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Green Process Design & Cost Benefit Analysis

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Green Process Design & Cost Benefit Analysis

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by

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ABSTRACT

What determines how sustainable the operations of an existing facility might be? How would one go about greening current processes and what are the benefits? The purpose of this project was to explore different aspects of sustainability, identify the major carbon footprint contributors of facility operations, implementing a process for green improvements, and illustrating the outcome with a cost benefit analysis. Our background in industrial engineering, along with our acquired knowledge of green engineering, has allowed us to design a process that makes the facility operations more carbon efficient. With the cooperation of a local WPI fraternity chapter house, Zeta Psi, and a minor budget of $500 we analyzed the operations of the fraternity house, implemented changes, and analyzed the results of our recommendations. We looked into process factors, more specifically electricity, lighting, insulation, heating, building size, landscape, local sustainability, waste water management, water heating, waste production, and recycling. We were also able to compare our implantation data to historical data for the city of Worcester and historical data specific to the operation of the fraternity through record keeping. After using techniques for green facility operation improvement, we were able to document an annual savings of $3,900 and reduced the carbon emissions from daily operation of the facility by 43,000 lbs of CO2, which is a36% reduction.

ACKNOWLEDGMENT

This report could not have been written without Professor Joe Zhu who not only served as the Advisor, but also encouraged and challenged our group throughout this innovative research initiative exploring the intersection of green processes and topics in industrial engineering. We would also like to give thanks to the Zeta Psi Fraternity house for their cooperation in providing information and acting as sample for analysis.

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1.1. Understanding Green

What is "green", how to become "green", and what are "green" benefits? These are all very complex and ambiguous questions. The concept of "going green" has been gaining much attention. The essential theory behind sustainability is taking the steps necessary to *reduce your carbon footprint*, or reducing "the total amount of green house gas emissions, both directly and indirectly by an individual, organization, event, or product"[1]. Design and fiscal focuses have swayed, basing more importance on how green a process, action, or facility is. The characteristics of a green process include measures to eliminate the environmental burden in such areas as resources input, waste output, chemical and non-renewable substances used, and energy consumption to the greatest extent possible in all the processes involved in operation. The concept of a "green" process is an area that can use the analysis and design of industrial engineers.

1.2. Industrial Engineering & Green

Industrial engineering is one of the largest disciplines of engineering because it can be applied to nearly every type of industry. Industrial engineers analyze and design processes and work to provide improvement for existing procedures. Some of the most common forms of improvement that an industrial engineer might enable include cost-

[1] UK Carbon Trust (2008) "Carbon Footprinting".

benefit, process streamline, supply-chain management, quality, and ergonomics. We feel that the idea of process design within industrial engineering can be directly applied and implemented to the exploding concept of "green" process.

Using our background in industrial engineering, we will investigate how to improve current processes and function of domestic level housing. With the cooperation of the Worcester Polytechnic Institute chapter of the Zeta Psi fraternity, we will perform research using their chapter house as our subject. We will be providing a brief introduction on characteristics "green buildings" have specifically which make them green using resources like LEED certification programs (The Leadership in Energy and Environmental Design Green Building Rating System which provides a suite of standards for environmentally sustainable construction)[2], and other topical books and journals on green processes. We will also mention specific green processes we would like to see Zeta Psi implement. First, we will analyze the house, determining where we can and cannot change current processes for the purposes of reducing the household's "carbon footprint". Examples of immediate in- house processes may include recycling, drinking tap water instead of purchasing water weekly, and reducing the amount of disposable items used in the house per day. We plan to uncover many other ways that we feel the concept and development of a "green" process can be incorporated in our analysis. We will also make several suggestions concerning the actions the members

[2] "Leadership in Energy and Environmental Design -." Wikipedia, the free encyclopedia. 23 Apr. 2009 <http://en.wikipedia.org/wiki/LEED_certification>.

living in the house can perform to help reduce their contribution to the carbon foot print of the Zeta Psi Fraternity house. Reasoning will be provided in conclusion, for theory, of a company or home deciding to go green, and will be explained and applied to our specific situation. After analyzing the house, we will outline the processes we are going to change and our reasoning. A process for becoming "greener" will be constructed, listing all the ways the house will be changing after background research has been conducted on the correct and practical green processes to adopt. A cost study analysis will be conducted over a two month time period, comparing costs the house pays before and after the new processes were enacted, including the cost to implement new products and the total cost of continuing to run the house in a non-green fashion. After the end of the two month study, we will be able to conclude roughly how much money the Zeta Psi fraternity house will save, if any, and provide a complete cost-benefit analysis if our recommended process are continued.

The project is interesting in the sense that it gives our group the ability to design a process for becoming "greener" specifically for households, in which recommendations will be implemented thanks to national Zeta Psi finances. Our data will be based on actual results, rather estimated, hypothetical, or theoretical figures. Thus ensuring the accuracy of our analysis, and providing real information gathered from actual implementation on the costs and benefits of going "green" for a specific house. We will be able to provide real data findings, real solutions, and real results.

Because of this, we feel that our MQP offers opportunities for growth that most other will not, in that everything we do will have a lasting effect and will not be forgotten after our graduation.

2. Green Background Information

2.1. Introduction

Green energy, or renewable energy, is an energy source that is considered non-polluting and can be produced and used with a relatively low impact on the environment. Using green energy, individuals and businesses are able to reduce their contributions to global warming. Renewable energy is generated from natural resources and can be naturally replenished. Examples of these environmentally friendly energy sources include the use of several renewables such as biofuels, biomass, wood- burning, and geothermal, hydro, solar, tidal, wave, and wind power generation. The majority of renewable energy technologies are powered by the sun. Aside from traditional solar panels, energy from the sun works indirectly with water sources (the hydrosphere absorbs solar radiation), and helps promote the growth of plants used in the production of biofuels. The International Energy Agency states "Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources.[3]" Today, renewable energy is growing more popular due to increasing oil prices and

[3] "Renewable energy -." Wikipedia, the free encyclopedia. 11 Apr. 2009 <http://en.wikipedia.org/wiki/Renewable_energy#cite_note-16>.

climate changes. Environmentalists predict that replacement of current energy technology with renewable energy will reduce CO_2 emissions by 50% by the year 2050[1]. The areas explained in this section are regarded as having the most potential for green process conversion or implementation. As stated, the main theory of being green is to *reduce* ones carbon footprint, with central concepts like reduction of waste, materials, energy, and efficiency.

2.2. Electricity

In order to conserve electricity intake in the home, several suggestions can be made. First, all appliances not in use should be turned off and unplugged if possible. Appliances still consume electricity even when they are in stand-by mode. Smaller appliances consume less energy, so try cooking with a microwave or convection oven instead of the traditional stove. If it is necessary to use a stove, try to turn off the gas when done. Another easy way to save electricity consumption is to shut off lights when leaving a room. Regular light bulbs can be replaced with fluorescent light bulbs, which produce more light but consume less energy. During leisure times, turn the sound down on your television or computer, as it takes more energy for the sound to be louder. Try turning your thermostat down 7 to10 degrees when no one is at home. Even if the heat is reduced for only a few hours a day, it can lead to a heating bill 10%

cheaper than usual[4]. Finally, replace major appliances with Energy Star certified appliances. These appliances pay for themselves in the long run, saving families about a third on their monthly energy bill while producing less green house gas emissions.

2.3. Lighting

One of the places a home can make the biggest impact in terms of going green is the usage of lighting. There are many factors, from the kind of bulbs, the fixtures, type of power, and personal habits that can contribute to the sustainability of a facility. An interesting fact is that only 5-10% of energy consumed is used for light in a conventional incandescent bulb while the rest is emitted as heat. Lighting is so crucial that nearly one- third of the requirements of LEED certification are related to lighting and the use of light. Approximately 20% of the world's global energy is used for lighting purposes. Some of common, environmentally friendly products include the use of Compact florescent bulbs (CFLs) or Light Emitting Diodes (LED), day lighting, dimmers and motion sensors. LED bulbs are one of the greenest bulbs, in which 80-90% percent of their energy is used for emitting light, lasting for upwards of 100,000 hours. Day lighting, or utilizing daytime sunlight, is another technique used to save electricity. However, aside from energy improvements, day lighting has shown to lead to better

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[4] "10 Tips for the Thermostat: Your Key to Savings | Healthy and Green Living." Care2 - largest online community for healthy and green living, human rights and animal welfare. 11 Apr. 2009 <http://www.care2.com/greenliving/10-thermostat-tips-save-money.html>.

business and make people happier. Day lighting has been shown to often increase worker satisfaction, productivity in offices, increased sales in retail settings, and result in better test scores. The optimization theory states one should study the daylight cycle to map each day around the planet's bountiful source of free full-spectrum.[5]

2.4. Heating, Ventilation, and Air Conditioning

Most homeowners find that their house may have heating flaws in the winter month. Cold air sneaking through small spaces near windows and doors throughout a home can significantly lower the temperature of the entire structure although it may seem like only a minor inconvenience. Doing as much as possible to properly insulate your home, be it eliminating spots allowing drafts to flow in and out, purchasing more, or a higher quality wall insulation, or simply drawing your drapes can save hundreds per year on your heating bill.

About two- thirds of average home energy consumption goes to space and water heating. Doing some small things, like investing in caulk and insulating strips to avoid drafts, can save you money monthly, as well as conserve the planets resources. The standard home uses central heating, which consists of a boiler, furnace, or heat pump for the heating of water, air, or steam. In warming the home, this heated fluid is passed

[5] Peterson, Josh. "Light Your House with LED Lights." Planet Green. 16 Dec. 2008. 24 Jan. 2009 <www.planetgreen.com>.

through either ductwork or pipe systems to radiators, which transfer the heat into each room. Systems such as forced air systems force warm air (or cold air in the summer months) through ductwork. Electricity is another way to heat air. Electricity- powered systems involve a filament that becomes hot when electricity is forced through it. These systems can be found in electric baseboard heaters, portable electric heaters, or as a backup heater for heating pumps. In any case, radiators and vents should be placed in the coldest part of the room, preferably next to a window, to minimize condensation and offset cold draft air.

More recently, Heating, Ventilating, and Air Conditioning systems , or HVAC, have become more popular in households and businesses because of their energy efficiency and the money that can be saved in a time of rising energy costs. The most proficient central heating method is geothermal heating, which uses thermal energy from the Earth itself to heat space. This type of heating has been used for centuries and utilizes areas of steam and hot water on or close to the Earth's surface[6]. In a home or business office setting, zoned heating can allow for the best and most desirable distribution of heat. This type of system uses several thermostats, which control zone valves attached to the heating source, and utilize zone dampers, block airflow according to the preferred user settings. These infamous HVAC systems, commonly known as

[6] Climate.org - Website of the Climate Institute. 03 Mar. 2009 <http://www.climate.org/topics/green/geo.shtml.>.

climate control, are based on the principles of fluid mechanics and heat transfer, and are used in establishments from skyscrapers to private homes all over the world.

Insulating your home properly can help cut down on electricity bills during any season. Whether you are paying to heat your home in the winter or running an air conditioning system in the summer, insulating windows and doors will keep outside air in and inside air from escaping. Adding more insulation inside your home, or purchasing thicker, stronger insulation, is simple and cheap, making it one of the most commonly used green practices. Gaps under doors and windows can also be easily filled with caulk to keep inside air in and outside air out. You may also choose to insulate outlets and switches with caulk or insulating foam gaskets. Better insulation in your home leads to not only better heat efficiency, but improved comfort and lower energy bills for a lifetime.

In the green community, windows are the weak link regarding heating and lighting practices in most building. Because we wish to utilize daylight, views, and ventilation, we compromise thermal performance, acting as a major contributor to energy loss. To help collect heat in the winter, green building design places the windows so that they are south-facing. This is referred to as "passive-solar" design because that area will receive a consistent amount of heat and light from the sun throughout the day. [7]Windows can easily be modified to promote a greener way of living. Unfortunately, windows allow for air leaks through cracks and gaps around the edges. Also, windows allow heat to radiate through as visible light and as infrared radiation. Because of the glazing, they tend to reflect certain wavelengths of radiation back towards the source and prevent all forms of heat and light available for use to be absorbed. There are many techniques such as insulating window frames, use of gaskets, sealants, and weather-stripping are all very efficient at preventing waste of heat or cooling energy through gaps and cracks which is often a great problem in older buildings such as the fraternity house. Doors, similar to windows, are another issue that can be improved upon to help conserve heating or cooling energy by using much of the same methods as stated above.

2.5. Building Size

Going green can start quite literally from the ground up. Different building sizes and locations require varying amounts of heat and electricity. If a new building is being constructed, or if an existing structure is being knocked down, reusable material should be salvaged and recycled. Materials such as wood, scrap metal, cardboard, and concrete can be recycled on-site or via a recycling facility. Larger buildings consume more energy, so smaller homes are considered greener than larger homes. Homes over a

[7] "HVAC." Northeast Sustainable energy Association. <http://www.nesea.org>.

certain size threshold must install an on-site renewable energy system in order to offset their higher energy consumption. Homes over 3,001 square feet must offset 25% of their energy, and homes greater than 4,001 square feet must offset 50% of their energy via an on-site renewable energy system[8]. More effort is also going into picking the proper location to build. LEED awards are given for building in "preferred locations" like infill sites, sites with nearby bike networks, and within close proximity to jobs, schools, and other business establishments, encouraging less car usage.

2.6. Landscape

Another way we can contribute to the preservation of the environment is not only to be conscious of our physical home, but how we manage our landscape. The strategic planting of trees around the yard can naturally cool your home in the summer months, saving money on air conditioning. If deciduous trees are planted, trees that drops their leaves in the fall, they allow sunlight to warm your home even in the fall months. Planting evergreen trees creates a natural windbreaker to keep your home warmer. When looking to plant a garden, consider plants native to your climate. Native plants will require less maintenance and water, and are also more resistant to the native bugs, which reduces the need for pesticides. When it comes to the maintenance of your lawn, make an effort to use a reel or electric lawn mower. These mowers are more

[8] "Land Use Code." Boulder County Government - Official Web Site. 11 Apr. 2009 <https://www.bouldercounty.org/sustain/GreenBuilding/LUC.htm>.

energy efficient, non-polluting, and are a great source of exercise. Installing a drip irrigation system will deliver water directly to your plants and are 90% efficient as compared to the 75% efficiency of a traditional sprinkler system[9]. Using compost creates a natural recycling process, reusing grass clippings, fruit peels, and leaves instead of simply throwing them away. Finally, growing produce at home can save money at the grocery store and make your garden beautiful as well as efficient.

2.7. Local Sustainability

One characteristic of a green house that does not deal with the actual construction of a particular structure is local sustainability. Local sustainability is a measure of how easily inhabitants of a certain house or facility can access such things as local produce, local sustainable resources, and public transportation. Green practices encourage walking, biking, or using take public transportation whenever possible. This will help to decrease personal vehicle usage, combine trips to reduce total mileage, and keep the vehicle well maintained to reduce oil leaks and runoff, reducing pollution, and increase air quality are all green benefits. Also, when purchasing from a local sustainable farm or ranch, you are cutting out the middle man known as mass-operation, which accounts for wasteful energy through traveling, transport, and operations . Buying local is investing in the community, and in food security. The idea

[9] Colorado State University Extension. 11 Apr. 2009 <http://www.ext.colostate.edu/PUBS/Garden/04702.html>.

is to reduce the amount of unnecessary transportation used to deliver distant resources by purchasing resources closely available to the consumer, making your community locally sustainable and thus greener.

2.8. Waste Water Management

Wastewater is another aspect of green buildings that should be examined. Often times, wastewater can be piped away and reused in nearby areas. Sometimes, runoff from storms can be collected and reused in toilets. Storm water runoff can be collected outside your home or business and reused directly. This type of water can be cleansed naturally by moss and vegetation, and also contains vital oils and heavy minerals which can be beneficial to plants. Saving water around the house doesn't necessarily have to consist of irrigation systems or special plumbing. It can also be helped through simple appliances. One suggestion is to purchase low- flow shower heads. These showerheads use 60% less water than a standard showerhead, but produce the same amount of water pressure[10]. Dual- flushing toilets can also cut down significantly on individual water consumption. These toilets reduce water usage by 67% as compared to the traditional toilet which can use 3-5 gallons in a single flush[11]. Low flow faucets can be purchased, as well as water- efficient appliances, to further cut down on water usage.

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[10] "Reduce Your Water Consumption | Ecologic Development Fund." Home | Ecologic Development Fund. 11 Apr. 2009 <http://www.ecologic.org/node/427>.

[11] "Dual Flush Toilet by Caroma :." TreeHugger. 11 Apr. 2009 <http://www.treehugger.com/files/2005/03/dual_flush_toil_1.php>.

2.9. Water Heating

In the past, water heating was viewed as the most efficient method of heating buildings, however today forced air systems are considered more efficient for heating, and can be used as air conditioning systems in the summer months. Heating and energy efficiency can be improved with the concept of zoned heating. By controlling parameters such as time of the day used, duration used, and location of heat, the operator is able to heat a building and reduce the amount of wasted energy. With ventilation systems, energy recovery can use the transfer of air by using enthalpy wheels to recover dormant hot air and to recycle the incoming outside fresh air. As with heating, zoned air conditioning can be implemented and can be set up to control the same parameters listed above.

2.10. Waste Production & Recycling

Recycling is one of the most used and talked about green practices. Recycling is defined as a "design principal, a law of nature, a source of creativity, and a source of prosperity."[12] An interesting fact is that recycling a ton of waste has two times the economic impact rather than burying. Also, recycling an additional ton of waste

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[12] Team Treehugger. "How to go green: Recycling." Planet Green. 07 Nov. 2008. 19 Jan. 2009 <www.planetgreen.com>.

accounts for an added $101 in salaries and wages, can generate an extra $275 in goods and services, and also produce $135 more in sales than if waste was disposed in a landfill.[13] The phrase "reduce, reuse, recycle" is ranked in order of importance. Think of "green" as a means of reduction. This is the main idea of recycling. With the first step of reducing that amount consumed completed, the next step should be to find practical uses for the waste. Recycling should be the last step of the process to ensure that it is as green as possible. An example of where recycling and green practices can be built upon in a facility is recycling empty bottles in a bin and placing it for the curb pickup. Recycling plastic is a good practice, but the process as a whole could be greener by using a water filter and reusable container. By doing something such as this, it is possible to completely eliminate your need for disposable plastic bottles.

[13] Team Treehugger. "How to go green: Recycling." Planet Green. 07 Nov. 2008. 19 Jan. 2009 <www.planetgreen.com>.

3. Current Sample Issues

3.1. Electricity

In terms of electricity conservation, the Zeta Psi house could definitely stand to see some improvements. Tenants are used to leaving many of their appliances on and plugged in majority of the day, even when they are not home. Televisions are left on at full volume, lights are left on, computers are left running, and several other various appliances are also kept at full power. In common areas, lights are almost always kept switched on and the common area television is on for several hours out of the day. Walking throughout the house, it was noted that only one appliance, a water cooler, was a certified Energy Star appliance. The thermostat temperature is left at 68 degrees on a regular basis and the boiler water temperature is left at 140 degrees Fahrenheit. Tenants live comfortably, but these settings can be adjusted slightly without compromising comfort level.

