wall of a home, homeowners can simply look behind an outlet cover and take a peak or inspect the area where the washer pipes or dryer vents pass through and exterior wall. A hole can also be drilled in the wall, in the back of a closet for example, where the hole will not be visible. If the wall cavities are not full, then insulation should be added. Wall insulation, when added to existing residences, is usually blown in from a hole in the wall. This can be done from an interior or exterior wall. This is also a job that should be left to the professionals.

3.3.1.b Heating and Air Conditioning

The heating and cooling system is one of the highest energy consumers in the home. When it comes to immediate changes with a heating and cooling system, the first and most simple move a homeowner can make is installing a programmable, automatic setback thermostat. It can be set to a lower temperature at night for sleeping, and a higher, less energy consuming temperature during the day. This is the best way around wasting energy during the day when no one is home.

According to the United States Green Building Council, in winter, the temperature of a home should be set to 62 degrees or less during the day. During summer, the thermostat should be set to 78 degrees or more during the day. This will

reduce a homeowner's energy bill by $100 a year or more (16 Ways to Green Your Home, n.d, para.2).

To make the most of a heating and cooling system, it is important that the ductwork is airtight and allows no leakage. To do this, the ductwork should be wrapped in fiberglass insulation or any green option that a homeowner chooses. The pieces should be cut as large as possible to avoid seams. Cut carefully and precisely to avoid gaps to get the most out of the insulation. Overlap all seams and fasten the insulation with tape, followed by twine, wire or plastic cable ties (Krigger and Dorsi, 2008, p. 136).

It is crucial for homeowners to maintain and clean the outdoor air conditioning coils to get the best performance from their air conditioning system. It is as equally important to keep the blower and air filter cleaned as well. The filter of the HVAC system should be cleaned monthly during times when it is used the most. Just keeping the filters clean can save a homeowner an additional $100 a year or more (16 Ways to Green Your Home, n.d, para.4).

3.3.1.c Appliances and Electronics

When it comes to appliance and home electronics use, it is important that these products be used correctly in order to achieve the most efficiency possible. Refrigerator temperatures should be set to 38 to 42°F, and the freezer should be set somewhere between 0 and 5°F (NRDC, 2004, para.4). For the most efficient performance of the refrigerator, the gaskets on the doors should be in top condition. If the door does not seem to be closing with a tight seal, the gaskets should be replaced.

If homeowners have two refrigerators in the home, or an extra in the garage for drinks, they should discontinue use of one of them immediately. A second refrigerator can be more than double the cost of operation for the first one, somewhere around $10 extra a month. The cost of operating a single ENERGY STAR refrigerator costs around $48 a year. If a second one is added to that, the overall cost of operating both averages about $111 a year (Amann, Wilson and Ackerly, 2007, p. 153).

When using the oven, do not open the door more than is necessary. Only open the door to put in and take out the food being baked. When cooking on a stovetop, make sure the pots and pans used have flat bottoms and are approximately the same size as the eyes being used. This avoids energy waste and makes the most of the energy the stovetop provides.

When using the dishwasher, wash only full loads. The same amount of energy will be used to wash a half-full or full load, so do not waste the energy on a half load of dishes. Also, be sure to turn off the heated dry option in order to conserve energy, as well as using the shortest cycles that the dishwasher offers.

For washers and dryers, be sure to use water levels appropriate to the size of the load of clothes being washed. It is recommended to use cold water for washing when practical. With the new detergents on the market today, washing clothes in cold water can be done regularly. When drying, be sure to clean out the lint filter before or after each use. However, the most efficient option for drying clothes is a clothesline.

Home electronics can be what are considered as “energy vampires”. Even when electronics are not being used and remain plugged in, they are using electricity.

Homeowners need to be sure to unplug appliances and electronics that are seldom used. Chargers for phones, cameras and computers should be unplugged when they are not in use. Another option is plugging these items into a power strip and switching it off when these items are not in use.

3.3.1.d Lighting

Changing the lighting type can be one of the biggest energy savers. If incandescent lighting is still being used in the home, homeowners should switch to compact fluorescent lighting (CFLs). "Changing five of the most frequently used light bulbs in your home can save you $100 per year on your electrical bills" (16 Ways to Green Your Home, n.d., para.1). There is a free way to cut back on lighting costs. All homeowners need to do is to be sure and turn off the lights when they leave the room. Homeowners should also consider installing dimmer switches or occupancy sensors. These can save up to $40 dollars a year.

3.3.1.e Water Use

Less water can be used "by adding aerators (available for a few dollars at your local home supply store) to your sink faucets and changing to low flow showerheads" (16 Ways to Green Your Home, n.d., para.6). Hot water heaters are the third highest energy consumer in the home. If the home has a storage type water heater, its efficiency is dependent upon its insulation.

To make the most out of a storage model water heater, wrap it in an insulated blanket to aid in heat storage. The thermostat on a hot water heater should be set to no higher than 120°F in order to help conserve energy. These changes will enable the

homeowner to save up to 25 percent of the energy used for heating water with a storage model water heater. It is also important for the lines between the hot water heater and the fixtures to be insulated to prevent the waste of gallons and gallons of water each day.

3.3.2 Changes to Consider Over Time

There are only a few things inside the home that are changes that should be considered and scheduled over a period of time. These, unlike the exterior changes, will have a return, but may be a little too pricey for immediate replacement.

3.3.2.a Heating and Cooling

ENERGY STAR's Guide to Energy Efficient Heating and Cooling says of a homeowner has noticed excessive dust or humidity problems, or a homeowner is spending excessive money on more than frequent repairs, then it may be time to replace the HVAC system. If the unit is noisy or older than 12 years old, then this is another sign that the unit is in need of replacement (A Guide to Energy Efficient Heating and Cooling, n.d., p. 5). This job should be left to the professionals. To ensure that a homeowner is installing the equipment that is best for their home, they should first consult with a heating and cooling contractor.

3.3.2.b Kitchen Appliances

Replacing kitchen appliances is also another task that can be considered and scheduled over a period of time. Appliance replacement can be expensive, but can also offer a significant financial return. When considering the replacement of these appliances, homeowners should consider the most efficient ENERGY STAR appliance

choices. The long-term savings associated with and ENERGY STAR purchase can be up to $50 dollars or more per year per appliance (16 Ways to Green Your Home, n.d, para.5).

3.3.2.c Water Heaters

The most efficient hot water heater on the market today is a tankless on-demand water heater. These units are completely tankless and heat the water only as it is needed. This type of water heat provides a continuous flow of hot water.

According to the U.S. Department of Energy, Energy Efficiency and Renewable Energy (2009):

> "For homes that use 41 gallons or less of hot water daily, demand water heaters can be 24 –34 percent more energy efficient than conventional storage tank water heaters. They can be 8 percent–14 percent more energy efficient for homes that use a lot of hot water—around 86 gallons per day. You can achieve even greater energy savings of 27 percent–50 percent if you install a demand water heater at each hot water outlet" (Energy Savers: Demand (Tankless or Instantaneous) Water Heaters, 2009, para.6).

