# HOME ENERGY AUDIT

## Environmental Science and Studies Senior Seminar Project

## Towson University

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Tim Carney
Jackie Carroll
Casey Fitzpatrick
Tom Hansford
Marguerite Harden
Aimee Harris
Brent Hood
Danielle Hurst
Amanda Joseph
Lu Anne Kimmitt
Emily Larson
Matt McCloskey
Megan McCormick
Tim McJilton
Emma Noonan
Angela Pacelli
Scott Pervola
Schuyler Pulleyn
Chris Renzo
Meghan Robinson
Josiland Sledge
Kane Stoner
Michael Valenti
Jahmilla Wilson

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# PREFACE

Energy resources play the defining role in creating and maintaining our current way of life, and this is evident no greater than in our home energy use. Energy use in the home occurs in two primary ways: direct on site use such as natural gas or propane for heating, cooking or hot water; and electricity use for air conditioning, refrigeration, and other appliances (including heating and cooking in all electric homes). The fuel mix for electricity production varies by region but most is generated by coal combustion. This process contributes heavily to climate change, acid deposition, and other environmental impacts. Overall, homes use 1/3 of all energy used in the United States and 2/3 of all electricity.

This semester, students in the Environmental Science and Studies program integrated and applied their educational and personal experience to investigate home energy uses. Overall, we called the project: A HOME ENERGY AUDIT, which is a commonly understood procedure to evaluate a homes energy performance. In our audit, however, our intent was to be as thorough as possible by looking at all possible energy related activities in the home. The result was a partition of the issue into eight groups of three students each in four main topics: fuels, uses, management, and context. It was my pleasure working with the students on this project and they should be proud of the knowledge they gained and the material they produced to share with the campus community and others.

I would like to thank Brian Masterson from Baltimore Gas and Electric for sharing information with the class regarding BGE's home energy programs and to Polly Bart for her enthusiastic seminar on green building. I also want to mention four students, Tim Carney, Brent Hood, Lu Anne Kimmitt, and Josiland Sledge, who helped format and edited this final document.

Brian D. Fath, Ph.D.
Associate Professor
Department of Biological Sciences
Towson University
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# CHAPTER 1

# INTRODUCTION

The population of the United States recently surpassed 300 million, making up a mere 5% of the total world population. Yet, the United States is a leader in energy consumption, consuming about 25% of the world's energy resources (EIA). Houses are getting bigger, the shift to larger cars is becoming more popular, and the amount of energy we consume has taken a back seat to convenience and luxury. In a world where energy resources are becoming scarcer these choices are not sustainable and more energy efficient initiatives need to take their place. The recent upswing in petroleum and natural gas prices has shifted our attention to energy, and conservation should be part of the solution. Home energy audits are a good way for the average American to discover simple ways to make their homes more efficient, save money, and reduce the strain on the environment. Energy audits can show where one's house is consuming energy and provide valuable feedback in the areas where the homeowner can become more efficient. Most inefficiency is due to the thermal shell, or the structure of the home. An audit can show where improving insulation quality in the home will reduce heat loss in the winter, and maintain indoor cooling in the summer. Audits can also identify areas of air infiltration in the thermal shell of the home. By repairing or replacing leaky doors and windows, homeowners can improve comfort and reduce energy consumption. Detailed energy audits can guide the homeowners in making wise decisions on the purchase of energy efficient appliances, checking your home for air leaks, maintaining HVAC systems, and other simple ways to become more energy efficient.

In 2002, the United States consumed 97.4 quadrillion Btu's of energy, compared to China, who only used 43.2 quadrillion Btu's of energy and has a population about 4.5 times greater than the USA (Figure 1.1, EIA).

**Representative Countries & Energy Usage, 2002**

| Country | Population in millions | Energy consumption in quadrillion Btu's |
|---|---|---|
| China | 1295 | 43.2 |
| India | 1050 | 14.0 |
| United States | 288 | 97.4 |
| Brazil | 176 | 8.6 |
| Pakistan | 150 | 1.8 |
| Russia | 144 | 27.5 |
| Bangladesh | 144 | 0.6 |
| Japan | 128 | 22.0 |
| Nigeria | 121 | 0.9 |
| Mexico | 102 | 6.6 |
| Germany | 82 | 14.3 |
| France | 60 | 11.0 |
| United Kingdom | 59 | 9.6 |
| Italy | 57 | 7.6 |
| South Korea | 47 | 8.4 |
| Canada | 31 | 13.1 |

This puts into perspective the extraordinary energy consumption of the American people compared to the rest of the world. The large consumption of energy can be contributed to our lifestyle choices, in particular, the size of our homes, our transportation dependencies, and our appliance use are all way above world averages.

The average home is about 2,500 square feet and will cost a family about $1,500 a year in utility bills (EIA). About 42% of the bill is contributed to heating and cooling the home. This heating and cooling is predicted to emit about 500 million tons of carbon dioxide into the atmosphere each year (EIA). Thus, if about 13 billion tons of carbon dioxide accumulates in the atmosphere each year (Andrew), heating and cooling accounts for about 4% of emissions. Installing proper insulation or a programmable thermostat can save significant amounts of money and decrease carbon dioxide emissions each year.

A significant amount of energy is consumed by transportation. The farther you live from work, convenience stores and schools, the more energy will be consumed. "The average American uses 500 gallons of gasoline every year, driving each vehicle about 12,000 miles, at $2 per gallon, that equals $1,000 in fuel costs alone" (EIA). Considering the average American family owns 2 vehicles; that is $2,000 a year in gasoline costs. These costs can be lowered by proper maintenance and efficient use of your vehicles. For example, changing the oil every 3,000 miles, inflating tires to recommended air pressure, and combining errands into one trip can significantly reduce fuel consumption. When buying a new vehicle, considerations should be made on fuel economy, amount of use, and the destination in which the car will be traveling most frequently.

The typical American consumes about 20% of their energy through appliances (EIA). Making "smart purchases" throughout the home and investing in appliances that meet government Energy Star codes can reduce energy consumption. Almost all appliances from refrigerators to toasters have alternative Energy Star efficient options. Even something as simple as changing your light bulbs to compact fluorescent can reduce energy consumption. These bulbs use about a quarter of the energy of incandescent and last about 10 times longer.

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# CHAPTER 2

# FUEL TYPES

Lu Anne Kimmitt
Scott Pervola
Jahmilla Wilson

**Introduction**

Why should homes be energy efficient? Perhaps it would be to decrease the amount of money spent on energy, or maybe to lessen one's ecological footprint. No matter what the reason, a home energy audit may be the first step towards this goal. Home energy audits assess how much energy a home consumes and identifies where improvements could be made (U.S. Dept. of Energy Home Energy Audits). The audit is excellent for dealing specifically with the issues of the home itself such as air leaks and heating/cooling equipment, but it neglects the actual energy sources that fuel the home. Factoring the fuels into a home energy audit is critical to efficiency because all energy sources are not equal in availability (renewable vs. nonrenewable), production, costs, and impacts on the environment.

Most of the United States' electricity is produced from non-renewable fossil fuels including coal, petroleum, and natural gas. These fuels are among the most dirty and unhealthy fuel types due to their release of greenhouse gases, and other environmentally harmful pollutants. These substances pollute our water supply, endanger wildlife and affect human health. However because these fuels have, until recently, been considered abundant and relatively inexpensive, they are the major energy sources in the United States and the world.

**Coal**

Among the major fossil fuels, coal is by far the most abundant and widely used in the United States. More than half of the homes in the United States receive electricity from the combustion of coal. In Maryland 56% of households receive electricity from coal plants (Figure 2.1). Of the 34 major power plants in Maryland, 9 of them use coal as the power source (Table 2.1). Coal is one of the most plentiful fuel types in terms of reserves in the United States. Recent estimates state that the United States has 18,944 million short tones of recoverable coal within its borders (Energy Information Administration, 2006). Coal use in the United States can be traced back to colonial times when it was used by blacksmiths; however coal use exploded during the 1800 and 1900's due to the country's industrial revolution and westward expansion. Coal played a huge role in the development of the country's various railroad systems, as coal is the major fuel source of the steam engine.

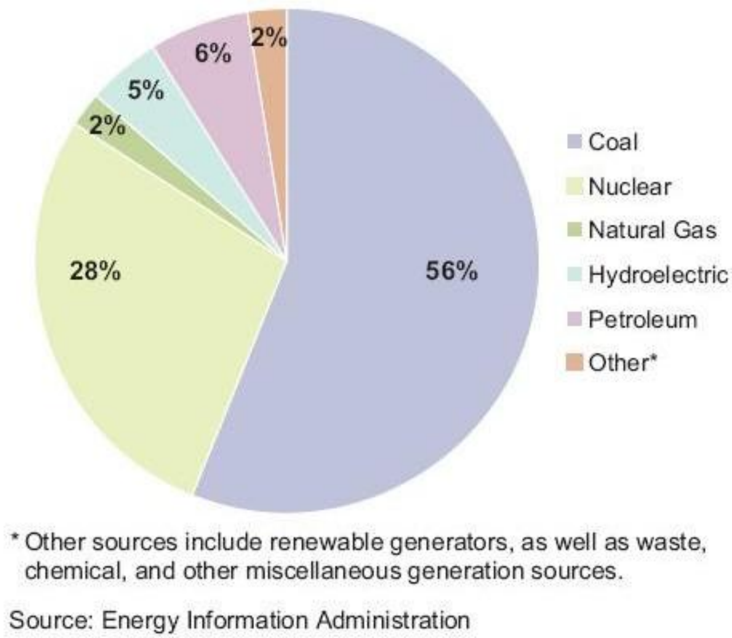


Figure 2.1. Maryland's Power Generation by Fuel Type
http://esm.versar.com/pprp/factbook/generation_fuel.htm

Table 2.1. Operational Generating Capacity in Maryland (>2 MW)

| Owner | Plant Name | Fuel Type | Nameplate Capacity (MW) |
|---|---|---|---|
| Independent Power Producers | | | |
| AES Enterprise | Warrior Run | Coal | 229 |
| Allegheny Energy Supply | R.P. Smith | Coal | 110 |
| Baltimore Refuse Energy Systems Co. (BRESCO) | BRESCO | Waste | 65 |
| Brookfield Power | Deep Creek | Hydroelectric | 20 |
| Conectiv Energy Supply | Crisfield | Oil | 12 |
| Constellation Generation Group | Brandon Shores<br>Calvert Cliffs<br>C.P. Crane<br>Notch Cliff<br>Perryman<br>Philadelphia Road<br>Riverside<br>H.A. Wagner<br>Westport | Coal<br>Nuclear<br>Coal<br>Natural Gas<br>Oil/Natural Gas<br>Oil<br>Oil/Natural Gas<br>Coal/Oil/Natural Gas<br>Natural Gas | 1,370<br>1,829<br>416<br>144<br>404<br>83<br>244<br>1,059<br>121 |
| Mirant | Chalk Point | Coal/Natural Gas | 2,563 |

| | | | |
|---|---|---|---|
| | Dickerson<br>Morgantown | Coal/Natural Gas<br>Coal | 930<br>1,548 |
| Montgomery County | Resource Recovery Facility<br>Gude Landfill | Waste<br>Landfill Gas | 68<br>3 |
| NRG | Vienna | Oil | 183 |
| Panda Energy | Brandywine | Natural Gas | 289 |
| Prince George's County | Brown Station Road | Landfill Gas | 7 |
| Suez Energy North America | Millennium Hawkins Point<br>Sweetheart Cup Facility<br>University of Maryland - College Park | Oil/Natural Gas<br>Natural Gas<br>Oil/Natural Gas | 11<br>11<br>27 |
| Susquehanna Power Co. and PECO Energy Power Co. | Conowingo | Hydroelectric | 550* |
| Publicly Owned Electric Companies | | | |
| Berlin | Berlin | Oil | 9 |
| Easton Utilities | Easton | Oil | 69 |
| Old Dominion Electric Cooperative (ODEC) | Rock Springs | Natural Gas | 680 |
| Southern Maryland Electric Cooperative (SMECO) | Chalk Point Turbine | Natural Gas | 84 |
| Self-generators | | | |
| American Sugar Refining Co. | Domino Sugar | Oil/Natural Gas | 18 |
| MD Department of Public Safety and Corrections | Eastern Correctional Institution (ECI) Cogeneration Facility | Wood | 5 |
| Mittal Steel | Sparrows Point | Natural Gas/Blast Furnace Gas | 120 |
| New Page | Luke Mill | Coal | 65 |
| Total | | | 13,346 |

Source: Energy Information Administration, EIA860 Database, 2003
http://esm.versar.com/pprp/factbook/generation.htm

Coal is formed from decaying vegetation about 300 million years ago during what is known as the Carboniferous Period. This period was characterized by a warm, wet climate with lush vegetation. This vegetation was deposited over millions of years under anaerobic conditions, which eventually converted it to the sedimentary rock we use today as fuel. There are many different types of coal with varying characteristics. The four main types are lignite, sub-bituminous, bituminous, and anthracite (Table 2.2).

Table 2.2. Energy density of different coal types**.**

| Type of Coal | Energy Density | Use/Facts |
|---|---|---|
| Lignite | 10-20 megajoules | Power plant combustion Highest amount of $CO_2$ |
| Sub-Bituminous | 20-28 megajoules | Low density/High water content. |
| Bituminous | 24-35 megajoules | Most abundant/widely used in power plant combustion |
| Anthracite | 26-33 megajoules | Cleanest of coal types. Least abundant. |

Lignite coal is the coal type with the lowest energy density, which is the amount of energy per unit volume. Lignite coal has an energy density between 10-20 megajoules per kilogram or between 3-6 kilowatt hours per kilogram, which is the lowest of the four main coal types. This type of coal is mostly used for combustion in power plants and it is one of the highest carbon dioxide emitters of the major coal types. Power plants using lignite coal are generally within a close proximity to the mine from which the coal is being extracted. This magnifies the environmental impact of the surrounding area as pollution from both combustion and mining are a factor.

Sub-bituminous is another type of coal found in the United States. Its energy density is between 20-28 megajoules per kilogram, which is the equivalent of 5-8 kilowatt hours per kilogram, slightly more than that of lignite coal.

The most abundant and widely used type of coal used in the United States is bituminous coal. The fact that it has a fairly high energy density, between 24-35 megajoules per kilogram or 8-10 kilowatt hours per kilogram makes it the coal of choice in most coal power plants. Due to the fact that bituminous coal has low sulfur content (except bituminous coal from Appalachia) it is also widely used in steel production, which uses a by-product of coal production called coke.

The last major fuel coal type is anthracite coal which is the hardest, most pure and cleanest to burn among the coal types. Anthracite coal has an energy density between 26-33 megajoules per kilogram or between 7-10 kilowatt hours per kilogram, which is comparable to the energy density of bituminous coal. Anthracite coal is more favorable than bituminous due to the fact that it is cleaner with lower sulfur content. Compared to bituminous coal, anthracite coal is one of the least abundant coal types due to over mining in the early days of coal use. Today it is primarily used in water filtration.

As previously stated, coal is one of the most impure fuel types which produce large amounts of pollution. Coal combustion produces carbon dioxide, sulfur dioxide, nitrous oxide, carbon monoxide, particulate matter and heavy metals. Carbon dioxide is one of the most abundant and harmful pollutants given off by fossil fuel combustion, as it is a major contributor to greenhouse gasses and climate change. Coal power plants release an average of 3.7 million tons of carbon dioxide a year, which is the equivalent of cutting down 161 million trees (Union of Concerned Scientists, 2006). Pollutants from coal power plants also contribute to urban smog and acid rain. This is primarily caused by sulfur and nitrogen released during combustion. Coal power plants also release carcinogenic heavy metals such as lead, mercury, arsenic and radium. Studies of pond sediments performed in remote locations of North America show that lead levels were raised as a result of human activities, and were more than 20 times the natural levels (Goudie, 2001). The particulate matters from coal power plants also affect people with respiratory problems such as asthma and bronchitis.

**Oil/Natural Gas**

Other major non-renewable fossil fuel sources in the United States include petroleum, oil and natural gas. Of the 34 major power plants in Maryland, 19 use either oil or natural gas, or a combination of both as their power source (Maryland Power Plant Research Program, 2006). Like coal power plants, electricity is generated by using oil or natural gas in order to generate steam, which drives turbines producing electricity. Oil has the highest energy density of the common fossil fuels, which is between 45-46 megajoules per kilogram, or about 12 kilowatt hours per kilogram. This high energy density makes it a good fuel for large-scale power generation. Oil is formed under similar conditions as coal; however it is formed from ancient plankton and algae deposits deep in the ocean. Most deposits of oil also contain another fossil fuel source known as natural gas. Natural gas or methane is a short chain, tetrahedral hydrocarbon with the chemical formula of $CH_4$. The energy density of natural gas is 39 megajoules per cubic meter or about 10-11 kilowatt hours per cubic meter. Oil and natural gas are used in large-scale power plants, but it also widely used in home appliances for house and water heating.

In Maryland, oil power plants account for 6% of the power generated compared to 2% for natural gas power. Due to rising costs of petroleum and natural gas (39% increase from 2000-2005) these fuel types usage have actually decreased slightly by about 3 % from 2000-2005(Energy Information Administration). The rise in prices can be attributed to natural disasters, such as hurricanes, which damage offshore oil-drilling facilities, instability in the oil rich region of the Middle East, and high demand in a petroleum hungry world. Many of the power plants in Maryland are a combination of coal and oil or natural gas. Which type of fuel used is based on the current demand, with coal being the main source, and the others as back-up in times of high demand.

Although all fossil fuel use emits carbon dioxide, compared to coal, petroleum and natural gas are cleaner burning. Coal produces 43% of carbon dioxide pollution from power plants, with oil and natural gas producing 34% and 24% respectively. However there are other factors that make oil and natural gas potentially harmful to the environment. Oil stored in tanks is susceptible to leakage, which can infiltrate the water table and enter the water supply. The fact that oil and gas are harmful to the environment without even being combusted is another disadvantage to these fuels. With increase in the population the need for fossil fuels for electricity is inevitable, however with the recent studies and concern about global warming and climate change, there needs to be an effort to integrate cleaner, renewable sources of energy.

**Alternative Energy Sources**

Alternative energy is defined as nontraditional energy that is typically renewable and sustainable. Renewable energy can be described as a naturally occurring energy that is in theory inexhaustible or can be replenished within a reasonable amount of time. In his essay, *Energy and the Environment*, John Rae states that renewables meet the criteria to become possible fuels of the future. These criteria include being relatively benign to the environment, inexhaustible and indigenous and so therefore secure (Energy and the Environment, 1993). Solar, wind, hydropower, biomass and geothermal, sometimes referred to as soft energies, along with nuclear energy are the important renewable energy sources that will be discussed. In 2004 only 6% of the 100,000 trillion Btu consumed in the nation was renewable energy (Energy Information Agency, 2006). All renewable energy sources, with the exception of nuclear, typically have a much lower energy density than traditional fuels such as petroleum, coal or natural gas.

**Solar Energy**

Solar energy is commonly thought to consist of photovoltaic cells, which are solar panels sometimes placed on roofs of homes or buildings. However, this type of energy also includes concentrating solar power and low temperature solar collectors (Department of Energy, 2006). Concentrating solar power uses reflective material to concentrate the sun's heat energy. Typical examples of this would be solar troughs or towers that produce energy for more than one structure or for a utility. Low temperature solar collectors absorb heat and use it for water or space heating. These are not as powerful as panels or collectors and are usually used for a specific purpose or appliance (Department of Energy, 2006).

The energy density for solar electricity generation is the highest among renewable sources with a global mean of 170 $W/m^2$. Solar energy consumption from 2000 to 2004 declined slightly from 0.061 to 0.057 quadrillion Btu for residential use. However during this same time period, domestic sales of photovoltaic cells almost quadrupled (Energy Information Administration, 2006). Of the 6% of renewable energy used in the nation only 1% was solar energy (Energy Information Agency, 2006). The cost of installing a typical off grid photovoltaic system is usually between $15,000 and $20,000 (Solar

Development, 2006).