The people living in the house will be encouraged to try to remember to turn lights off when exiting a room, but another, more accurate lighting solution to this problem would be to install automatic light switches, which will turn lights off after a certain time period when it senses no one is in the room. Power strips could easily be used in each room to power up and easily shut off all appliances since most appliances are left on full power or standby mode throughout the day. Special attention should be paid to chargers, which take in energy constantly when plugged into the wall, even if they are not in use. The thermostat temperate has been turned down about seven degrees from 71 to 64 degrees, and the boiler water temperature has been reduced to about 120 degrees to try to cut down on their impact on the energy bill. Natural daylight could be used more often than it is in both common and individual rooms. Curtains are drawn more times than not, blocking out useful, all natural light. Light shelves could even be installed inside or outside the windows of the house to help project natural light deeper into each room. At about $200.00 per shelf, this addition may be the most economical way to utilize natural light.

3.2. Lighting

We walked through and around the entire structure documenting every aspect of the house that could be adjusted to improve the greenness of the building. For 2008-2009 year, the building has 18 people living in it from August to May, however those numbers vary from year to year. The building has four floors including the basement with 9 bed rooms, 2 bathrooms, 1 kitchen, 1 dining room, 1 bar room, 1 TV/family room, and the basement. The house has a total of 65 incandescent light bulbs and 12 long florescent light bulbs. The 3rd floor has 18 light bulbs, the second floor has 24 light bulbs, the first floor has 17 light bulbs and 6 florescent, and the basement has 5 regular and 4 florescent light bulbs. Aside from personal use of lighting, the common room lights (bathrooms, hallways, TV room, dining room, bar room, and kitchen) are on almost all the time, omitting the rare occasion that they are shut off for the night or unnecessary use during the day. There are a total of 37 incandescent lights and 12 florescent lights in the common rooms listed, which comprises 56.1% of the houses light bulbs, and 100% of the house florescent light bulbs. This is clearly an area where improvement can be made because more than half of the houses lights are unnecessarily on and wasting energy majority of the time.

3.3. Heating, Ventilation, and Air Conditioning

After comparing three years worth of bills and analyzing them based on month (or seasons), we confirmed assumptions that most of the energy was consumed in the winter months. During that time of year, energy demand rises and price rises as a result. Right now, the house has two main doors downstairs, a door on the third floor, and several windows. These open spaces cause cold air to leak into the house in the winter months. Brothers may also leave windows open while they leave the house, causing more cold air to come into the house and driving the tenants to turn up thermostat settings. The thermostat setting has been reduced to around 64 degrees on each floor (7 degrees cooler than its original setting), and windows have been caulked to avoid drafts.

Next, we analyzed the Heating, Ventilation and air conditioning (HVAC) factors of the house. We first looked at the room temperature and the desired temperature listed by the thermostat. The fraternity's room temperature was listed as 71 F, with a desired temperature of 72 F. The only two people who have control over the temperature of the thermostat are the house manger and the treasure.

The next aspect of the house that we looked into regarding HVAC was loss of heat through areas around windows and doors. After checking all windows we noticed that several windows had a serious draft of cold air leaking around them. There are 4 windows on the 3rd floor, 3 windows on the 2nd floor, 2 of which allow for an unreasonable loss of heat. This loss of heat has a major impact on the greenness of the house. Because of the lack of efficient insulation, the heater must unnecessarily work harder to make up for the heat lost through the holes, cracks, and leaks around the house. If the heat were to be lowered to a more reasonable temperature and the areas that allowed the heat to leak out of the house were properly insulated, a smaller amount of therms would be necessary to heat the house. The less gas that is used, the greener the house is, reducing its carbon footprint in addition to reaping the benefit of saving money.

3.4. Building Size

The Zeta Psi Fraternity house was built in 1900. It has 3 floors and a basement, totaling an approximate 3800 sqr ft. The property is 6432 sqr ft, which converts to .15

acres. The building has four common rooms, 2 bathrooms, 3 showers, 4 bedrooms, and 1 basement.

3.5. Landscape

Each side of the house is completely different from the other three. The front yard consists of a 12 foot long by 60 foot wide grassy area within a retaining wall. There are many low to the ground shrubs and flowers that require constant watering and care taking. They provide no shade for outdoor activity nor do they block sunlight from entering the widows, thus diminishing the additional potential heat and natural sunlight.

The yard to the left is a paved walk way that stretches the entire length of the house. There is no vegetation, however there is a fire escape that runs from the mid section of the third floor to the rear of the house. On the right side of the house, there is a very large tree that extends to the third floor and partially blocks about half of the windows on the front end of the house. The entire side yard is covered with stone gravel, so no water is needed to take care of grass, plants, or shrubs. The back yard spans the entire width of the house and approximately 25 feet back. There is a porch covering approximately half of the area, with dirt beyond that to a fence. In the back left corner of the yard, there is a tree that is not on the fraternity property but is so large that the majority overhangs onto the property, touching the house. This tree has very large leaves that not only provide shade for the porch by blocks the 2 windows on the back right section of the house.

3.6. Local Sustainability

The house is in an interesting city where sky scrapers, large buildings, colleges, suburban areas, and farms are all relatively close. This is beneficial to the greenness of the house because essentially all the resources one would need to maintain operation are all within a reasonable distance. One can walk, bike, or take public transportation to get where they need which reduces, and in some cases, eliminates amount of negative impact that the fraternity house has on the environment in terms of travel time. There are many farms in the suburbs surrounding the city of Worcester, MA which allows the inhabitants of the fraternity house to buy more local goods. Buying local goods is a very green practice. For example, purchasing a renowned Idaho potato transported from the state of Idaho to Worcester, MA has a greater negative impact on the environment than purchasing one that has been grown locally because of all the transportation, processes, and services necessary to deliver the good.

3.7. Waste Water Management

In terms of trying to conserve water in the Zeta Psi house, we must first consider the facts. The house has two bathrooms (containing two toilets and two sinks), two showers, and a high powered industrial sink in the kitchen. What can we do to cut down on water wasted per use?

In order to conserve water in the house without buying any new appliances, the brothers can adopt several new habits. For example, taking shorter showers can add up to a lot less water wasted per brother per shower. Flow control showerheads can be purchased to adjust the amount of water that comes out according to preference, as opposed to the current high pressure showerheads. It is also important to fix all leaky faucets and showerheads. Constant dripping wastes energy and water, and furthermore could waste up to 2,700 gallons per year if not adjusted[14]. Making sure to adjust the water heater temperature, especially when no one is in the house, can be a valuable habit to get into. Some water heaters should be drained every 6 to 8 months to eliminate sediment that can build up inside and reduce efficiency. Timers can also be purchased so that the water heater only heats up for several hours in the morning and at night for people who only use their hot water once or twice a day. In the case of the Zeta Psi house, the water heater temperature has been reduced to 120 degrees Fahrenheit in attempts to save money on monthly bills.

Another handy home improvement that can be made to a water heater is wrapping fiberglass around the heater and water pipes to reduce heat loss. Newer water heaters are already insulated, but for those that are five or more years old, this

[14] "Conserving Water -." Green Wiki. 03 Mar. 2009 <http://green.wikia.com/wiki/Conserving_Water>.

can reduce your energy bill by 10%. These slight improvements will be examined and compared to the budget for adjustments in the house.

3.8. Water Heating

Currently, the setting on the hot water heater is at 140 degrees F, which is on the high side. This can make a significant impact on the gas consumption because, the hot water heater keeps water at whichever temperature desired for 24 hours a day, 365 days a year. If it is keeping water at an unnecessarily high temperature, as in this case, it is a waste of energy.

3.9. Waste Production& Recycling

Currently in the Zeta Psi household, there are five large garbage bins, costing about $40.00 each, which are almost completely filled each day. The house, on average, generates ten bags of trash per day and does not practice recycling habits. The large amount of miscellaneous waste produced by the tenants living the house is picked up twice a week by the city of Worcester. As the fraternity adds more members to its roster, the amount of trash generated on the premises grows. Accordingly, the amount of space for waste will eventually decrease.

Aside from the inconvenience excess waste causes for Zeta Psi, city landfill sites are filling up fast. Many items that could and should have been recycled are taking up space in these already overcrowded sites. Without the use of recycled materials, new products have to be made with raw materials which are more costly and use up our limited natural resources. Reusing old paper, plastic, glass, aluminum, or any other type of recyclable material, eliminates the need to turn to our earth for new matter. Furthermore, larger amounts of energy are used when manufacturing products from raw materials. Energy is necessary to uproot and transport these raw materials for production, whereas recycled materials are already at hand. Using raw material as opposed to recycled material also puts a strain on the population economically. Aside from saving money on energy and transporting raw materials, recycling eliminates the need to spend money on processing natural matter. The recycling process creates employment opportunities, resulting in global financial growth in the long run. In essence, recycling reduces pollution, preserves the environment, and promotes economic increase.

3.10. Conclusion

The Zeta Psi Fraternity house is an excellent candidate for our experiment because it is not very green. The building is very rundown and has had no improvements within the last 10 years, especially none which help reduce the carbon foot print that the structure and the inhabitants create. This sample will give us many realistic improvement ideas which will make an impact and increase the greenness of the house in its natural environment. Another reason why the Zeta Psi Fraternity house is a prime candidate is because we will have access to the current bills and bills from years past to make a proper assessment as to whether or not our changes have led to a reduction of resources such as the consumption of energy or gas. We will also be able to generate monthly trends using the previous information and will be able to create possible resource consumption and usage projections. One of the goals we hope to meet is to complete the construction of a process design that can be used by any similarly sized residence, office, or small facility that can be consulted in order to begin green improvement.

4. Approach

4.1. Introduction

This section will discuss the approach used to investigate the issues in the fraternity house. Having a well thought out and thoroughly detailed process in looking at the house is the key to successfully discovering where improvements and changes can be made.

4.2. Electricity

Many of the tenants at the Zeta Psi fraternity house, along with many other members of the population, are not always mindful of the environment or trying to save energy. At a school like Worcester Polytechnic Institute, students are more concerned with maintaining a good grade point average, sustaining a relatively normal social life, and trying to find a job. Being highly technical in nature, WPI has a lot of coursework that involves the use of computers or the internet, making it almost impossible for a given student to feel comfortable being away from their laptop. That being said, it is rarely a thought to completely shut off an unused computer. The demanding schedule makes it so that students are constantly going up to campus for project meetings, extracurricular activities, sports practice, or using campus resources. With this many things going on, how can we expect an average 20 year old student to consider the environment?

One way to go about solving the problem of wasted energy in a house full of forgetful students was to install motion- sensor light switches in common areas. When the amount of time lights remained on in the three main hallways, the living room, the bar area, dining room, kitchen, the two bathrooms, and basement was noted, it was decided that this type of lighting had to be installed in all areas except for the basement and kitchen. Without sensory switches, lights in these commonly inhabited areas were left on anywhere from eighteen to twenty- one hours every day. What these switches do is make sure that lights aren't in use aren't kept running, or left on during the day when manmade light isn't necessary. These can be especially helpful in areas like the bathroom, which are low traffic areas, and lights are commonly left on. More information on lighting can be found in the following section

In attempts to cut down on electricity consumption, "Smart Strip" power strips were purchased and installed in the kitchen and living room areas. These specialized power strips are able to monitor power consumption and detect whether a device is on or off. If a device is discovered to be off and plugged into the power strip, it eliminates idle current by shutting off power[15]. Major appliances such as the refrigerator in the kitchen and the big screen television in the living room area were plugged into these new strips, as they run almost constantly and drain the largest amounts of electricity.

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[15] ""Smart" Power Strips: Helping to Stop Idle Current Now! :." TreeHugger. 01 Apr. 2009 <http://www.treehugger.com/files/2005/12/smart_power_str.php>.

The television is left on throughout the day, idle or not, but the Smart Strip allows for the excess idle current to be shut up, essentially “unplugging” the appliance.

In the kitchen, the refrigerator cannot ever be shut off, but the strip serves as a sensor for the amount of power needed depending on how often the door is open and closed to maintain the preset temperature. Tables and graphs displaying information regarding the houses energy consumption can be found in the appendix

4.3. Lighting

The lighting situation in the house had to be examined and modified. We counted and categorized every light bulb in the house in order to identify where changes could be made. On the top floor (third) of the house there are exactly 18 incandescent light bulbs total in the 5 rooms and 1 hallway. On the second floor, there are a total of 24 incandescent light bulbs within the 4 rooms, hallway, and the bathroom. On the first floor, there are 17 incandescent light bulbs in the hallway, dining room, bar room, and family room. The kitchen uses six 45” florescent light tubes, and the pantry also uses two florescent light tubes. The basement uses 5 incandescent light bulbs and also uses 4 florescent light tubes. Altogether, the fraternity house uses 65 incandescent light bulbs and 12 florescent lighting tubes. About 84.5% of the lighting in the house uses incandescent lighting, which is the most inefficient method of lighting a house. This is an area where a change can easily be implemented. To ameliorate this situation, we purchased 16 packs of n:vision 14 watt Compact Fluorescent Light bulbs (CFL'S) with an individual price of $4.43 per pack of 4 bulbs and a total cost of $74.42. This 14 watt spiral CFL uses 75% less energy than a 60 watt incandescent light bulb while staying just as bright. These CFL's also last 10 times longer and have a projected savings of over $46 per bulb over the life of a given bulb.

Once we documented the number of lights in the fraternity house, our next step was monitoring the usage. Since there are a total of 18 people who live in the house, the lighting usage and schedules would be independent from room to room. The best way to go about keeping track of personal lighting usage within each of the bedrooms was to talk to the people who lived in the room and ask them to keep track of the total time and times of the day lights were on. We felt that brothers would have the best knowledge of their personal light usage, and this would be something that would be difficult to accurately document independently.

Another area of lighting that needed special consideration during the project was in common rooms. Common room lighting includes hallways, bathrooms, the basement, and all lighting on the first floor. There are a total of 9 common room lights, which is 63 % of the houses total lighting. Documenting the hours of operation for the common room lighting is something that we were able to accurately record. With the cooperation of the residents, we monitored the usage of the lights and documented the hours of operation throughout the entire day separating the day into five 4 and 5 hour segments for one week. We posted an hourly log sheet at every light switch and asked the residents to list the times they either turned on or off the lights for each particular room. It was decided that if the common room lights were on at 2 am and still on at 8 am then they were on throughout the duration of the night. We were able to enter the number of hours corresponding to each switch into an excel sheet and analyze the results. Table5.1.2 displays the average recorded hours of operation for the common room lighting.

Table 5.1.2: Weekly Lighting Time Average & Sum

Table 5.1.2 shows the sum and average of the amount of hours lighting remains on in each area in the house in a given week. The sum and average of hours in each day is also shown for each location.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Sum	Average
H way 1	22	22	22	20	19	20	22	147	21
H way 2	24	24	24	24	19	20	22	157	22.43
H way 3	24	24	18	24	23	21	22	156	22.29
Family/TV	9	20	6	12	9	9	9	74	10.57
Bar	20	20	13	20	14	17	13	117	16.71
Dinning	11	15	9	12	15	10	9	81	11.57
Kitchen	24	24	21	19	20	24	24	156	22.29
B room 1	24	24	21	22	24	24	24	163	23.29
B room 2	20	23	18	18	21	21	24	145	20.71
Basement	14	15	15	14	14	14	14	100	14.29
Sum	192	211	167	185	178	180	183	1296	
Average	19.2	21.1	16.7	18.5	17.8	18	18.3		

4.4. Heating, Ventilation, and Air Conditioning

In order to go about keeping heat in and cold air out of the house, the windows and doors had to be better insulated. Upon first examining the condition of the house, we noticed that there were several small open areas around both the windows and doors. In order to go about fixing this problem quickly and with little expense, the draft areas present around the windows were filled with caulk, while weather stripping was added to the two large downstairs doors. Plugging these gaps with inexpensive caulk is a cost- effective way to bring down energy costs. Other forms of draught excluder include insulating foam, brush strips (for the bottom of doors), silicone- rubber sealant, and sprung strips. Another way to go about insulating windows would be to replace the few single- pained windows with storm windows, which are already present in several areas throughout the house. Unfortunately, this kind of home improvement was not within our budget. In performing the draft proofing, we had to be careful not to block vents designed to prevent dry rot and allow fresh air to circulate. Sealing up these air leaks became increasingly important after the thermostat was turned down seven degrees from its original set temperature.

The next course of action that we took regarded the thermostat. We decided that it would be a good idea to install a programmable thermostat so we could better control the temperature during all parts of the day. We lowered the overall average temperature of 71◦degrees Fahrenheit to be 64 degrees Fahrenheit during the day and 65 degrees during the night. Lowering the temperature by an average of 7 degree Fahrenheit for particular times during the day will require less gas and reduce energy costs. We also replaced the steam valve regulators so that the heaters would heat the room more efficiently. For reference, Figure 5.2.12 and Figure 5.2.13 below display the past cost and therm usage for the years 2005 -2008. Further analysis of data collected can be found in the appendix.

Figure 5.2.12: Gas Cost Year Comparison

Figure 5.2.12 shows the gas cost trend, mapping the cost for each month from January 2005 to December 2008.