3.4 When Should I Contact a Professional?

As is specified throughout the guidelines, the homeowner should not carry out all jobs alone. Jobs including water heater and HVAC replacement should strictly be left to the professionals. There are also some changes that allow hiring a professional to be

optional. Installing insulation is one of those changes that is not completely necessary to hire a professional for. However, adding wall insulation is best left to a professional.

Window and door replacement should be left to the professional as well to ensure to most airtight seal. Roofing changes should always be left to a professional. This is a job that homeowners should never attempt to do. Landscaping changes are the choice of the homeowner; typically a professional landscaper will know which plants and trees are best for the homeowner's region.

3.5 Conclusion

The primary goal of these guidelines is to help homeowners cut back on energy cost while reducing their impact on the environment. These guidelines are intended to be more user-friendly than all other energy efficient how-tos on the market. The approach to this set of guidelines is as direct as possible. The overall goal is for homeowners to feel confident in knowing what steps they should take to cut back energy costs while crossing the "green" threshold and improving their living environment and their impact on the planet.

It is important to understand that these guidelines will be dependent on the current condition and characteristics of the home that they are being applied. Some improvements are relevant to all homes, and some are not.

A booklet was created from the guidelines developed in this chapter. This booklet takes the guidelines and puts them in a simple and easy-to-use format for homeowners. The booklet including the guidelines was used to evaluate and make theoretical changes in a home in Henagar, AL and is documented in chapter 4. Images of the booklet follow.

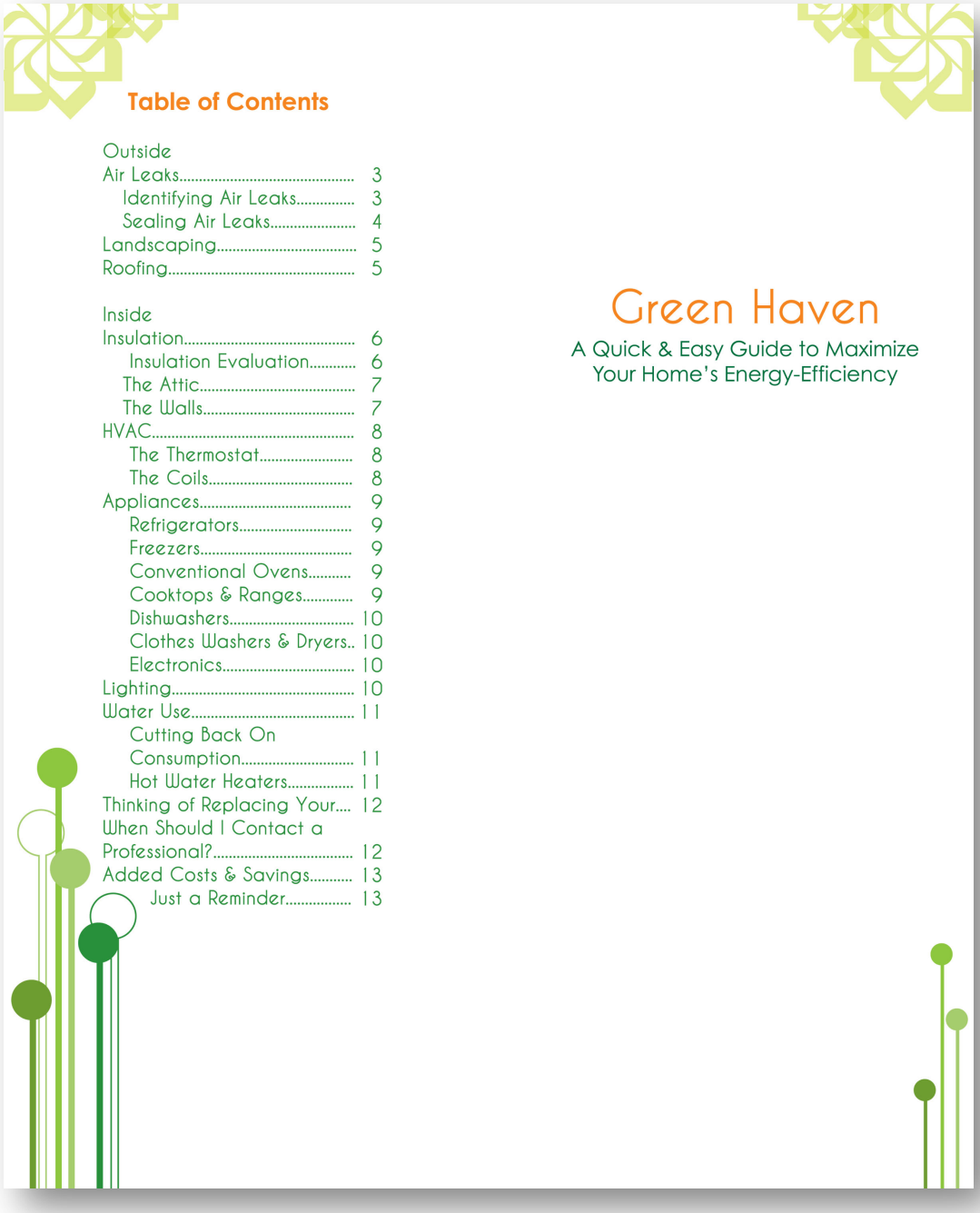


Table of Contents

Green Haven

A Quick & Easy Guide to Maximize Your Home's Energy-Efficiency

FIGURE 17: Pages 1 & 2 of Green Haven Booklet (Table of Contents and Introduction Page)

Outside

Making sure the exterior of your home is in top condition is crucial to achieving maximum energy efficiency. Making the changes suggested in this handbook can cut your energy consumption by up to 80 percent.

Air Leaks

priority level

Identifying air leaks in the exterior of your home will be the most important inspection that you perform. Upon sealing these air leaks, your energy costs can be cut up to 25% of your heating and cooling bill. Air leaks in the home can account for up to 25 to 40% of heat loss in the winter and cool air loss in the summer.

Identifying Air Leaks

A homeowner has two options for identifying air leaks:

- Hire a Professional
- Do It Yourself

To identify air leaks yourself, you will need :

- A windy day
- A stick of incense or smoke pen

Hold the stick of incense next to any window, door, electical box, outlet, plumbing or pipe entrance, attic hatch, or any other location where there is a possible air path to the outside.

If the smoke blows horizontally, then a leak has been located.

Sealing Air Leaks

The best options for sealing air leaks you have detected include these products: Caulk, Foam Sealers, or Weather Stripping.

Basement Sill Plate

The most common place for air leakage in the home is the basement sill plate. This is where the frame of the house meets the home's foundation.
The Solution: Apply caulk where the wood frame meets the home's foundation, and where the joists penetrate the foundation.

Windows & Doors

An 1/8" opening in just two doors can let in as much as a 12" window opened 6" all winter long.
The Solutions: Apply caulk to gaps between the window and door frames of the home structure. The bead of caulk should overlap both the frame and the exterior wall in order to achieve the best seal.

Weather-stripping or foam sealer should be used for larger gaps. Apply weather stripping to the inside of doorjambs to reduce air flow.

If the windows on your home are single paned, consider adding a storm window. Adding storm windows can be more cost effective than window replacement. Adding storm windows can cut heating costs in half

Fireplaces

An open damper on a fireplace can allow air to sneak in and out of your home.
The Solution: Make sure to keep the damper closed when the fireplace is not in use. If the fireplace is no longer being used, consider having it sealed to prevent air loss.