As with any energy source, there are advantages and disadvantages to using solar energy, although ultimately all energy sources can be traced back to the sun. Advantages include having no $CO_2$ emissions in the production of energy. However, $CO_2$ is emitted in the production of the actual photovoltaic units. Solar energy is a clean, efficient and sustainable fuel. It is an important source of energy for remote locations with many benefits in developing countries. Many states, including Maryland, allow net metering, which is a way of "selling back" energy to the electric utilities. The excess amount of energy made is deducted from the total energy used and allows the meter to spin backward if one produces more than one consumes. The disadvantages of solar energy include the high capital costs of the initial acquisition of equipment. Payback times depend on the size of the equipment purchased, the amount paid for that system and the price per kilowatt that the utility company is charging. A typical situation suggested through Solarbuzz.com explains that if the electricity rate is $0.20 per kilowatt-hour to the utility company and a system is installed which cost $4 per watt; payback time would be about 15 years (Solarbuzz.com, 2006). Another disadvantage to solar energy is the need to store the energy produced. This is especially important to an off grid home since utility produced electricity could not be used during nighttime or cloudy weather. The maintenance cost for the system also needs to be considered and is typically about 1% of the purchase price per year. Also, solar is an intermittent source of power, disrupted by diurnal cycle as well as clouds.

**Wind Energy**

Wind is another important source of renewable energy. Historically, energy from the wind has been used for thousands of years. Nationally, wind power accounts for about 2% of the renewable energy used. However, in Maryland very little wind power is used as the central portions of Maryland fall into a poor category for wind potential. The eastern shore of Maryland as well as western Maryland range from fair to good for wind energy potential (Energy Information Administration, 2006) (Figure 2.2). Wind uses kinetic energy to generate electricity, charge batteries, and pump water. Wind farms with large turbines en masse are typically perceived as wind power, but small turbines are available for home use. Wind is created by a temperature gradient and so is also directly linked to the sun (Middlebury, 2006). Wind power usage has increased from 2000 to 2004 from 0.057 to 0.143 quadrillion Btu. Small turbines for home use cost between $6,000 and $22,000 depending on size (American Wind Energy Association, 2006).

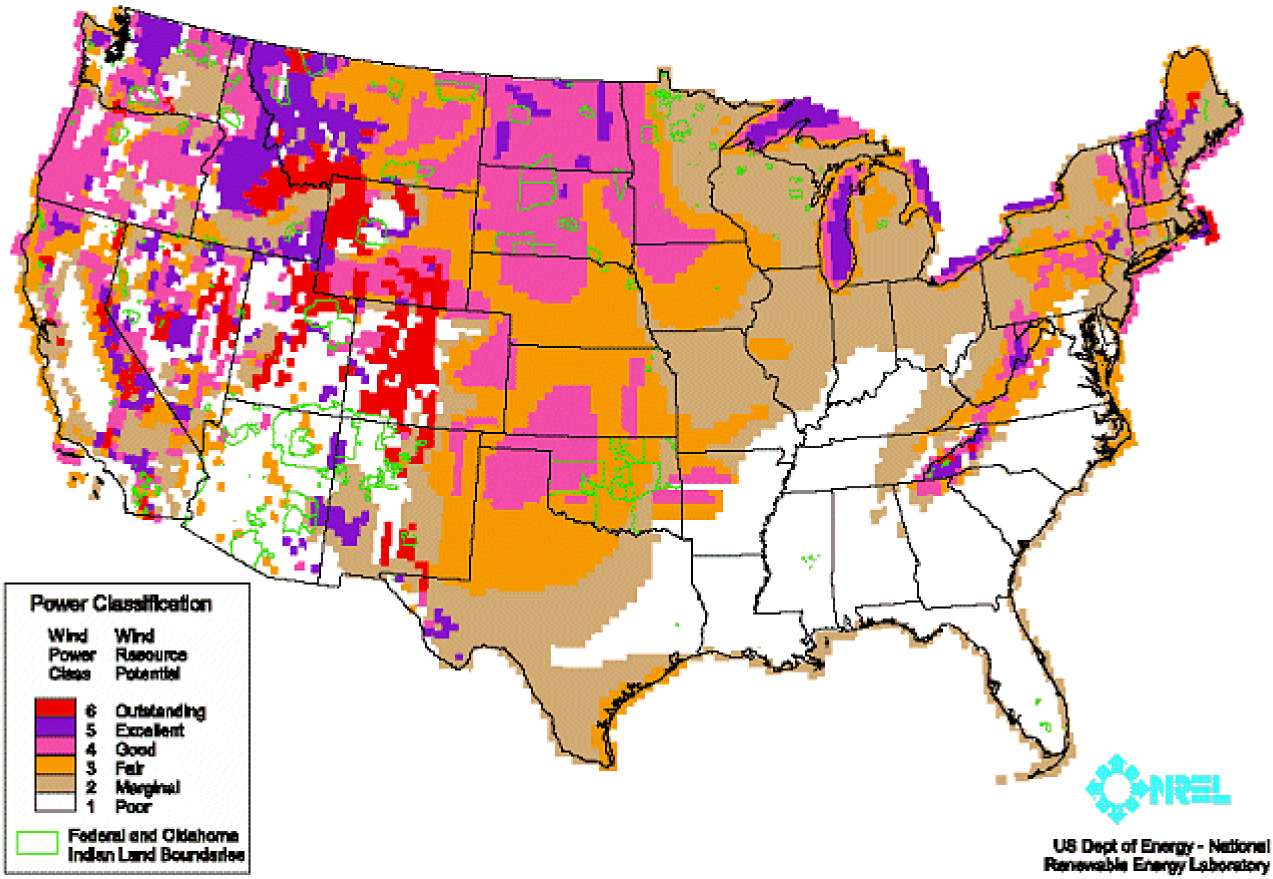


Figure 2.2. Map of Wind Potential in United States. This map is reproduced from the Energy Information Administration website and shows the wind potential in the contiguous United States. Most of central Maryland shows a poor rating with a fair to possibly good rating in the western portions and the eastern shore of Maryland.

Advantages of wind power include no production of greenhouse gases as well as no toxic or radioactive waste produced. Wind is sustainable and has no fuel costs associated with its production. According to an electric utility in Wisconsin, one pound of coal is saved for every kilowatt-hour generated by wind as well as other alternatives (Madison Gas and Electric, 2006). However, wind turbines are found by some to be unattractive, causing noise pollution and are only an intermittent source of power. Bird deaths are another disadvantage cited by opponents of wind energy. Initially a wind turbine costs more than a fossil fuel generator, however since there are no fuel costs associated with this source of energy, the payback time is much shorter (Middlebury, 2006).

## Hydropower

Hydropower currently is the leading renewable energy source used by utilities to generate electricity. Maryland produces only 1% of the electricity in the state by this method (Department of Energy (DOE) – Energy Efficiency and Renewable Energy, 2006). Globally 24% of the world's electricity is hydropower, but the United States produces only 10 – 13% of its electricity with this source which is only 20% of its potential (Middlebury, 2006). According to the Department of Energy, hydropower facilities in the United States can generate the equivalent of 500 million barrels of oil (Department of Energy, 2006).

Hydropower is the oldest source of energy and has been used for thousands of years. It is a very cheap source of energy with no combustion so there is very little pollution (Energy Information Administration, 2006). There is also good potential for developing this source of energy. Disadvantages include environmental impacts associated with habitats when damming water to be used for hydropower. Certain areas of the country do not have access to this type of energy because of their location away from water sources. The initial capital costs are between $1,700 and $2,300 per kilowatt (Energy Information Administration, 2006).

## Biomass Energy

Prior to 1860, the United States used biomass, primarily wood, for nearly 91% of all energy produced. However, biomass includes more than just wood and is defined as all plant material or vegetation including grasses, residues from agriculture, wood waste and fast growing trees. Currently 14% of the world uses biomass for electricity. Only 7% of all annual production of biomass is used as a fuel source. Also biomass can either produce methane as it decays or can be converted to ethanol by alcohol fermentation, both of which can then be used as energy (Middlebury, 2006). The energy density for biomass depends on the material used.

Proponents of biomass use for energy believe an important advantage is its possible replacement of a portion of our fossil fuels used (Middlebury, 2006). The preservation of agricultural land is another important advantage. It is believed that land used to produce fuel would not be developed. Landfill waste would also be reduced, as would methane as a greenhouse gas. There would not be an increase in $CO_2$ because this compound had been currently sequestered by the biomass, and would balance the $CO_2$ emitted. There is also a reduced risk of wildfire in some parts of the country due to the removal of tinder and small trees which could instead be used as a productive fuel source (Colorado Office of Energy Management and Conservation, 2006). Concerns about biomass as an energy source include that it is typically more expensive to produce than other forms of energy costing about $0.09 per kWh to produce compared to less than $0.05 per kWh for conventional fuels. Also there is a concern that in the future as the population increases, using land to produce crops for fuel may become competitive with land used for food crops (Berkshire Renewable Energy Collaborative, 2006).

**Geothermal Energy**

Geothermal is another alternative fuel source. It has two applications for energy production. Power plants can convert hydrothermal fluids to electricity. The conversion type depends on whether the fluid is in a gas or liquid state. Geothermal can also be used in individual residences. It uses the heat in the earth's interior from either hot water or rocks to produce heat as well as cooling for buildings. The earth's temperature is fairly constant between 50 and 60 degrees and can be extracted with piping buried in the ground. In the summer, heat from the building is pulled through the pipes and cooled via this constant temperature or can be used to heat water (Department of Energy – Energy Efficiency and Renewable Energy, 2006). This method of obtaining energy is not commonly used today but provides a possible potential for future energy production. This energy source is clean and reliable and does not require any fuel to function.

**Nuclear Energy**

Nuclear energy is the product of a reaction that takes place when a neutron collides with the nucleus of a uranium-235 atom. The reaction gives off large amounts of heat that is used to create steam to power electric generators (Environmental Science, 1996). The uranium fuel that is used is so efficient that a fingertip-sized portion does the same amount of work as 17,000 cubic feet of natural gas, 1,780 lbs. of coal, or 149 gallons of oil. There are no greenhouse gas emissions or acid rain effects associated with the reaction and in fact, plutonium, one of the by products of the reaction, can be used as a fuel source (Joseph Gonyeau, 2005).

Nuclear energy is a relatively new technology that began providing electricity for residential use in 1955. It has grown to become the second largest source of electricity in the United States, supplying close to 20% of the nation's total (Nuclear Energy Institute) and 28% of the electricity in Maryland (U.S. Dept. of Energy-Maryland Energy Statistics, 2006). Today, the United States is home to 103 nuclear power plants located in 31 different states (Figure 2.3). In 2005, these plants generated a combined 782 billion kilowatt-hours of electricity. While nuclear provides an important contribution to America's base load electricity production there are also several disadvantages.

The uranium that fuels nuclear reactions is currently abundant, but still non-renewable and it has to be mined and enriched before it can be used. These processes are associated with radon (Uranium Information Center) and fossil fuel emissions. Nuclear energy also requires high capital costs for dealing with waste product storage and emergencies (Gonyeau, 2005).

http://www.nei.org/documents/U.S._Nuclear_Plants_Country-Wide_Map.pdf

Figure 2.3. Distribution of nuclear power plants in the United States (indicated by the red dots). This map illustrates that nuclear energy use is currently limited due to the location of power plants.

**Recommendations and Conclusions**

A combination of renewable and non-renewable fuel sources is necessary to accommodate the various energy needs of Maryland homes. Due to diverse circumstances including location, orientation, housing shell energy requirements, availability of energy sources, energy demand, affordability, and local policy, certain fuels may be better suited than others. It is difficult to recommend one specific fuel choice because of all the conditions listed previously.

Both traditional and alternative fuels have advantages and disadvantages associated with their use. Traditional fuels typically have a higher energy density and are more efficient, but they are harsh to the environment and are finite sources. While alternative fuels have a reduced environmental impact and offer a sustainable, renewable source, they incur a high initial capital cost and have a much lower energy density with exception of nuclear energy. However, while alternative fuels may not be feasible to implemented exclusively at this point in time, their use should be phased in as quickly as possible as they do not harm the environment as fossil fuels do.

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# CHAPTER 3

# HEATING AND COOLING

Aimee Harris
Josiland Sledge
Kane Stoner

There are many appliances that are used in a home, but space heating and cooling, water heating, and refrigeration are the largest areas of energy concerns. As shown in the graph below, space heating, air conditioning, water heating, and refrigeration account for 66% of energy consumption in the home (Figure 3.1). These appliances are essential for a comfortable lifestyle, which creates difficulty in managing energy uses and costs. There are ways to improve efficiencies of these appliances to cut both costs and environmental impact.

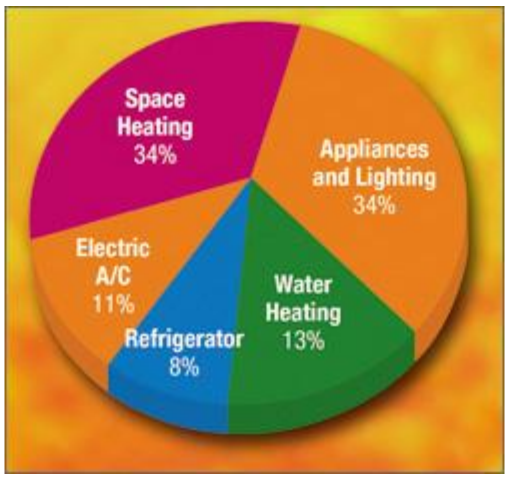


Figure 3.1 Source: U.S. Department of Energy

## Space Heating

Heating and cooling can account for 45% of total energy use in the home, making it the largest energy use in residential homes (U.S. Department of Energy, 2006). There are several options to consider when heating households. The most common appliances for space heating are furnaces and boilers, but other options include geothermal heat pumps, wood and pellet stoves, electric resistant heating, solar, and radiant heating (U.S. Department of Energy, 2006).

Furnaces and boilers are the most common method of heating the home. Furnaces heat the air in a unit and disperse the warm air throughout the home through air ducts. Hot water boilers heat water, which is then circulated throughout the house through piping and then to baseboards or radiators. Once the water reaches the baseboards or radiators, the heat is projected through the house. Steam boilers operate in the same manner as hot water boilers except steam is moved throughout the pipes rather than hot water. Steam boilers require more energy to run because the water must reach higher temperatures and results in a higher energy cost. There are, however, efficient furnaces and boilers currently available (U.S. Department of Energy, 2006).

Furnaces and boiler efficiency is measured by Annual Fuel Utilization Efficiency (AFUE). The Federal Trade Commission has mandated that the efficiency of the units be displayed so that buyers can compare energy costs. Basically, AFUE measures the annual efficiency of the unit. For example, a unit could have an AFUE value of 90%, which means that 90% of the fuel used is converted to 90% heat for the home. The other 10% of the fuel used will escape through the chimney or lost in other ways. Furnaces and boilers that use electricity do not require chimneys for the escape of exhaust so the AFUE can range between 95%-100%. Unfortunately electric appliances tend to be more expensive.

There are minimum requirements for AFUE for each heat type. A non-condensing fossil-fueled, warm-air furnace has an AFUE standard of 78%, a fossil-fueled boiler 80%, and for a gas-fueled steam boiler, 75% (U.S. Department of Energy, 2006).

There are also ways to improve the efficiency of furnaces and boilers such as sealing leaky ducts in furnaces, insulating supply and return pipes in boilers, managing the pilot light, cleaning or changing filters in furnaces, installing radiator reflectors in boilers, cleaning registers in furnaces, ensuring complete servicing, installing a vent damper in the flue, installing zone control radiators, and installing a programmable thermostat (Rocky Mountain Institute, 2004).

Geothermal heat pumps can also be an efficient source of heat. Conventional heat pumps work by absorbing what little warm remains in the outside winter air by the refrigerant circulating in the system, and transferring that heat into the home (Rocky Mountain Institute, 2004). This is the reason why conventional heat pumps are energy inefficient in colder climates, because there is very little heat in the air to absorb in the wintertime. Geothermal heat pumps, however, perform similarly to conventional heat pumps except the heat is absorbed into the refrigerant from the earth rather than the ambient air and can save heating bills by as much as 30-70% (Rocky Mountain Institute, 2004).

Wood stoves are another means of space heating. Wood burning before the 20$^{th}$ century was a common practice accounting for 90% of space heating in homes. Once fossil fuels became the prevalent method of heating, wood burning declined to 1% by 1970, until the energy crisis of the 1970s, during which wood burning gained popularity (U.S. Department of Energy, 2006). Considerations for maximum efficiency of wood stoves are stove location and structural design (Woodheat.Org, 2006).

Another heating method, similar to the wood stove, is the pellet stove. Instead of large pieces of wood, the pellet stove uses fuel pellets that are approximately 3/8 to 1 inch in length. The pellets can be made of compacted sawdust, wood chips, bark, agricultural crop waste, waste paper, nutshells, corn kernels, small wood chips, barley, beet pulp, sunflowers, dried cherry pits, or soybeans. Pellet stoves are environmentally friendly since smoke emissions are limited having a 78%-85% combustion efficiency, which eliminates these stoves from the EPA smoke-emission test. Pellet stove size is important because a stove sized too large for its location, will tend to burn slower creating smolder, which is one of the biggest air polluters (U.S. Department of Energy, 2006).

One of the most inefficient methods of heating a home is through electric resistance heating. An electric resistant heater runs the same as a toaster, which requires large amounts of electricity to heat the coils to the desired temperature. There are several types of resistance heaters such as electric furnaces, electric baseboard heaters, electric wall heaters, and electric thermal storage. Electric resistance heaters are primarily used for dry climates such as the southwestern portion of the US, where there are very few cold days. In addition, electric resistance heaters can be practical for additions to the home by expanding the original heating source (U.S. Department of Energy, 2006).

One of the most environmentally friendly and energy efficient method for space heating is solar energy. There are two basic types of active solar energy, liquid and air. They act as mediums, heated when sunlight hits the solar energy collectors (U.S. Department of Energy, 2006). Liquid systems heat an antifreeze solution or water in a hydronic collector, while air systems are heated in an air collector (U.S. Department of Energy, 2006). Both the liquid and air type systems are heated by solar radiation and then transferred to a storage unit where the heat will be distributed throughout the home. If not enough heat is available from solar radiation, then a back-up heating system that takes over (U.S. Department of Energy, 2006). Typically, solar heating is used in colder climates that have plenty of sunshine, and is used in combination with other heat sources (Rocky Mountain Institute, 2004)

Radiant heat is another type of heating, which describes categories of heat: radiant air floors, electric radiant floors; and hot water (hydronic) radiant floors. Radiant heat systems are simply a series of tubes stretched throughout the floor, walls or ceiling that can have liquids or other medium passing through them for heat. These systems are more efficient than baseboard heating and forced air units because no energy is lost through ducts. Radiant heat prevents dust and other air transmitted illnesses since the system does not move air around the home (U.S. Department of Energy, 2006).

A very inefficient and dangerous method of heating is space heaters. Space heaters are generally used for heating one room, not the entire house. There are four primary fuels used for operation, which are electricity, propane, natural gas, and kerosene. Space heaters are extremely dangerous because the heating mechanism itself becomes extremely hot, and is typically located in a room. According to the U.S. Consumer Product Safety Commission, space heaters result in 25,000 residential fires a year with 300 deaths, and 6,000 people a year sustain burns that require medical treatment. Because of the dangers and expenses associated with space heaters, they are primarily used for heating one room, and not for primary heating (U.S. Department of Energy, 2005).

**Water Heating**

Water heating comprises 14-25% of the energy consumed in the home (Department of Energy, 2006). Hot water is used for washing dishes, cooking, washing clothes, as well as bathing. There are many different types of water heaters including heat pump, gas, tank-less, and solar. The pump is used for electric water heating. It is three times more efficient than electric water resistant heaters. Gas heaters are the most common. The temperature rises about two times as fast as electric water heaters. Gas water heaters are also less expensive, costing less than half of electric units. Tank-less water heaters limit the amount of hot water that can be produced. These models are more expensive and take longer to heat the water. Solar water heaters use the sun's energy to make the water hot. These models can work in any climate (Brain, 2006).