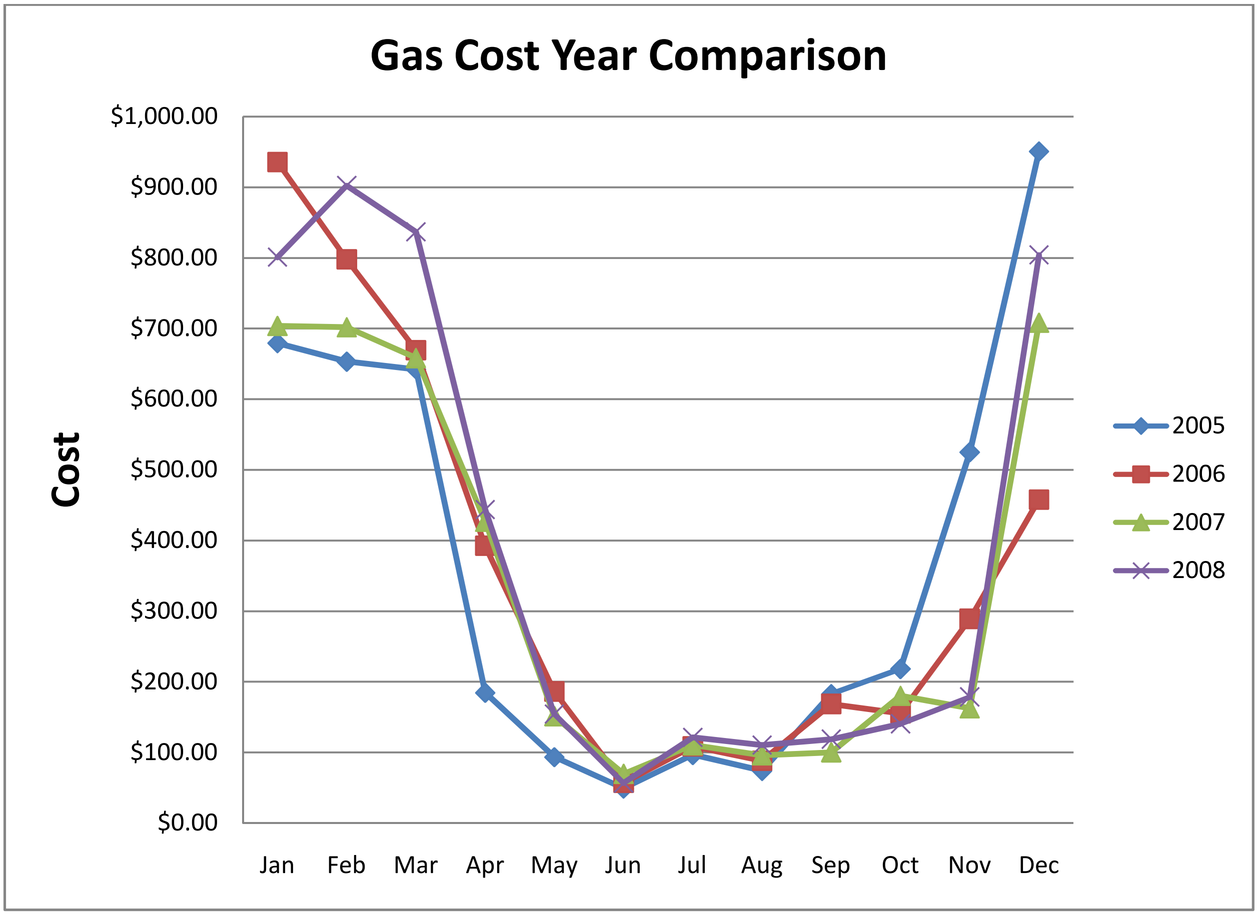
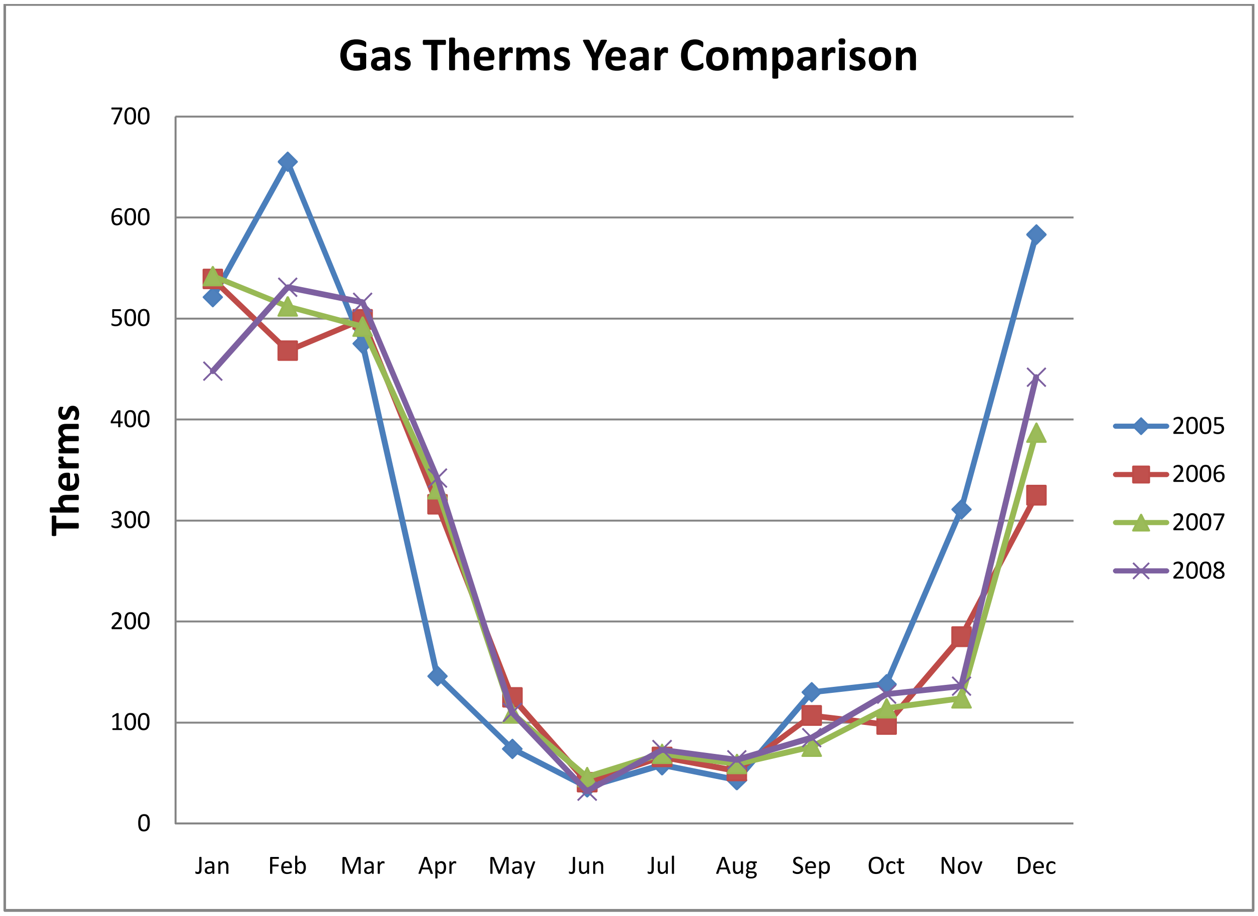


Figure 5.2.13: Gas Therms Year Comparison

Figure 5.2.13 shows the therm usage trend. Each amount of therms used per month is shown from January 2005 to December 2008.



4.5. Landscape

Unfortunately, there are no plans to help improve the greenness of the landscape. Improving the greenness of the landscape can be a very costly aspect of reducing your carbon footprint when in comparison to other areas that can allow for improvement. In regards to this particular house, national Zeta Psi headquarters just spent $20,000 on a landscape improvement job. The new landscape job included a gravel side yard, which will not require any maintenance or watering. It included a stone patio and stone walkway as well, also requiring no maintenance, which replaced areas previously containing grass. Many low level shrubs were planted in the front of the house, removing the previous plants which blocked the lower two windows, now allowing natural light to enter the building. An 18 in by 60 ft stone retaining wall was also placed along the street. This has no affect on the greenness of the building and was built for aesthetic reasons.

4.6. Local Sustainability

The house, located in the city of Worcester, MA currently has a functional and satisfactory local sustainability program. There are public transportation stops at both ends of the street that the fraternity house resides on. Because this is a fraternity house in association with a college, all day to day activities are reasonably close distance by walking or biking. This is unlike a family home in a suburban neighborhood where use of vehicle is near unavoidable. Almost all time is either spent at campus, at the fraternity house, or a nearby facility. There is essentially no need for the use of a vehicle, and if there were public transportations is within walking distance. One of the few reasons students would have to leave the campus is to go to the grocery store, and there is local grocery store within walking distance. The major factor in a self sustaining local community is that it has nearly everything someone could need within a short walking, biking, or public transportation commute, and the area of Worcester that the campus of WPI is located has this opportunity.

4.7. Waste Water Management

The step to improving waste water management in the house is to check all of the pipes to ensure that none were leaking and that the house wasn't wasting any water. A significant amount of water is lost each year due to negligence of leaks in the piping system and at the heads of the showers. After we performed our search we went back and installed low flow shower heads and faucet ends. These help to reduce the amount of water necessary to complete normal tasks especially in the shower where the residents have the freedom to take as long a shower as they wish, wasting significant amount of water.

The last physical change that we made concerned the toilets. Since most toilets in homes today use 3-5 gallons of water per flush, a lot of water is wasted in comparison to a low flush toilet that only use 1-3 gal per flush. We took two half gallon milk jugs and filled them with rocks and sand, and then taped the top so nothing would escape into the tank. This takes up a gallon worth of space in the tank of the toilet so that it cannot physically fill up all of the way. There is no noticeable change in the performance of the toilet, and now the toilet operates with at least 1 gallon less per flush, cutting back on a major contributor to waste water. We also asked the residents to mind the amount of water that they are using when showering, brushing their teeth, and using the sink to wash anything.[16]

4.8. Water Heating

The water heater in the Zeta Psi house was turned down ten degrees from 140 degrees to roughly 120 degrees Fahrenheit. It should be noted that water heaters don't just create hot water, but they store it as well. Water in storage is kept at the set temperature constantly, making hot water readily available to the residents of the house whenever they need it. The water heater in our particular scenario is relatively new, so it is properly insulated. The more insulation a water heater has, the lower the amount of energy it takes to keep the water hot twenty four hours a day. Turning down the water heater is a no- cost, quick improvement that saves the house money monthly in energy bills. It is of slight concern that if the water temperature is turned down too low,

[16] Ehow editor. "How to Use Less Water in the Toliet." Ehow. <www.ehow.com>.

bacteria could build up on the bottom of the heater. Legionella bacteria, the water-dwelling microorganisms, can generally be killed with the use of soap, as in a shower or cleaning dishes[17].

4.9. Waste Production and Recycling

To help counter the large waste production issue, we decided to take a hard nose approach to recycling. We explained to tenants the ramifications and pounds of CO_2 that is given off by facilities that do not recycle and the amount of CO_2 production that can be reduced by recycling. Originally having five 64 gallon barrels that are picked up twice a week, we replaced two the barrels with 64 gallon recycling barrels and three 20 gallon recycling containers.

The majority of trash production and recycling opportunities arise in the kitchen, thus we placed the two 64 gallon barrels in the kitchen so they would be in sight and close to the problem. This will also help to encourage the members of the house to recycle because improving the greenness of the house in this area lies on them. We also placed one of the 20 gallon containers on the third floor of the house, and the other two on the second floor of the house. We decided to place two of the 20 gallon containers on the second floor because it receives the second most amount of traffic. We assume that the recycling will make a great impact in the greenness of this house because of the

[17] "Is it Safe To Turn Down Your Water Heater Temperature? :." TreeHugger. 10 Apr. 2009 <http://www.treehugger.com/files/2009/03/turning-down-water-heater-safe.php>.

significant amount of trash production that is created. This will also help to cut costs spent on garbage removal by 40%.

5. Results & Analysis

5.1 Comparison of average Worcester temperatures and gas/ energy prices

Like the rest of New England, Worcester, Massachusetts experiences extremes in both the summer and winter months. It can be expected that Worcester will be slightly colder in the winter and slightly warmer in the summer its sister cities, Boston and Providence. The city's dipped landscape retains both colder and warmer air for longer periods of time because of the hills surrounding it. Furthermore, because Massachusetts juts out into the North Atlantic, Worcester is especially prone in Nor'easter weather conditions, which can cause northeast coastal flooding, heavy snow, and hurricane force winds. Year round warm air currents coming from the southwest and dry, cold air from the north meet in the New England region, resulting in unpredictable and sometimes harsh weather conditions. Winters are usually cold, windy, and particularly snowy, averaging about 68 inches of snowfall each season. Summers are hot and humid, the warmest month being July. Temperatures range from an average high of 79 degrees and an average low of 61 degrees Fahrenheit. On a yearly basis, Worcester, MA, averages about 47 inches of precipitation[18].

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[18] "Worcester, Massachusetts -." Wikipedia, the free encyclopedia. 26 Mar. 2009 <http://en.wikipedia.org/wiki/Worcester,_Massachusetts#Climate>.

Naturally, in the winter months, families require more heat to keep their families comfortable. Relative to the increase in the amount of heat used is an increase in the gas bill. Referencing table 5.1.6, it can be noted that the average number of therms used in the winter months is drastically larger than in the summer months. The number of therms used was at its highest in February, with an average cost of $763.79, while the number of therms used on average was at its lowest in June, with an average cost of $58.19. Obviously heating the Zeta Psi house isn't necessary in the summer months with the exception of hot water for showers and cleaning. Upon further analysis, it is noted that the number of therms each month isn't the only reason price rises. During the long and cold season, the demand for more heat goes up dramatically all over the area. As demand goes up, supply inevitably goes down. In order to counteract the heightened demand, heating providers raise the price of their resources slightly. Notice, for instance, that in July, the average number of therms is 66.5 with an average cost of $109.29 and in December, the average number of therms is 434.25 with an average cost of $730.12. The cost per month went from being roughly $1.64 per therm in the summer to about $1.68 per therm. Although this is only a small increase, the pennies can add up over time. Also to be noted is the number of inhabitants living in the house in certain times of the year. In the summer months, more than half of the tenants living in the house go home. When the school year starts up again, the number of tenants doubles as does the need for hot water. The average number of therms can be relative not only to the weather conditions, but to the number of people requiring heating resources in the house.

5.2 Electric & Gas Bill Comparison after Implementation

To measure if our implemented changes had any actual affects on the fraternity house we consulted historic data for the house listing the average total therms, the measure of the amount of gas used, and the average total KWH, the measure of the total amount of electricity used) and entered it into an excel sheet. Using that excel sheet we calculated the average for each month. These numbers will be in comparing date from the months in which we implemented our changes, February and March. Table 5.1.5 below demonstrates the following average KWH by month for the years 2005-2008, and the following Table 5.1.8 shows the average therm usage by month between the years of 2005-2008:

Table 5.1.5: Electric Bill Average KWH & Cost by Month for 2005 -2008

Table 5.1.5 shows the average kilowatt hours and the average cost of all electricity bills received between January 2005 and December 2008 on a monthly basis.

AVERAGES	AVERAGE KWH	AVERAGE COST
Jan	3368	$431
Feb	4461	$571
Mar	4317	$552
Apr	4401	$563
May	3774	$483
Jun	3295	$421
Jul	3892	$498
Aug	3596	$460
Sep	5143	$658
Oct	5061	$647
Nov	4285	$548
Dec	4640	4593
average	4186	$535
Average in school	4304	$551

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Table 5.1.8: Gas Bill Average Therms & Cost by Month for 2005 -2008

Table 5.1.8 shows the average number of therms and the average cost of all gas bills received between January 2005 and December 2008 on a monthly basis.

AVERAGES	AVERAGE THERMS	AVERAGE PRICE
Jan	516.00	$762.23
Feb	541.50	$763.79
Mar	520.50	$736.56
Apr	283.75	$361.86
May	104.50	$146.38
Jun	38.75	$58.19
Jul	66.50	$109.29
Aug	54.25	$92.24
Sep	99.50	$142.57
Oct	119.50	$173.64
Nov	189.00	$288.78
Dec	434.25	$730.12
Average	247.33	$363.80
Average in school	286.28	$419.82

Figuring out where we could make the biggest improvement in the area of saving energy, along with making the house as green as possible within our budget was not an easy task. We decided that our biggest improvements would be in making lighting power consumption more efficient. With the combination of changing all the light bulbs to compact fluorescent light bulbs and implementing motion sensing light switches, we hoped to have the best results in minimizing electricity usage.

Other factors that have a significant effect on energy consumption are in regards to the heating of water in the house. We lowered the water temperature on the hot water heater by 20 degrees, reducing the electricity necessary to keep the temperature of the water warm around the clock. In addition to turning down the temperature of the water heater, we also wrapped it in a thermal blanket to help insulate the hot water heater. The hot water insulated wrap will help minimize the loss of heat, and therefore less energy will be required to keep the water heater at the set temperature. We also asked the residents of the house wash both their clothes and dishes in cold water, and to only do so when there was enough for a full load. Table 5.1.6 below shows the results of the implanted changes in comparison to the historic data in regards to energy consumption:

Table 5.1.6: Electric Bill KWH & Cost Comparison for Data Received

Table 5.1.6 displays a comparison between the average kilowatt hours and the average cost of all electricity bills received for the months of February and March and is compared to the data received after implementation.

		Month	KWH	Cost
05-08 Historic Data	05	Feb	4411	$562
"	05	Mar	4356	$555
"	06	Feb	5041	$643
"	06	Mar	5115	$652
"	07	Feb	3900	$497
"	07	Mar	3913	$499
"	08	Feb	4491	$573
"	08	Mar	3884	$495
Test Data	09	Feb	2507	$320
"	09	Mar	2590	$330

Average Historic	Feb	4,461	$569
Average Test	Feb	2,507	$320
Difference		1,954	$249

Average Historic	Mar	4,317	$550
Average Test	Mar	2,590	$330
Difference		1,727	$220

	Average Historic KWH	**Average Historic Cost**	**Test KWH**	**Test Cost**
Feb	4,461	569	2,507	320
Mar	4,317	550	2,590	330

Averages generated for the year 2009 were less than the averages generated for years 2005 through 2008. In the month of February, the average number calculated was 1,954 KWH less than the monthly average for the past 4 years, while the month of March was 1,727 KWH's less. These two numbers are nearly identical which is expected, because the techniques that we used to reduce the energy consumption dealt with the issues of constant inefficient energy usage and should have minimal variation. We have reduced the energy consumption of the house by 40% and have reduced the electricity costs by 41%. With this data we project an annual estimated savings of $2,148 and an annual estimated savings of 20,626 lb's of C02 which is 17% the total production C02 emissions for the house.

In the house there are two main resources responsible for gas consumption; heat and the stove. There is really no way to minimize the amount of gas used by the stove, and in relation to the amount of gas that is used to heat the enormous fraternity house, it is miniscule. We figured that the best way to improve the greenness of the house by minimizing the amount of gas that the house uses would be to increase the efficiency of the heating system in the house. To help minimize the total consumption we first had to install a device that could regulate the temperature of the house. We installed a programmable thermostat, and set the temperature to be 65◦ F, 7◦ F below the high average temperature of the house during the day, and 63◦ F during the night. The thermostat was set to a lower temperature during the night because it is colder at night than it is during the day. This drop in temperature requires the heating system to work harder than it would have to than during the day when the temperature is warmer and sun naturally heats the house through the windows.

Once we had our heating system performing efficiently, the next step was to ensure that heat would remain inside the building. Most heat in an average building is lost through windows, doors, and the space around. A few months before the start of our experiment, the fraternity house had all the windows replaced with energy star single pane windows. To make sure that heat was not being lost through the space around the windows and doors, we pulled the molding off, insulated, and caulked around all the windows where there was a significant draft. We also installed draft blockers on all of the exterior doors to help minimize heat loss. The following is a table that displays the results of our implementations in comparison to the average from the years 2005 -2009:

Table 5.1.9: Historic Gas Therms & Cost vs. Test Data

Table 5.1.9 is a comparison between the average historic monthly therms and cost and the average therms and cost from the test months after implantation of energy efficiency techniques.