Pipe & Wire Entrances & Electrical Outlets

These areas can account for up to 20% of air loss if they are not sealed properly.
The Solution: These areas should be caulked or foam sealed around their edges. Foam sealer will be required for pipe and wire entrances due to the size of the gaps.

FIGURE 18: Pages 3 & 4 of Green Haven Booklet (Air Leaks)

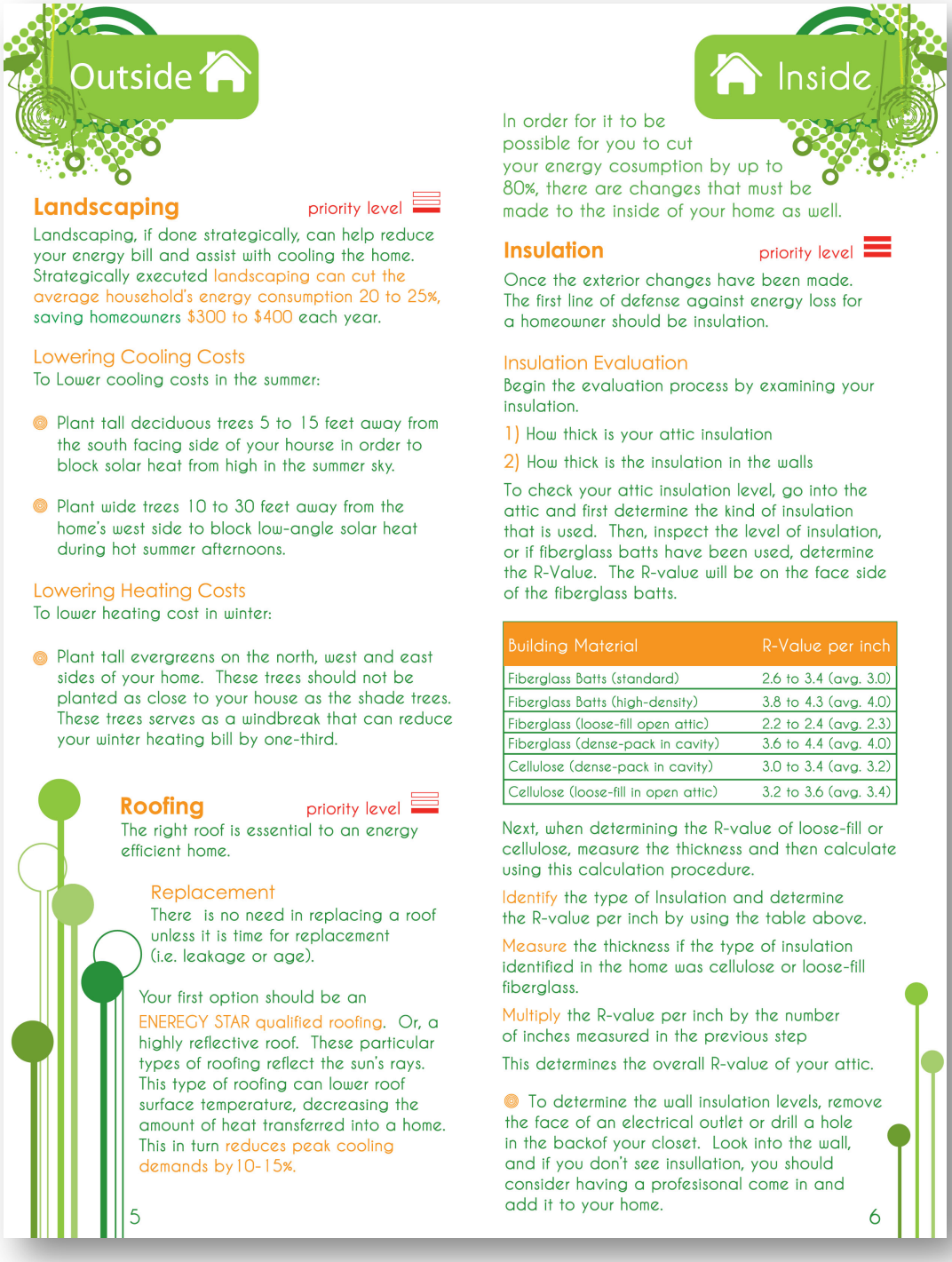


FIGURE 19: Pages 5 & 6 of Green Haven Booklet (Landscaping and Insulation)

Inside

Insulation Continued.....

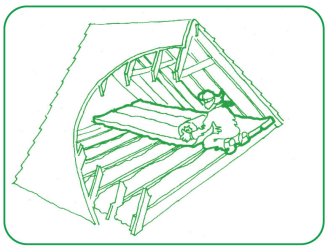
The Attic

The attic and it's insulation levels are the most critical in achieving energy efficiency in your home. Adequate insulation in your home is the next most important thing after sealing the exterior of your home.

- Attic insulation level should be no less than R-40.
- If your attic levels do not meet the recommened R-Value of R-40, then it is crucial to get your attic insulation to the appropriate and most effective levels.

If your home has an open attic adding insulation can be completed by the homeowner if they feel that they possess the skills to do this job on their own.

Some homes do not have an open attic, but have an attic cavitiy. If this is the case, improving your attic insulation is best left to a professional.



The Walls

Wall insulation is the most underestimated and neglected enregy savers for the home.

Adding wall insulation is a difficult process and is best left to the professionals.

Wall insulation is usually blown in from a hole on interior or exterior wall of your home.

Heating, Ventillation & Air-Conditioning Systems

priority level

Heating and Cooling is one of the highest energy consumers in the home.

The Thermostat

The first step you should take is:

- Replace your thermostat with a programmable, automatic set-back thermostat.

The thermostats should be programmed to 62 degrees or less during the day during winter, and 78 degrees or more during summer. This prevents wasting energy during the day when no one is home. Doing this can reduce your energy bill by up to $100 or more a year.

The Ductwork

If the ductwork isn't air tight, it could be allowing for air leakage and wasting money during heating and cooling seasons.

The Solution:

- The ductwork should be wrapped in some form of insulation (i.e. fiberglass batts or any other green option the homeowner chooses).
- These pieces should be cut as large as possible in order to avoid seams and gaps to make the most out of the insulation.
- Be sure to overlap the seams and fasten the seams with tape, followed by twine, wire or plastic cable ties.

The Coils

It is crucial for you to maintain and clean the outdoor air-conditioning coils. Doing this ensures the best performance of your air conditioning system.

It is equally important to keep the blower and air-filter clean.

All of these can be cleaned with an air hose.

The filters should be cleaned monthly. Doing this will save the homeowner an additional $100 or more a year.