To heat the water, the temperature must be set by the thermostat. The thermostat controls the temperature of the water inside the tank. The temperature can be set between 120 and 180 degrees Fahrenheit (49 to 82 degrees Celsius). It is generally recommended, however, that you keep the temperature between 120 to 140 degrees F (49 to 60 C) to save energy. "Each 10 degree reduction in the water temperature setting cuts the heater's energy consumption by 3-5%" (Brain, 2006).

According to Energy Star, ways to save energy are to install a programmable thermostat and to seal heating ducts. Insulating the hot water pipes keeps the water hot and saves energy as well. Another way to save energy with the hot water heater is to wrap it in a water heater jacket, especially if the heater was made before 1992. Buying a jacket for a hot water heater will reduce the heat lost through the walls of the tank by 25-40%. Buying a jacket will lead to dramatic savings on older models because the owner can still make use of their older model more efficiently (Brain, 2006).

Solar hot water systems are an alternative to regular hot water heaters. Though expensive to buy, in the long run more money is saved (The Alternative Energy Store, 2006). Solar hot water heaters help the environment by reducing fuel emissions. For the best, most energy efficient hot water heater available, purchase an Energy Star appliance.

**Air Conditioning**

Table 4.1 below shows the rising trend in air conditioning over the last twenty years. The table also shows the amount of households with central and room air conditioners, the number of degree cooling days, and the number of central air conditioner units sold during the year.

Table 4.1. Household Consumption of Electricity for Air-Conditioning

| Survey Year | A/C Electricity Consumption (Quad Btu) | # of Homes with Central A/C (million) | # of homes with Room A/C (million) | Ave # of Cooling Degree-Days | Ave. SEER of Central A/C Units Sold During Year |
|---|---|---|---|---|---|
| 1978 | 0.31 | 17.6 | 25.1 | 1,109 | 7.34 |
| 1980 | 0.32 | 22.2 | 24.5 | 1,200 | 7.55 |
| 1981 | 0.33 | 22.4 | 26.0 | 1,108 | 7.78 |
| 1982 | 0.30 | 23.4 | 25.3 | 1,011 | 8.31 |
| 1984 | 0.32 | 25.7 | 25.8 | 1,101 | 8.66 |
| 1987 | 0.44 | 30.7 | 26.9 | 1,139 | 8.97 |
| 1990 | 0.48 | 36.6 | 27.1 | 1,124 | 9.31 |
| 1993 | 0.46 | 42.1 | 24.1 | 1,085 | 10.56 |
| 1997 | 0.42 | 47.8 | 25.8 | 1,056 | 10.66 |
| Sources: Energy Information Administration, 1978-1982, 1984, 1987, 1990, 1993, and 1997 Residential Energy Consumption Surveys; National Oceanic and Atmospheric Administration; Air-Conditioning and | | | | | |

Source: htttp://www.eia.doe.gov/emeu/consumptionbriefs/recs/actrends/recs_ac_trends.html

Conserving energy while cooling the home is just as important as conserving energy while heating it. “About one-sixth of all the electricity generated in the US is used to air condition buildings” (Energy Star, 2006). There are many types of air conditioners for a homeowner to choose. Room air conditioners cool rooms rather than the entire home, providing cooling only where it is needed. Room air conditioners are less expensive to operate than central units. Their efficiency is generally lower; however, they do have timers, which limit the amount of energy being used. Central air conditioners circulate cool air through a system of supply and return ducts and can be categorized as a split-system unit or a packaged unit. Split-system units are the most economical to buy, especially if the home is already equipped with a furnace. Packaged units are used in small commercial buildings. These particular units remove the need for the owner to purchase a separate furnace (How Things Work, 2006).

The best alternatives to cooling the home, other than using an air conditioner, are ceiling fans. According to Energy Star, ceiling fans are 50% more efficient when the fan is combined with lights. Another alternative to keeping the house cool is to open windows, especially at night when the temperature drops. During the day, turn the blinds up so that sunlight is barred from the home, keeping out excess heat.

Recommendations for air conditioners are those with the Energy Star label. Energy Star air conditioners have higher Seasonal Energy Efficiency Ratios (SEER). Seasonal Energy Efficiency Ratios, which are regulated by the government, determines the efficiency of the unit. Energy Star models are 8% more efficient than standard models (Energy Star, 2006). According to Energy Star, room air conditioners are the better model to use because they use 10% less energy than average models.

**Refrigerators**

Refrigerators are a significant source of energy consumption in households. According to the U.S. Department of Energy, a refrigerator accounts for 8% of home energy use; using more electricity than any other appliance. The efficiency of refrigerators however has increased significantly. For example, a typical automatic defrost model with a top-mounted freezer uses about 500 kWh per year. In 1973, the same style refrigerator used over 1,800 kWh per year (Top-Rated Refrigerators, 2006).

The National Appliance Energy Conservation Act was enacted in 1987 and set minimum energy efficiency requirements for refrigerators and standalone freezers (Air conditioning and Refrigeration, 2006). These standards cover all factors of refrigerator styles, size, defrost mode, and ice making systems (Residential ENERGYsmart, 2006). They are calculated depending on the configuration of the refrigerator or freezer and its adjusted volume (AV). The adjusted volume of a refrigerator is calculated by multiplying 1.63 by the total volume of the refrigerator. Then the adjusted volume is used in another equation according to its product category. In each product category, the AV is multiplied by a specified constant and then added to another specified constant to produce a standard of maximum energy usage in kWh/year, as shown in the example below.

Over 8 million refrigerators are sold every year, coming in many styles, sizes, and models (Residential ENERGYsmart, 2006). The most common is the top mount style, which accounts for 70% of all units sold. This style has the freezer unit on top and a larger refrigeration unit on the bottom. Another style is the side-by-side model, which has the freezer on one side and the refrigerator on the other. The side-by-side style accounts for 25% of sales and consumes about 25% more electricity that a top mount model. The bottom mount model has the freezer on the bottom and the refrigerator on the top, accounting for 3% of sales. This style is more energy efficient than the side-by-side model and slightly more efficient than the top mount model. The remaining style has a single door with an internal door to access the freezer (Residential ENERGYsmart, 2006).

A refrigerator's size is measured by storage capacity in cubic feet. The smallest home units are countertop models, which have about 6 cubic feet of storage. The average home refrigerator has a storage capacity of 18-20 cubic feet. The largest home units have about 30 cubic feet.

Many factors affect the amount of energy a refrigerator consumes. A full size refrigerator is said to have a minimum storage capacity of 14 cubic feet. Each additional cubic foot storage capacity beyond 14 cubic feet adds 20-30 kWh of energy consumption each year (Residential ENERGYsmart, 2006). Another factor affecting energy consumption is the automatic or manual defrost mode. Auto defrost consumes 30% more electricity than manual defrost. Automatic icemakers also affect energy consumption. They can increase energy consumption of a refrigerator by 10%-15%. This increase in consumption can be attributed to a heater that releases the cubes from the mold (Residential ENERGYsmart, 2006). Moisture control devices prevent condensation on the outside of the refrigerator and add to energy consumption. This device can add a 10% increase in energy consumed by the refrigerator. Another major contributor to refrigerator energy consumption is room temperature. The warmer the room, the more energy the refrigerator uses. A 10 degree Fahrenheit increase in room temperature can increase energy consumption by 40% (Residential ENERGYsmart, 2006). This is why it is best to keep refrigerators in a cool, well-ventilated environment away from heat sources such as ovens or dryers.

Energy Star labeling currently encourages more efficient refrigerator models to be manufactured. Energy Star labeling is recognizable by 60% of Americans (Energy's Role, 2006). Many consumers will choose Energy Star products to conserve electricity and cut electrical costs. In order to be labeled Energy Star, refrigerators must use 15% less energy than federal standards and 40% less energy than conventional models sold in 2001 (Refrigerators & Freezers, 2006). Freezer models must use 10% less energy. Many models of refrigerators and freezers meet these minimum requirements and are labeled Energy Star.

Sun Frost Refrigerators exceed the minimum requirements for Energy Star labeling. Sun Frost was founded in 1986 by solar pioneers trying to meet the need for energy efficient refrigerators (Refrigerators, home compost bins, 2006). Sun Frost refrigerators can cut energy costs by up to 80% compared to normal refrigerators. The design of the refrigerators reduces energy consumption. Unlike other refrigerators, the cooling system is mounted on the top of the refrigerator, preventing heat from reentering the system. The compressors in these systems are also smaller and run less often. Defrosting is also easy because there is no air circulation between the freezer and refrigerator, causing frost to form slowly.

Space heating, air conditioning, water heating, and refrigeration account for 66% of energy consumption in homes (U.S. Department of Energy-Efficiency, 2006). Since these areas of energy consumption comprise such a large percentage of an electrical bill, understanding options and ways to cut energy costs are vital. All homes can be improved in some way to become more energy efficient.

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# CHAPTER 4

# APPLIANCES AND LIGHTING

Tom Hansford
Meghan Robinson
Michael Valenti

## Introduction

A home energy audit can be divided into three specific areas of evaluation: the shell, appliances, and consumption. These evaluations can be used to recognize areas of improvement in the structure and orientation of the home, the energy consuming products used in the home, and how those products are used. Consumers ultimately have control over what they purchase and how they use those products. The market is filled with technologies that make lives comfortable and convenient. Products like cooking appliances, washing appliances, lighting utilities, and home entertainment technologies are often used in the home, but seldom are they used consciously. Consumers buy and use these products, paying little or no attention to how much energy the commodity consumes.

Appliances and lighting account for about 34% of the energy consumed in the home. Buying energy-efficient appliances and lighting products can conserve much of this energy. However, most people are more concerned with the initial cost of these lights and appliances than how efficient they are. By overlooking the energy-efficiency of the products, consumers are essentially ignoring chances to save money, as well as the environment. Evaluating the efficiency of appliances and lighting products in homes is an important step in understanding the impact it has on the environment, as well as recognizing the opportunity to lessen that impact.

Money is one of the most effective tools in motivating people to do something. Whether it's the idea of sacrificing less of it to acquire what they need or the prospect of earning more of it to satisfy wants and dreams, money can bring plans into action. In the realm of the environmentally conscious, *money* has long been in the form of *cost*. Changing from environmental convention to alternative can be seen easily as a monetary burden, which deters many people from considering more environmentally sound products. But what if the goal of a better environment could be met by the innate societal urge to save money? One way to achieve this coupling of two desires is through energy-efficiency.

In 1992, a program to address energy-efficiency in the home was created by the US Environmental Protection Agency (EPA) and the US Department of Energy (DOE) (Conners, 2006). The program was engineered to direct consumers toward more energy-efficient products and services (Conners, 2006). It was named the *Energy Star* Program, a voluntary labeling of consumer products that strived to be better than a federal standard of efficiency (ES, 2006). The EPA and DOE first set a federal standard on the efficiency of the specific manufactured goods, and then encourage companies to meet or beat the standard with new energy-efficient products (ES, 2006). *Energystar.gov* claims that, "energy-efficient choices can save families about one-third on their energy bill" (ES, 2006). This statement attracts both the average consumer, as well as the environmentally concerned consumer in the way that it compromises energy use with environmental impact. In theory, if consumers purchase and use energy-efficient products, they will save money while lessening their impact on the environment.

**Household Appliances**

In the home, appliances consume a fair amount of energy. Of particular importance are the cooking range, oven, dishwasher, clothes washer, and dryer. These appliances can be inherently inefficient depending on the available technology and also used inefficiently, possibly wasting much energy over their lifetime. To rectify the cost of this wasted energy, buying an energy-efficient model can help save money and lessen the impact of the appliance on the environment. However, an issue with energy-efficient technologies is that they almost always cost more initially than conventional products. As with thinking about environmental impact in general, a different perspective must be used when considering the cost of a product.

When an appliance is purchased, the consumer agrees to pay the initial cost of the product as well as the cost to operate it over its lifetime (ACEEE, 2006). This operating cost can include any maintenance fees as well as the cost of the energy required to operate it as long as it is able to be used. If the consumer considers both of these costs when purchasing the product, they can find that buying the product with the lower initial cost may not be justified by the amount of money it will cost to operate it over its lifetime. Thus, the more energy-efficient models of the same type of appliance may have a higher initial cost, but over the lifetime of that product, the cost may be much less than the conventional models; saving the consumer money over the life of the appliance (ACEEE, 2006). These savings also impacts the environment. When less energy is needed to do the same task, it saves the 'surplus' energy for another task or lessens the overall demand for energy.

Energy-efficient appliances generate a triple-incentive for the consumer. They can increase the competitiveness of the country's economy by decreasing the demand for oil from other countries. Energy-efficient appliances can use oil, gas, and electricity in an effective way, thereby reducing the amount of environmental pollution that results from producing those forms of energy. Finally, when compared to conventional appliances, energy-efficient alternatives can save the consumer money over the appliance's lifetime (ACEEE, 2006).

**Cooking Appliances**

Cooking appliances have become increasingly complex over the past few decades, in design and variety (ACEEE, 2006). Choices for cooking appliances include: down-vented ranges, microwave technology, convection ovens, crock-pots, bread ovens, and toaster ovens. The optimum use of each of these choices should reflect the size of meal being cooked or heated. The conventional range has changed over the years. Any new range that uses gas is required to have an electric spark igniter; which is a change from the former pilot light, a constant waste of energy (ACEEE, 2006).

The most common ranges are the conventional metal coil elements. The American Council for an Energy-Efficient Economy outlined four newer range-cooking technologies. The first alternative to coil elements is the solid disk element (ACEEE, 2006). This type of element is becoming common in newer development. Solid disk elements are easier to clean because they are flush with the counter surface. However, these elements take longer to heat up than the conventional metal coil elements and, in turn consume more energy. The next type of range contains radiant elements under ceramic glass, which are also very easy to clean. These elements are more efficient than the disk or coil types but have a heating time slightly slower than the coil elements. Halogen elements use lamps to heat the glass surface on which the cookware sits. These elements heat a little faster than the radiant type, but are less efficient. The newest type of cooking range is the induction element. These elements convey electromagnetic energy directly to the area where heat is needed, and therefore are the most efficient of range elements. Induction elements use less than 50% the energy of conventional coils and leave almost no lingering heat once cooking has stopped. The negative aspect of this type of range is that the initial cost is high, and the savings from the conserved energy does not justify the cost over its lifetime (ACEEE, 2006).

Oven cooking is usually a much longer and energy intensive form of cooking. The conventional gas/electric self-cleaning oven is well insulated and efficient; however, if the self-cleaning feature is used more than once a month, the benefit of increased insulation will be negated by the overuse of energy. A convection oven can be more efficient because the heat generated is constantly circulated throughout the oven, heating the food evenly, and often times faster than conventional models. Furthermore, the average convection oven can decrease energy use by close to 20%, as compared to conventional ovens. A relatively new alternative to traditional cooking is the microwave oven. These types of ovens are most suitable for small meals or divided portions of larger foods. Overall, the microwave oven uses 66% less energy than conventional ovens, as well as generates much less ambient heat. Ambient heat from cooking can raise the temperature of the home, and especially during warm summer months, can cause the air conditioning to run longer and thereby consume more energy cooling the home (ACEEE, 2006).

Dishwashers use more energy heating the water than used to clean the dishes (ACEEE, 2006). An energy-efficient dishwasher would be able to clean the dishes just as well or better than conventional models while consuming energy and less water. Dishwashers that were manufactured before 1994, if replaced by newer models, can save the consumer more than $25 a year in energy cost (ES, 2006). Energy Star dishwasher models use one-fourth less energy than the federal standard for consumption, as well as less water than conventional models (ES, 2006). The most efficient models have booster heaters built in that heat water beyond the household water heater temperature, which can allow the consumer to lower the overall temperature of their water heater, and save more money and energy (ES, 2006). New models also can use less than half of the water required for manual cleaning. To further save water and energy, efficient dishwashers have been equipped with 'soil sensors' that can detect the amount of water needed sufficiently clean the dishes (ACEEE, 2006).

**Washers and Dryers**

Clothes washers follow similar guidelines as dishwashers when being evaluated for efficiency. One of the most important considerations when purchasing an energy efficient clothes washer is the amount of water it consumes (Ashley, 1998). As with dishwashers, nearly 90% of the energy consumed by clothes washers is used to heat the water (Ashley, 1998). There are two main types of clothes washers available: horizontal axis models, and vertical axis models (Ashley, 1998). The most common type found in the home is the vertical axis model. These washers are top loading and require the drum to be 90% filled with water to completely submerse the clothes. Horizontal axis washers are front-loading and require much less water filling about 30-50%, and in turn less energy to clean the same amount of clothes. However, there are newer vertical axis washers that utilize water-sprayers located near the top of the drum. The drum spins like conventional vertical models, while a panel in the bottom of the drum bounces the clothes into the washing stream. These newer versions use much less energy and water than conventional models, but are still less efficient than the horizontal model (ACEEE, 2006).

Clothes dryer technology has had limited improvements since its conception (Conners, 2006). Choosing which fuel type to use is one of the only ways to save money and energy when considering a dryer (Conners, 2006). Gas fuel dryers are more most efficient and may cut energy consumption by 25% when compared to conventional electric models (ACEEE, 2006). A definitive feature on newer dryers is the option of a moisture sensor or a temperature sensor. Moisture sensors that are located inside the drum are more effective in that they measure the amount of moisture on the clothes surface, opposed to some moisture sensors that measure the dampness of the air exhaust (Conners, 2006). Temperature is the less efficient sensor because it does not sense if the clothes are actually dry, rather, correlates the air temperature with the heat needed to dry certain amounts of moisture (Conners, 2006). Having some sort of sensor is important because it can profoundly decrease the amount of energy used. Conventional time cycle dryers operate via a timer. In comparison, the sensor-equipped models can stop drying once the clothes are dry; saving energy that would be wasted (ACEEE, 2006).

**Other Appliances**

Many consumers have replaced original home movie VHS machines with DVD players. This transition, while good for picture quality and longevity, means that the average household now uses more energy to watch their movies. The average VCR uses 30 watts per hour, while the DVD player uses an average of 65 watts per hour (Public Service of New Hampshire, 2006). That is an average with discs either in or out of the player itself as some DVD players will actually use more power if a disc is in the machine. DVD players, like many home entertainment devices remain constantly on even when the external power is off. The typical DVD player runs at 4 watts per hour on standby.

The average smaller radio uses 30 watts per hour and a household with a radio will use an average of 20-40 kilowatts per year (Delmarva Power, 2006). In comparison the average larger stereo uses 75 watts per hour and just like television sets, even when the machine is not being used, is still consuming energy to read any incoming signal from the remote. The largest of the stereo systems, the home theater system, of course uses the most energy. The average home theater receiver uses 100 watts per hour. Just like computers, home receivers are packaged with confusing labeling. If a home theater receiver is marked with 500 watts, that 500 watts is the peak power that the stereo will deliver for a split second to the speakers, not how much power at which the receiver constantly operates.

**Home Computers**

In today's technological world, most typical households have at least one computer. In many of these households, the computer is left on for most of the day without thought as to how much energy is being used. The average home computer uses 65-250 watts per hour (Bluejay, 2006). The labels themselves on computers can be deceiving. While the label might read 300 watts, that is only the theoretical peak performance. The computer itself might just be using 80 watts per hour and jump up 100 watts when the need comes for more advanced processing.

The type of monitor used can affect the overall energy usage of the computer system. A 17 inch CRT monitor uses 80 watts per hour when running, while a LCD monitor uses 35 watts per hour. Laptop computers can generally use about 15-45 watts per hour (Bluejay, 2006), which is less than the average desktop computer. Dell Computer's new line of laptops has been designed to be more environmentally friendly. "Current Dell Latitude notebooks consume up to 70% less energy than the previous model called OptiPlex GX620.The energy saved results in a reduction of pollution to the environment. In addition, every 1000 units of Latitude notebooks installed instead of the GX260 helps reduce carbon dioxide omission by about 1 million pounds" (Dell Computers, 2006).