		Month	Therms	Cost
05-08 Historic Data	05	Feb	655	$653.05
"	05	Mar	575	$642.06
"	06	Feb	468	$798.02
"	06	Mar	499	$769.37
"	07	Feb	512	$701.85
"	07	Mar	492	$658.26
"	08	Feb	531	$902.24
"	08	Mar	516	$876.55
Test Data	09	Feb	445	$598.81
"	09	Mar	421	$569.28
	Average		511.4	$716.95

Average Historic	Feb	541.5	763.79
Average Test	Feb	445	598.81
Difference		96.5	164.98

Average Historic	Mar	520.5	736.56
Average Test	Mar	421	569.28
Difference		99.5	167.28

	Average Historic Therms	Average Historic Cost	Test Therms	Test Cost
Feb	542	763.79	445	598.81
Mar	521	736.56	421	569.28

The data received from the months of February and May once again show a reasonable decrease by 96.5 therms in February and 99.5 in March in comparison to the averages. The average savings alone between those two months is enough to heat a small apartment. This is a 19.16% decrease in total gas consumption and is a reasonable gain and a definite stride to improving the greenness of the house. There was a total savings of $332.26 between the 2 months and an average savings of $166.13 per month, which is a 20% savings. If 20% the original heating therm usage and cost was applied to the winter months when heating the house is necessary (8-7 months) there is a projected savings or approximately $811.86 and a total reduction of 561 therms.

Results show that our methods have not only worked to make the house greener, but also have saved the house a significant amount of money. Our methods have shown to reduce electricity consumption by 40% and gas consumption by 20%. They also have the ability to produce a projected total savings of $2,958 annually. This number is nearly more than 6 times the amount that we spent on material, products, and equipment to make the house green. From this data alone is it clear that there is significant support to justify the changes that we have implemented, not only saving money, but making the house and the planet much greener at no extra expense.

5.3 Carbon Footprint Comparison

A carbon footprint is the total amount of greenhouse gas emissions caused directly and indirectly by an individual, event, or facility, usually measured in tons of carbon dioxide, or CO_2. This "footprint" is a measure of the impact our day to day activity has on the environment and climate change. It consists of two key parts, the primary footprint and the secondary footprint. The primary footprint measures direct emissions of CO_2 from the consumption of fossil fuels, both in a domestic energy consumption situation and in transportation. More specifically, this sector consists of the measure of home fossil fuel consumption as in gas, coal, or oil, holiday flights, food and drink, electricity usage in the home, and public and private transportation. The secondary footprint measures indirect CO_2 emissions from products throughout their whole life cycle, comparing the amount a given person consumes or purchases to the amount of emissions caused by that person. Items considered in this segment of carbon footprint calculation include share of public services, financial services, the building of homes and furnishings, recreation and leisure, car manufacture and delivery, and clothes and personal effects. The carbon footprint concept was derived from the ecological footprint measurement, which compares human demand with the Earth's ability to regenerate ecologically[19].

[19] "Carbon Footprint - What Is A Carbon Footprint?" Carbon Footprint - Home of Carbon Management. 04 Apr. 2009 <http://www.carbonfootprint.com/carbonfootprint.html>.

In order to reduce a carbon footprint, a person, business, or organization should adopt a Carbon Diet, or begin reducing their impact on climate change. In order to do this, several steps should be followed. Firstly, a Life Cycle Assessment should be applied to find the current carbon footprint. After this has been done, one should identify the areas in their home or personal lifestyle in which the most energy is required. From here, assess whether or not it is possible to switch to an electric company with renewable energy sources in order to reduce CO2 emissions during production of resources. Lastly, carbon offsetting investments should be made, such as planting trees, to reduce greenhouse gas emission[20].

A Life Cycle Assessment was conducted on the Zeta Psi fraternity house to determine the current carbon footprint, before changes were made to the house itself, and the brothers in the house were told to become more conscious of shutting off television sets, computers, and lights when they weren't in use, amongst other considerations. After the implementation of several environmentally friendly changes throughout the building, another carbon footprint was calculated and compared to first measurement. The differences between the two measures will be presented and explored in this section.

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[20] "Carbon footprint -." Wikipedia, the free encyclopedia. 04 Apr. 2009 <http://en.wikipedia.org/wiki/Carbon_footprint>.

There are C02 emissions that are emitted though every process and material. The level of greenness of a process or material is dependent on the amount of necessary carbon emission versus the amount of cardon dioxide actually emitted. The goal is to emit as little carbon as possible, making the carbon emissions of that process or material green efficient. A comparative carbon footprint analysis is the best way to place the greenness of the house in measureable terms. We researched the amount of C02 that was produced by certain processes, the cost associated with the production of that C02, and the savings in cost and C02 that could be gained though our recommended implementation. To measure the carbon footprint of the house, we had to first determine what exactly comprised the carbon footprint for the facility. We decided that the major contributor to our carbon footprint was electricity consumption, gas usage, waste water management, and waste management (recycling). To measure the impact our implanted changes would have on the environment, we performed the carbon footprint analysis using data from the original operating process and factors of the house regarding the sub areas that comprise the C02 footprint. After we improved house processes, we recalculated the carbon footprint using new data from our changes. All equations used for the calculations are listed below:

Gas

- Average number of therms consumed per month / Emission Factor * months in a year; *Emission factor (natural gas/therm) = 11.7*

Electricity

- Average number of kWh consumed per month * electricity emission factor * months in a year ; *Emission Factor = .909*

Waste Water

-

Waste

- Aluminum- Number of people in household * average number of pounds of CO_2 equivalent per person per year that could be saved by aluminum and steel cans; *average number of pounds of CO_2 equivalent per person per year that could be saved by recycling metal = 145.58*
- Plastic - Number of people in household * average number of pounds of CO_2 equivalent per person per year that could be saved by recycling plastic; *average number of pounds of CO_2 equivalent per person per year that could be saved by recycling metal = 145.58*
- Glass- Number of people in household * average number of pounds of CO_2 equivalent per person per year that could be saved by recycling glass; *average number of pounds of CO_2 equivalent per person per year that could be saved by recycling glass = 29.95*
- New Paper- Number of people in household * average number of pounds of CO_2 equivalent per person per year that could be saved by recycling newspaper; *average number of pounds of CO_2 equivalent per person per year that could be saved by recycling newspaper = 172.38*
- Magazine- Number of people in household * average number of pounds of CO_2 equivalent per person per year that could be saved by aluminum and steel cans; *average number of pounds of CO_2 equivalent per person per year that could be saved by recycling magazines = 51.91*

Implementation

Turn down the Thermostat in the Winter

- Natural gas, then, CO_2 emissions from natural gas * percentage of energy source allotted to heating * savings per degree of setback (heating season) * number of degrees thermostat is turned down; *savings per degree of setback (heating season) = 3%, percentage of natural gas allotted to heating = 77%*

Energy Star Windows

- (Average annual energy savings from switching single pane windows to low-e ENERGY STAR windows / Btu's per thousand cubic feet of natural gas) * natural gas emission factor; average annual energy savings from switching single pane windows to low-e ENERGY STAR windows = 25,210,000 BTUs

Lighting

- Number of 75-watt incandescent light bulbs replaced * annual KWH savings per lamp * electricity emission factor; *annual kWh savings per lamp = 80, annual energy cost saving per lamp = $7.00, Emission Factor = .909*

Sleep Feature

- Emission reduction annual energy savings from enabling sleep feature on computer and monitor * electricity emission factor; *annual energy savings from enabling sleep feature on computer and monitor = 98 kWh*

Washing your Clothes in Cold Water

- average estimated kWh per load * emission factor * total number of loads per week * number of weeks in a year; average estimated kWh per load = 1.07 kWh

Below is the carbon footprint analysis for the original condition of the facility processes.

Table 5.1.10: Carbon Footprint Analysis before Implementation

Table 5.1.10 displays the estimated total carbon emissions from the original process of the fraternity house

Before Implementation

Before Green Implementation		C02 (lbs)
Number of People in Home	18	
Primary Heating Source	Natural Gas	
Natural Gas used per month	286 Therms	40,154
Electricity used per month	4300 KWH	46,899
Water Management		12,779
Recycling Total		18,378
Recycle aluminum	No	
Recycle Plastic	No	
Recycle Glass	No	
Recycle News Paper	No	
Recycle Magazines	No	
Totals		**118,210**

The chart above displays the original information gathered about the facility from the gas bill, electric bill, water consumption, and water management. We used the calculations to determine the pounds of C02 emitted given the process of the facility. After creating a bench mark to compare new data to, we began the implementation process in attempts to make the house more green efficient and hopefully produce a cost savings as well.

Table 5.1.11: Carbon Footprint Cash Flow and Cost-Benefit Analysis

Table 5.1.11 displays the calculated savings in dollars and lbs of C02 from the implemented green process change for the fraternity houses. The chart also displays the percent savings of total carbon emissions from the current activity and energy practices of the house in comparison to the total carbon emissions of the original sate of the house.

Cost- Benefit Analysis

Item	Cost	Annual Savings	C02 Reduction (lbs)	% Total C02
Electricity				
Enabling sleep mode on computers	$0	$10	89	
Installing automatic light switches	$147	$472	4,336	
Sum	**$147**	**$482**	**4,425**	**4%**
Lighting				
Replaced incandescent bulbs with CFL's	$130	$1,582	14,521	
Sum	**$130**	**$1,582**	**14,521**	**12%**
Water Heating				
Turned temperature down 10 ◦ F	$25	$48	480	
Insulate Water Heater	$25	$36	1,200	
Sum	**$50**	**$84**	**1,680**	**1%**
HVAC				
Turn down thermostat 7◦ F	$0	$760	6,493	
Weather strip doors/ Caulking windows	$18	$50	692	
Sum	**$18**	**$810**	**7,185**	**6%**
Waste Water Management				
Low flow showerheads & faucet ends	$30	$435	4,050	
2 half- gallon milk jugs in toilet tanks	$0	$70	1,162	
Sum	**$30**	**$505**	**5,212**	**4%**
Waste Production and Recycling	-	-	-	-
Implement Recycling Total	$80.00	$480		
Recycle aluminum	"		2,620	
Recycle Plastic	"		2,620	
Recycle Glass	"		539	
Recycle News Paper	"		3,103	
Recycle Magazines	"		934	
Sum	**$80**	**$480**	**9,816**	**8%**
Total	***$455***	***$3,944***	***42,839***	***36%***

In table 5.1.10, we see the total amount of C02 that is initially created from the amount of gas used is about 40,154 lbs, the amount of C02 that is created from electricity used is 46,899 lbs, and the amount of C02 that is generated from not recycling in a house with 18 people is about 18,378 lbs. The house had no current practices in place to help manage waste water, such as low flow shower heads, devices to minimize the gallon per flush of the toilets, or green water usage habits, producing a total annual amount of about 12,779 lbs of C02. The total amount of C02 that is created through these actions and process in a house of 18 people is 118,210 lbs of C02. Using the equations listed, we were able to take information from the changes that we had implemented and calculate the total costs the house would save, the total C02 emissions reduction, and the percent total reduction of new conditions in comparison to the old process. We took the most measureable changes that we had implemented and calculated the data and effect they had on the house. One of the more involved calculations that had many variables was the process of lighting the house. Below is Table 5.1.3, which displays all data and results from calculations in regards to lighting. From this data, it can be seen that our implemented changes in the lighting have reduced annual carbon emissions by nearly 15%.

Table 5.1.3: Cash Flow and Cost-Benefit for Lighting

Table 5.1.3 displays a cash flow analysis and cost benefit analysis for the electricity used, cost, C02 produced, and C02 saved from implementation

	Original Lighting	Green Implementation
# 48" FL	12	12
48" FL Watt	40	40
# CFL	0	65
CFL Watt	14	14
# Incandescent	65	0
Incandescent Watt	60	60
# bulbs in Personal room	25	25
# of Bulbs in Common Room	40	40
# of FL's in Common Room	12	12
Common room hrs	16	12
Person Room Hrs	12	12
Price Per KWH	$0.129	$0.129
Monthly KWH for Lighting	1794.24	467.04
Annual KWH for Lighting	21530.88	5604.48
Monthly Cost	$231.46	$60.25
Monthly savings	$171.21	
% Savings	73.97%	
Annual Cost	$2,777.48	$722.98
Annual Savings	$2,054.51	
% Annual Savings	73.97%	
Monthly CFL KWH	606.48	
Monthly CFL KWH with Auto Switches	467.04	
Savings of Auto Switches	139.44	
CO2 Produced (lbs)	25,493	6,636
CO2 Saved (lbs)	18,857	
% total CO2 Savings	15.7%	

1 KWH grid energy = 1.184 lb CO2 $ per KWH = $ .129

After performing calculations for each field, our changes retuned an estimated total annual savings of $3,944. More importantly, our changes also reviled that the new total carbon emissions of the house would be 75,371 lbs of C02, which is 42,839 lbs less than the original carbon emissions of 118,210 lbs of C02. This is a calculated 36.2% reduction of carbon emissions in comparison to original operation of the fraternity house.

Table 5.1.12: Carbon Footprint Comparison

Table 5.1.12 is a simple table that displays the C02 emissions from before and after implementation and the % reduction of the original process.

	Before	After	Difference	% original	% Decrease
HVAC	40,154	32,969	7,185	82.1%	17.9%
Electricity	46,899	26,273	20,626	56.0%	44.0%
Waste Water Management	12,779	7,567	5,212	59.2%	40.8%
Recycling	18,378	8,562	9,816	46.6%	53.4%
Sum	118,210	75,371	42,839	63.8%	36.2%

From the chart above it can be seen that our largest improvements were in the area of electricity, using nearly 20,626 less lbs of C02 than before, improving the efficiency of the process and allowing it to operate at 56% the carbon emissions of the original process. We were also able to decrease the total emissions from usage of HVAC by 7,185 lbs of C02 which is 17.9% less than the total carbon emitted from the previous usage amount. One of our largest percent reduction in C02 was in the area of recycling, allowing the recycling process of the house to operate while emitting 47% of the original total of emissions of C02. We also showed significant improvement in the area of waste water management, reducing the total process by 41%, the new process emitting a total of 7,567 lbs of C02. The pie chart in Figure 5.2.20 below illustrates the potential reduction of carbon emissions of the fraternity house. Further analysis can be seen though the bar graph in Figure 5.2.18:

Figure 5.2.20: Pie Chart Carbon Footprint Comparison

Figure 5.2.20 uses a pie chat to demonstrate the new carbon footprint in comparison to the old carbon footprint and the percent emissions reduction

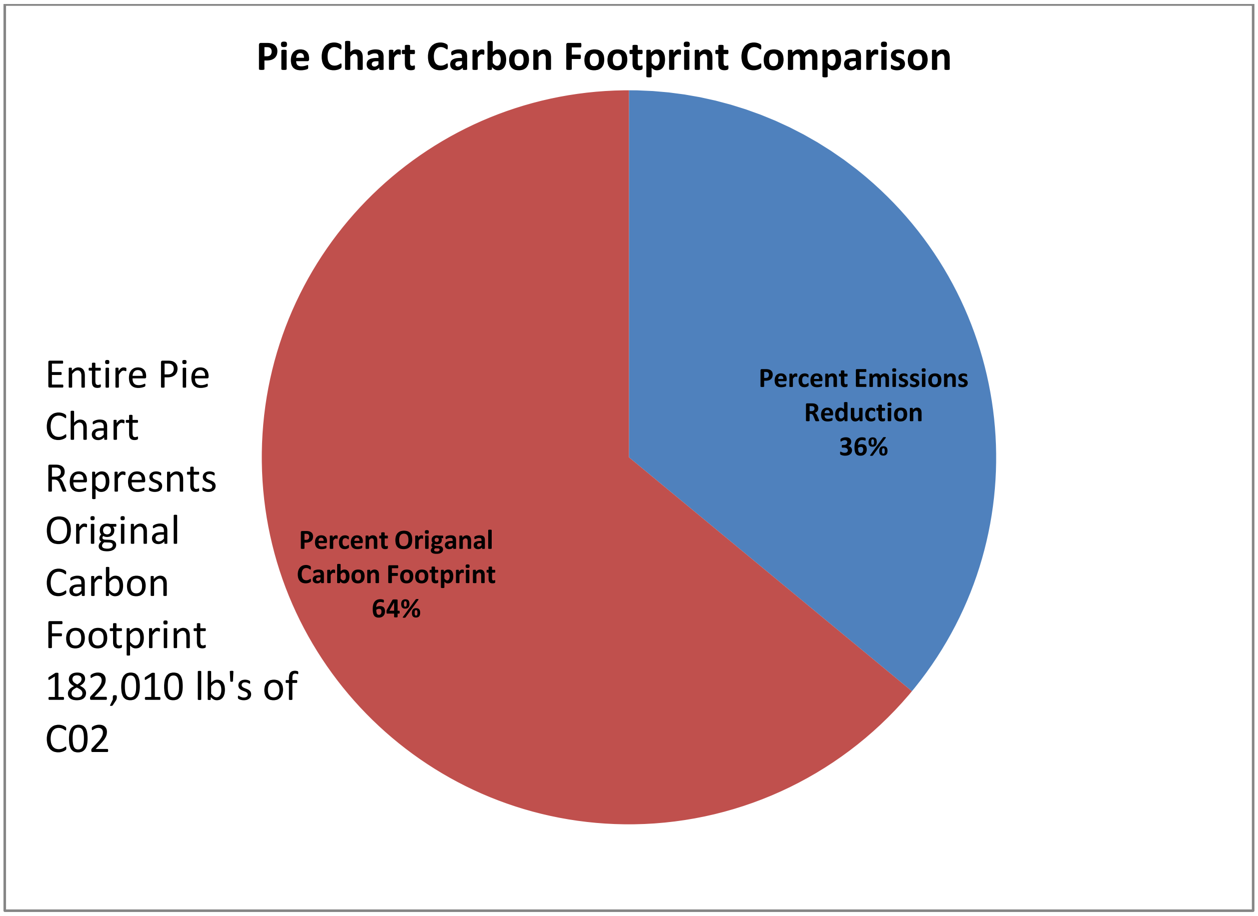
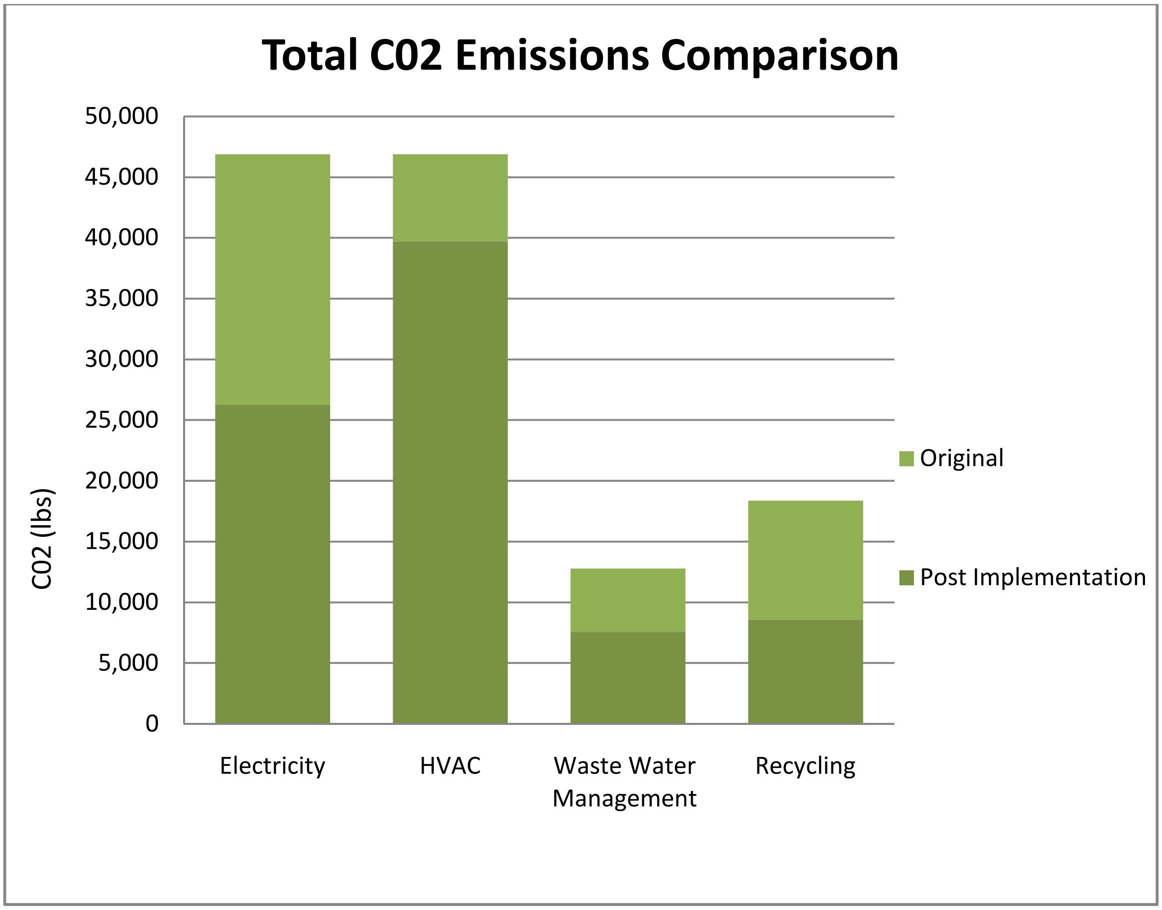