FIGURE 20: Pages 7 & 8 of Green Haven Booklet (Insulation and HVAC)

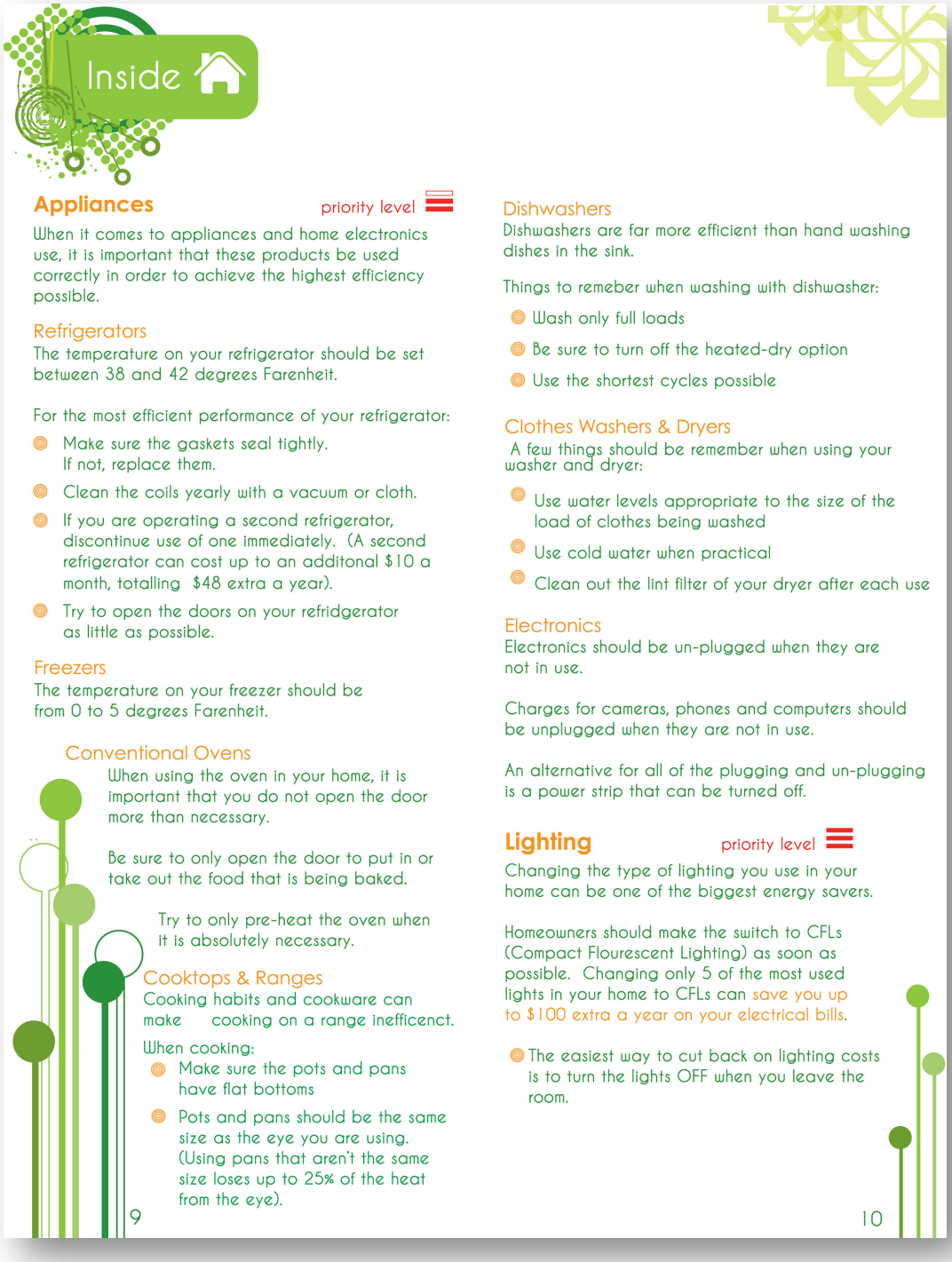


FIGURE 21: Pages 9 & 10 of Green Haven Booklet (Appliances and Lighting)