The brand and type of the computer can matter as well. A Dell Dimension B110 uses a maximum of 120 watts per hour, a minimum of 60 watts per hour and 3 watts per hour in sleep mode. In comparison, the more powerful Dell Dimension XPS 400 uses a maximum of 258 watts per hour with a minimum of 149 watts per hour and 2 watts per hour when in sleep mode (Bluejay, 2006).

Many people use some type of screensaver, some of which can be quite elaborate. This essentially can consume just as much energy as when the computer is being used. The only way to save energy is to let the computer screen go dark or in standby mode. When the computer is on standby it typically uses 1-6 watts per hour. Other devices attached to the computer can consume small amounts of energy but at a constant rate. A cable modem uses around 7 watts per hour, while a router uses around 4.5 watts per hour. Computer habits and uses can affect the amount of energy being consumed. A person or family who needs to print a high volume of documents would use much more energy than the average household. The computer printer when running uses 600 watts per hour (Public Service of New Hampshire, 2006).

**Television**

Televisions are staples in most American homes whether it is for news, sports or soap operas. In fact 99% of households have at lest one television set in their homes. Children can spend an average of 4 hours a day watching television, or about 2,400 hours a year and nearly 18,000 hours by the time they graduate from high school. In comparison, they spend only 13,000 hours in school, from kindergarten through twelfth grade (FCC, 2006). The average black and white television uses an average of 45 watts per hour. For households with a black and white television there is an average of 90 kilowatts used per year. The black and white television uses far less energy on average than color sets, which use around 100 watts per hour. On average, a home using one color television will use 100 to 300 kilowatts per year.

The amount of energy use of a color television set also depends on the size of the set itself. Many American homes subscribe to the "bigger is better" policy when it comes to the size of their television which, in turn, means that the home is spending more on energy. While the average 19 inch set uses 100 watts per hour, a 36-inch set uses 130 watts per hour. Going even larger, the typical 55 inch set uses 220 watts per hour, which is more than twice as much as the 19-inch television set. The average television/VCR/DVD combination device uses 120 watts per hour. While the typical Cable converter box uses 35 watts per hour and is constantly running. The average home with a cable box spends around $3.33 cents per month for electricity for that box (Public Service of New Hampshire, 2006). Table 4.2 provides an estimated amount of electricity that your typical household appliances use.

Table 4.2 How Much Electricity Do Your Home Appliances Use?

| Food Preparation | **Typical Wattage** | **KWH Used Per Year** |
|---|---|---|
| Coffee Maker | 1,200 | 80 |
| Dishwasher | 1,201 | 170 |
| Microwave Oven | 400-1,200 | 40-200 |
| Range w/Oven | 12,200 | 500-700 |
| Range w/Self-Cleaning Oven | 12,200 | 600-800 |
| **Food Preservation** | | |
| Freezer-Manual Defrost | 20 cu. ft. | 790 |
| Refrigerator/Freezer Manual Defrost | 14 cu. ft | 710 |
| Refrigerator/Freezer Automatic Defrost | 19 cu. ft. | 820 |
| **Laundry** | | |
| Clothes Dryer | 5,000 | 770 |
| Iron (hand) | 1,100 | 50 |
| Automatic Washing Machine * | 512 | 145 |
| Water Heater ** | 4,500 | 4,811 |
| **Comfort Conditioning** | | |
| Air Conditioner (room) ** | 5,000-12,000 btu | 470-1,260 |
| Fan (ceiling) | 88 | 50 |
| Fan (window) | 200 | 10-30 |
| Fan (rollaway) | 171 | 60 |
| Heater (portable) | 1,500 | 240-1,000 |
| Furnace Fan | 300-750 | 300-900 |
| **Health and Beauty** | | |
| Hair Dryer | 1,200 | 20-70 |
| Shaver | 15 | 1 |
| **Home Entertainment** | | |
| Radio | 20-50 | 20-50 |
| Television (B&W Solid State) | 45 | 90 |

| | | |
|---|---|---|
| Television (Color Solid State) | 100 | 100-300 |
| Home Computer | 150 | 80-170 |
| VCR | 30 | 20-60 |

* Excluding Hot Water Consumption
** Based on Delmarva Power service territory

http://www.delmarva.com/home/education/conserving/usage/.

**Lighting**

One of the quickest ways to lower energy bills these days is by making improvements to the lighting inside and outside of the home. The consumer can consider things such as lighting controls, lighting maintenance, and day lighting. When looking at lighting within the home, certain areas like the types of lighting, and lighting outdoors and indoors should be considered.

Lighting can be broken down into three principles: light quantity, light quality, and lighting uses. To be able to analyze and understand lighting in the home, these principles and terms should be noted. Light quantity is broken down into illumination and lumen. Illumination is when light is distributed on a horizontal surface; this is the main purpose of all lighting, to create illumination. Lumen is the light given off that is measured from a lamp. Light quality, refers to color temperature and glare. Color temperature, looks at the color from the light source, for example people refer to warm colors being yellow or red, and cool colors being blue or green. Color temperature is measured in Kelvin; the average color temperature for indoor general lighting varies between 2700-3600 K. Glare just refers to an intense amount of light that makes it tough for a person to see. Lighting uses refers to types of lighting, like ambient lighting, and accent lighting. Ambient lighting is the typical lighting for indoor and outdoor activities. Accent lighting tends to draw a person's attention on an object; this type of lighting can be both indoor and outdoor. Now that some terms and principles have been introduced, the main types of lighting in households can be discussed (Table 4.3).

Table 4.3 Lighting Comparison Chart

| **Lighting Type** | Efficacy (lumens/watt) | Lifetime (hours) | Color Rendition Index (CRI) | Color Temperature (K) | Application |
|---|---|---|---|---|---|
| ***Incandescent*** | | | | | |
| Standard "A" bulb | 10–17 | 750–2500 | 98–100 (excellent) | 2700–2800 (warm) | Indoors/outdoors |
| Tungsten | 12–22 | 2000–4000 | 98–100 | 2900–3200 | Indoors/outdoors |

| | | | | | |
|---|---|---|---|---|---|
| halogen | | | (excellent) | (warm to neutral) | |
| Reflector | 12–19 | 2000–3000 | 98–100 (excellent) | 2800 (warm) | Indoors/outdoors |
| ***Fluorescent*** | | | | | |
| Straight tube | 30–110 | 7000–24,000 | 50–90 (fair to good) | 2700–6500 (warm to cold) | Indoors/outdoors |
| Compact fluorescent lamp (CFL) | 50–70 | 10,000 | 65–88 (good) | 2700–6500 (warm to cold) | Indoors/outdoors |
| Circline | 40–50 | 12,000 | | | Indoors |
| **High-Intensity Discharge** | | | | | |
| Mercury vapor | 25–60 | 16,000–24,000 | 50 (poor to fair) | 3200–7000 (warm to cold) | Outdoors |
| Metal halide | 70–115 | 5000–20,000 | 70 (fair) | 3700 (cold) | Indoors/outdoors |
| High-pressure sodium | 50–140 | 16,000–24,000 | 25 (poor) | 2100 (warm) | Outdoors |
| Low-Pressure Sodium | 60–150 | 12,000–18,000 | -44 (very poor) | | Outdoors |

http://www.eere.energy.gov/consumer/your_home/lighting_daylighting/index.cfm/mytopic=12030

There is a wide variety of options when deciding on lighting, but for the most part there are five main types of lighting: fluorescent, high density discharge, incandescent, low pressure sodium, and outdoor solar. A normal incandescent light bulb is only considered to be economic, if the average time it is used is less than 15 minutes at a time and it is not used more than 1.5 hours a day (EERE). Compact Fluorescent lightbulbs (CFL) combine the energy efficiency of fluorescent lighting with incandescent fixtures (EERE). They are recommended in areas where lights are used for a substantial amount of time. Another plus to CFL bulbs are since they do not need to be changed nearly as often as regular light bulbs they are ideal for objects such as fans with lights or tough spots to reach. Whereas incandescent bulbs typically last 750-1000 hours, CFLs are rated to last 10,000 hours. So while the initial cost of the CFL is higher (~$2-4) compared to an incandescent bulb (~$0.50), the lifetime cost of the CFL is much lower due to energy saving and longevity. High Density Discharge lighting (HID) is known to produce the highest value and longest life of any light source. They can save 75-90% of energy when they replace incandescent lamps (ES, 2006). This type of lighting is mostly used in arenas and outdoors lighting because of the strong light projected, and the lamps stay on for hours at a time. Incandescent lighting is the most common in households. This type of lighting has delivered about 85% of household illumination (ES, 2006). These types of lamps, typically give off a warm light and good color, but they are inefficient because they tend to have short life spans, and end up costing more to operate. Low-pressure sodium lamps are energy efficient outdoor lighting lamps. This type of lighting is typical on highways, and security lighting. Low-pressure sodium lighting requires a warming up period and has to cool before they can be restarted (EERE, 2006). Outdoor solar lighting has become popular with people becoming more interested in landscaping their yards. This type of lighting has become popular due to ease of installation and freedom from maintenance. Solar lighting uses solar cells that convert sunlight into electricity. Batteries then store the electricity and use that electric at night. One thing that should be considered with outdoor lighting is geographic location, which will have an effect on the amount of electricity that will be available. These are the five types of lighting available and most commonly used in households.

For indoor lighting the most commonly used are fluorescent and compact fluorescent lights. These tend to provide the highest quality and most efficient lighting and, have been found to be four times more energy efficient than incandescent bulbs (Orange & Rockland, 2006). With the design of most houses, certain fixtures are recommended for the best light availability. Fluorescent fixtures are recommended for ceiling and wall fixtures that will be on for more than two hours a day (EERE, 2006). Compact fluorescent fixtures are recommended for portable lights that are normally operated more than two hours a day. For indoor lighting, minimizing the use of lights and using CFL's wherever applicable is recommended. Aesthetics, security, and utility are three types of methods that can be used to have efficient lighting. Aesthetics is illumination of the exterior of the house, security referring to the grounds near the house, and utility illuminating the porch and driveway. These are the main areas that are typically lit outside a home.

When trying to improve the household to be more energy efficient with lighting, there are certain steps in general that can be taken to help decrease the electric bill. Lighting controls can be applied, such as dimmers, motion sensors, and timers. Timers help with the amount of time that light fixtures are used, and dimmers help maximize energy efficiency by using only the required amount of energy during appropriate times of use. Simple light maintenance such as cleaning or dusting fixtures can help improve efficiency. Taking advantage of day lighting, such as windows and skylights, can help light the home and greatly reduce the need for lighting products. For best results when improving household lighting, use a comparison chart like Table 4.3 to help you identify what type of lighting would be best in certain situations.

The availability of energy-efficient products on the market can help consumers save money while also lessening their impact on the environment. It is important for the consumer to be aware of the lifecycle cost of the appliances and lighting products they buy. Energy-efficient technologies can cost more initially but over the life of their use, they can save enough money and energy to offset the initial increase (ACEEE, 2006). Buying these products can cut utility bills down considerably, but behavior and lifestyle changes can possibly have even a greater impact (ES, 2006). With dishwashers and clothes washers, it is the most efficient practice to use the appliance when cleaning a full load. This can help to lower the amount of loads that are done overall, and maximize the energy and water use when the washing appliance is actually used. Using cold water to wash clothes is a good way to reduce energy consumption, saving hot water to be used on only deeply soiled clothes. Air-drying clothes whenever time is available is a good practice; this saves a lot of energy and prolongs the life and use of the material (ACEEE, 2006). Unplugging appliances that are not regularly used can help to save money and energy (ES, 2006). This practice can be thought of as cumbersome and tedious, but in the long run it can save a good amount of energy that would be literally wasted (NRDC, 2006).

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# CHAPTER 5

# THERMAL SHELL AND LIFESTYLE

Tim Carney
Casey Fitzpatrick
Emily Larson

Maintaining desirable temperature within a home demands large amounts of energy. With increasing energy prices it is in the best interest of homeowners to limit their energy use. By properly insulating a home the need for heating and air conditioning is reduced considerably.

## Insulation

Due to the fact that heating and cooling of homes is responsible for a large portion of total energy consumption worldwide, the building structure efficiency – or thermal shell – is critical. Insulation is the critical building material for maintaining an efficient thermal shell. A well insulated building limits the amount of heat transferred into or out of the building. In warmer temperatures, less heat can be transferred into the building. In cooler temperatures, less heat is able to escape the building. The ability to limit heat transfer results in an increased heating and cooling efficiency, which in turn reduces energy expenses. The Department of Energy supplies energy efficiency tips for homebuilders on its website.

Insulation is divided into two categories, cavity and continuous insulation. Cavity refers to insulation that is installed into the cavities between wood studs or metal framing. The structures that make up the framing of the building act as a thermal bridge, which allows the transfer of heat (Department of Energy. "Energy Building Codes Program"). Continuous insulation is applied over the structural frame as not to be interrupted by thermal bridges.

Cavity insulation is the most commonly used form of insulation in residential homes. It comes in many forms and ratings of thermal capability, and is derived from several different materials. Home insulation is usually made of cellulose, fiberglass, or rock wool (Department of Energy. "Energy Building Codes Program").

Insulation should be strategically placed through a home to maximize thermal efficiency. All living spaces of a home being heated or cooled should be well insulated. Generally an attic should have insulation installed on the floor, and wall cavities that divide heated from unheated spaces. If a basement is being heated, homeowners should insulate the ceiling and concrete walls of the basement (Graser et al., 2003).

When choosing the correct insulation, there are several factors to consider. Regional climate dictates the amount of energy used to maintain comfortable temperatures in a home. Therefore insulation needs for a home in cooler climates may require a considerably larger amount of insulation than a home in warmer temperatures. The return on investment for a properly insulated home also varies with the type of home and climate in which it is found.

A homeowner can choose insulation based on a rating system. Insulation is rated on its ability to reduce heat flow. The insulation rating system is based on a set of R-values. The higher an R-value the more effective the insulation will be at reducing heat flow (Graser et al., 2003). When purchasing insulation, homeowners can easily identify an insulations R-value on the packaging. The various materials used in insulation vary on thickness required to reach a certain R-value.

Insulation derived form cellulose materials have an R-value range of 3.5–3.7 per inch. Fiberglass batt insulation, which is tightly compact, has an R-value range of 3.0–3.8 per inch of insulation. Loosely filled fiberglass insulation or blanket insulation has a lower R-value range of approximately 2.2–3.0 per inch. Rock wool insulation has an R-value of 2.7–3.0 per inch (Graser et al., 2003).

Cellulose-based insulations are made of ground recycled paper and other wood products. This type of insulation is typically blown onto the floor of an attic. The ground paper and wood is treated to resist fire, fungal, and mold growth. Fiberglass insulation is derived from strands of molten glass (Graser et al., 2003) and is most commonly found between wood joists of a house’s frame structure. Rock wool is made from molten rock. It is fungal and water-resistant. It is available in blankets or batts (Graser et al., 2003).

Rigid board insulation is used to add thermal capacity to a home (Energy Efficient Rehab Advisor) made of a variety of components compressed into a board. It can be installed around the foundation of a home to insulate a basement, and can also be placed under the siding of an exterior wall to increase the ability of the home to reduce heat flow. Often it is recommended to combine rigid board and cavity insulations to reach desired R-values and maximize resistance of flow. It is available in a variety of thickness and as a result typically has an R-value range of 4 – 8 per inch (Energy Efficient Rehab Advisor).

**Windows and Doors**

Another key factor in the efficient use of home energy is the type of windows, doors and skylights that are used. When properly placed, these portals can allow for additional sunlight to insulate in colder climates or block it in warmer climates. Sunlight can also be a factor in the longevity of household possessions, and certain materials can block sunlight and prevent it from destroying such possessions. The materials used in windows and doors are also critical to an efficient use of home energy, as windows and doors are the primary sources of air leaks in the home (Energy Star. "Anatomy of an Energy Efficient Window"). Proper sealing can reduce the flow of air into the home, and thus reduce the amount of money spent on unnecessary heating and cooling used to balance indoor temperatures.

It was previously thought that the number of panes measured the energy efficiency of a window, but recent technologies have been proven to be more effective regardless of the number of panes. Energy Star's website (http://www.Energy Star.gov) claims that specialized framing materials, coatings and window designs can lead to an even more effective use of energy than having more than two panes per window (Energy Star. "Anatomy of an Energy Efficient Window"). Several of these designs are climate-specific, meaning that certain materials should be used in a particular climate to balance out side effects of particular weather patterns such as cold weather or rain.

There are two key measures of a window's energy efficiency: the U-Factor and the Solar Heat Gain Coefficient (SHGC). The U-Factor measures insulation. Windows with lower U-Factors are better at insulating. The SHGC is a numerical representation of how much heat is blocked by the windows. It is measured on a scale of 0 to 1, with lower values blocking the most heat and thus being most beneficial in warm climates[8].

The most critical part of a window in maintaining energy efficiency is the actual framing. It is here that air leaks are most likely to occur, leading to either increased heating or cooling to balance out the indoor ambient temperature. Properly sealed window frames are imperative to prevent not only air leaks, but also the accumulation of condensation, the latter of which is least likely to occur if thermally broken aluminum frames are used in warmer climates (Energy Star. "Anatomy of an Energy Efficient Window").

Another important factor in the energy efficiency of a window is the glazings, or coatings, that are applied to the surface of the windows. These coatings are also climate-dependent, trapping as much solar heat as possible in colder climates and blocking as much as possible in warmer ones. Energy Star describes these coatings as being Low-E, or low emittance (Energy Star. "Anatomy of an Energy Efficient Window").

Further technologies designed to maximize energy efficiency in windows include gas fills, edge spacers and window stripping. Certain windows have gases like krypton and argon between the panes, which allow for more insulation. These gases are nontoxic and transparent. Energy Star suggests that argon be used in windows with ½-inch spacing and krypton with ¾-inch spacing (Energy Star. "Anatomy of an Energy Efficient Window").

These technologies are useful for the initial design of the window, but there is always a possibility that windows might be installed improperly. If a homeowner suspects that a draft might be occurring, he or she should check using a flame of a candle or lighter. Hold the flame near the perimeter of a door or window when outside conditions are windy. If the flame bends horizontally or goes out, there is a leak. Re-caulking the window can occasionally assist with preventing air from infiltrating into the house; however, improper installation is usually the culprit with air leaks and reinstalling the window is usually the only way to correct the problem (The Efficient Windows Collaboration: FAQ).

Several of the technologies mentioned earlier regarding windows can also be applied to doors, such as low-emittance coatings, gas insulation and several layers of glass. Like windows, doors can be a source of air leaks and other factors that affect indoor temperature. Newer doors are assumed to be more energy efficient than older ones, and swinging doors are more energy-efficient than sliding ones[10]. When installing a new door, homeowners should make an effort to properly seal the frame with caulking material[10]. Also of note is that weather-stripping surrounding the doors weakens with time and eventually loses its capacity to block air leaks (Department of Energy. "EERE Consumer's Guide: Exterior Door Selection and Installation").

**Sealing**

Windows and doors are not the only elements of a home that need proper sealing to prevent air leaks and drafts. Ducts, as well as holes in attics, crawlspaces and other such "hidden" areas of a home, are all primary sources of undesired air leaks which could easily be prevented with proper sealing. In fact, about 20% of the air moving through ducts is lost due to air leaks. One point to consider is that proper ventilation from the outside is necessary to maintain a healthy indoor environment, so not all air leaks are detrimental (Energy Star. "Air Seal and Insulate with ENERGY STAR Home Sealing").

Materials such as caulk, spray foam and weather stripping can be used to seal openings and prevent future air leaks from combustion appliances (furnaces, water heaters, dryers). Energy Star recommends hiring a professional to ensure that these appliances are venting properly after their attached ducts are (re)sealed. Ducts may be harder to seal, since many are located in hard-to-reach areas. Those located in more-accessible areas such as crawlspaces or attics can be sealed with duct sealant (Energy Star. "Air Seal and Insulate with ENERGY STAR Home Sealing").