Figure 5.2.18: Carbon Footprint Comparison

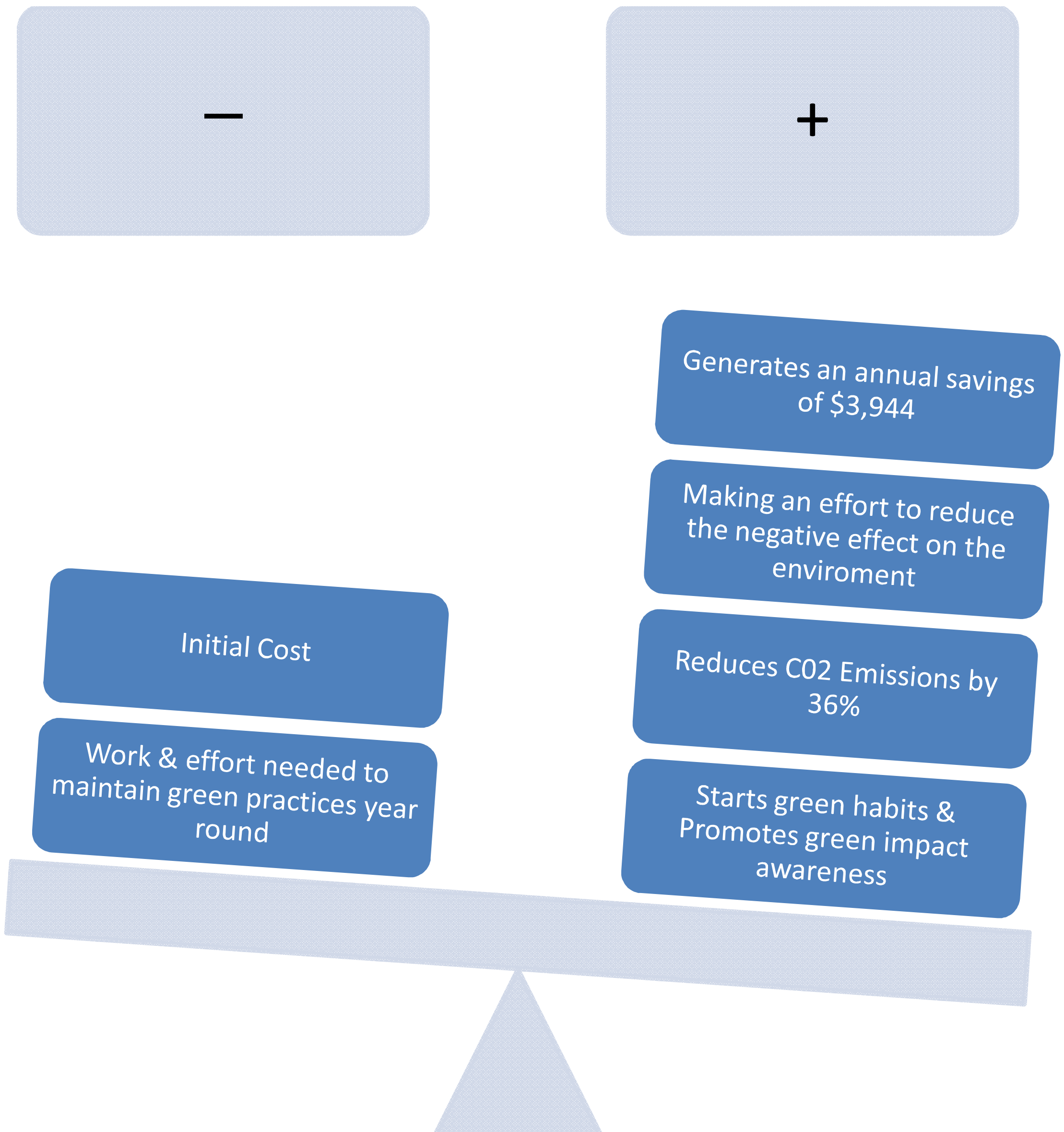
Figure 5.2.16 shows the difference between the emissions produced from Gas/heat, Electricity, Wastewater Management, and Recycling before and after the implementation of our emission reduction technique



The information gathered concerning the amount of C02 that has been reduced is fairly accurate given the equation. Using the equation for our green implantation techniques, the house was to decrease gas usage by 18%, operating at 82% the original quantity of gas used. From the hard data that we received, our implementation showed a 78% decrease in overall gas consumption. With our estimated calculations retuning data that was exactly the same as our hard data and a mere 4% off our estimated calculation, we see these calculations as reliable in regards of the amount of C02 produced. Also, using the equations to calculate the projected savings after our implemented changes for electricity usage, we expected to receive an increase in green operating efficiency by 44%. After analyzing the hard data received from the electric bill, and comparing the data from our implemented changes to the historic electricity consumption for that month, our savings were less than the original process. This means that our calculations were 3% off our actual results. This is very impressive and reinforces the accuracy of our calculations considering the number of variables that could affect the results over the course of a month.

The data from the carbon footprint analysis verifies that our green implementation process has had significant reduction in the amount of C02 produced. In terms becoming greener, the main concern is not the amount of money that is saved, but the reduction of carbon emissions through improved operation techniques in comparison to original operations. In a house that is over 100 years old and had been owned by a fraternity for 35 years, making improvements to the reduction of C02 emissions was no easy process. Below is Figure 5.2.23: Benefit Analysis and it is used to demonstrate the positives (+) and negatives (-) for our implementation:

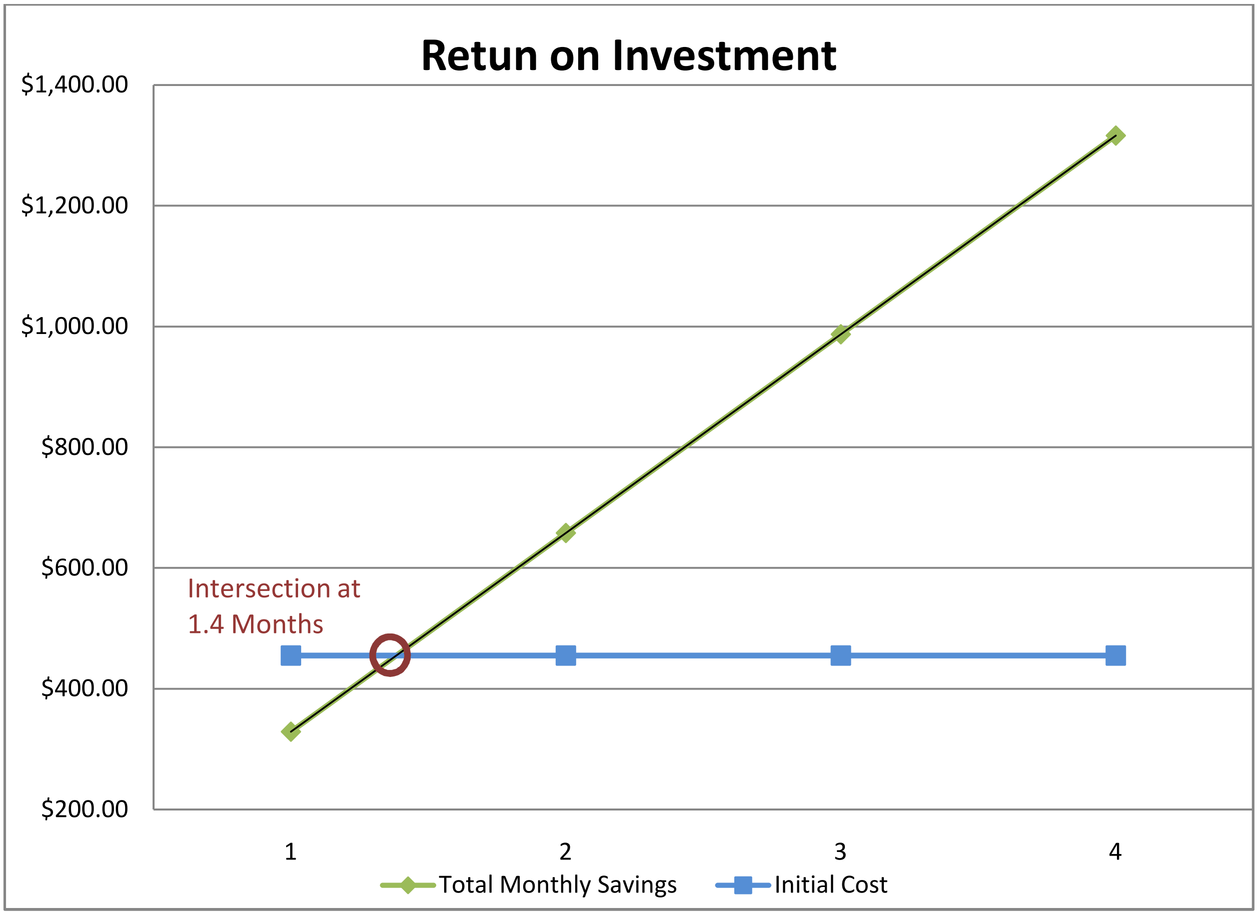
Figure 5.2.23: Benefit Analysis



The positives from this cost benefit analysis weigh heavily in the favor of continuing our green process implementation. Since the costs are reasonably low, and the projected savings are reasonably high compared to the initial investment, the cost aspect is completely justified. With an initial investment of $455 and a projected annual savings of $3,944, the payback period for the return on investment is 1.4 months. This means that since our implementation in February of 2009 to current month of April 2009, we have past the breakeven point of our investment and have received a return of $532. For those reasons alone the costs of our efforts to improve the green efficiency are completely justified.

Figure 5.2.19: Break Even Analysis

Figure 5.2.19 uses a Break Even Analysis to look into where a return on investment can be seen from the savings versus the cost.



However, in “greening up” a process, the most important factor is not the cost or savings, but the reduction that new green process has on the environment. In some situations this means additional costs and lower savings or profits, because the impact that is being made on the environment is given a higher weight of importance. In this case, justifying reduced costs vs. reduced impact on the environment would be more difficult if only one of the two situations were achievable. However, we have created a process where both are achievable and the overall benefit to the process has been maximized. The positives and negatives for the decisions are displayed in Figure 5.2.23.

Aside from the statistics presented in terms of emissions reductions and savings generated, other benefits to improving the facility’s process are starting green habits, promoting green impact awareness, and making an effort to minimize the negative impact of the current process on the environment. All of these aspects are very important because they help encourage people to be mindful and conscious of their actions. They also help to spread the benefits of going green in a continuous effort to minimize our impact on the world and to treat the earth with respect.

7. Conclusion

Can simple home improvements really do that much in terms of saving the environment? Would a budget of $500.00 be enough to see any significant improvement over time? The answer is an overwhelming and almost surprising yes. Examining the houses carbon footprint after all of our changes were implemented allows us to see where our CO_2 emissions were reduced the most, the new percent of total emissions in a given area, and how much money we were able to save in each area. It can also be noted that lower carbon emissions are interrelated with consuming less energy and thus a lower energy bill.

In the short amount of time allotted to us to perform this experiment, we have seen significant results in just one month. That being said, the amount of carbon dioxide prevented from traveling into the atmosphere on the Zeta Psi fraternity house's behalf has been significantly reduced. The first step in the experiment was to see what the damage was before implementation of changes. The amount of natural gas used per month was estimated to be roughly 286.28 therms during the school year, running an average bill of $419.82. It was found that gas alone roughly caused 40,154 lbs of carbon dioxide to be emitted each year. An estimated 46,899 lbs of CO_2 per year was calculated as a result of electricity use amongst the eighteen inhabitants of the house, averaging on 4304 KWH during the school year with an annual average cost of $551.00. Wastewater management could have been considered poor, ultimately amounting to roughly 12,779 lbs of CO_2. Finally, it should be noted that the house was not recycling on a regular basis, which amounted to roughly 18,378 lbs of CO_2 emissions. Aluminum, plastic, glass, news paper, and magazines were simply being disguarded, causing for more CO_2 to be emitted than necessary. Altogether, the house was generating a whopping 118,210 lbs of CO_2.

After putting our suggested changes into practice, another carbon footprint was estimated. Comparing our historic gas bill data to the new data collected for the months of February and March, we see that the average number of therms used in February historically was roughly 542 and the average number of therms used in March historically was about 521, with average costs of $763.79 and $736.56 respectively. After the completion of our experiment, we found the average number of therms used in February to be 445 with test cost $598.81, and the average number of therms used in March to be 421 with an average cost of 569.28 for the year 2009. This yielded a difference of 97 therms and $164.98 in February and 100 therms and $167.28 in March.

Significant improvements were also made in the area of electricity usage. Average historic electric bill data held that the average number of KWH for February and March were 4,461 and 4,317, with average costs of $569.00 and $550.00. Our test data showed that only 2,507 and 2,590 KWH were used during the months of February and March after implementation with costs of $320.00 and $330.00. Altogether we were able to save 1,954 KWH and $249.00 in February and 1,727 KWH and $220.00 for the month of March. After our green implementations, the average monthly savings resulted in approximately $171.21, roughly 73.97% on each bill. Annually, we reduce $2,777.48 to $722.98, saving $2,054.51 and 18,857 lbs of CO_2.

Waste water management was improved via installing low flow showerheads and faucet ends, along with adding half gallon milk jugs filled with sand into the toilet tanks to cut down on the water used per flush. Altogether, the low flow showerheads and faucet ends cost the house $30.00 which was nothing compared the $435.00 we were able to save annually. This one improvement alone was able to reduce CO_2 emissions by 4,050 lbs. The half gallon milk jugs cost the house nothing but saved the house another $70.00 and the environment from 1,162lbs of CO_2. In total, 5,212 lbs of CO_2 were saved, saving $505.00 in annual costs and serving as 4% of the houses' new percent total emissions.

The last big change the house underwent was a new recycling policy. Tenants were required to recycle aluminum, plastic, glass, news paper, and magazines. The purchase of the recycling bins was only a minor cost compared to the $480.00 the house was able to save in trash collection fees. Aluminum and plastic, if recycled, could save roughly 2,620 lbs of CO_2 per person per year. Surpassing the amount of potential CO_2

savings of aluminum and plastic is news paper, potentially saving around 3,103 lbs of CO_2. Next, the recycling of magazines could save about 934 lbs of CO_2 yearly, and last is glass, when recycled, saving about 539 lbs per person yearly. In total, after applying the recycling guiding principle, the house saved 9,816 lbs of CO_2 from being released. Being as the recycling process requires a higher amount of energy, this procedure accounts for 8% of total emissions.

After adding up all cost saving, CO_2 emission reduction, and the percent of total emissions, we found the estimated reduction of annual emissions to be about 42,839lbs, the potential cost savings to be about $3,944, and the new estimated CO_2 emissions to be 75,371 lbs, an improvement from the previous 118,210 lbs. Heating ventilation and air conditioning dropped from 40,154 lbs of CO_2 emission to 32,969 lbs, electricity went from a devastating 46,899 lbs to 26,273, wastewater management reduced from 12,779 to 7,567lbs, and recycling plunged from 18,378 lbs to 8,562lbs. Percent total emissions were reduced by about 36%. This 36% is broken up into six different categories. Water heating accounts for only 3% of the percent savings, waste water management improvements account for 11% of savings, green electricity implementations account for 12% of savings, HVAC improvements caused for 17% savings, recycling accounted for 23% of savings, and last but certainly not least was the lighting improvements, accounting for 34% of total savings. This dramatic decrease was the result of only a few basic and low- cost home improvements.

A small budget of $500.00 paid for itself in excess of two times over within one year's time, breaking even around 1.4 months. Our process is cheap, easy, and will show results within a period of just one month in several areas. The entire facility operation was improved, both cost wise and emissions wise, using the process we have created for going green in an already- existing and inhabited building. The initial costs and cost of continuing green practices year round are outweighed, in a positive sense, by the annual cost savings amount, saving the environment from several negative impacts, the reduction of CO_2 emissions, and the beginning of the development of personal green habits. This project proves that going green isn't a difficult or wasteful task, but one that could save you money while protecting the environment from the harmful effects human consumption can have on its resources and atmospheric conditions.

7. Appendix

7.1. Tables

Table 7.1.1: Weekly Lighting Time

Table 7.1.1 shows the number of hours in each day lighting remains on in different areas of the house as designated in the table.