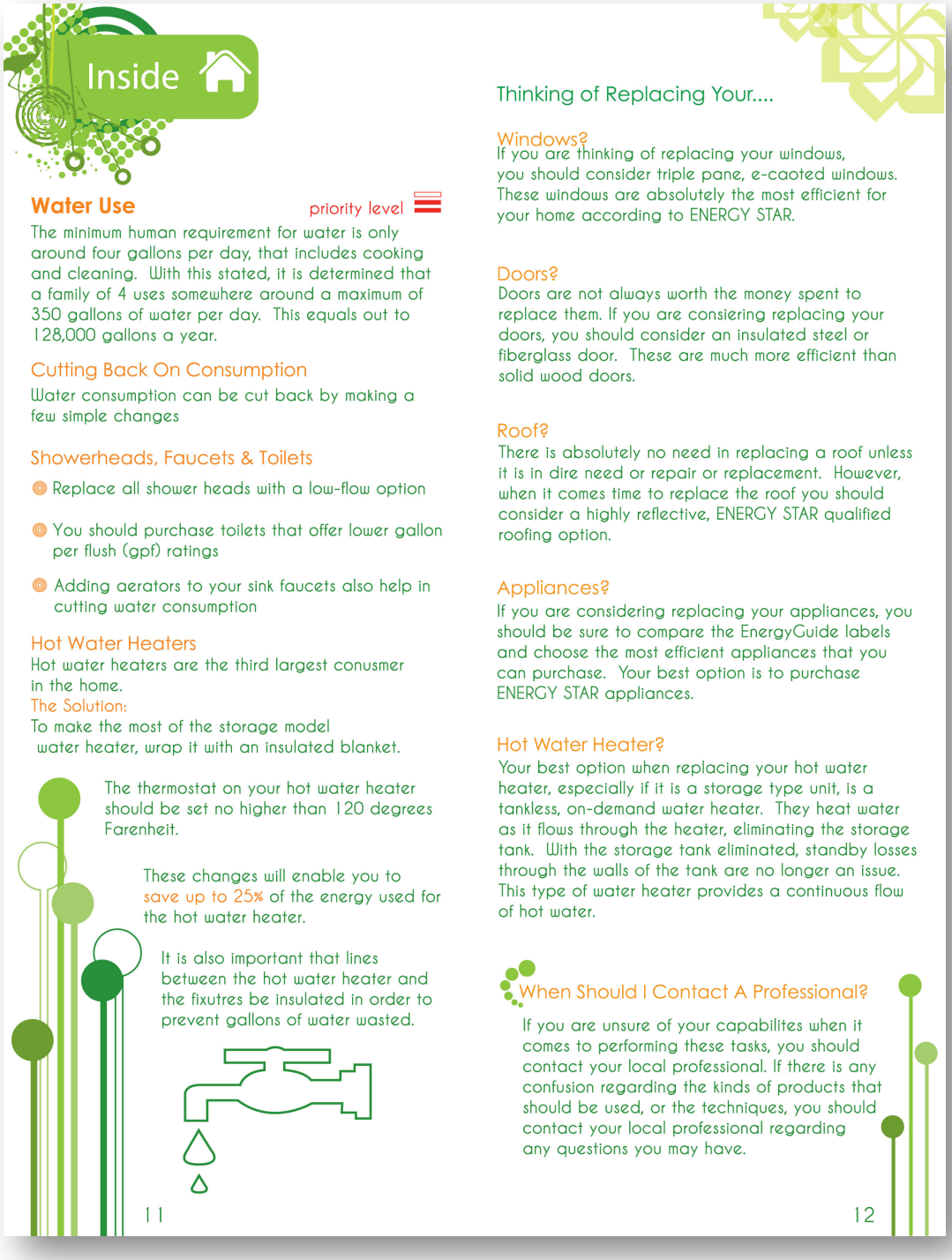
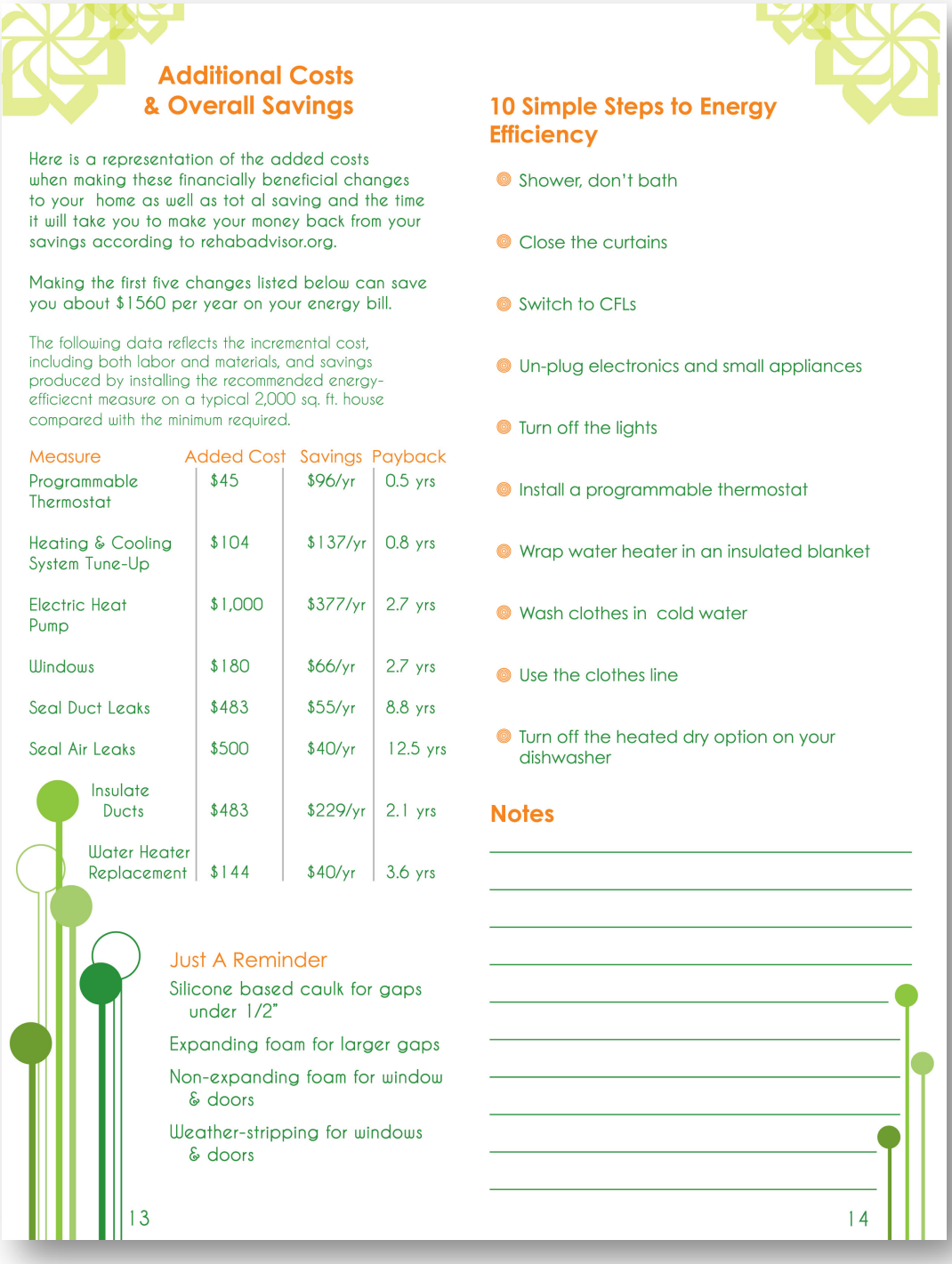


FIGURE 22: Pages 11 &12 of Green Haven Booklet (Water Use and Replacement Suggestions)



Additional Costs & Overall Savings

Here is a representation of the added costs when making these financially beneficial changes to your home as well as tot al saving and the time it will take you to make your money back from your savings according to rehabadvisor.org.

Making the first five changes listed below can save you about $1560 per year on your energy bill.

The following data reflects the incremental cost, including both labor and materials, and savings produced by installing the recommended energy-efficiecnt measure on a typical 2,000 sq. ft. house compared with the minimum required.

Measure	Added Cost	Savings	Payback
Programmable Thermostat	$45	$96/yr	0.5 yrs
Heating & Cooling System Tune-Up	$104	$137/yr	0.8 yrs
Electric Heat Pump	$1,000	$377/yr	2.7 yrs
Windows	$180	$66/yr	2.7 yrs
Seal Duct Leaks	$483	$55/yr	8.8 yrs
Seal Air Leaks	$500	$40/yr	12.5 yrs
Insulate Ducts	$483	$229/yr	2.1 yrs
Water Heater Replacement	$144	$40/yr	3.6 yrs

Just A Reminder

- Silicone based caulk for gaps under 1/2"
- Expanding foam for larger gaps
- Non-expanding foam for window & doors
- Weather-stripping for windows & doors

13

10 Simple Steps to Energy Efficiency

- Shower, don't bath
- Close the curtains
- Switch to CFLs
- Un-plug electronics and small appliances
- Turn off the lights
- Install a programmable thermostat
- Wrap water heater in an insulated blanket
- Wash clothes in cold water
- Use the clothes line
- Turn off the heated dry option on your dishwasher

Notes

14

FIGURE 23: Pages 13 & 14 of Green Haven Booklet (Additional Cost & Savings and 10 Simple Steps to Energy Efficiency)

CHAPTER 4: IMPLEMENTATION OF STUDY

4.1 Introduction

Using an existing home in the Henagar, Alabama area, the guidelines were theoretically applied including cost and financial benefits. The home is 56 years old and has had 4 remodels over the years, adding to the square footage. Due to its age, there are many things that can be applied to this home from the guidelines, but there are also things that must be handled strictly by a professional. These would include abatement issues like radon resulting from 50-year-old lead-based paints.

Four rooms and the exterior where chosen for the guidelines to be theoretically applied. An estimated cost savings was determined per change made. An image of the home chosen for the implementation of the study is pictured in Figure 24.

FIGURE 24: Home Chosen for Theoretical Application of Guidelines.

4.2 Outside

Beginning with the exterior of the home, an examination of the windows was the first duty to be carried out. The home, as mentioned earlier, is 56 years old. Sometime in the past twenty years, the homeowner added storm windows to every window on the home. Upon inspection, it was noticed that caulk was used to seal the windows. However, the caulk was not only used as directed by the guidelines. The windows had been caulked shut as well as being caulked appropriately. This was not a wise decision on the homeowner's part. Fresh air is needed to maintain a healthy living environment.