**Conclusion**

As our population grows, so will our energy consumption. This is a critical issue considering Americans use more energy than any other country in the world. Many new technologies are proving to be beneficial in cutting back the use of energy, especially in the home. If these technologies are widely adopted in homes across the country, homeowners can do their part to save energy, and are also helping themselves financially. Taking the time to ensure efficiency of windows, doors, ducts and thermal shell structuring will prove beneficial when less is spent on heating and cooling bills. Hopefully there will be a shift towards a more energy-efficient and sustainable future as more of these technologies and practices are applied.

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# CHAPTER 6

# SITING AND LANDSCAPING

Jackie Carroll
Matt McCloskey
Angela Pacelli

**Introduction**

The management of one's home energy audit goes beyond one's internal living space and the materials that are involved. An often-overlooked aspect of energy management is the involvement of landscaping and siting. Landscaping and siting do not only provide aesthetic benefits, but can help one save greatly on energy bills.

In order to understand how home landscapes affect energy costs and uses, one must first develop a basic understanding of what siting and landscaping are. Landscaping is the practice of modifying the outdoor environment for the sake of meeting human needs (Greenacres, 2006). Terrains, foliage, human-created structures [buildings, statues, fences, etc.] are all elements of landscaping. Siting is selection of a location for a facility and the facility's placement in regard to the chosen lot's form. Siting can be broken into two categories: lot siting and home siting. Lot siting involves the surrounding neighborhood and the details of the building location. Home siting is how one's house corresponds specifically to the lot on which it is located in terms of terrain and other environmental factors. Both of these categories of siting affect what building materials are to be used and how these building materials are to be incorporated into one's home (Matching Your Home, 2006).

If one were to address energy management in regard to landscaping and siting, the primary concerns would be location, orientation, summer and winter vegetation, roofing, and lawn care. The location, orientation, and vegetation selected may significantly alter the use of heating and cooling in one's home. This is important, considering that climate control within one's home is the primary contributor to the average American's energy uses and costs. Roofing can be considered part of landscaping if one were to implement green roofing as part of his or her home; green roofing also affects home heating and cooling. The method in which a lawn is prepared affects whether or not fuel-consuming lawn equipment, such as mowers, are needed.

**Current State of the Issue**

Currently, while some homeowners do have various elements of energy-saving landscaping, very few have all of the possible aspects that could be implemented to save energy and money. According to Carrie Engel of Valley View Farms Garden Center and Nursery in Cockeysville, Maryland, there is increased interest in landscaping techniques that will lower people's energy bills. There has been a fluctuation over the years that have coincided with events in the energy market. During the energy crisis of the 1970s, there was a large demand for these energy-saving methods, at least in the Baltimore area. Interest waned during the 1980s, but is now beginning to rise again. BGE has set up a program with Valley View Farms that informs people how they can save money by using certain landscaping techniques (Engel, pers. comm.). A survey of consumers in the Baltimore area showed that although some were not initially interested in investing in energy-saving landscaping most changed their minds once they knew just how much money they could save.

**Location and Orientation**

The site and general orientation of a house make a significant difference in energy efficiency. There are many things to consider when choosing a location for one's home. One should not choose a site that is downwind from a large hardscape area in order to avoid heat island effects. Avoiding unshaded hardscape to the north, east, and west of a home is especially important because, if present, this condition would cause heat to be reflected into the windows of the home during summer months (Meerow, 2003). Proximity to stores, schools, entertainment, and any other places to which one might frequently travel should also be considered to minimize the transportation needed to reach these services. Approximately 90% of Americans drive everywhere they travel locally. The average amount of time spent driving is around 87 minutes a day. For those who commute, the average is 100 minutes per day and for people with children at home, it is 104 minutes per day (Langer, 2005). The average car in the United States has a gas mileage of about 21 mpg (Plungis, 2005). Significant amounts of energy could be saved if one lived closer to their desired destinations. Proximity to public transportation would decrease energy use as well, considering that this could decrease the energy wasted by commuting long distances in individual cars.

For maximum energy efficiency, homes should be oriented to have the long axis running east-west, which maximizes solar heating in the winter and minimizes it in the summer (Figure 6.1). With this orientation, the smaller walls of the house are hit with the most direct sun instead of the larger walls, which reduces the total heat load. In homes with this type of orientation, \$75.00 to \$100.00 is saved in cooling costs alone each year (Meerow, 2003). During the winter, the sun is lower in the sky and the long wall, which faces South, gets the heating benefits of solar radiation. The long axis of the home can be off by up to 10° in either direction from the east-west line to compensate for the prevailing wind direction or any situations specific to the site, and still receive the benefits of proper orientation (Meerow, 2003).

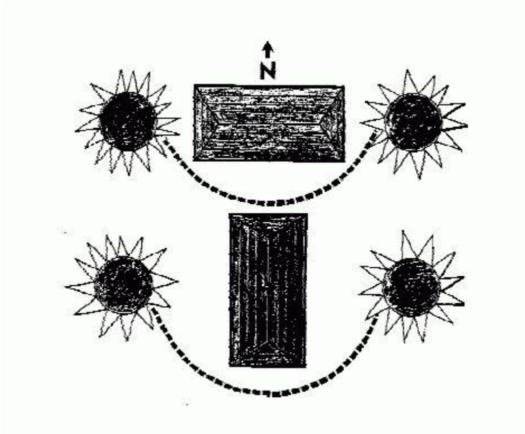


Figure 6.1. East-west orientation of the home. With the long axis built as above, the smaller sides of the home receive less hot summer sun than the long walls would if oriented differently.

**Landscaping**

*Summer Landscaping*

With proper landscaping, summer air-conditioning costs can be reduced by up to 50%. Shading is the simplest, most effective way to cool your home and reduce energy consumption. Shading from trees can reduce nearby air temperatures by up to 9°F. In the temperate climate, deciduous trees should be used to block sun from the home because they have a thick canopy in the summer but leaves fall in the winter and let the warming sunlight reach the home (Figure 6.2).

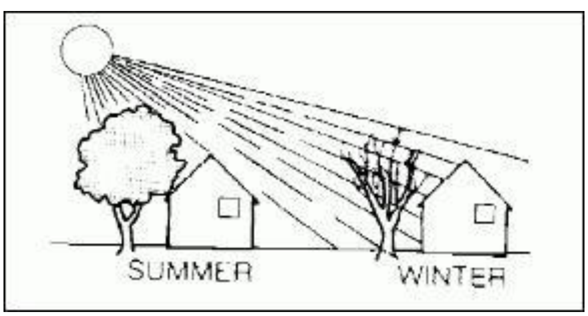


Figure 6.2. Deciduous trees used for shading and winter sun warming.

Computer simulations have shown that planting 3 trees, costing approximately $100.00 each, around an unshaded and well-insulated home reduced annual cooling costs by 31% or approximately 583 kWh (Engel, pers. comm.; McPherson, 1994). These trees should be placed on the southern and western sides of the home. Choosing trees that are native, fast growing, and tall enough to block the home successfully is the best option. The size of one's yard, as well as the height of the mature tree affect the distance at which a new shade tree should be planted. Planting medium-sized trees about 15 to 20 feet from the house and 35 feet apart is most effective. Large trees work well for two-story houses, but must be planted at least 35 feet from the home (Eartheasy, 2006). The best trees to plant are adapted to the area, resistant to diseases in that area, and long-lived (Evans, 2006). Native, well-established trees do not require irrigation or fertilization, which also saves energy. Shading with trees may be a good alternative to expensive retrofitting of an older home with poor insulation. These trees can also improve the appearance of the yard.

Unfortunately, most large growing trees take at least 20 years to reach full height. Fast growing, slightly less effective trees can be planted amongst the trees used in the long-term plan to provide benefits while the permanent trees are growing. These temporary trees can then be cut down once the other trees have matured. However, one must be sure that these temporary trees do not affect the growth of the permanent vegetation (Meerow, 2003). Existing trees should be incorporated into the design whenever possible to receive benefits immediately. Shrubs may be used to block the sun from lower portions of the walls. Small-leafed shrubs with open branches that will not block cooling winds in the fall or spring are the best to use. Vines can also provide shading and usually grow much quicker than trees. They can be placed on a trellis that is 6 inches from the wall on the hottest side of the house to block the sun as well as provide a buffer zone of cool air (Natural Cooling, 2006).

The siting of trees must be well planned in order to maximize benefits while minimizing potential problems. One should be sure that the roots of shrubs and trees will not conflict with underground wires, sewer lines, building foundations, or septic tanks (Natural Cooling, 2006). Also, consider that too many trees around a home may lead to problems with moisture, such as mildew and mold. Large trees too close to the home may damage the building with falling limbs and can often clog rain gutters. Solar panels on the roof should not be blocked with the shade of surrounding trees to ensure that the efficiency of the system is kept at its peak (Chiras, 2004).

Shading an air-conditioning unit can increase its efficiency up to 10%. Trees easily shade the unit during peak sunlight hours and shrubs can block the sun during the early morning and late afternoon. One must be careful not to block air flow, which would keep warm discharge air near the unit and cause the intake air temperature to increase, thereby minimizing the efficiency of the unit (Meerow, 2003).

Trees can also cool surrounding air through evapotranspiration and can be used to channel air movement away from or towards the house. Evaporative cooling can lower air temperatures around the vegetation by as much as 9°F. The more vegetation present, the more significant the cooling effects. If summer winds are directed across vegetation, their ability to cool increases. In a home that does not use air-conditioning, trees and shrubs should be placed to direct cooling winds toward the windows (Figure

6.3).  In this case, trees having low branches must be avoided on the southeastern and southwestern sides of the house so winds are not blocked (Meerow, 2003).

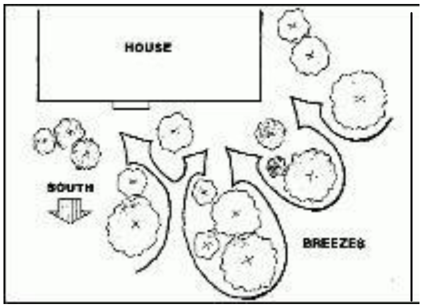


Figure 6.3.  Trees and shrubs used to direct breezes toward the home in a passively cooled home.

In homes cooled by air conditioning, wind movement during summer months actually increases energy costs by bringing in more hot humid air through cracks in the home.  In this case, shrubs and trees must be positioned around the house, diverting winds away from the building (Meerow, 2003).

*Winter Landscaping*

A building's shell is the best source for retaining heat in the wintertime, but regardless of how efficient it is, it will always lose some heat to the cold winter environment.  The combination of the escaping heat from a building's shell with the cold winter winds that penetrate a home; account for approximately 25-40% of winter heating requirements (Pedersen, 2003).  An additional technique that can be used to slow this heat loss in the winter is using proper winter landscaping around your home.  The main focus in creating an energy efficient landscape in the winter is to block cold winds that could potentially cause drafts in the home.  The most effective way of doing this is by planting windbreaks on the northwest side of your home.  The location of these windbreaks is crucial as to not block beneficial summer breezes that blow from the south.  The most effective windbreak should be constructed of a mix of tall deciduous trees and low dense shrubs.  This mix of greenery should be long enough to block your entire home as well as tall enough to lift winds over the home.  If properly landscaped, a windbreak can reduce winter heating bills by approximately one third.  There are also many other beneficial winter landscaping techniques that will lower home energy bills.  Any shrubs that are planted on the windward side of a home will stop blowing snow from accumulating against the walls of a home.  In addition, foundation shrubs that are planted about one foot around the outside perimeter of the home can be one of the most beneficial landscaping techniques to reduce winter heating costs.  These shrubs not only block unwanted winter winds but also create a "dead air" space that acts as an extra layer of insulation around the home.  Climbing vines on a trellis may also create the desired "dead air" space.  A tall trellis system of vines also affectively absorbs the suns heat, and through conduction, allows the heat energy to warm the layer of air against the home.

**Green Roofing**

Green roofs [*also known as:* garden roofs, ecoroofs] are specialized roofs that support the growth of vegetation due to the use of specific roofing materials and can be thought of as an extension built on top of traditional roofs. Despite the fact that technology has allowed for these types of roofs to be supported in relatively any type of climate, these roofs are rare in the United States (Using Garden Roof Systems, 2005). Green roofs are mostly found in European nations, notably Germany, Austria, Switzerland, and France (About Green Roofs, 2005). These roofs are both aesthetically pleasing and energy efficient due to their design (Penn State, 2006).

Green roofs consist of five components: 1) waterproofing membrane, 2) drainage layer, 3) filter membrane, 4) growing medium, and 5) vegetation. These layers are placed in a particular order so that the roofs operate effectively (Figure 6.4).

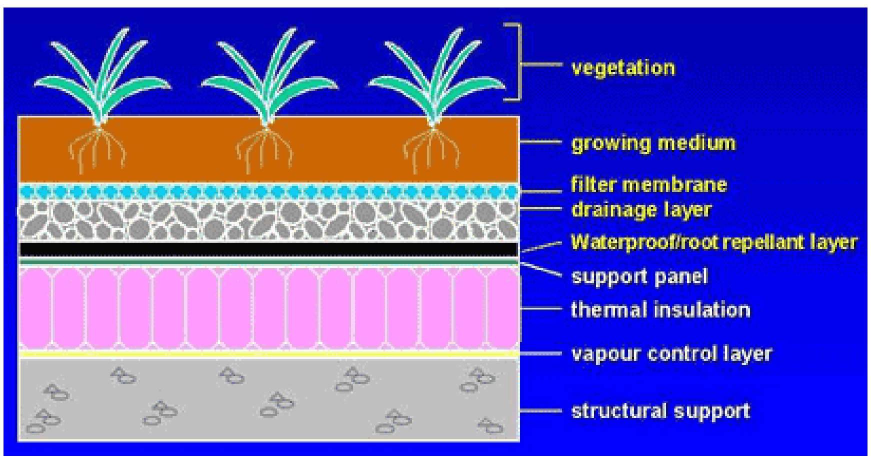


Figure 6.4. The layers of a general green roof and how they are arranged.

1) A *waterproofing membrane* prevents any water seepage and root penetration into a building. This layer generally is made of polyvinyl chloride (PVC), thermoplastic polyolefin (TPO), or high-density polypropylene.
2) The *drainage layer* prevents excessive water from collecting into the growing medium. This layer may be designed to retain some water so that the roofing vegetation is adequately watered. The drainage layer may be made of a porous polymer or polymer foam.

3) The *filter membrane* prevents small particles from the growing medium from clogging the drainage layer. This layer is generally made of fabric.

4) The *growing medium* is the material in which the roofing plants are embedded. Its composition depends largely on the type of vegetation being used. Sometimes, artificial mediums are used instead of conventional mediums, such as soil and gravel, considering that conventional mediums may be too heavy for building supports to maintain.

5) The *vegetation* is the plantings used in the roofing. Their selection depends largely on the climate in which the roof is located. (Liu, 2004)

Green roofs come in two varieties: extensive and intensive. Extensive green roofs contain low-lying plants and a growth medium of 2 to 6 inches deep and are means of erosion resistance, transpiration, and water retention (Green Roof Plants, 2005). Little maintenance is required once roofs have been installed and are accessed only when maintenance is performed (Using Garden Roof Systems, 2005). Intensive roofs are intended to emulate a natural landscape and may involve trees. The growth medium is generally several feet deep (Green Roof Plants, 2005). These roofs require extensive irrigation and gardening, but allow regular access to residents for the sake of enjoyment (Using Garden Roof Systems, 2005). One must consider that some homes may not be able to support the weight that an intensive green roof may bear on a structure.

Green roofing installation is more costly than the installation of a traditional roof. Roughly, extensive green roofs cost about an average of $8.00 per square foot (EPA: Heat Island, 2006), but possibly $10.00 to $24.00 (About Green Roofs, 2005). A traditional roof runs a cost of $1.50 per square foot (EPA: Heat Island, 2006). The high cost of green roof installation is due to the amount of materials needed and the rarity of contractors capable to install these roofs; the price is anticipated to decrease as more contractors become familiar with green roofing technology (EPA: Heat Island, 2006). Despite installation costs, green roofs can help one save money. Green roofs have been known to extend the life of a roof by preventing harmful ultraviolet radiation and temperature fluctuations from harming the roof's substrate (EPA: Heat Island, 2006). Some places also provide grants to homeowners and small commercial building owners to install green roofs, which obviously help offset installation costs; Chicago has been offering twenty $5,000.00 grants in 2006 for this purpose (Save Heating, Cooling Costs 2006).

Data published concerning green roofs is not widely available (Penn State, 2006), yet the information available about the benefits of green roofing is promising. Green roofs have been known to improve the thermal insulation of a building (Thompson, 2000). Some field experiments have determined that a 6-inch extensive green roof has 26% less heat escaping than a traditional roof (About Green Roofs, 2005). Green roofs also absorb less heat than a traditional roof, which reduces the "heat island" effect found in urban areas (Thompson, 2000). Studies have shown that green roof surfaces may reduce roof temperatures by 39°F (22°C) (Sonne, 2006). Quite possibly, a one-story house that has a green roof with 3.9 inches of growing medium may experience a 25% decrease in its cooling needs during the summer (About Green Roofs, 2005).

**Lawn Care**

An area of landscaping that has one of the highest environmental impacts is the conventional lawn. Conventional lawn care requires heavy watering, fertilizing, application of herbicides and pesticides, and mowing in order to keep its unnatural green appearance. Each year conventional lawn care costs Americans thirty billion dollars and $400.00 to $700.00 per acre to maintain (Natural Landscaping, 2006). Each riding lawn mower used to maintain their conventional lawns puts as much pollution into the air each year as 43 new cars driving 12,000 miles each, collectively burning 800 million gallons of fuel each year (Natural Landscaping, 2006). One study also found that on the east coast an estimated 30% of all water used was used for the watering of lawns (Natural Landscaping, 2006).

There are many alternatives to the conventional American lawn that can be environmentally friendly as well as minimizing the amount of energy inputs needed for maintenance. These natural types of lawns use mainly native species of plants and try to minimize native vegetation disruption. Since the natural vegetation has been there for many seasons it is already adapted to the local climate and weather conditions. This means that additional watering or supplemental herbicides and pesticides are not needed since these native plants can basically care for themselves. If extra watering is needed to sustain some species of plants, recycled or collected rainwater is the best alternative to wasting energy that would normally be used when pumping well water. These natural lawns are best kept untouched, so weekly mowing is not needed, which saves annual fuel and energy consumption. The natural lawn seems like a very good idea for new homes and businesses to use, but it may be hard for already existing homes to make this transition from a conventional to a natural lawn. One of the easiest things to do to make this slow transition is to minimize the amount of pesticides and herbicides that one applies on the lawn. If fertilizer is still needed, grass clippings and compost can be used in place of chemical fertilizers. One can also start planting natural species of plants in areas of your yard and avoid disturbing it as you would a conventional lawn. During this transition your lawn will require less time and energy to maintain, as well as have improved hydrologic and environmental features.

**Conclusion**

Greener landscaping and siting practices are relatively simple, yet effective measures of maintaining one's home energy audit. Many of these practices can be implemented by both old and new homes.

When one is planning a new home, be mindful of its location and orientation. Be certain not to locate new homes downwind of hardscape surfaces and build near the places where one will frequently travel. Try to build near places where public transport is accessible, if possible. In temperate climates, build the smaller walls of your house so that they will face the most ambient areas of sunshine; practicing this reduces the needs of excessive indoor cooling.

For homes that are already in existence, one can still practice greener landscaping techniques. Placing proper vegetation on one's lot is an easy way to manage energy use. Use deciduous trees for blocking summer solar heat and allowing winter solar heat to reach your home (EERE Consumer's Guide, 2005). Be mindful that deciduous tree root systems grow relatively quickly, so carefully plan where these trees are planted; tree plantings too close to one's home may result in structure damage due to root growth. Hedges can buffer the heat reflected off of driveways and patios (EERE Consumer's Guide, 2005). Implement old trees into the landscaping design as much as possible.