Monday	H way 1	H way 2	H way 3	Family/TV	Bar	Dinning	Kitchen	B room 1	B room 2	Basement
8 am -12 pm	3	3	3	4	0	1	3	3	3	0
12pm- 5 pm	2	4	4	0	0	1	4	4	4	4
5 pm -10 pm	4	4	4	4	4	4	4	4	4	4
10 pm -2 am	3	3	3	3	3	3	3	3	3	3
2 am-8 am	5	5	5	1	5	0	5	5	5	0
Tuesday	H way 1	H way 2	H way 3	Family/TV	Bar	Dinning	Kitchen	B room 1	B room 2	Basement
8 am -12 pm	3	3	3	1	0	0	3	3	3	1
12pm- 5 pm	4	4	4	4	4	4	4	4	5	4
5 pm -10 pm	5	5	5	5	5	5	5	5	5	0
10 pm -2 am	4	4	4	4	4	4	4	4	4	2
2 am-8 am	5	5	5	5	5	5	5	5	5	0

Table 7.1.1: Weekly Lighting Time

Wednesday	H way 1	H way 2	H way 3	Family/TV	Bar	Dinning	Kitchen	B room 1	B room 2	Basement
8 am -12 pm	3	3	3	1	0	0	4	1	3	0
12pm- 5 pm	2	4	4	4	0	0	4	3	4	0
5 pm -10 pm	4	4	4	1	2	4	4	4	4	4
10 pm -2 am	3	3	3	3	3	3	3	3	2	3
2 am-8 am	5	5	0	0	5	0	5	5	5	5
Thursday	H way 1	H way 2	H way 3	Family/TV	Bar	Dinning	Kitchen	B room 1	B room 2	Basement
8 am -12 pm	1	3	3	0	0	3	3	3	3	0
12pm- 5 pm	2	4	4	2	4	2	3	2	4	4
5 pm -10 pm	4	4	4	4	4	4	4	4	4	4
10 pm -2 am	3	3	3	3	3	3	3	3	3	3
2 am-8 am	5	5	5	0	5	5	5	5	0	0
Friday	H way 1	H way 2	H way 3	Family/TV	Bar	Dinning	Kitchen	B room 1	B room 2	Basement
8 am -12 pm	3	2	3	1	0	0	3	5	5	0
12pm- 5 pm	2	0	3	2	4	5	5	5	5	4
5 pm -10 pm	4	4	4	4	4	4	4	4	5	4
10 pm -2 am	4	4	4	4	4	4	4	4	4	3
2 am-8 am	5	5	5	5	5	5	5	5	5	0

Table 7.1.1: Weekly Lighting Time

Saturday	H way 1	H way 2	H way 3	Family/TV	Bar	Dinning	Kitchen	B room 1	B room 2	Basement
8 am -12 pm	3	3	3	0	0	0	4	4	3	0
12pm- 5 pm	2	0	1	0	1	0	4	4	4	4
5 pm -10 pm	5	5	5	4	4	4	5	5	1	4
10 pm -2 am	4	4	4	4	4	4	3	3	3	3
2 am-8 am	5	5	5	3	5	5	5	5	5	0
Sunday	H way 1	H way 2	H way 3	Family/TV	Bar	Dinning	Kitchen	B room 1	B room 2	Basement
8 am -12 pm	3	1	1	2	0	0	3	3	3	0
12pm- 5 pm	2	4	4	0	3	0	4	4	4	3
5 pm -10 pm	4	4	4	4	4	4	5	5	4	2
10 pm -2 am	3	3	3	3	3	3	3	3	3	3
2 am-8 am	5	5	5	3	0	0	5	5	5	5

Table 7.1.2: Weekly Lighting Time Average & Sum

Table 7.1.2 shows the sum and average of the amount of hours lighting remains on in each area in the house in a given week. The sum and average of hours in each day is also shown for each location.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Sum	Average
H way 1	17	21	17	15	15	18	17	120	17.14286
H way 2	19	21	19	19	15	17	17	127	18.14
H way 3	19	21	14	19	19	18	17	127	18.14
Family/TV	12	19	9	9	16	11	12	88	12.57
Bar	12	18	10	16	17	14	10	97	13.86
Dinning	9	18	7	17	18	13	7	89	12.71
Kitchen	19	21	20	18	21	21	20	140	20.00
B room 1	19	21	16	17	23	21	21	138	19.71
B room 2	22	18	14	14	16	16	19	119	17.00
Basement	11	7	12	11	11	11	13	76	10.86
Sum	159	185	138	155	171	160	153	1121	
Average	15.9	18.5	13.8	15.5	17.1	16	15.3		16.01

Table 7.1.3: Cash Flow and Cost-Benefit for Lighting

Table 7.1.3 displays a cash flow analysis and cost benefit analysis for the electricity used, cost, C02 produced, and C02 saved from implementation

	Original Lighting	Green Implementation
# 48" FL	12	12
48" FL Watt	40	40
# CFL	0	65
CFL Watt	14	14
# Inca decent	65	0
Incandescent Watt	60	60
# bulbs in Personal room	25	25
# of Bulbs in Common Room	40	40
# of FL's in Common Room	12	12
Common room hrs	16	12
Person Room Hrs	12	12
Price Per KWH	$0.129	$0.129
Monthly KWH for Lighting	1794.24	467.04
Annual KWH for Lighting	21530.88	5604.48
Monthly Cost	$231.46	$60.25
Monthly savings	$171.21	
% Savings	73.97%	
Annual Cost	$2,777.48	$722.98
Annual Savings	$2,054.51	
% Annual Savings	73.97%	
Monthly CFL KWH	606.48	
Monthly CFL KWH with Auto Switches	467.04	
Savings of Auto Swathes	139.44	
CO2 Produced (lbs)	25,493	6,636
CO2 Saved (lbs)	18,857	
% total CO2 Savings	15.7%	

1 KWH grid energy = 1.184 lb CO2 $ per KWH = $ .129

Table 7.1.4: Electric Bill 2005 – 2008, KWH & Cost

Table 7.1.4 shows data from electricity bills Zeta Psi received between January of 2005 and December of 2008. Bills are sent monthly and include the kilowatt hours and cost.

Year	Month	Kilowatt Hours(KWH)	Price
05	Jan	3106	397.26
05	Feb	4411	564.17
05	Mar	4356	557.13
05	Apr	5223	668.02
05	May	4457	570.05
05	Jun	4188	535.65
05	Jul	5057	646.79
05	Aug	4801	614.05
05	Sep	6862	877.65
05	Oct	6438	823.42
05	Nov	5441	695.9
05	Dec	5579	713.55
06	Jan	4231	541.14
06	Feb	5041	644.74
06	Mar	5115	654.21
06	Apr	4430	566.6
06	May	3773	482.57
06	Jun	3367	430.64
06	Jul	4399	562.63
06	Aug	3841	491.26
06	Sep	4396	562.25
06	Oct	4776	610.85
06	Nov	4009	512.75
06	Dec	4076	521.32
07	Jan	2555	326.78
07	Feb	3900	498.81
07	Mar	3913	500.47
07	Apr	4017	513.77
07	May	3515	449.57
07	Jun	2720	347.89
07	Jul	3168	405.19

Table 7.1.4: Electric Bill 2005 – 2008, KWH & Cost

Year	Month	Kilowatt Hours(KWH)	Price
07	Aug	3081	394.06
07	Sep	4821	616.61
07	Oct	5035	643.98
07	Nov	3856	493.18
07	Dec	4248	543.32
08	Jan	3382	432.56
08	Feb	4491	574.4
08	Mar	3884	496.76
08	Apr	3935	503.29
08	May	3349	428.34
08	Jun	2903	371.29
08	Jul	2945	376.67
08	Aug	2659	340.09
08	Sep	4492	574.53
08	Oct	3996	511.09
08	Nov	3834	490.37
08	Dec	4658	595.76
09	Jan	3564	455.84
09	Feb	2507	320.65
09	Mar	2590	331.26
	Average	4105	525

Table 7.1.5: Electric Bill Average KWH & Cost by Month for 2005 -2008

Table 7.1.5 shows the average kilowatt hours and the average cost of all electricity bills received between January 2005 and December 2008 on a monthly basis.

AVERAGES	AVERAGE KWH	AVERAGE COST
Jan	3368	431
Feb	4461	571
Mar	4317	552
Apr	4401	563
May	3774	483
Jun	3295	421
Jul	3892	498
Aug	3596	460
Sep	5143	658
Oct	5061	647
Nov	4285	548
Dec	4640	593
average	4186	535
Average in school	4304	551

Table 7.1.6: Electric Bill KWH & Cost Comparison for Data Received

Table 7.1.6 displays a comparison between the average kilowatt hours and the average cost of all electricity bills received for the months of February and March and is compared to the data received after implementation.

		Month	KWH	Cost
05-08 Historic Data	05	Feb	4411	$562
"	05	Mar	4356	$555
"	06	Feb	5041	$643
"	06	Mar	5115	$652
"	07	Feb	3900	$497
"	07	Mar	3913	$499
"	08	Feb	4491	$573
"	08	Mar	3884	$495
Test Data	09	Feb	2507	$320
"	09	Mar	2590	$330

Average Historic	Feb	4,461	$569
Average Test	Feb	2,507	$320
Difference		1,954	$249

Average Historic	Mar	4,317	$550
Average Test	Mar	2,590	$330
Difference		1,727	$220

	Average Historic KWH	**Average Historic Cost**	**Test KWH**	**Test Cost**
Feb	4,461	569	2,507	320
Mar	4,317	550	2,590	330

Table 7.1.7: Gas Bill 2005 – 2008, Therms & Cost

Table 7.1.7 shows data from gas bills Zeta Psi received between January of 2005 and December of 2008. Bills are sent monthly and include the number of therms and cost.

Year	Month	Therms	Price
05	Jan	521	$679.27
05	Feb	655	$653.05
05	Mar	575	$642.06
05	Apr	146	$184.56
05	May	74	$93.45
05	Jun	36	$49.16
05	Jul	58	$96.65
05	Aug	43	$74.25
05	Sep	130	$182.56
05	Oct	138	$218.29
05	Nov	311	$524.86
05	Dec	583	$950.33
06	Jan	539	$935.59
06	Feb	468	$798.02
06	Mar	499	$769.37
06	Apr	316	$392.57
06	May	125	$186.42
06	Jun	41	$57.23
06	Jul	66	$108.89
06	Aug	52	$88.45
06	Sep	107	$168.76

Table 7.1.7: Gas Bill 2005 – 2008, Therms & Cost

06	Oct	98	$155.62
06	Nov	185	$289.26
06	Dec	325	$457.95
07	Jan	542	$703.63
07	Feb	512	$701.85
07	Mar	492	$658.26
07	Apr	331	$426.45
07	May	109	$151.18
07	Jun	46	$69.58
07	Jul	69	$110.12
07	Aug	59	$95.64
07	Sep	76	$100.01
07	Oct	114	$179.98
07	Nov	124	$162.23
07	Dec	387	$708.23
08	Jan	448	$801.02
08	Feb	531	$902.24
08	Mar	516	$876.55
08	Apr	342	$443.87
08	May	110	$154.48
08	Jun	32	$56.79

Table 7.1.7: Gas Bill 2005 – 2008, Therms & Cost

08	Jul	73	$121.50
08	Aug	63	$110.63
08	Sep	85	$118.95
08	Oct	128	$140.67
08	Nov	136	$178.75
08	Dec	442	$803.98
09	Jan	530	$691.62
09	Feb	445	$598.81
09	Mar	421	$569.28

Table 7.1.8: Gas Bill Average Therms & Cost by Month for 2005 -2008

Table 7.1.8 shows the average number of therms and the average cost of all gas bills received between January 2005 and December 2008 on a monthly basis.

AVERAGES	AVERAGE THERMS	AVERAGE PRICE
Jan	516.00	$762.23
Feb	541.50	$763.79
Mar	520.50	$736.56
Apr	283.75	$361.86
May	104.50	$146.38
Jun	38.75	$58.19
Jul	66.50	$109.29
Aug	54.25	$92.24
Sep	99.50	$142.57
Oct	119.50	$173.64
Nov	189.00	$288.78
Dec	434.25	$730.12
Average	247.33	363.80
Average in school	286.28	419.82

Table 7.1.9: Historic Gas Therms & Cost vs. Test Data

Table 7.1.9 is a comparison between the average historic monthly therms and cost and the average therms and cost from the test months after implantation of energy efficiency techniques.

		Month	Therms	Cost
05-08 Historic Data	05	Feb	655	$653.05
"	05	Mar	575	$642.06
"	06	Feb	468	$798.02
"	06	Mar	499	$769.37
"	07	Feb	512	$701.85
"	07	Mar	492	$658.26
"	08	Feb	531	$902.24
"	08	Mar	516	$876.55
Test Data	09	Feb	445	$598.81
"	09	Mar	421	$569.28
	Average		511.4	$716.95

Average Historic	Feb	541.5	763.79
Average Test	Feb	445	598.81
Difference		96.5	164.98

Average Historic	Mar	520.5	736.56
Average Test	Mar	421	569.28
Difference		99.5	167.28

	Average Historic Therms	Average Historic Cost	Test Therms	Test Cost
Feb	542	763.79	445	598.81
Mar	521	736.56	421	569.28

Table 7.1.10: Carbon Footprint Analysis Before Implementation

Table 7.1.10 displays the estimated total carbon emissions from the original process of the fraternity house

Before Implementation

Before Green Implementation		C02 (lbs)
Number of People in Home	18	
Primary Heating Source	Natural Gas	
Natural Gas used per month	286 Therms	40,154
Electricity used per month	4300 KWH	46,899
Water Management		12,779
Recycling Total		18,378
Recycle aluminum	No	
Recycle Plastic	No	
Recycle Glass	No	
Recycle News Paper	No	
Recycle Magazines	No	
Totals		**118,210**

Table 7.1.11: Carbon Footprint Cash Flow and Cost-Benefit Analysis

Table 7.1.11 displays the calculated savings in dollars and lbs of C02 from the implemented green process change for the fraternity houses. The chart also displays the percent savings of total carbon emissions from the current activity and energy practices of the house in comparison to the total carbon emissions of the original sate of the house.

Cost- Benefit Analysis

Item	Cost	Annual Savings	C02 Reduction (lbs)	% Total C02
Electricity				
Enabling sleep mode on computers	$0	$10	89	
Installing automatic light switches	$147	$472	4,336	
Sum	**$147**	**$482**	**4,425**	**4%**
Lighting				
Replaced incandescent bulbs with CFL's	$130	$1,582	14,521	
Sum	**$130**	**$1,582**	**14,521**	**12%**
Water Heating				
Turned temperature down 10 ◦ F	$25	$48	480	
Insulate Water Heater	$25	$36	1,200	
Sum	**$50**	**$84**	**1,680**	**1%**
HVAC				
Turn down thermostat 7◦ F	$0	$760	6,493	
Weather strip doors/ Caulking windows	$18	$50	692	
Sum	**$18**	**$810**	**7,185**	**6%**
Waste Water Management				
Low flow showerheads & faucet ends	$30	$435	4,050	
2 half- gallon milk jugs in toilet tanks	$0	$70	1,162	
Sum	**$30**	**$505**	**5,212**	**4%**
Waste Production and Recycling	-	-	-	-
Implement Recycling Total	$80.00	$480		
Recycle aluminum	"		2,620	
Recycle Plastic	"		2,620	
Recycle Glass	"		539	
Recycle News Paper	"		3,103	
Recycle Magazines	"		934	
Sum	**$80**	**$480**	**9,816**	**8%**
Total	***$455***	***$3,944***	***42,839***	***36%***

Table 7.1.12: Carbon Footprint Comparison

Table 7.1.12 is a simple table that displays the C02 emissions from before and after implementation and the % reduction of the original process.

	Before	After	Difference	% original	% Decrease
HVAC	40,154	32,969	7,185	82.1%	17.9%
Electricity	46,899	26,273	20,626	56.0%	44.0%
Waste Water Management	12,779	7,567	5,212	59.2%	40.8%
Recycling	18,378	8,562	9,816	46.6%	53.4%
Sum	118,210	75,371	42,839	63.8%	36.2%

Figures

<u>*7.2.1 Figures*</u>

Figure 7.2.1: Average Hrs Mon – Sun

Figure 7.2.1 shows the average number of hours per day lights are turned on in common areas.

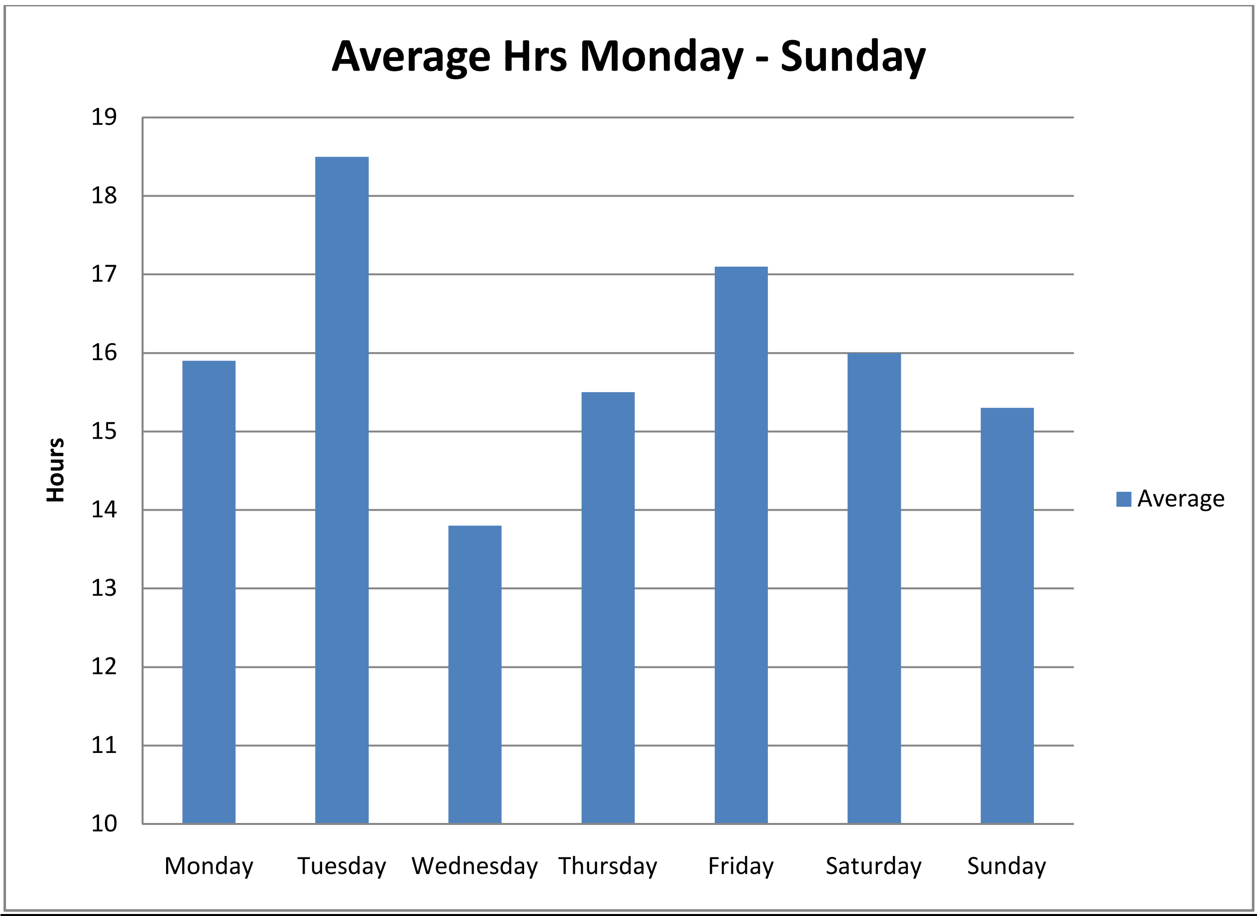


Figure 7.2.2: Average Hrs by Room

Figure 7.2.2 shows the average number of hours per week lights remain on in each location.