The first thing that should be done to these windows is to take a chisel and hammer and break that seal.

The windows were caulked appropriately, but due to years of weather and wear, the caulk needed to be removed and re-applied (Figure 25). The next step is to apply caulk where the window meets the exterior of the home. This will ensure that air doesn't sneak in or out. Upon researching the cost of caulk and the amount needed per window, it was determined that it takes about a half of a caulk cartridge per window. The job can be done from $25 to $50 dollars for the cost of a caulk gun and a 12 pack of caulk, depending on the color of caulk chosen. White caulk was $10 cheaper than clear. This would be a decision based on the homeowner's preferences. The average price of a caulk gun is around $12.

FIGURE 25: Caulk in Need of Replacement

This homeowner should consider window replacement as an option in the future due to the current window condition from years of wear. Pictured in Figure 26 is a window on the home that is in need of replacement. Not all of the windows on the home fell victim to this much damage and weathering. The storm window had been removed for some reason, resulting in the deterioration of the original window frame. Most of the

windows were older, but had had storm windows installed over them that in turn helped to preserve the windows (Figure 27).

FIGURE 26: Window in Need of Replacement

FIGURE 27: Storm Windows

The same caulking procedure should be applied around the door facings as well. The doors on this home have been replaced recently, so consideration of replacement is unnecessary. Both doors sealed as tightly as they should in order to prevent air loss (Figure 28).

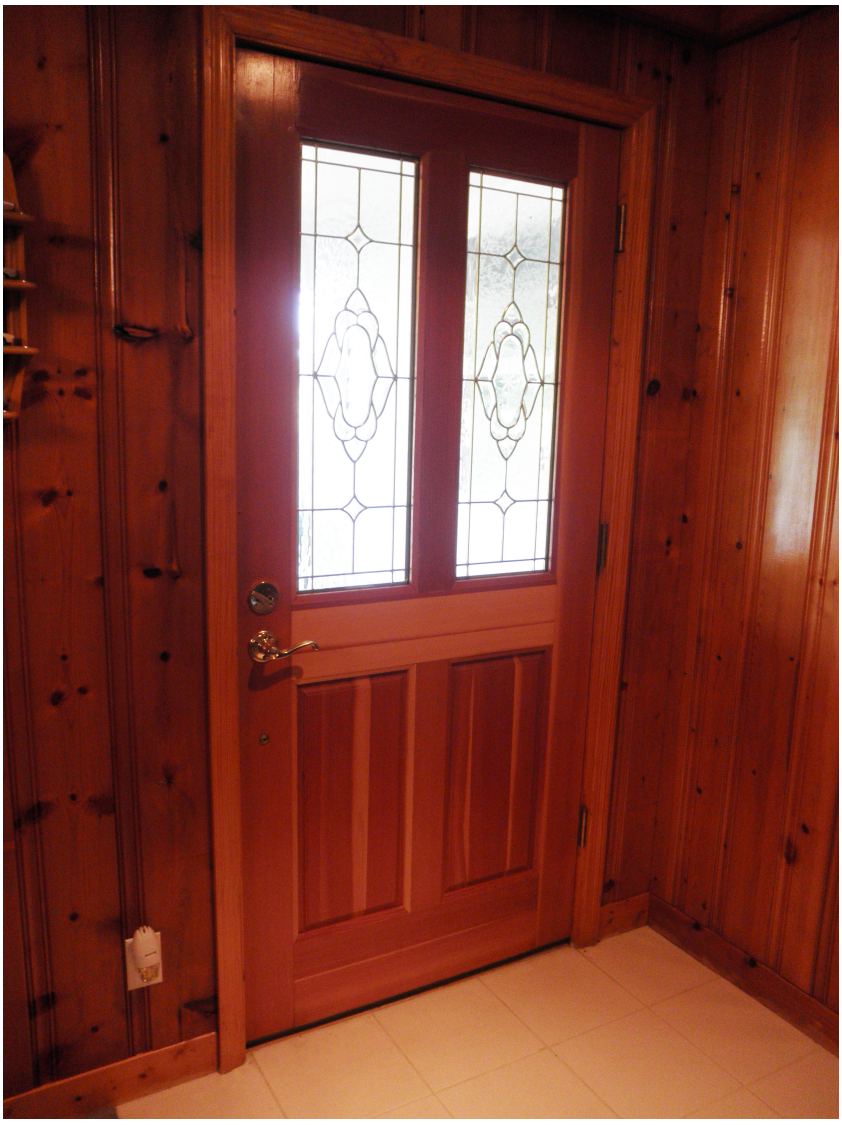


FIGURE 28: Front Door

Next, the foundation sill was examined. It appeared that the foundation had been sealed at some point in the past, but because of weatherization, it was in need of a new application. This application would take about five cartridges of caulk. This fix is a very affordable fix to the home, but is the most crucial. With out the home's air leaks being sealed, it will be impossible to achieve energy efficiency. It is important to keep in mind

that an accurate caulking and weather stripping job, along with sufficient home insulation, can eliminate air leaks in a home and cut the electric bill up to 25 percent.

There are two fireplaces in the home (Figure 29). Both have gas logs installed. However, the homeowners had failed to make sure to close the dampers on both fireplaces. The dampers do not need to be sealed shut permanently, but should definitely be closed when the gas logs are not in use.

FIGURE 29: Both Fireplaces in the Home

After inspecting the roof, the homeowner is in dire need of roof replacement. This homeowner does not have the time to waste by making this an option to plan for overtime. There are missing shingles and a small roof leak on the south end of the home. There is also moss and mold growing on the north side of the roof (Figure 30). This is a result of lack of maintenance. The homeowner should replace the roof with a highly reflective roofing option to reduce temperatures inside the home. This home is in the

heart of the south and hot weather is commonplace. Therefore, the most beneficial choice for the homeowner would be to replace the roof with one that will help cut back on cooling costs.

FIGURE 30: Moss and Mold Growing on the North-Facing Roof

When it comes to landscaping, the home is well shaded (Figure 31). This has helped with heating and cooling costs in the past. There are also two walls of a mix of deciduous and evergreens that serve as a windbreak barrier for cold winds in the

wintertime (Figure 32). There is very little left to be done when it comes to landscaping for this home. The homeowner made an unknowingly wise choice over forty years ago. The choices, have helped in cutting energy costs in comparison to surrounding homes of similar size.

FIGURE 31: Deciduous Shade Trees

FIGURE 32: Windbreak Landscaping

In summary for the outside of this home, here is a clear list of changes that should be made to the exterior of the home. Immediate changes include caulking the windows, doors and foundation sill. The dampers on the fireplaces should be closed immediately and kept closed when the unit is not in use. Also upon inspection, it was determined that the roof should be replaced immediately as well. The damage from the roof leak should also be immediately repaired as well. There is only one change that the homeowner should consider for the future. This is the ultimate replacement of all the windows in the

home. The home was already efficient enough for the price of window replacement to make replacing the windows less of a priority.

4.3 Inside

4.3.1 Insulation

For the inside of the home, the first thing that should be inspected is the insulation level in the attic. The attic of this home is rather small and a little difficult to access. Upon inspection of this insulation, dark spots indicating leaks were found in the attic. After talking with the homeowner, it is understood that the leaks had been from years ago and had been repaired. The insulation had not been replaced upon repair of the leaks.