Green roofs can be placed on old and new houses. Prior to installing these, make certain that houses are structurally sound in order to bear the extra load placed by these roofs and that the pitch of the roof is not too steep. Green roofs may wreak damage on weakly structured homes, whereas green roofs may wash off of extremely steep roofs. Proper green roof installation may provide cooling effects in the summer months and thermal insulation for your home in the winter.

Do not remove native vegetation from lawns. Lawns composed of native vegetation require little or no pesticides, fertilizer, or water. If fertilizers are needed, allow grass clippings to remain on the lawn; clippings act as a natural fertilizer. If water is required, collect water in rain barrels; well pumps require energy.

Keep in mind that a home spends about 42% of its energy bills on maintaining its inner climate (energy efficiency). Proper, greener landscaping practices allow for a reduction of heating and cooling within a home. By adjusting one's landscaping habits, a home can save about 25% on its energy bills (Natural Cooling), or about $1,500.00 annually (energy efficiency).

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# CHAPTER 7

# POLICY AND TRENDS

Marguerite Harden
Megan McCormick
Emma Noonan

## Introduction

Governmental policies have the potential to shift and lower demands on home energy use. The rise in population and per-capita energy consumption, coupled with concerns of dependence on fossil fuels, pollution, and greenhouse gas emissions rising makes it increasingly important to decrease energy usage and to implement renewable alternatives. However, most renewable alternatives, technology, and appliances designed to conserve and reduce energy are still in the relatively early stages of technological development and can be initially more costly. Even though alternative energy sources and new technology have lower operating costs because of the reduced energy use, financial incentives for the manufacture, purchase, and installation of alternatives are critical to meeting the population's long-term energy needs in a sustainable way. To push the development and adaptation of these technologies, both federal and state governments have offered tax incentives for the manufacture, installation, and use of renewable energy systems as the main energy conservation policy (SERC, 2006). Other policies concerning energy efficiency may include zoning laws and regulating limits of energy use, both of which are difficult and costly to enforce.

## Energy Policy and Conservation Act of 1975

The Energy Policy and Conservation Act (EPCA), signed by President Ford in 1975, became the first piece of legislation for energy conservation and the basis for future conservation activities (Regens, 1979). The need for energy conservation legislation became apparent after the 1973-1974 oil embargo, which created economic crises throughout the U.S.; the EPCA is often considered a reaction to this oil crisis (EIA, 2002). The EPCA instituted three primary programs (EIA, 2002). The Strategic Petroleum Reserve is one of these programs, which established a reserve of up to one billion barrels of petroleum. The United States also became involved in the International Energy Agency under the EPCA. Numerous efforts were made under the EPCA to reduce vulnerability due to oil dependence through several energy efficiency and conservation programs. For example, the EPCA first established the addition of labels on certain products with information of the products' energy efficiency. This labeling has more recently been instituted by the ENERGY STAR program, but the EPCA provided the first basis for this type of energy conservation measure.

**Maryland Office of Home Energy Assistance Programs**

The Maryland Energy Assistance Program (MEAP) and the Electric Universal Service Program (EUSP) are part of a program package to help low-income Maryland residents with home heating costs. These programs were created by the Office of Home Energy Programs (OHEP), and aim to "promote energy conservation, customer financial responsibility and energy independence" (OHEP, 2006). There is also limited help available to replace inefficient or broken furnaces. The EUSP is administered by the Department of Human Resources and aides in paying electric bills in low-income households. There are three stated ways in which eligible electric customers may receive help: help to pay current electric bills, help to pay past due electric bills, and help with energy efficiency measures to reduce future electric bills (DHP, 2006).

Another program is the Utility Service Protection Program (USPP). This program allows customers to enter into a year-round even monthly payment program based on the customer's average annual utility usage. This avoids dramatically higher costs of heating in colder months and evens out the costs over a year's time (DHP, 2006).

The Office of Home Energy Programs also offers a Weatherization Assistance Program (WAP) to help low income, elderly, and disabled persons better equip their homes to reduce excessive heating and cooling needs by providing home weatherization. Weatherization provided through this program include weather stripping, caulking, and plastic window covering, to improve the thermal shell of the house and reduce the amount of leakage that wastes energy (DHR). This increased efficiency comes at no cost to the family, reducing their energy bills by reducing their energy use. This program is in competition for funds with the EUSP. Whereas the EUSP may provide an incentive to use excess energy within the home, the WAP provides and incentive to take action to reduce energy use (DHP, 2006).

To qualify for any of these programs, a household must be considered low-income. The standards for being considered low-income are defined by the number of persons per household as well as maximum yearly incomes. For example, a household of two must make no more than $26,400 and a household of three must make no more than $33,200. There are other energy customers that may be automatically eligible aside from low-income households. Some of these include those who are elderly or disabled living on a limited income, those who receive food stamps, certain veterans or recipients of Social Security disability benefits, as well as others (DHP, 2006).

**Energy Star**

In 1992, the Environmental Protection Agency (EPA) developed a voluntary labeling program designed to save consumers money and protect the environment through promoting energy efficient products and practices. The program is called ENERGY STAR. The very first products that were labeled were computers and monitors. In 1995, the program expanded to include other office equipment, as well as residential heating and cooling systems. In 1996 the EPA partnered with the United States Department of Energy (DOE), and today, over forty categories of products are labeled with thousands of models. Typical households can spend up to $1,900 annually on energy bills. According to ENERGY STAR, installation of their products can reduce energy bills by 30%, or up to $600 a year (ENERGY STAR, 2006).

Some of the different categories of the labeling program are appliances (clothes washer and dishwashers, refrigerators and freezers, water coolers, and others), heating and cooling systems (central air conditioning, furnaces, different heat pumps, etc), products related to the home envelope (roofing materials, windows, and doors), home electronics, office equipment, and lighting (ENERGY STAR, 2006).

ENERGY STAR has also recently developed a label for energy efficient new homes. These homes must be 15% more energy efficient than homes built to the 2006 International Energy Conservation Code (IECC). Efficiency is achieved through a variety of features such as ENERGY STAR qualified lighting, appliances, insulation, tight ducts and construction, and efficient heating and cooling units. Along with decreasing energy use, the new ENERGY STAR homes also help to reduce air pollution and improve indoor air quality (ENERGY STAR, 2006).

An example of the kind of efficiency and savings ENERGY STAR products can produce is illustrated by the use of certain dishwashers. On the ENERGY STAR webpage (2006), a description of energy efficient dishwashers with the ENERGY STAR label can be found as well as some suggested practices that may reduce energy use, such as always running a full load. These dishwashers use 25% less energy than the federal minimum standard for energy (these standards are given by the National Appliance Energy Conservation Act). They also use much less water and there is an estimated savings of over $100 during the lifetime of the dishwasher. With the information given on the United States government's ENERGY STAR website (2006), buying these labeled products is an excellent way of helping the environment as well as saving money at a time when energy costs are rising. However, there may be some ambiguity when looking into buying ENERGY STAR appliances.

While the EPA provides ample information on the potential savings and efficiencies of certain products, an actual understanding of what constitutes the federal standards is not provided. When accessing documents that provide the standards, one will encounter technical measurements that are not easily understood. Knowledge of the way these appliances run is needed in some cases to comprehend exactly how much is being saved, as the units are often specific to the appliance (Meier, 2003).

Another criticism of ENERGY STAR is that the entire life cycle of the products is not examined. The labeling only includes efficiency and operation and leaves out what raw materials were extracted, the manufacturing and transporting of the product, and also costs of its disposal. With the life cycle factored in, the product may be worse for the environment than expected. Many also believe that standards should be of greater efficiency. Technology is indefinitely changing and many feel the standards could be more stringent considering this technology. To be an ENERGY STAR labeled computer, all that is needed is a power-saving option and it is up to the consumer to use it (Leavens). There are various other products that are labeled energy efficient if they use less after it is turned off. This does not account for appliance usage and consumer behavior. There are also products, which are major sources of energy consumption but are labeled energy efficient in comparison to other models of the same category without the label. An example is the type of refrigerator a consumer may purchase. A large refrigerator with the freezer at the top consumes a great amount of energy, but it may have the ENERGY STAR label if it uses less than other similar refrigerators. The better product to buy would be a smaller, bottom-freezer refrigerator that uses much less energy.

A rebound effect may cancel out any real energy savings if the consumer feels they can use their ENERGY STAR product more because it is deemed efficient. Other behaviors that the ENERGY STAR website mentions that may help reduce energy use include asking consumers to wash clothes using full loads in only cold water. These are good ways to save energy but the EPA does not mention that hanging clothes up to dry would be the most energy efficient. The only practices that are suggested relate to using the products, where the greatest reduction in energy use could come from no usage (Leavens, 2006).

The EPA does update their standards and on October 20, 2006 revised their computer specifications. Beginning in July of 2007, computers, monitors, workstations, and game consoles will need to meet the new revisions. Updates are necessary to keep the program useful as technology changes continuously. The ENERGY STAR label is a good way to guide consumers towards an environmentally friendly purchase, but must be used with caution. Consumers should remember the greatest way to save energy and ultimately money is by monitoring their own actions and reducing, or even eliminating, usage.

**Energy Policy Act of 2005**

The Energy Policy Act (EPACT) of 2005 replaced the Energy Policy and Conservation Act of 1975 and was signed into law by President G.W. Bush on August 8, 2005. This act focuses on economic incentives, offering consumers federal tax credits from 2006 to 2007 for purchasing energy-efficient appliance for the home. These incentives work if consumers are knowledgeable about their options because they provide the opportunity to lower energy bills, increase their indoor environmental quality, and reduce air pollution. Locally, the state of Maryland also offers many tax incentives for renewable energy options and appliances.

Tax credits are even more valuable than tax deductions because they deduct taxes by the actual amount paid for the appliance instead of only applying a percentage decrease in taxes. A homeowner can receive a maximum credit of $500 for installing energy efficient products, such as heating and cooling equipment. Additionally, credits of 30% up to $2,000 for solar water heating and $3,000 for photovoltaics will be provided for purchases of solar power equipment (SERC, 2003). Investing in renewable energies offers other incentives as well; some additional returns include an increase in real-estate value and lowered life cycle costs. Exceptions to the tax credits include solar water heating for pools or hot tubs. This exception is needed in order to reduce the likelihood of an energy rebound effect, which can occur when people install water heaters for unnecessary commodities because their renewable energies allow them to save money on other water heating needs (SERC, 2003).

The energy rebound effect may be a paradox to current thought. When increasing energy efficiency, the expected result is a decrease in demand for energy. However, the reduction in costs that results from increasing the energy efficiency in the home often has the reverse incentive to use more at the same cost (Gottron, 2001). There are direct effects in which the consumer uses more of the resource instead of taking in the cost savings, and indirect in which they use the cost savings to purchase other goods or services that use the same resources. The incorporation of the rebound effect into projected policy would help better assess the true benefits of a proposed policy (Gottron, 2001).

The Maryland Energy Administration began issuing grants in September 2006 for ground loop geothermal heat pump systems. This type of renewable energy can be used to heat and cool buildings as well as heat water. $1.5 million have been made available for grants of this type, allowing up to $1,000 per system installed. Energy tax credit incentives range from $75 to $3,000 for energy upgrades such as central air conditioners, heat pumps, water heaters, envelope improvements (windows, insulation), new homes, and fuel cells.

The EPACT 2005 directed Federal Trade Commission to make improvements on energy labeling systems (Prindle and Nadel, 2005). Some of the important provisions of the EPACT 2005 that are authorized have still yet to be funded. These include a public information campaign on saving energy, state-based appliance rebate programs and an energy efficiency resource standard pilot program. The EPACT has directed the Department of Energy to report on the demand response to the tax incentives and energy efficiency resource standards. Currently in Maryland, the interest in demand-side management has diminished due to a deregulation of energy sources through which the main distributor (BGE) sells its energy. However, continued research in demand response to tax incentives will provide insight to future amendments to the policy regarding energy pricing and other incentives.

The main policies affecting home energy use involve voluntary incentives of tax credits and rebates and lowered energy costs, promotion of a holistic approach to energy conservation in the home, zoning, funding of research and development grants, and energy pricing itself. Department of Energy (DOE) and the Environmental Protection Agency (EPA) funded one of the recent promotions for their Home Performance with Energy Star program (Auburn, 2006). The grant money was given to Maryland, Delaware, Virginia and Washington, D.C. to implement pilot programs in designated counties that provide a holistic approach to home energy efficiency and will also improve indoor and outdoor environmental quality. Included in these programs is the development and training of contractors to undertake renovation and remodeling projects in comprehensive approach to energy performance (Auburn, 2006). The EPA has also named October 4th *Change a Light, Change the World Day,* in which people are urged to pledge to change one or more incandescent light bulbs in their homes with Energy Star compact florescent bulbs (Fawell, 2006).

Improvements in the ICC's International Energy Conservation Code (IECC), which developed the Model Energy Codes for new building and additions to home, have been important in increasing compliance. These codes cover ceilings, walls, foundations, insulation, floors and foundations, as well as lighting mechanisms and power systems. The Department of Energy facilitates compliance with these codes by offering free software, such as REScheck and technological support to help residents understand the codes in their state and make the necessary changes to comply (DOE, 2006). Some changes to the IECC include redefining climate zones to represent geographic areas rather than climatic areas, reducing the amount of zones coded from 19 to 8. This is beneficial because compliance and enforcement is simplified, using political boundaries such as state and county lines to keep areas together. Any federal tax-credits are applied after the basis of the state credits has been applied. This way, the full amount can be credited to the consumer. Further, the government has implemented a scheme for net energy metering so that tax savings are not the only savings affecting the choices of consumers, but energy costs as well can be greatly reduced by installing renewable energy resources in ones own residence (World Energy Council, 2005).

Net energy metering is a type of distribution that allows customers with an eligible power generator to offset the cost of their electric usage with any energy they export to the grid. A specially programmed "net meter" is installed to keep track of the difference between electricity the given to and taken from the grid (SERC, 2006). Most of these opportunities come from wind and solar power. The EPACT states also that,

> The General Assembly finds and declares that a program to provide net energy metering for eligible customer-generators is a means to encourage private investment in renewable energy resources, stimulate in-State economic growth, enhance continued diversification of the State's energy resource mix, and reduce costs of interconnection and administration….An electric company serving an eligible customer-generator shall ensure that the meter installed for net energy

metering is capable of measuring the flow of electricity in two directions (MD Code, 2006).

**Energy Pricing**

There are two main approaches to implementing energy conservation, including the mandating of various conservation measures and increasing fuel prices (Regens, 1979). U.S. energy policies reveal a major focus on mandating and regulating energy end uses, while the possibility of rising prices on polluting energy sources has been largely ignored. Governmental policy has the ability to affect energy use by setting energy prices. Countries that have not adjusted energy prices before implementing energy efficiency programs have had disappointing results because there is no incentive for consumers to change their behavior to use energy efficient technology (World Energy Council, 2005). The raising of fixed prices or the taxation of non-renewable, polluting sources can effectively direct consumer trends toward more efficient energy use.

Many analysts believe that adequate energy pricing allows for the internalization of externalities (EIA, 1999). Externalities occur as a result of the decisions and actions of producers or consumers, which affect the common resources of all, for better or worse. According to this view, environmental costs of polluting energy sources should be accounted into the fixed price of that energy source. Failure to internalize recognized externalities may be seen as implicit governmental subsidizing of polluting energy sources. This situation is a classic case of Garret Hardin's famed, 'tragedy of the commons' which results from a conflict of interest between individuals and the common good. Some renewable energy advocates believe that this form of subsidy is the main reason why fossil fuels continue to dominate the energy market.

**Research and Development Funding**

Besides energy pricing, government policies can also affect the energy market by funding research and development (R&D) programs for energy systems. Federal investments in R&D in the energy sector have comprised about one-third of the total funds for energy R&D, while other sources of R&D funds were from private companies (Mansfield and Switzer, 1984). There are three broad categories of R&D funds, including basic research, applied research, and development (World Energy Council, 2005). Basic research funds go toward the original investigation of a sector, without regard to commercial objectives. On the other hand, applied research considers commercial objectives. Development funds involve the translation of a discovery into a commercial product or process.

The amount that R&D funding affects the energy market is difficult to discern (EIA, 1999). For instance, the results of R&D funds have a time lag, and are only measurable years after the funding was granted. Also, the results of some programs advance general knowledge, but do not actually change market demand for a particular form of consumption. Additionally, some funded R&D results conclude that the technology being studied is not a realistic possibility. The Environmental Impact Association Report (1999) also notes that some R&D funding goes more toward environmental restoration or waste management of research sites; this funding does not actually affect the future possibility of alternative energy implementation. Therefore, only a portion of R&D funds actually end up supporting viable energy markets. On the other hand, supporters of R&D note that the development of alternatives is vital for a smooth transition into a sustainable, green energy market after oil resources have diminished. Without development of alternative energy technologies, the U.S. may have to rely on importing these technologies from nations that began developing them first, which would be more costly in the future (DRI, 2006). In order to compensate for the flaws in federal R&D funds, closer monitoring and better allocation of funds should be incorporated into more strict funding policies.

Trends in R&D reflect federal priorities. Figure 7.1 compares all sectors of R&D funding, revealing that energy receives relatively little funding compared to the national defense R&D funds.

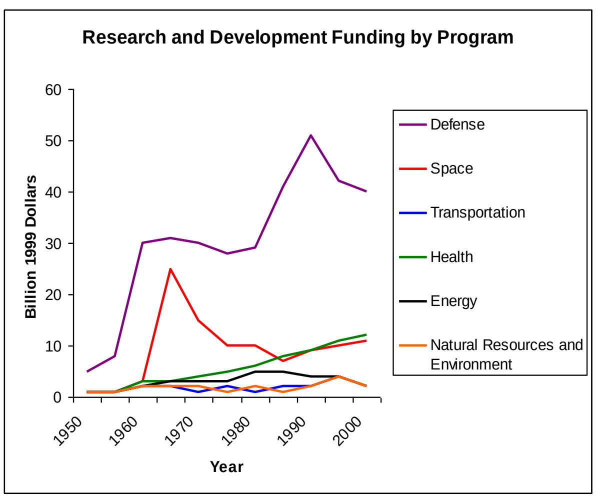


Figure 7.1: Research and Development funds of different programs (EIA, 1999).

Figure 7.2 displays the amounts of R&D funding for different energy types, (Gielecki et al., 2001). Figure 7.3 compares R&D funding within different renewable energies. Typically funds have focused mainly on solar energy technologies. Recently there has been a rise in the amount of funding for biofuel research development, which reflects Presidential energy initiatives that have focused mainly on ethanol, and relates more to the transportation sector than the home energy sector (Gielecki et al., 2001).

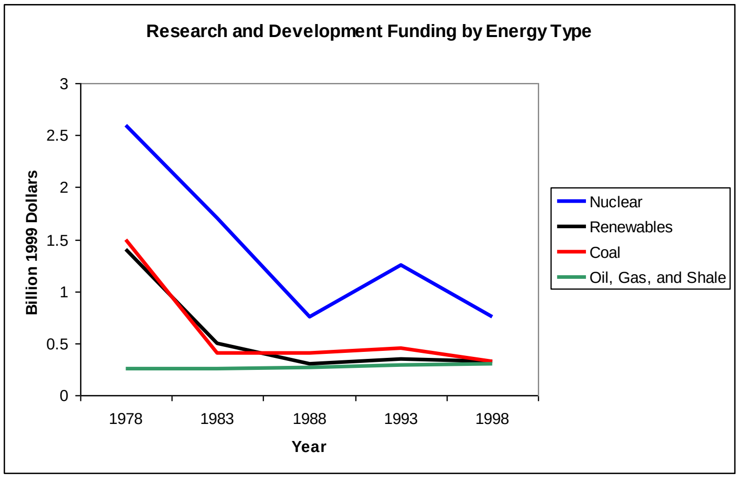


Figure 7.2: Research and Development funds of different forms of energy (EIA, 1999).