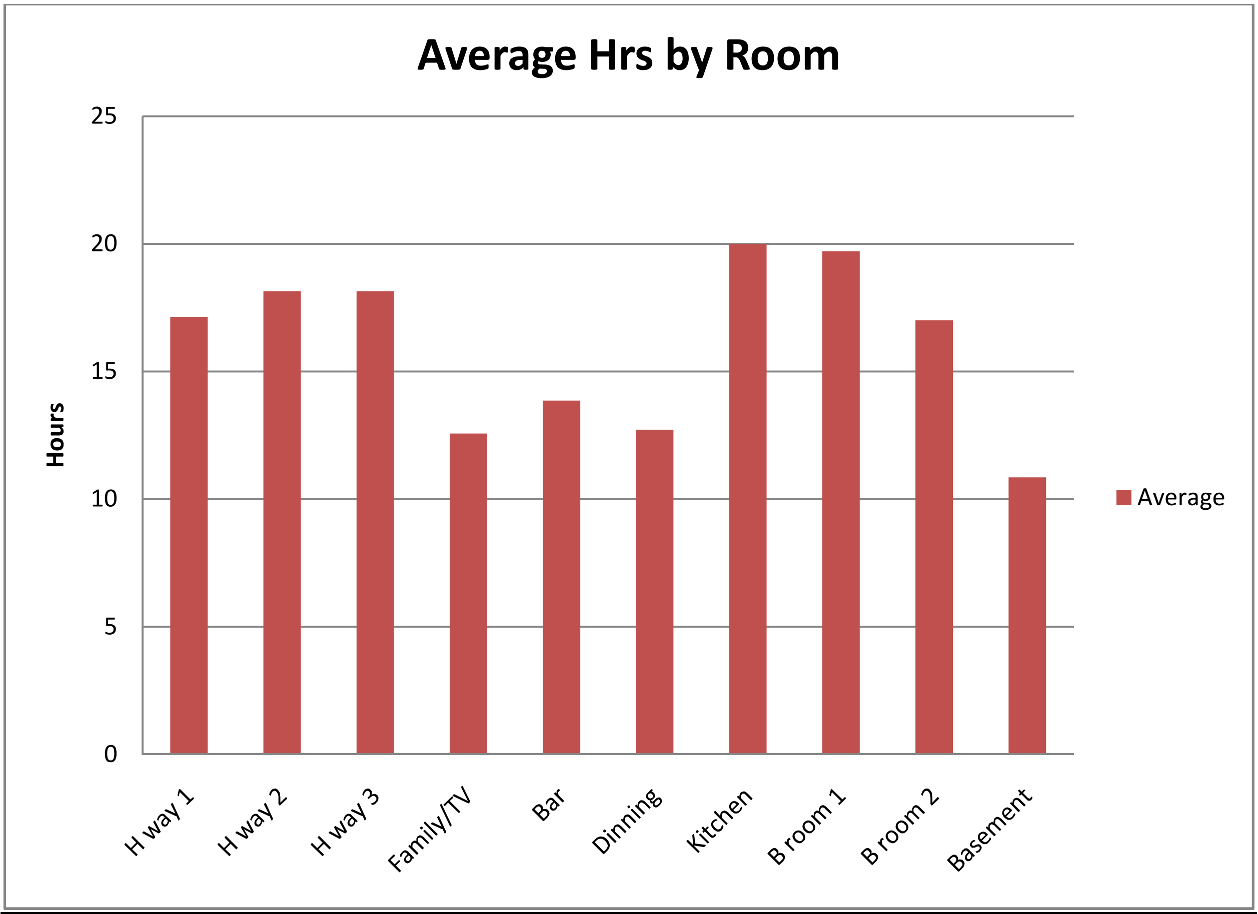


Figure 7.2.3: Common Room Sum Hrs by Room

Figure 7.2.3 shows the number of hours in a given week lights remain on in each area.

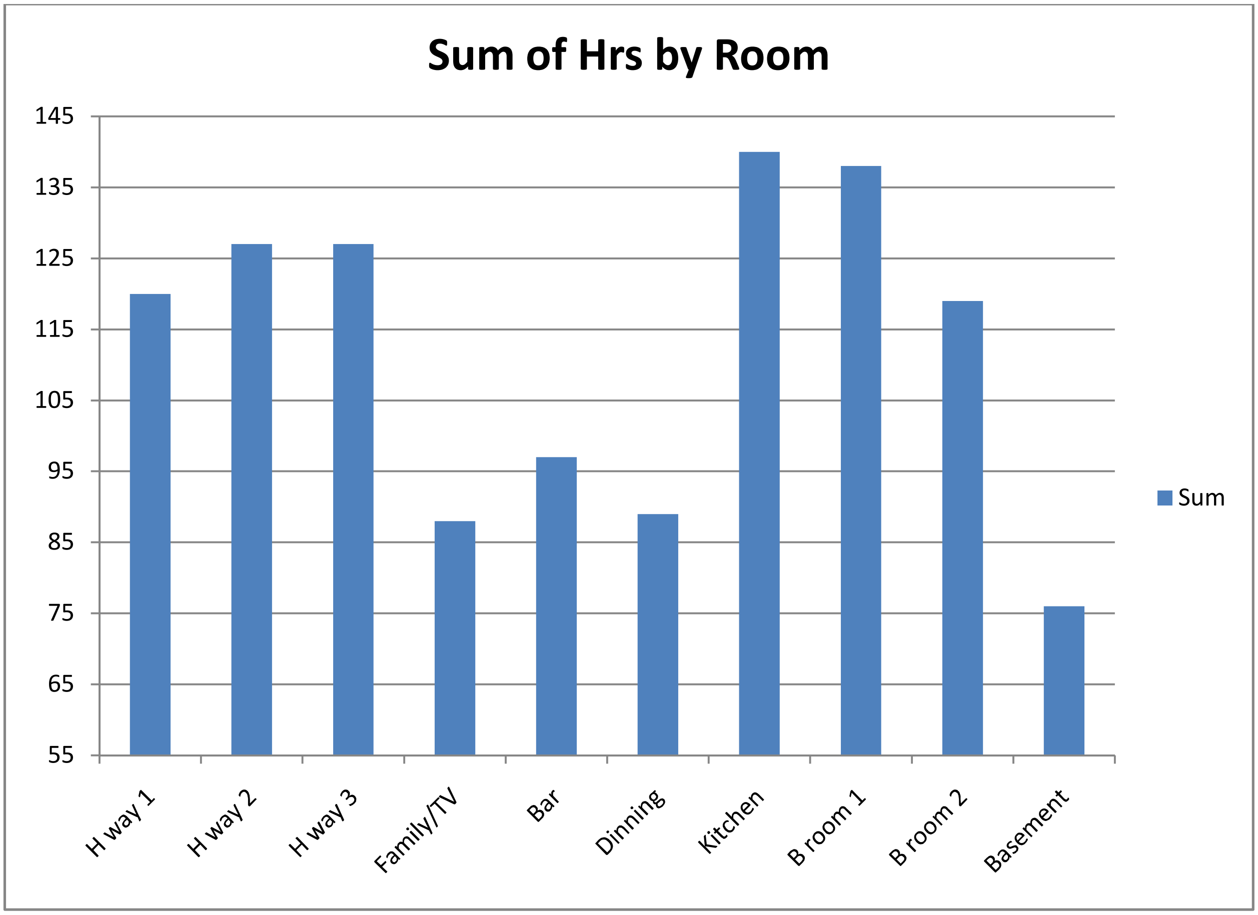


Figure 7.2.4: Common Room Sum Hrs by Day

Figure 7.2.4 shows the number of hour's total in which lights remain on per day.

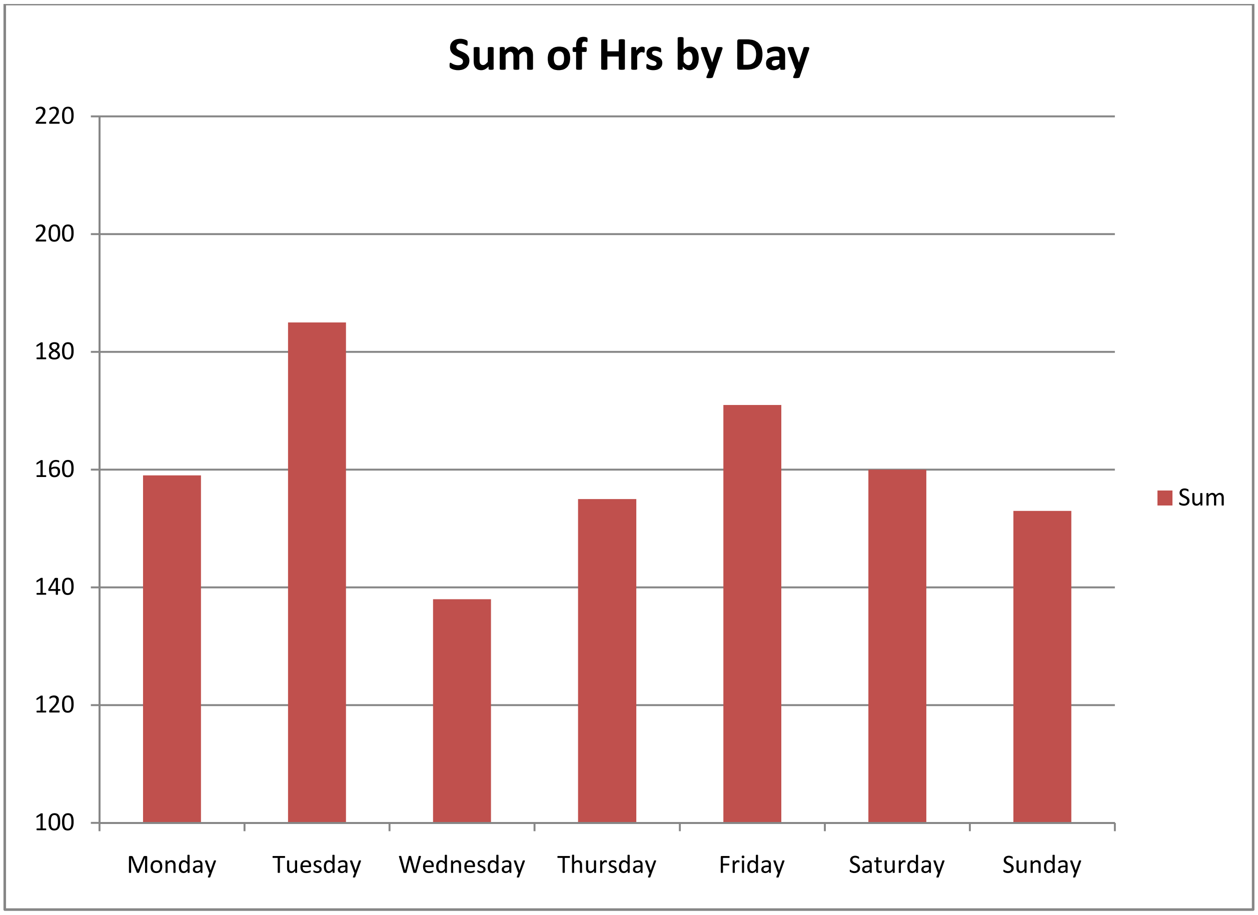


Figure 7.2.5: Common Room Average Hrs Room Comparison

Figure 7.2.5 is a comparison of hours lights are left on each day in each designated area.

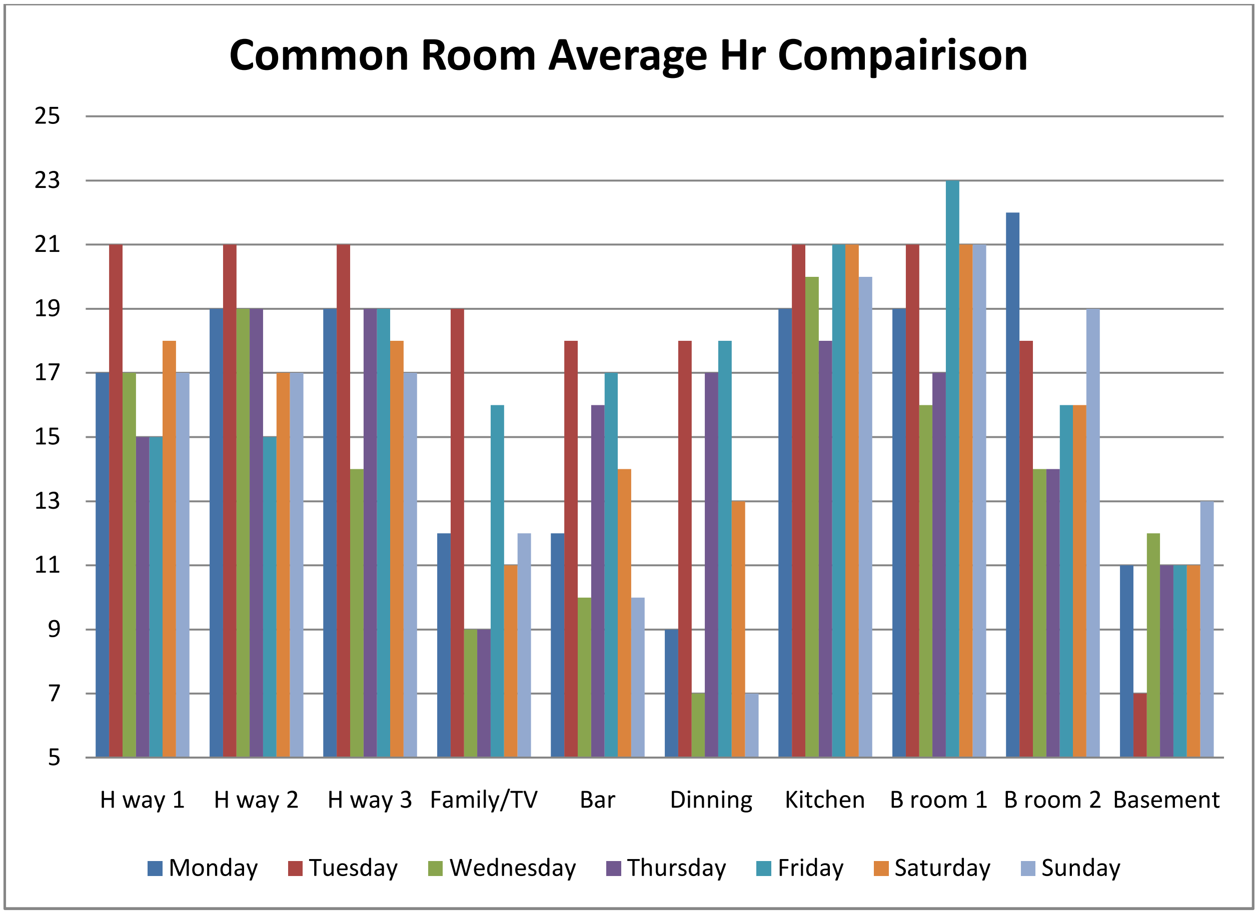


Figure 7.2.6: Electricity Cost Year Comparison

Figure 7.2.6 is a comparison of electricity bill expenses per month from 2005 to 2008.

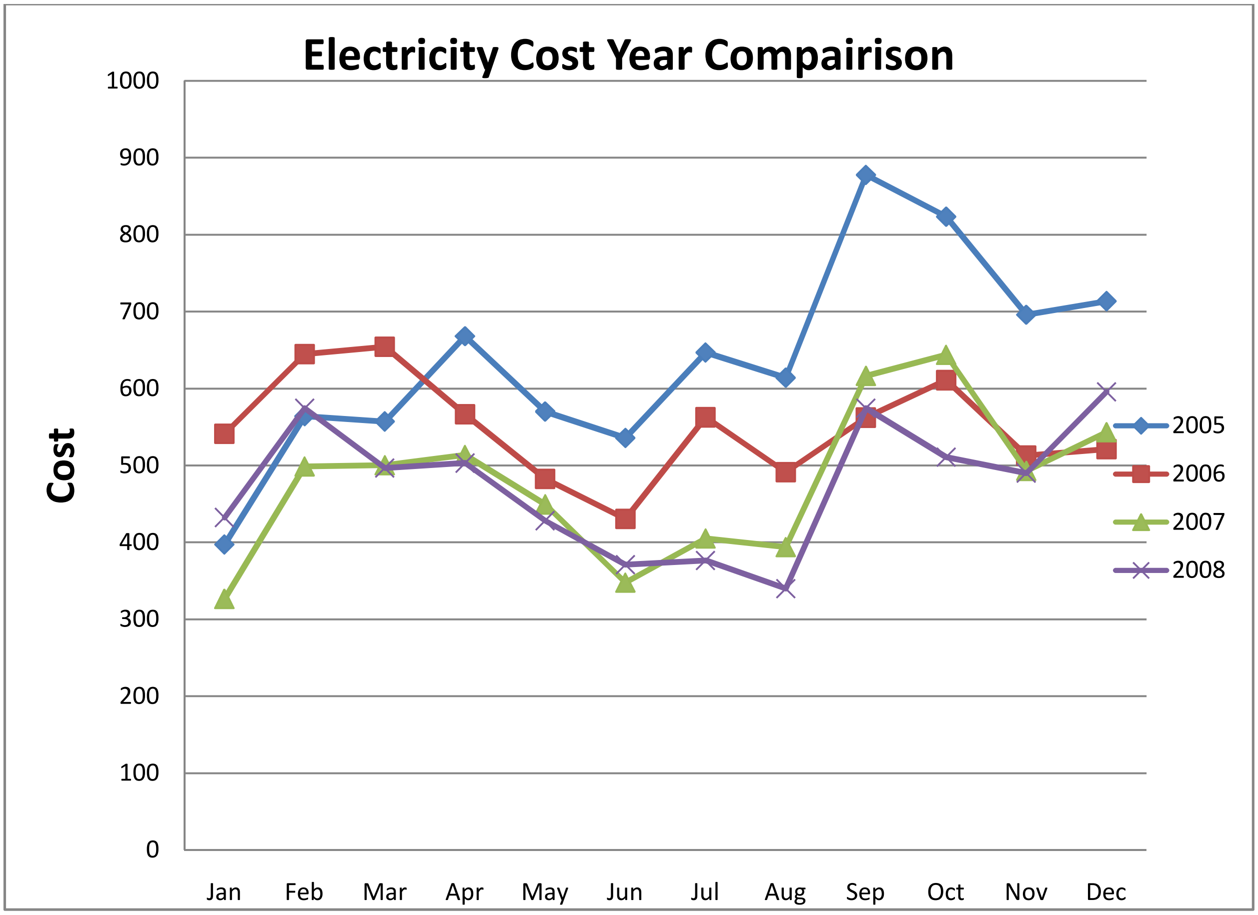


Figure 7.2.7: Electricity KWH Year Comparison

Figure 7.2.7 is a comparison of kilowatt hours per month from 2005 to 2008.