It is here that the insulation should be removed and new should be installed. The insulation that had been used previously in the home was a rolled fiberglass insulation that was upwards of 30 years in age. This attic is so small that it would be best if a professional do the extracting and replacement. The new insulation can be of the homeowner's choice. However, the easiest to install is either loose fill fiberglass or cellulose with an R-value at a minimum level of R-40.

With the changes to the exterior of the home, and the insulation replacement and improvement, a homeowner is guaranteed a 25 percent price cut in their power bill. All these changes work together as a system, inside and out. Making sure the home is sealed and appropriately insulated is critical to cutting electrical costs.

4.3.2 Heating and Cooling Systems

The next step in evaluating this home is to evaluate the heating and cooling units. There are two air conditioning units on this home. Both of these units have been replaced within the last seven years, and seem to be performing up to standards.

The thermostats in this home were at least 15 to 20 years old (Figure 33). The first step that should be taken is replacing the existing thermostats with programmable automatic setback thermostats. These thermostats should then be programmed to 62° or less during the day in the winter and 78° or more during the day in summer. Just this one replacement can save the homeowner up to $100 or more a year.

FIGURE 33: Home's Current Thermostat

Next, to make the absolute most out of the homeowner's heating and cooling systems, the ductwork was inspected for efficiency. Upon inspection, the ductwork seemed to be in reasonably good shape, but could have afforded to be insulated. The next step in this process was to wrap the ductwork in fiberglass insulation, avoiding as many gaps in the insulation seams as possible. Everything else to do with the HVAC system had been maintenanced appropriately and was performing as it should.

4.3.3 Appliances

Most of the appliances in the home are 10 years or older. Also, this homeowner was operating two refrigerators in their home (Figure 34). This is the ultimate offense in energy efficiency. The first thing the homeowner should do is narrow down to one refrigerator. Next, the thermostats in the refrigerators and freezers should be adjusted. Cutting out the extra refrigerator will cut $10 a month from the energy bill.

FIGURE 34: The Homeowner was Operating Two Refrigerators

The refrigerator should be set from somewhere between 38 and 42°F. The freezer should be set between 0 and 5°F. The seals on the refrigerator were still working appropriately, so there was no need for replacement. This homeowner should make a long-term plan to replace all the appliances in the home, including refrigerator/freezer, washer, dryer, and dishwasher. The homeowner should ultimately resort to buying ENERGY STAR appliances as replacements. Doing this will reduce the energy bill by up to $50 dollars per appliance a year. CFLs cost anywhere from $5 to $7 for a 4 pack of 14W, the equivalency of a 60W halogen bulb.

4.3.4 Lighting

Most all of the lighting in this home was incandescent. There were a few CFLs in some lamps, but that was the limit of CFL usage. The homeowner should immediately replace all incandescent bulbs with CFLs. Just by doing this, the homeowner save around $100 a year in lighting costs. Some other options the homeowner could consider installing in the future are dimmer switches or timer switches. These are not a necessity, but could save the homeowner a few additional dollars in lighting costs.

4.3.5 Water Use

The water heater in this home is a gas storage style water heater. The water heater is snugly stored in a small closet all to itself (Figure 34). This is an efficient location for this water heater, but wrapping the unit in an insulated blanket could save a few additional dollars. The original EnergyGuide label was still on the water heater. This unit is not efficient according to the EnergyGuide label.

FIGURE 35: Hot Water Heater

The water heater temperature was set a little too high, so the thermostat on the water heater should be immediately turned back to 120°F at the highest. These changes prevent energy loss, saving the homeowner up to 25 percent of the energy used for heating the water. This requires less time for the water to be heated according to the users desires.

The water heater is fairly old, and the homeowner should plan to replace this unit with a new one in time. The suggested water heater for this home is a tankless on-demand water heater. These units only heat the water as it is needed, cutting back on energy use and money spent. This replacement should be left to the professionals.

In order for the homeowner to achieve more efficient water usage, aerators should be installed to all sink faucets. Also, the 20-year-old showerheads should be replaced with newer, low flow showerheads (Figure 36).

FIGURE 36: Shower Head in Need of Replacement

4.4 Conclusion

Overall, the home chosen to theoretically apply these guidelines was efficient in comparison to the surrounding homes. However, with some small changes and even a few large ones, the homeowner is ensured a substantial financial return. Ultimately, there is a possibility of reducing a home's energy consumption by up to 80 percent. This can only be achieved if the homeowner takes into effect all of the guidelines that are applicable to the home. Any investment to improve a home's energy efficiency will reduce monthly utility bills while aiding in saving the planet.

CHAPTER 5: CONCLUSIONS

5.1 Summary of Study

Chapter one addresses exactly what this study is about. Beginning with the problem statement and needs for study, it then leads into the preliminary research in order to provide structural support for the study. Following this are the objectives, assumptions, scope and limits, procedures and methods. Finally, chapter one concludes with the anticipated outcome.

Chapter two begins the design research that is specific to solving the problem. In this chapter a number of statistics are introduced for all part of the home. Also, many solutions and suggestions for going green are brought to the readers' attention.

In the chapter to follow, chapter three, this information is evaluated and incorporated into the guidelines based on the health and financial benefits to the homeowner. This is chapter is devoted to the development of the approach. At this point, enough information has been gathered at this time to create a set of guidelines to assist homeowners in greening an existing home.

In chapter four the guidelines are applied theoretically to an existing home. The guidelines are designed so that homeowners can pick and choose according to their

needs. The guidelines were theoretically applied to four rooms in an existing home in Henagar, Alabama.

5.2 Recommendations

The purpose of this project was to design a set of guidelines that eliminated the complexity of going green. Ultimately, the deliverable was to generate a set of guidelines to enable homeowners to green their homes with ease in order to improve their living environment. This is the path I chose to pursue in my study, but it could also be tailored to be used on commercial and industrial buildings as well.

For future use, the approach should be modified to accommodate the current trends, technologies and costs. This approach may be modified to fit the criteria for structures other than homes.

5.3 Synopsis

These guidelines can aid homeowners in creating a healthy living environment all while reducing one's impact on the environment. In the thesis, the guidelines were theoretically applied to a home in Henagar, Alabama, but were only an example of the application of the guidelines and how they can be tailored by the choice of the homeowner.

BIBLIOGRAPHY

"16 Ways to Green Your Home: Lower the Impact of Everyday Living." U.S. Green Building Coucil. 25 Aug. 2009 <www.usgbc.org/ShowFile.aspx?DocumentID=2121>.

"A Guide to Energy-Efficient Heating and Cooling." Energy Star. 25 Aug. 2009 <www.energystar.gov/ia/products/heat_cool/GUIDE_2COLOR.pdf>.

"Air Seal and Insulate with ENERGY STAR : ENERGY STAR." Home : ENERGY STAR. 16 Sep. 2009 <http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_sealing>.

Amann, Jennifer Thorne, Alex Wilson, and Katie Ackerly. Consumer Guide to Home Energy Savings, 9th Edition: Save Money Save Earth. Gabriola Island: New Society Publisher, 2007.