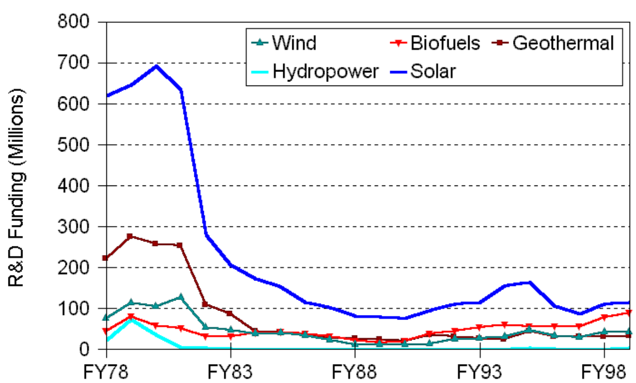


Figure 7.3: Research and Development funds of different renewable energies (Gielecki et al., 2001).

**Conclusions**

While America's energy demand is growing steadily, energy prices are also rising. More information is acquired daily concerning the dangerous environmental and health impacts of a primarily fossil fuel based energy source. Therefore, government policy must take a proactive role in reducing energy waste, or increasing energy efficiency and conservation.

Economic incentives are often the most effective and cost efficient policies that can be implemented. Through economic incentives, people are making choices that directly affect their own lives. Without incentives, it is difficult for the common consumer to recognize the significance and impacts of their choices. Therefore, economic incentives have been purported as the main conservation strategy of the EPACT 2005 and other state and local policies.

State and local policy also have the ability to play a critical role in shifting energy demands and setting energy efficiency standards for consumer products and energy sources. One way for state policies to shift energy demands is by increasing the standards of household appliances. This not only saves consumers money on their electricity bills, but it also reduces the need to construct new power plants that will be costly to the economy, environment, and power suppliers. ENERGY STAR certifications are one way in which the government encourages energy conscious buying, though it is also a weak voluntary program that could be improved. Research and Development funds are another way in which policy can improve energy use, though an assessment of R&D shows that funds are often misallocated and could be better allocated. While policies have the ability to shift energy demands, there are many improvements that could be implemented in order to meet realistic energy goals.

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# CHAPTER 8

# UTILITIES AND ECONOMICS

Brent Hood
Schuyler Pulleyn
Chris Renzo

**Introduction**

The premise of a home energy audit is to evaluate energy use in the home and identify ways to reduce energy consumption. Reducing energy consumption is advantageous for homeowners through lower energy bills, utility companies through lower production capacity and the environment through lower emissions due to lower electricity production. However, one must recognize that the premier incentive for homeowners to conserve electricity is to save money, especially now with the recent increase in electricity prices in Maryland. There are two factors responsible for the 72% increase in electricity prices in Maryland, increased costs of electricity production and deregulation of the electricity market. Price caps set in 1999 as part of this deregulation initiative expired in July of 2006 causing prices of electricity to reflect actual production costs that increased over the period the price caps were in effect. To promote energy savings, Maryland utilizes Energy Efficient Mortgages, which assists homeowners and homebuyers in increasing the efficiency of their home through upgrades and improvements. The state also encourages the establishment of onsite renewable energy production via solar panels by providing assistance with installation costs of these systems.

The economics of public utilities has been a unique situation for many years. In an economy that outlaws monopolistic companies, utilities are granted monopoly power over a defined service area (Figure 8.1), with prices regulated by the state's public service commission. Major utilities in a state include gas, electric and telecommunication lines. In the case of these services, the only way for feasible delivery is through one set of transmission lines controlled by one company, justifying monopolistic power in a specific region.

As utility rates increase, homeowners are looking for ways to reduce their usage and search for alternatives. The biggest contributor to increased electricity rates is the increasing expense of fossil fuels. Since most power plants use fossil fuels to produce electricity, the price of electricity is directly affected by a rise in fuel costs. Another important factor is that unlike petroleum, electricity cannot be stored so it must be consumed as it is produced. As a result, electricity costs are influenced by how well the generation supply can meet the inconsistent needs of the customer (Constellation).

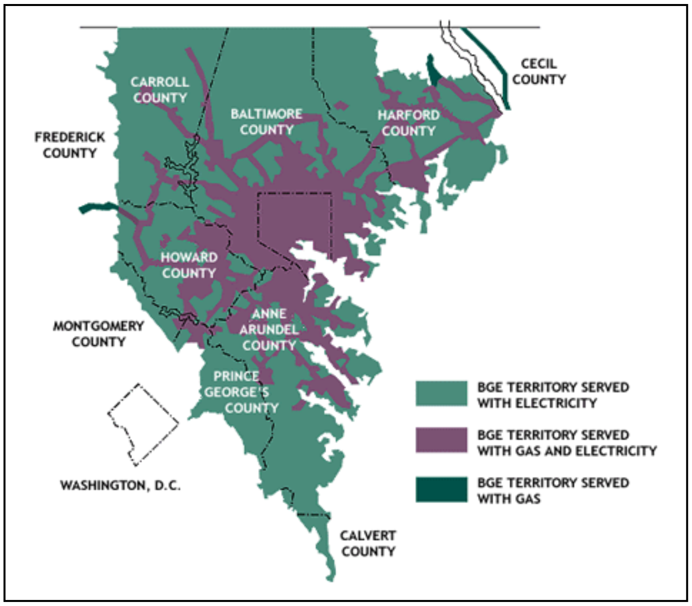


Figure 8.1  BGE Service Territory http://bge.com/portal/site/bge/menuitem.a204a222c42e8048ec8f1457025166a0/

**Deregulation**

The Electric Choice and Competition Act, passed by the Maryland General Assembly in 1999, is the initial step in electricity deregulation in Maryland.  This act called for transitioning the electricity market from a government-controlled monopoly to a partially deregulated market.  Previously a utility was granted monopoly power in its service area and prices were regulated by the public service commission in the state (Thompson et al., 2004).  Partial deregulation means that transmission and distribution are still regulated by the Maryland Public Service Commission, while production is now possible by more than one company.  This gives consumers a choice of companies from which to purchase electricity.  The prices of electricity in this market are subject to market conditions that include; supply and demand, fuel costs, as well as generation capacity and costs associated with increasing generation capacity (MPSC, 2005).  Part of this act was a 6.5% decrease in rates, for Baltimore Gas and Electric Customers, followed by a rate freeze that would expire in July 2006 (MPSC, 2006).  Upon expiration of these rate freezes for distribution companies, different companies would be able to compete to provide electricity with prices commensurate with market prices (Strategic Energy 2006).

In 2005, electricity costs accounted for a lower proportion of household income than the average between 1990 and 1999 (PPRM, 2006).  This summer those rates expired and Baltimore Gas and Electric customers were faced with a 72% increase in rates as a result of market prices.  The repercussions of such an increase prompted legislators to fight this increase.  The final result was a gradual implementation of the increase over the next several months.  Starting in July 2006 the rate increase is limited to 15%.

Starting in June 2007, customers will have ten years to pay back deferred prices. In January 2008 customers will begin to pay full market prices (MPSC, 2006).

Deregulation has led to decreased priority of more conservation oriented programs such as demand side management (Swisher and McAlpin, 2006) and peak load pricing which focuses on reducing demand during peak load times when the base load capacity is unable to meet demands of customers. Shifting demand away from peak times enables utility companies to reduce costly investments into new production capacity and transmission, thus enabling them to provide cost effective electricity to customers (Dunn, 1999).

Demand side management programs are a tool to influence patterns and levels of electricity consumption (Dunn, 1999). These state mandated programs are a method of reducing energy costs by reducing peak load demand and thus eliminating the need to increase production capacity (Swisher and McAlpin, 2006). In Maryland, Baltimore Gas and Electric promoted the use of electric heat pumps as a way to balance the high demand for electricity in the summer and lower demand in the winter (Masterson, B. 2006. personal communication).

Peak load or time of use pricing deviates from traditional average cost pricing in which prices reflect average cost of production. In peak load pricing the cost of electricity varies throughout the day reflecting higher costs of peak production. Higher costs of electricity during peak demand time would decrease demand for electricity allowing base load facilities to meet customer needs. If peak demand is reduced over a long period of time, incentives may arise to promote investment in renewable resources that have lower emissions (Swisher and McAlpin, 2006).

The potential lower costs of electricity created by more competitive electricity markets may have negative effects on the environment due to rebound effects of increased demand and production causing higher emissions (Swisher and McAlpin, 2006). Rebound effects are a negative consequence of increased energy use efficiency. Increased efficiency leads to decreased costs, which are succeeded by a higher demand for the product. For example, a rebound effect of hybrid cars is that people will drive more as a result of cheaper operating costs. The rebound effect can be calculated by subtracting the amount of money actually saved from the amount that would have been saved by the increased technology (De Haan et al. 2006). From a conservation standpoint, rebound effects demonstrate the importance of prices on amount of consumption. In the case of electricity deregulation, competition may drive producers to resort to cheaper sources of fuel that produce greater amounts of emissions. If electricity is cheaper due to deregulation, consumer demand may possibly increase (Swisher and McAlpin, 2006).

Swisher and McAlpin (2006) reported positive environmental consequences of more competitive markets. A case in point is that deregulated states have higher rates of production from renewable sources than regulated states. Furthermore, competitive markets allow the consumers to buy electricity from a green producer, which is more environmentally friendly (Swisher and McAlpin, 2006). The rising cost of energy has promoted states across the country to take action, and provide means for homeowners to supplement their energy use with onsite renewable electricity generation.

**Energy Saving Programs**

Various states have set up monetary incentive programs to create an incentive to homeowners, businesses and industrial establishments to adopt on-site renewable energy generation. The state of Maryland is apparently at the forefront of implementing economic incentives for renewable energy. The Maryland Energy Administration has set up the Solar Roofs Program to help alleviate utilities' fiscal burden and to create the incentive for individuals to exploit renewable energy. This program was passed on April 27, 2004 when Governor Ehrlich signed Senate Bill 485 (MEA). The program includes two initiatives: 1) to implement the Solar Energy Grants Program and 2) to implement the Net-Metering Program. These two initiatives work hand in hand to help promote the expansion of small-scale renewable energy generation.

The Maryland Energy Administration implemented an application process, which began on June 1, 2006 to provide grants through the Solar Energy Grants Program. The grants were awarded to selected participants beginning July 1, 2006 (MEA). The general assembly passed a budget of 1.5 million to be allocated to the Solar Energy Grant Program as well as the Geothermal Heat Pump Program. After funds where allocated for the 2007 Maryland state budget, 1 million dollars was made available for the Solar Grants Program (MEA).

Photovoltaic systems as well as Solar Water heater systems are two renewable energy-generating systems that are qualified for the grants program in Maryland. The grants will cover 20% of the installation cost of the systems and are subject to price caps (MEA). There are three categories for grant applicants. The first is for the solar water heating installations. This grant covers 20% of the start-up cost and up to $2000. The second qualified energy system is the Photovoltaic system for residences, which can receive grants for 20% of installation costs up to $3000. The last group is non-residential participants who are subject to receive grants to cover 20% of the installation costs and up to $5000 (MEA). The non-residential sector cap is higher due to higher annual demand of electricity from these sectors. The implementation of the Solar Grants Program in Maryland works hand in hand with the Net Metering Program.

Net-metering encourages direct customer investment in the development of renewable energy (Starrs, 1996). Thirty-five states across the country have such programs. According to Thomas Starrs, economic analyst, if properly implemented "net-metering will provide a simple, low-cost and easily administered method for encouraging direct customer investment in renewable technology while minimizing the adverse utility revenue impacts." Starrs illustrates how the proper incentive can twine together market interests between consumers, politicians, and utility companies. The net-metering process focuses on the cost of financing energy usage at the homeowners' level. Although the capital costs are high to install photovoltaic and solar water heater systems, programs similar to Solar Grants may help implement the net-metering program in Maryland.

There are two types of metering options available nationwide for small-scale renewable energy generation. The first option is called Net Purchase and Sale and the second option is Net Metering (Starrs, 1996). The first option, Net Purchase and Sale option allows customer-generators to use their renewable generation to offset their simultaneous electricity consumption. Net Purchase and Sale requires that consumers are to have two uni-directional meters to measure only excess consumption and generation (Starrs, 1996).

Under Net Purchase and Sale, the electricity that the consumer uses from the utility is purchased at the normal retail rate. The electricity generated on site by the consumer is sold to the utility at a lower rate (Starrs, 1996) or consumer-to-utility retail rate. This stipulation under the law was set up to ensure utilities profits are not at risk. For example, a house with a 2kW photovoltaic generator is producing energy for 3 hours consecutively at its maximum production rate. Assume that the retail rate for electricity is 12 cents per kilowatt-hour and the consumer-to-utility retail rate is 4 cents a kilowatt-hour. If 2kW are consumed in the first hour, this offsets what was generated. In the second hour if 3kW are consumed, 1kW must be purchased from the utility company at the normal retail price. During the third hour 1kW is consumed, more is produced than consumed and 1kW is sold back to the grid at the lower consumer-to-utility price. Overall, the bill has been lowered, but the utility company must be paid although the electricity generation has been offset. Table 8.1 below represents the illustration above.

The second option, Net Metering, allows consumers the option to offset their electrical consumption with their electricity generator over an entire billing period, opposed to offsetting their electricity production on an hour-to-hour basis. As we will see this option may be more beneficial to the residential consumer.

Table 8.1. Net purchase and sale (Starrs, 1996)

| | **Hour 1** | **Hour 2** | **Hour 3** | **Total** |
|---|---|---|---|---|
| **Gross Generation (kWh)** | 2 | 2 | 2 | 6 |
| **Gross Consumption (kWh)** | 2 | 3 | 1 | 6 |
| **Net Generation Meter (kWh)** | -- | -- | +1 | +1 |
| **Net Consumption Meter (kWh)** | -- | +1 | -- | +1 |
| **Effect on Electricity Bill** | **0 cents** | **12 cents** | **-4 cents** | **8 cents** |

This option uses a single bi-directional meter (Starrs, 1996). The meter moves back and forth as it registers the electricity flow between consumption and production. At the end of the billing period, if the meter registers an overall net-consumption over zero, the consumer will purchase the electricity from the utility at the normal retail value. If the meter reads that generation is greater than consumption, the utility company will buy back the electricity at the consumer-to-producer lower price. Net Metering allows the customers to offset a higher proportion of their electricity consumption with their own generation. The customer receives a higher rate of return on their renewable investment. Table 8.2 shows the outcome of net metering.

Table 8.2. Net metering (Starrs, 1996)

| | Hour 1 | Hour 2 | Hour 3 | Total |
|---|---|---|---|---|
| **Gross Generation (kWh)** | 2 | 2 | 2 | 6 |
| **Gross Consumption (kWh)** | 2 | 3 | 1 | 6 |
| **Net Consumption Meter (kWh)** | 0 | +1 | -1 | 0 |
| **Effect on Electricity Bill** | **0 cents** | **12 cents** | **-12 cents** | **0 cents** |

States set their own limit on total generation of small-scale renewable generation. In Maryland, the state allows for 0.2% of the state's adjusted demand peak load of 1998 to be covered by small-scale renewable generation. This is a total output of 34.7 MW of electricity. For the sake of comparison, the state of California allows 2.5% of the states adjusted demand peak load of 1998 and a total output of 50MW of electricity (Starrs, 1996). The cap implemented allows for future cap flexibility. As market genetrations of small scale renewables reach its legal capacity, politicians can asses and adjust the cap as needed without this affecting utility companies.

The congeries of small-scale renewable energy generation is under close watch because of the implication net metering may have on utility companies. Utility companies worry that an exploitation of on-site electricity generation and its penetration into the market would substantially diminish profits. Policy makers have put caps on net-metering capacity to diminish the possible adverse impacts on utility revenues. Policy makers believe that the cap is high enough so that incentives for self-generation and renewable energy exploitation are still viable. Simple computer models are used by utility companies to advise politicians to what can be implemented without adverse effects to the utility (Starrs, 1996).

It is true that these programs set up nationwide for small-scale renewable generation has been a success at creating the incentive necessary for consumers to implement these technologies, but the real question is whether or not these programs have any substantial effects at curbing energy usage at the national level. It should be imperative of any program that aims to reduce fossil fuel emissions, to do so at the national scale. Although the renewable energy programs of Maryland and other states are steps in the right direction, the limit that states put on net metering disables the programs ability for all homeowners to eventually be more if not completely self-reliant.

Utility companies benefit from the implementation of the Solar Grants and Net Metering programs. These programs lower demand peak electricity demand, and thus utility companies do not need to operate aging power plants that are less effective and more costly to operate. These programs also put less pressure on utilities to construct new power plants that take considerable amounts of capital to produce. The implementation of these incentive programs is a favorable situation for utility companies. They do not need to spend excess capitol on new power plant production and the cap set by the net-metering program ensures they will not lose profits. Unless these programs makes utility companies realize that it is beneficial to invest and produce large-scale renewable generation sites, these programs are only of small benefit to reduce our reliance on fossil fuels.

**Energy Efficient Mortgages**

Another result of higher energy costs is programs that assist homeowners to invest in more energy efficient homes, or to upgrade current homes to be more energy efficient. There are several types of programs available. One popular economic program that has received interest from homeowners and homebuyers is the Energy Efficient Mortgage.

The Energy Efficient Mortgage (EEM) was developed by the lending industry. It offers homebuyers credit for having homes that have lower energy costs. In 1992, Congress mandated a pilot demonstration of energy efficient mortgages in five different states. In 1995 the mandate had been implemented nationally (HUD 2006).

An Energy-Efficient Mortgage is a type of mortgage that allows a homebuyer to borrow more money to help pay for energy efficiency improvements or upgrades. The cost of the improvements can be allocated over the entire period of the mortgage or loan. Because an energy-efficient house will have lower monthly utility bills, many lending institutions are willing to stretch the buyer's qualifying ratio, a ratio calculated by a lender to determine how much a potential buyer can borrow. Energy-Efficient Mortgages can be useful for new homes and existing homes that need updating.

The benefits of an EEM extend well beyond lower energy bills for the homeowner. As stated before, the premise of an EEM is that the homeowner will be paying less in energy bills due to the energy efficiency of the purchased home. Therefore, the homeowner will qualify for more money to put towards a monthly mortgage as he or she saves on energy bills. Also, after going through the process of getting an energy-efficient home or upgrading an older existing house to meet EEM standards, the homeowner can advertise the home as an efficient home and have a higher resale value. Potential homebuyers will feel comfortable knowing that they are purchasing an energy efficient home.

To qualify for an EEM, a home should meet ENERGY STAR criteria, or demonstrate that it meets EEM requirements through an official Home Energy Rating System (HERS) report. A HERS report is a measurement of the relative efficiency of a house. A trained professional provides the report after performing an on-site inspection of the house and its systems. The report will give an estimate of the annual energy performance and costs of the house as well as suggestions for the most cost-effective energy efficiency improvements (Flex Your Power). However, there are other home rating methods that are acceptable for some Energy Efficient Mortgages.

In October of 2000, U.S. homeowners spent close to $1,300 a year on utilities (DOE). However, energy-efficient homes with such features as high-efficient heating and cooling systems, energy-efficient windows, and proper insulation saved the homeowners between 10-50% ($130-$650) on their utility bills.

There are many types of EEMs. The Federal Housing Authority (FHA) allows borrowers to finance the cost of adding energy-efficient improvements to new or existing homes as part of their FHA-insured purchase or refinancing mortgage. Some benefits are finances of up to $4,000-$8,000, no additional down payment is required, and no new appraisal is needed. Federal Housing Authority also has a few other EEM options available.

Fannie Mae offers the HomeStyle Energy Efficient Mortgage. It is a program that uses underwriting adjustments. An underwriting adjustment allows the lender and borrower to select the mortgage product best suited for the borrower's situation. This will allow the borrower to qualify for more mortgage funds. They will also use a below market interest rate. Fannie Mae EEMs can be used for refinancing or purchasing a home.

