HOME ENERGY AUDIT

Environmental Science and Studies Senior Seminar Project

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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 fin( )-1Us n( )-1Us n( )-1Us ÊÌÖ(a)9(n)11( )-n D. F

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

CHAPTER 2

FUEL TYPES

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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

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)

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.

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, 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

Hydropower

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

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CHAPTER 3

HEATING AND COOLING

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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.

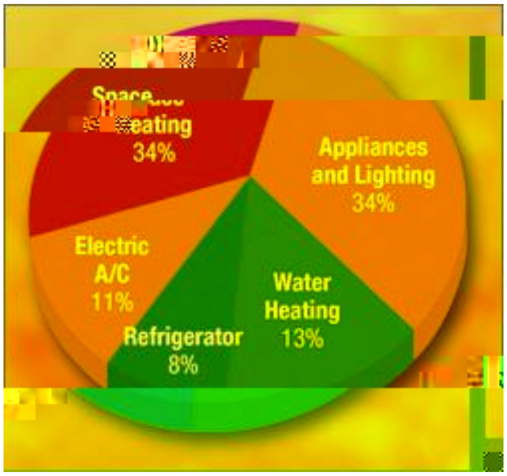

Figure 3.1 Source: U.S. Department of Energy

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

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%-

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

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).

CHAPTER 4

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.

Cooking Appliances

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 fil9( )-0u4s wla5440050>1100510e7 0 1 72.025.1 Tm[(-)] TJETBT51.210e7 0 1 72.02551( )-6,as

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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% laer] l l y every 1000 units of Latitude notebooks installed instead of the GX260 helps reduce carbon dioxide omission by about 1 million pounds‖ (Dell Computers, 2006).

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

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halogen	(excellent)	(warm to neutral)

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.

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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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

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

increased interest in landscaping techniques that will lower people‘s energy bills. There has been a

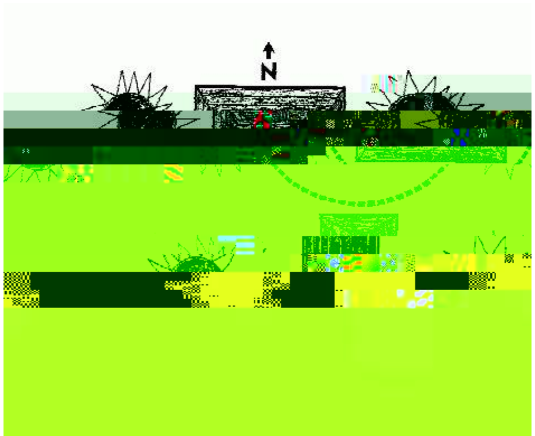

Figure 6.1. East-west orientation of the home. With the long axis built as above, the smaller sides of the home receive less hot summer sun than the long walls would if oriented differently.

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).

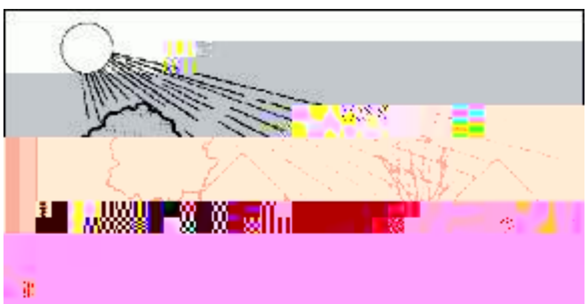

Figure 6.2. Deciduous trees used for shading and winter sun warming.

Computer simulations have shown that planting 3 trees, costing approximately $100.00 each, around an unshaded and well-insulated 5(ou)11(nd -6(n6)] TJETBT1 0 0 1 439216 149.06 Tm[(educ)-2(ed)-185(ansu)9aol)-5( )-73

E(ng)35(el)-5h,per75(F.)343(cum)5(m)17.;t pr. (e)9(er)-3( )312(t)6(r)-3(ee)8(s)343(s)9(houl)-4(d)312(be)335(p)11(l)-4

f t64(he)-22(hom)17(e.)-22( )-21(C)4ho(o)11(si)-6ong trees t64((at)5( )-21(er)5(.)-22n(a)9(t)6(i)-4(v)11(e,)-22(f)-3(sa) 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.

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).

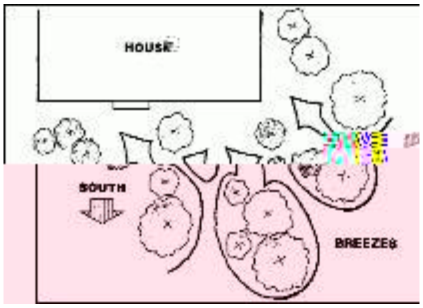

Figure 6.3. Trees and shrubs used to direct breezes toward the home in a passively cooled home.

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

of vines alslSsf[(oe)-5ctve-64(ay-75(s)9(lSsb-4(neor4(nebl)-5s)9(lSt)11(h-75(es)9(7(sun)-5ss)9(7(hea)8St)11(,s)9(lSs)-5n

3) The filter membrane prevents small particles from the growing medium from clogging t

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

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.

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CHAPTER 7

POLICY AND TRENDS

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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

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.

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 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

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).

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

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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

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

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 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

This option uses a single bi-

Mortgages. They can also team up with builders and promote energy efficient building practices while efficient nation and a sustainable way of living is possible, but only with the cooperation and sacrifice of

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 functi

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 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 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‘

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 concentra

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 fu-4(o)i5s0P fu-4(o)3ETBT1482.95

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

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