"America's Energy Crisis - Our Energy Crisis." Energy Literacy Advocates - An Informed Democracy Will Act Responsibly . 26 Aug. 2009 <http://www.energyliteracy.org/crisis.html>.

Construction Dictionary. Phoenix: Greater Phoenix, Arizona Chapter #98 of The National Association of Women in Construction, 1991.

DeGunther, Rick. Energy Efficient Homes for Dummies. Indianapolis: Wiley Publishing, Inc., 2008.

"EIA - Energy Basics 101." Energy Information Administration - EIA - Official Energy Statistics from the U.S. Government. 26 Aug. 2009 <http://www.eia.doe.gov/basics/energybasics101.html>.

"ENERGY STAR Training Center : ENERGY STAR." Home : ENERGY STAR. 24 Aug. 2009 <http://www.energystar.gov/index.cfm?c=pt_univ.pt_univ_home_env>.

"Efficient Cooking - Energy Saving Tips." ACEEE - American Council for an Energy-Efficient Economy. 24 Sep. 2009 <http://www.aceee.org/consumerguide/cooking.htm#tips>.

"Efficient Dishwashing - Energy Saving Tips." ACEEE - American Council for an Energy-Efficient Economy. 24 Sep. 2009 <http://www.aceee.org/consumerguide/dishwashing.htm#tips>.

"Energy Efficient Cooking." Organic Gardening, Modern Homesteading, Renewable Energy, Green Homes, Do it Yourself’ MOTHER EARTH NEWS. 6 Oct. 2009 <http://www.motherearthnews.com/Green-Homes/1993-04-01/Energy-Efficient-Cooking.aspx>.

"Energy Efficient Roof Shingles." Professor's House â€“ Reliable advice regarding home and family . 8 Jan. 2009. 16 Sep. 2009 <http://www.professorshouse.com/your-home/environmentally-friendly/energy-efficient-shingles.aspx?terms=energy+efficient+roof+shingles>.

"Energy Primer 101." Energy Literacy Advocates - An Informed Democracy Will Act Responsibly . 26 Aug. 2009 <http://www.energyliteracy.org/energy_101.html>.

"Energy Savers Tips: Sealing Air Leaks." EERE: EERE Server Maintenance. 15 Jan. 2009. 12 Oct. 2009 <http://www1.eere.energy.gov/consumer/tips/air_leaks.html>.

"Energy Savers: Demand (Tankless or Instantaneous) Water Heaters." EERE: Energy Savers Home Page. 24 Mar. 2009. 10 Oct. 2009 <http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12820>.

"Energy and the Economy." Energy Literacy Advocates - An Informed Democracy Will Act Responsibly . 26 Aug. 2009 <http://www.energyliteracy.org/economy.html>.

Field, Anne. "Caulking windows and doors." Home Remodeling, Repair and Improvement - Products, Ideas and How-To Tips. 8 Oct. 2009 <http://www.oldhouseweb.com/how-to-advice/caulking-windows-doors.shtml>.

"For Homeowners and Homebuyers." Build It Green. 26 Aug. 2009 <http://www.builditgreen.org/homeowners-homebuyers>.

"Go Green Initiative - What's the problem?." Go Green Initiative - Helping the World Go Green. 26 Aug. 2009 <http://www.gogreeninitiative.org/content/WhyGoGreen/>.

Harris, Cyril R.. Dictionary of Architecture and Construction. United States: R. R. Donnelley and Sons Company, 1993.

Hirst, Eric, Jeanne Clinton, Howard Geller, and Walter Kroner. Energy Efficient Buildings: Progress and Promis. Washington D.C: American Council for am Energy-Efficient Economy, 1986.

Horn, Greg. Living Green: A Practical Guide to Simple Sustainability. Topanga: Freedom Press, 2006.

"How Green is Your Home?." Green @ Home Summer 2009: 14-16. This article was adapted from "Green Building Primer: 20 Questions," available at GreenBuildingAdvisor.com.

Johnston, David, and Scott Gibson. Green From the Ground: Sustainable, Healthy, and Energy-Efficient Home Construction (Builder's Guide). Newtown: The Taunton Press, Inc., 2008.

Krigger, John, and Chris Dorsi. The Homeowner's Handbook to Energy Efficiency: A Guide to Big and Small Improvements. Helena: Saturn Resource Management, Inc. , 2008.

Lars. "Dishwashers, Energy Star, water efficiency and the environment. A consumer guide.." Practical Environmentalist â€" Useful environmentally friendly news and advice.. 21 Sep. 2007. 6 Oct. 2009 <http://www.practicalenvironmentalist.com/eco-gadgets/dishwashers-energy-star-water-efficiency-and-the-environment-a-consumer-guide.htm>.

Lipschutz, Ronnie D., Deborah L. Bleviss, William R. Alschuler, and David W. Conover. The Energy Saver's Handbook for Town and City People. Emmaus: Rodale Press, 1982.

Matheson, Christie. Green Chic: Saving the in Style. Napperville: Soucebooks, Inc., 2008.

Montgomery, Richard H. . The Home Energy Audit. New York: John Wiley and Sons, Inc., 1983.

"NRDC: How to Reduce Your Energy Consumption." NRDC: Natural Resources Defense Council - The Earth's Best Defense. 27 Sep. 2004. 25 Aug. 2009 <http://www.nrdc.org/air/energy/genergy.asp>.

"Radon | Indoor Air Quality | US EPA." U.S. Environmental Protection Agency. 3 Sep. 2009. 21 Sep. 2009 <http://www.epa.gov/radon/>.

Rogers, Elizabeth, and Thomas M. Kostigen. The Green Book: The Everday Guide to Saving the Planet One Simple Step at a Time. new york: Three Rivers Press, 2007.

"Roof Products : ENERGY STAR." Home : ENERGY STAR. 16 Sep. 2009 <http://www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products>.

Scheckel, Paul. The Home Energy Diet: How to Save Money by Making Your House Energy-Smart (Mother Earth News Wiser Living Series). Gabriola Island: New Society Publisher, 2005.

Slattery, Ellen. "Top 10 excuses for not going green - Green Daily." GreenDaily. 22 Apr. 2008. 12 Oct. 2009 <http://www.greendaily.com/2008/04/22/top-10-excuses-for-not-going-green/>.

"Top Green Lighting Tips : Planet Green." Planet Green : Sustainable Living, Energy Conservation, Earth Day. 23 Sep. 2009 <http://planetgreen.discovery.com/go-green/green-lighting/green-lighting-top-tips.html>.

Trask, Crissy. It's Easy Being Green: A Handbook for Earth-Friendly Living. Layton: Gibbs Smith, 2006.

Walker, Tate . "GreenHomeGuide | Why Making Your Home Energy Efficient Matters." GreenHomeGuide | Connecting You to Advice, Information, and Green Professionals. 13 Sep. 2005. 8 July 2009 <http://www.greenhomeguide.com/index.php/knowhow/entry/780/C236>.

"What is Green Building?." Build It Green. 26 Aug. 2009 <www.builditgreen.org/homeowners-homebuyers>.

Wilson, Alex. Your Green Home; A Guide to Planning a Heathy Environmental New Home. Gabriola Island: New Society Publisher, 2006.