The Veterans Administration's (VA) EEM allows for energy efficient improvements ranging from $3,000 – $6,000, to qualified military personnel, reservists, and veterans when purchasing an existing home (Energy Star).

EPA Energy Star Mortgages and Loans that are sponsored jointly by the U.S. Department of Energy and the U.S. Environmental Protection Agency promote voluntary partnerships with home builders to construct new homes that are 30% more efficient than the guidelines established by the Model Energy Code—a "model" national standard for residential energy efficiency (DOE). Their incentives are discounted interest rates, free HERS ratings covered by lender, higher qualifications, reduced closing costs, and many others.

As homeowners benefit from the energy savings and resale value, the lending companies also benefit. Lenders are able to write larger loans for more money with less risk for the Energy Efficient

Mortgages. They can also team up with builders and promote energy efficient building practices while helping to protect the environment. The Energy Star program has been very successful, having enrolled over 1,000 builders in the past year and they have over 2,000 builders in their program currently participating. It is estimated that these builders will construct over 125,000 Energy Star qualified homes (Energy Star), many which will need financial assistance (Energy Star), which is where an EEM will be useful.

Probably the most important benefit from Energy Efficient Mortgages other then lower ownership costs, better performance, and higher resale values, is the environmental protection. Homes can be a greater source of pollution than automobiles. A large proportion of the energy used in our homes comes from burning of fossil fuels on site or at power plants (Energy Star). The burning of fossil fuels contributes to smog, acid rain, and emission of greenhouse gasses, which contribute to global warming. Homeowners that choose to take advantage of energy efficient methods and use less energy in their homes, produce less air pollution. These are all benefits for homeowners as they save money while helping to make a difference in the environment.

**Conclusion**

The home energy audit has allowed consumers to see the implications of their energy use choices. It shows how their conscious decisions have had the power decrease their utility bills. Because of the recent changes in utility policy, energy prices now reflect the true cost of production and homeowners have innovative programs in which to get involved resulting in lower energy bills as well as energy consumption. Demand Side Management practices, such as Energy Star projects, the implications of deregulation and peak load pricing, as well as monetary incentive programs such as the Solar Grants and Net Metering programs have allowed consumers to become more energy efficient. The outcome has been an increase in energy efficiency, but the long-term trends of energy consumption are still troubling. Utility corporations have enormous political clout, which possibly ensures high profits. Real energy conservation starts at the utility/corporation level. Although energy efficiency at the household level is a step in the right direction, it is crucial that the utility and cooperate institutions of our nation invest in large-scale renewable energy. Furthermore, if the caps were lifted on net-metering programs nationwide homeowners may substantially invest in small-scale renewable energy, putting monetary pressure on utility companies, which may spur them to seek out other avenues of electricity generation, namely renewable energy.

The consumer needs more power to influence the market. Policies that protect the utility companies ensure that the change needed to influence the market will not happen. Developing an energy efficient nation and a sustainable way of living is possible, but only with the cooperation and sacrifice of utility companies, consumers and large corporations.

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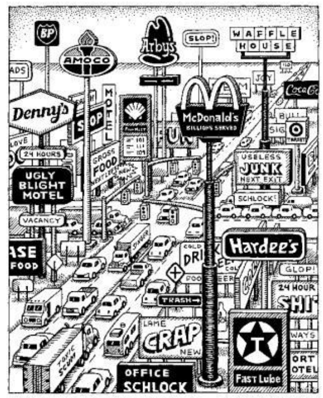
# CHAPTER 9

# ACCESSIBILTY

Danielle Hurst
Amanda Joseph
Tim McJilton




**Introduction**

The topic of urban accessibility becomes important when looking into the current state and recent trends in development with their far-reaching effects on the environment and their weighty demand for non-renewable energy. The ongoing spread of sprawling development has led to the increase in impervious surfaces, the destruction of farmlands and open space, the stifling dependence on cars and now its effects on personal homesteads is becoming apparent. The choice of where one lives has become just as important as how a person lives and with what amenities he or she employs. In terms of environmental impact and energy use, accessibility is a foremost concern. The most environmentally friendly home still will require a high energy input if located in a poorly designed city with all uses separated. A well-planned city works with an environmentally conscious homeowner by offering different options and innovations with mixed use and new urban design.

The trend toward sprawl has occurred for a number of reasons. When the Home Owners Loan Corporation (HOLC) was initiated as a means for relief during the depression in the 1920's, loans were more readily awarded to a specific type of homeowner looking to buy a specific type of house. These homes consisted of a large lot size, a large square footage, and ample space between the house and the street. This was the beginning of the typical "American" house. The homeowners to whom these loans were given were primarily working and middle class, which consequently pulled this population out of the urban core into the surrounding suburbs. Working in conjunction with the HOLC were the zoning laws. These laws reinforced the site specifications of the HOLC and also mandated the separation of uses in cities. Residential areas had to be separated from industrial areas, which were separated from commercial areas. These zoning laws forced the cities to expand even further, instead of growing upward with a higher density, mixed use development. Before the Superfund, previously developed land—known as brownfields—were affordable to developers. This helped to deter vacancy in the inner city. However, the initiation of Superfund increased sprawl by making greenfields more monetarily attractive to developers. Government subsidies for highways eased the way for a car dependent society with roads through the cheaper urban core and farmlands. These legislative measures have all increased the occurrence of sprawl and the abandonment of urban cores that is apparent in today's cities.

The consequences of sprawling development are realized with road congestion and the lack of available public transit. This leads to decreased air and water quality with a heavy burden on maintaining the increased amount of infrastructure. Cities are in the unique position to make significant changes in the way in which they are constructed, which influences their constituent's environmental impact and energy use.

Using the ratings of the 50 largest cities we looked into the cities with the highest and lowest ratings in the categories that deal with urban accessibility based on the research done by SustainLane, an online community devoted to sustainable living. This group publishes a list of America's most sustainable cities every year. To put into context the effect that accessibility has on a home's energy use our group has chosen to look into the design and function of two major cities; Portland, Oregon, and Oklahoma City, Oklahoma. Portland will be used as the positive example to show that through intelligent planning, a city can heavily influence its constituent's energy use. Oklahoma City will be used as a counter example to show that even the most environmentally conscience home will use a great amount of energy if built in a sprawling, environmentally negligent city. The local example of Baltimore City will also be compared with these two cities.

**Portland Public Transit & Roadway Congestion**

The city of Portland, Oregon, and the surrounding metropolitan area is serviced by the Tri-County Metropolitan Transportation District of Oregon, more commonly known as TriMet. TriMet provides bus, light rail, and streetcar transportation options for residents of Portland and its surrounding metropolitan area. The service area covers a nearly 600 square mile region with a population of 1.3 million. TriMet is a national leader in providing transit service, carrying more people than any other US transit system its size (Detweiler, 2005; "Facts about TriMet, 2005).

TriMet operates more than 700 buses on 97 bus routes, 79 of which connect with light rail service. A continual focus on on-street bus stop amenities sets priorities for sidewalk and crosswalk needs, in addition to installing new shelters each year. Of the current 8,435 bus stops, shelters are present at 948 of these sites. Stop maintenance is promoted through an "adopt-a-stop" program, and new shelter designs help to minimize graffiti. Buses are an integral part of TriMet's commitment to increasing transit ridership by improving pedestrian access.

The Metropolitan Area Express (MAX) light rail system currently covers 44 miles. It has three lines: Blue, Red, and Yellow, which have won awards for its superior design and roadside beautification. The Yellow Line is one of the "greenest" systems built to date, utilizing environmentally friendly construction practices and recycled materials.

TriMet also offers a six-mile streetcar loop, with stops approximately every two blocks. It shares a lane with cars for much of its alignment, and encourages infill development, facilitating new housing and supporting other planned development. It also provides a convenient connection to the light rail, helping to build overall ridership.

In the Portland region, 43% of adults use TriMet public transportation at least twice a month. Of these mass-transit riders, 59% have a car but prefer to use TriMet, and an additional 11% choose not to own a car at all. In all, 70% of riders chose TriMet over driving.

During the 2005 fiscal year, bus and MAX light rail provided 95.8 million rides, with daily boarding averaging 306,100 trips, which greatly eased traffic congestion. MAX carries approximately 26% of afternoon rush-hour commuters traveling from downtown. Combining the use of TriMet's bus and light rail systems, 199,390 car trips are eliminated daily, which adds up to 62.5 million trips each year. Altogether, TriMet's service eliminates about 4.2 tons of smog-producing pollutants every day ("Facts about TriMet," 2005)

Portland has an obvious commitment to reducing the use of cars. Commuters can park for free at 21 TriMet "Park & Ride" lots, which offer 8,242 parking spaces. Portland is also a pioneer behind car sharing. Flexcar, a car-sharing company, has a wide assortment of vehicles available in more than 20 locations in neighborhoods and downtown. The service provides the benefits of auto use for personal trips while offering an incentive to use transit, biking, and walking. For many downtown commuters, the cost of Flexcar is far less than they would otherwise spend just on parking (Detweiler, 2005).

Although Portland is a national leader in its public transit system, it still faces the same rising congestion problem as the rest of the country. According to a 2004 report by the Center for Transportation Studies at Portland State University, annual traffic congestion delay for peak-period travelers in Portland has increased from seven hours per year in 1982 to 46 hours per year in 2002. This is reported to be close to the average for large urban areas. "Despite increases in congestion, travel times in the Portland area have not changed as noticeably as in other regions because shorter-than-average travel distances have eased the impact of congestion on travel times" ("Portland Ranks…," 2004). This decreased commute can be attributed to the fact that Portland is a condensed city, as opposed to a sprawling city, where the commutes are generally longer.

**Oklahoma City Public Transit & Roadway Congestion**

Ranking number 45 out of 50 in public transportation, the Oklahoma City public transit system offers a bus and trolley service. The bus system covers 465 miles out of the sprawling 607 square mile city area. It maintains a fleet of 98 vehicles; however, only 43 vehicles are currently accessible. The METRO Public Transit program has been active in Oklahoma City for the last thirty years, and is available to an average population of 803,078 citizens in the metropolitan area ("OKLAHOMA Publicly..," 2006). Regular service is offered on weekdays from 5:30 am to 7:30 pm. A limited Saturday service is offered from 6:15 am until 7:10 pm, and service is unavailable on Sundays and holidays.

The most recent addition to the public transit program is the "Oklahoma Spirit" trolley. Designed in the style of the traditional American Heritage Streetcars, nine trolley replicas provide shuttle service around the downtown area ("The City of..," 2005). Intercity travel is available from Amtrak, which serves Oklahoma with one shorter-distance train, the *Heartland Flyer*, offering daily trips between Oklahoma City and Fort Worth, Texas. Combining METRO Transit's twenty-five interconnecting bus and trolley routes and the Amtrak rail, Oklahoma City provides 5.7 million unlinked passenger trips every year ("Oklahoma City..," 2006); however, this accounts for less than 1% of the commuter population.

There were plans in the early 1990s to build a light rail system for the city as part of an urban redevelopment program, but the project was never implemented due to lack of funding. Therefore, cars remain the transportation of choice in the Oklahoma City area, with the majority of transportation funding going into highways. Oklahoma City ranks #49 in commuting due to the fact that approximately 85% of the population commutes alone by car; however, Oklahoma City enjoys a relatively low amount of traffic congestion compared to other US cities, as most highways throughout the city have six to eight lanes ("SustainLane..., 2006). Parking is also not a problem, as public and private parking garages provide ample space for those coming into the downtown area ("The City of.., 2005). A common quality of sprawling cities is the developmental focus on car use, making a priority of parking lots and larger, multi-lane highways.

**Air and Water Quality**

In addition to factors such as traffic patterns, alternative modes of transportation, city planning and innovation, a cities' resource use or abuse plays a major role in its ability to sustain itself. Factors such as water quality, air quality as well as a city's use of renewable energy can significantly impact its stature among larger American cities.

Tap water quality is a major concern among individuals today. In Portland Oregon, the nation's second best city in regards to drinking water quality, there have been numerous efforts to ensure that their water is clean and pathogen free. A large portion of Portland's drinking water is supplied by the heavily protected Bull Run reservoir with 9.9 billion gallons of water for usable storage (Portlandonline.com, 2006). Portland's water supply at Bull Run is considered an "unfiltered" resource. Rather than filtering, they simply disinfect the water with chlorine as well as ammonia. Portland is one of very few cities that are able to be exempt from filtration because of strict environmental and pathogen regulations (portlandonline.com, 2006). The city of Portland also follows the Long Term 2 Enhanced Surface Water Treatment Rule which was published in December of 2005 and reduces the occurrence of illness due to waterborne pathogens. The city of Portland also prides itself on the fact that Bull Run is far from any type of human impact or interaction.

Oklahoma City's water, ranked 7$^{th}$ in the country according to SustainLane, is also a city in the forefront of water quality. According to the city of Oklahoma City, the environmental department has 554 water monitoring sites used to "inventory, detect and remediate any illicit discharges on a pro-active annual schedule." Oklahoma City also has numerous programs such as Watershed Characterization Program, Illicit Discharge Detection and Elimination Program, Optical Brightener Monitoring (which locate sanitary sewer leaks) and the Wet Weather Analytical Monitoring Program that monitors the quality of runoff during storms. (okc.gov)

Air Quality also plays a major role in a city's environmental stature. Portland, ranked second, prides itself on the fact that they have had zero carbon monoxide violations since 1985. Within Portland, 33% of the pollution comes from cars and trucks, 25% from non-road engine sources, 23% from households and 19% from industry.  Portland is considered a leader in air quality standards as in the following examples.  Portland "was the first U.S. city (1993) to adopt a carbon dioxide reduction plan" which "prescribed a regional 20% reduction from 1990 $CO_2$ levels by 2010" however, due to large population growth, the percentage has been reduced to 10%.  The new 10 % target "is more aggressive than the 1997 Kyoto Protocol, which would establish a $CO_2$ reduction of 7% by 2008 to 2012" (portlandonline.com, 2006). Given Portland's area of 134 square miles and its population of about 539,000 with a density of 4,000 persons per square mile, Portland is making numerous strides to lessen its contribution to air pollution.

Oklahoma is ranked twelfth overall in terms of air quality according to SustainLane.  Oklahoma City's planning department gives no specific plans or indications concerning the city's air quality standards.  However, Oklahoma City's large area (607 square miles) and its population density of only 834 persons per square mile may limit the concentration of airborne pollutants that would lessen their environmental impact.

**Renewable Energy Use**

Portland is at the forefront of sustainable development through renewable energy in the form of wind power.  "The City of Portland is currently negotiating with a private power supplier to have all city energy needs met from 100% new renewable resources (primarily wind power) generated in Oregon" (portlandonline.com, 2006). Furthermore in 1995, "the City signed an innovative contract with Portland General Electric (PGE) to purchase "green" power generated by wind or other renewable resources.  The contract allowed the city to take advantage of wholesale rates for a 10 Mw minimum power purchase, and to require PGE to purchase 5% of that power from renewable resources." (portlandonline.com, 2006)  In addition to purchasing electricity or generating their own electricity from wind power, Portland is looking to the sewers for alternative fuels.  Portland is utilizing microturbines to generate energy from sewer gas.  Four microturbines have been installed at the Columbia Boulevard Wastewater Treatment Plant to convert the greenhouse gas methane to a viable energy source.  According to Portland's Office of Sustainable Development, methane is a clean burning gas with no emissions.  The turbines can currently generate 120 Kw of energy, which can generate enough electricity to entirely power about 75 homes (portlandonline.com). Out of Portland's residential energy use, 8% comes from resident-generated renewable energy.

Currently, Oklahoma City has about 205,000 occupied housing units in which 65.6% of the residents use natural gas as their primary energy source. Only 0.4% of its residents use renewable energy. Oklahoma City currently has no indication of a renewable energy plan for its residents, which indicates why Oklahoma City is ranked last out of 50 in regards to energy usage and alternative fuels.

**City Planning and Innovation**

Planning focused on sustainable land use reduces dependence on cars and encourages mixed-use real estate development. More park space provides more health-based recreational opportunities along with psychological relief from city stressors such as noise pollution.

In Portland, the zoning and building permit process is highly concerned with providing safe and convenient pedestrian, bicycle and vehicle circulation. Their planning department is focused on connectivity and street and pedestrian friendly improvements. Portland makes use of the Pedestrian Design Guide that will "integrate the wide range of design criteria and practices into a coherent set of new standards that will, over time, promote an environment conducive to walking."(www.portlandonline.com). There is 15.1% of city acreage devoted to parks, a low level of sprawl compared to other similar sized cities, and a vacancy rate of only 5.7%.

In conjunction with the Pedestrian Design Guide, Portland also utilizes the concept of Travel Smart. Travel Smart is an innovative way to encourage environmentally friendly ways to travel. The concept, used in more than 300 projects around the world, identifies individuals who want to change the way they travel and uses personal, individualized contact to motivate them to think about their travel options. Travel Smart provides customized information and training to help people take public transit, bike, walk or carpool for some of their trips. Travel Smart gives only inquiring participants the information they ask for to help them get started. Materials are delivered in the most efficient and cost effective way – by bicycle. Coupons for local business, maps of the city (walking routes, public transportation), and pedometers are all made readily available. The concept is praised for its fun, not preachy attitude (www.portlandonline.com).

In sharp contrast, Oklahoma City has a population of 30,000 less than Portland but is spread out over an area that is 4.5 times larger, resulting in a density of only 833 people per square mile. The population growth is seen almost exclusively in the outskirts of this spreading city and there are very high vacancy rates in the urban core. The focus of their planning department is maintaining the quality of their historic districts.

Because of the vacancy rates and the urban core abandonment, much of the older area of Oklahoma City has been designated as a federal Empowerment Zone. The U.S. Department of Housing and Urban Development Empowerment Zone program was established to generate economic development in urban areas. Residents living within the designated zones receive incentives to stay, and these incentives are also an attraction for new residents and businesses. Incentives for Empowerment Zone businesses include wage credits, which include tax credits of up to $3,000 for each employee who lives and works in the Empowerment Zone. There is also bond financing which is a tax-exempt facility bond to finance property, equipment and site development. There are tax deductions, which are increased expensing deductions, up to $35,000, for depreciable assets acquired that year (http://www.okc.gov).

The Empowerment Zone was last updated in March 2003 but the most recent census shows continuing urban core desertion. Here, it is important to note again the importance of strong planning capabilities when dealing with city environmental issues. The enacted plan has shown little, if any, success in the past three years yet an alternative plan has not been implemented. The sprawling trend of Oklahoma City will continue until the city itself formulates a working set of initiatives and plans that will produce results.

**Conclusions**

Investigating Portland, Oregon and Oklahoma City, Oklahoma, draws the conclusion that city planning has a profound effect on environmental impact and energy use (Table 9.1). An environmentally conscious person must be aware of the consequences of their location. A poorly planned city has the ability to negate the positive effects of an eco-friendly, energy-conscious household. A well-planned city will incorporate inhabitants into a high density, mixed use, new urban development regardless of their environmental consciousness, thereby reducing the city's energy demand and environmental impact.

Table 9.1. Comparison of several of the key environmental differences between cities.

| | Portland | Oklahoma City | Baltimore |
|---|---|---|---|
| Population | 538,544 | 506,132 | 635,815 |
| Area (sq / mi) | 134 | 607 | 81 |
| Population Density (per/sq. mi) | 4,019 | 833 | 8,058 |
| Transit Ridership | 43% | 1% | 20% |
| Car Usage | 53% | 85% | 58% |

Despite the discouraging sprawling trends there are current pockets of development occurring where the main focus is Smart Growth. Learning from mistakes made since the 1920's, these developments utilize new urbanist ideals and environmentally friendly construction to decrease the impact of development and the use of non-renewable energy. A prime example of this type of development is Kentlands, located in Gaithersburg, Maryland. Kentlands is located on 358 acres and contains 1,800 residential units. Kentlands is an award-winning neo-traditional community and remains the most successful and largest New Urbanist project in North America. Projects such as this are gaining national attention; therefore development can be seen as a promising solution to intensive urban energy use, rather than its cause.

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