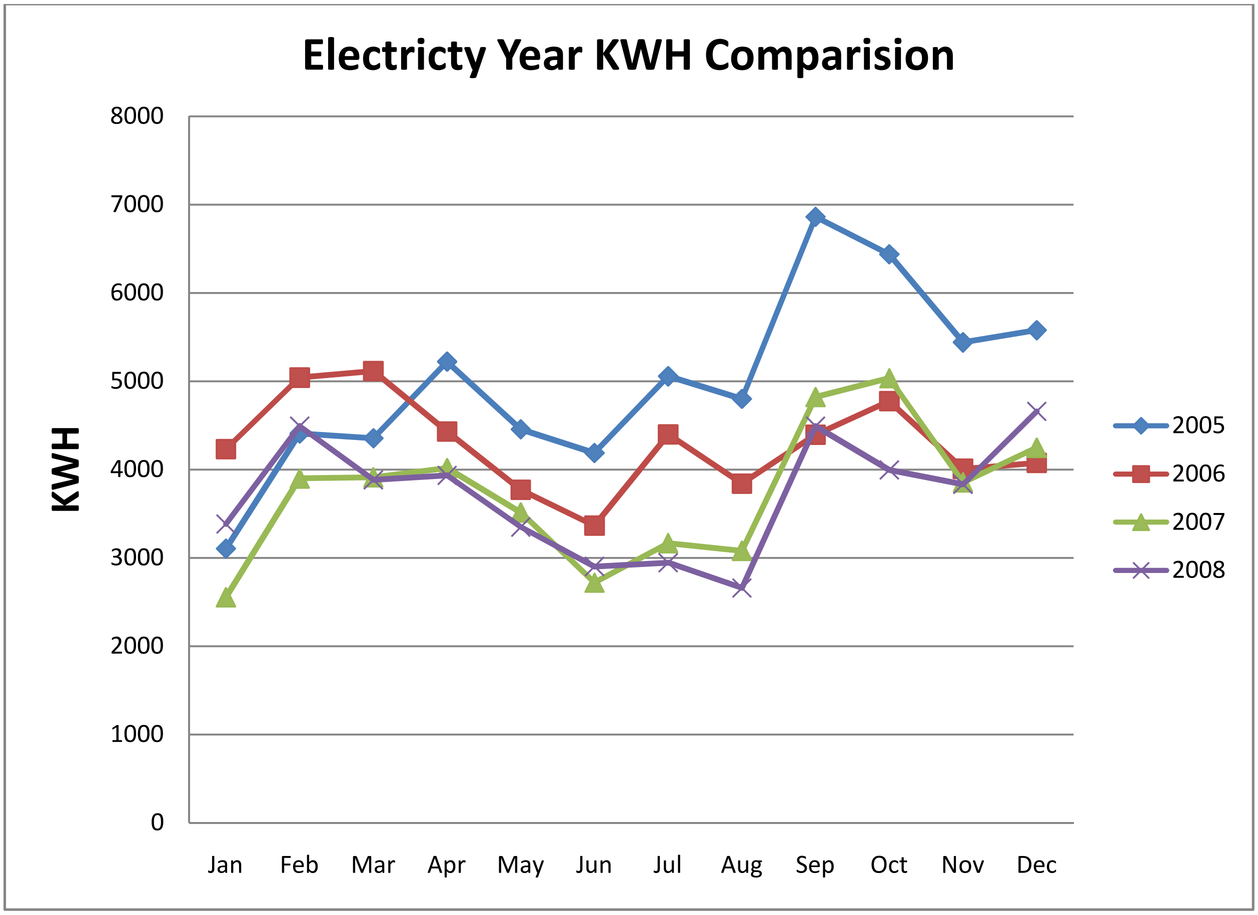


Figure 7.2.8: Average Electricity Cost Jan –Dec

Figure 7.2.8 shows the average electricity cost per month for years 2005 through 2008.

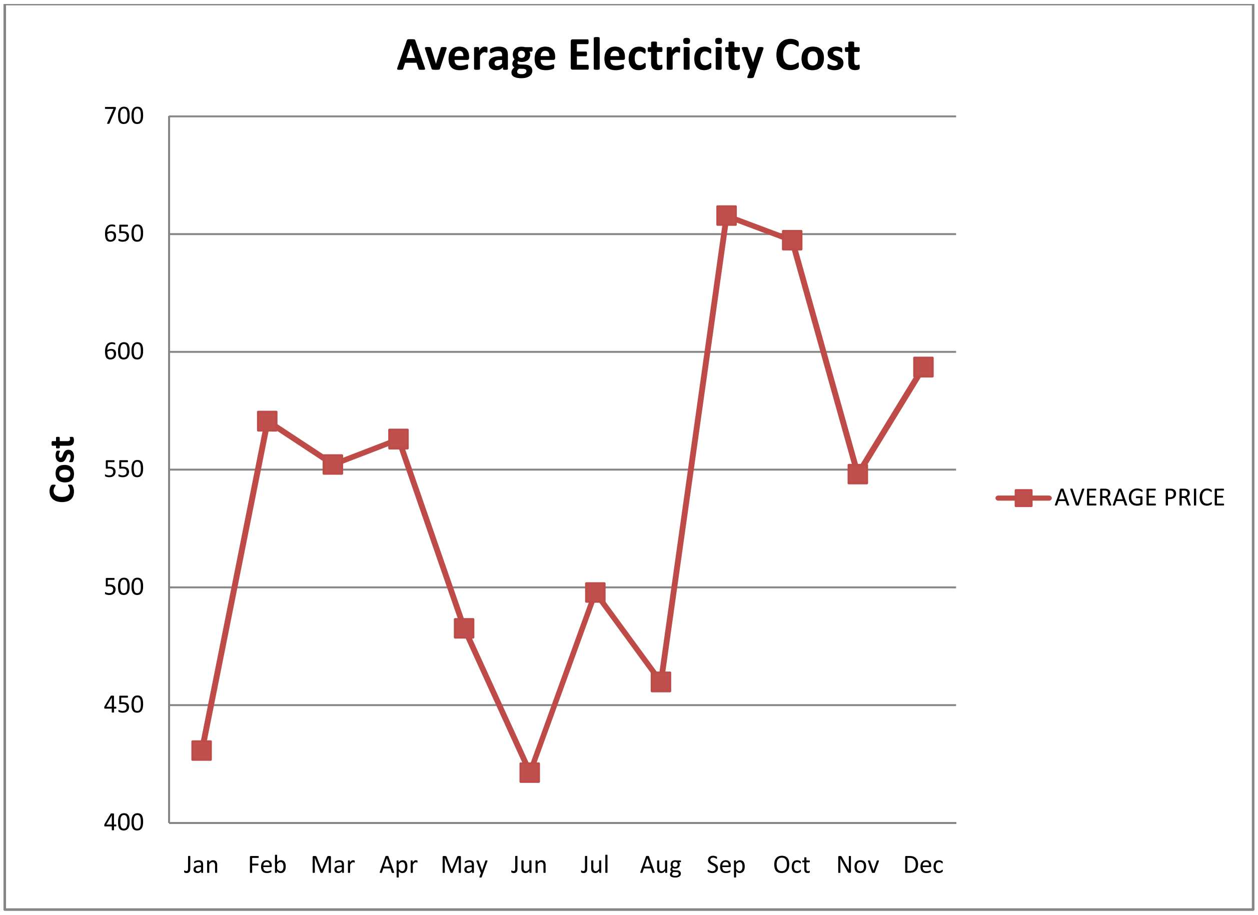


Figure 7.2.9: Average Electricity KWH Jan –Dec

Figure 7.2.9 shows the average kilowatt hours used per month for years 2005 through 2008.

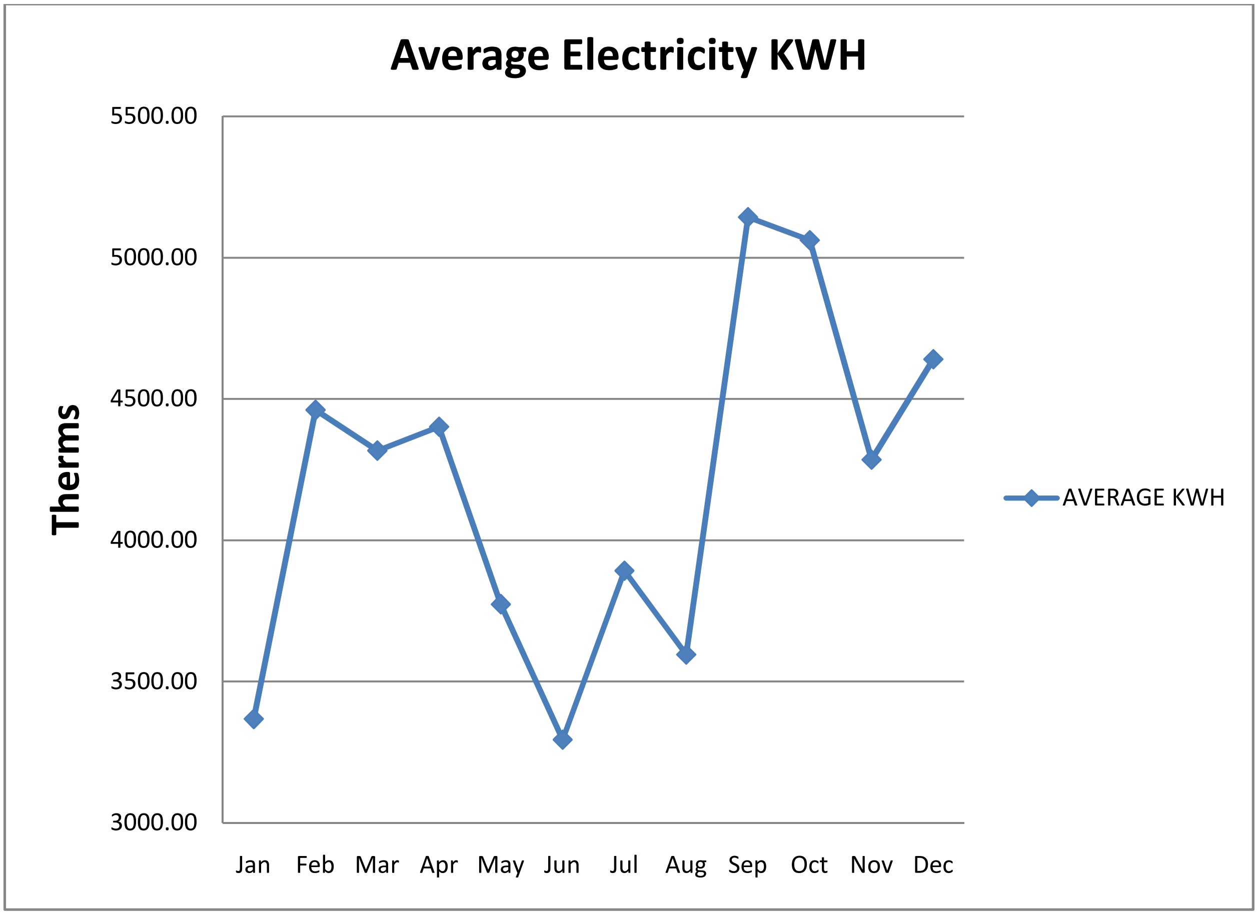


Figure 7.2.10: Electricity Cost Trend 2005-2008

Figure 7.2.10 shows the electricity cost trend, mapping the cost for each month from January 2005 to December 2008.

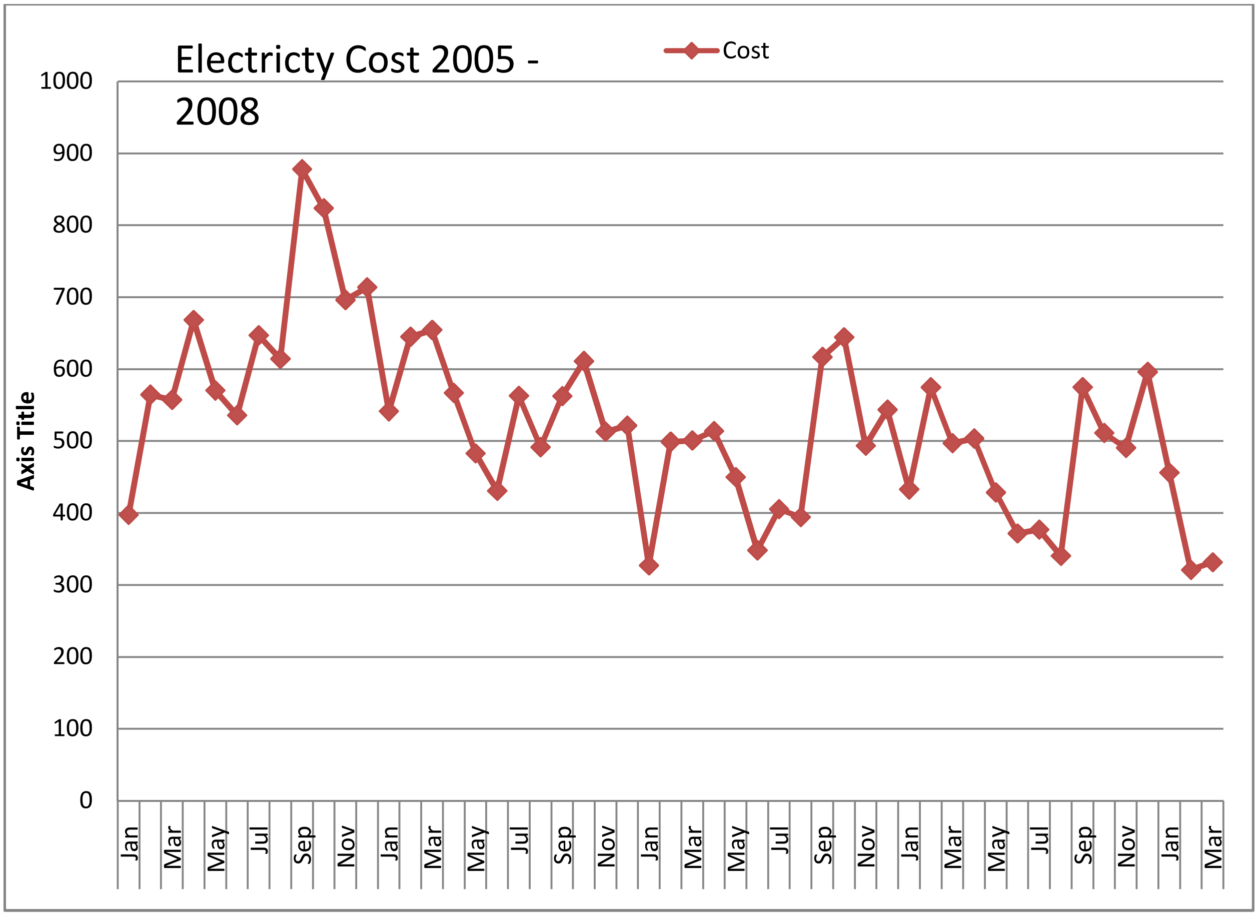


Figure 7.2.11: Electricity KWH Trend 2005-2008

Figure 7.2.11 shows the electricity kilowatt hour usage trend. Each amount of kilowatts used per month is shown from January 2005 to December 2008.

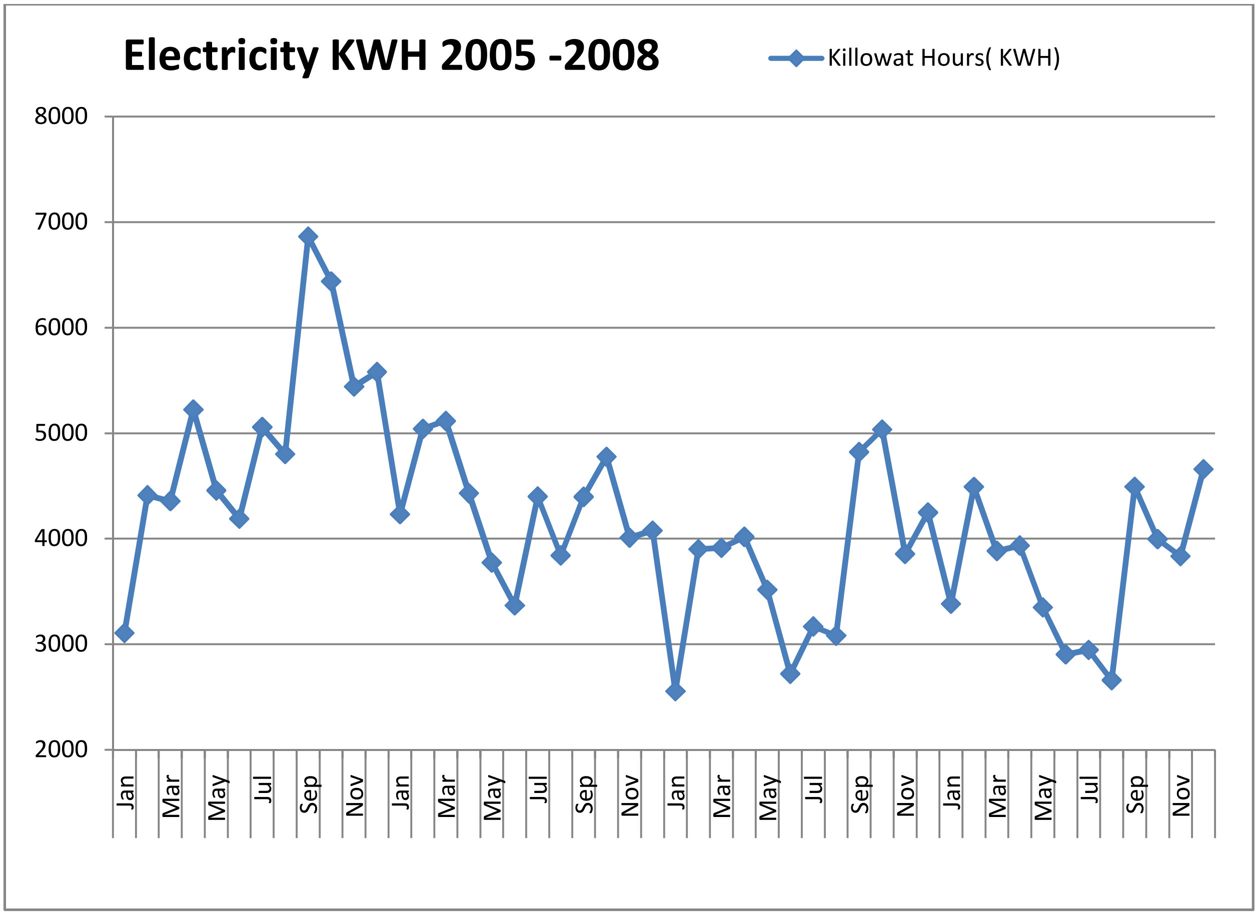


Figure 7.2.12: Gas Cost Year Comparison

Figure 7.2.12 shows the gas cost trend, mapping the cost for each month from January 2005 to December 2008.

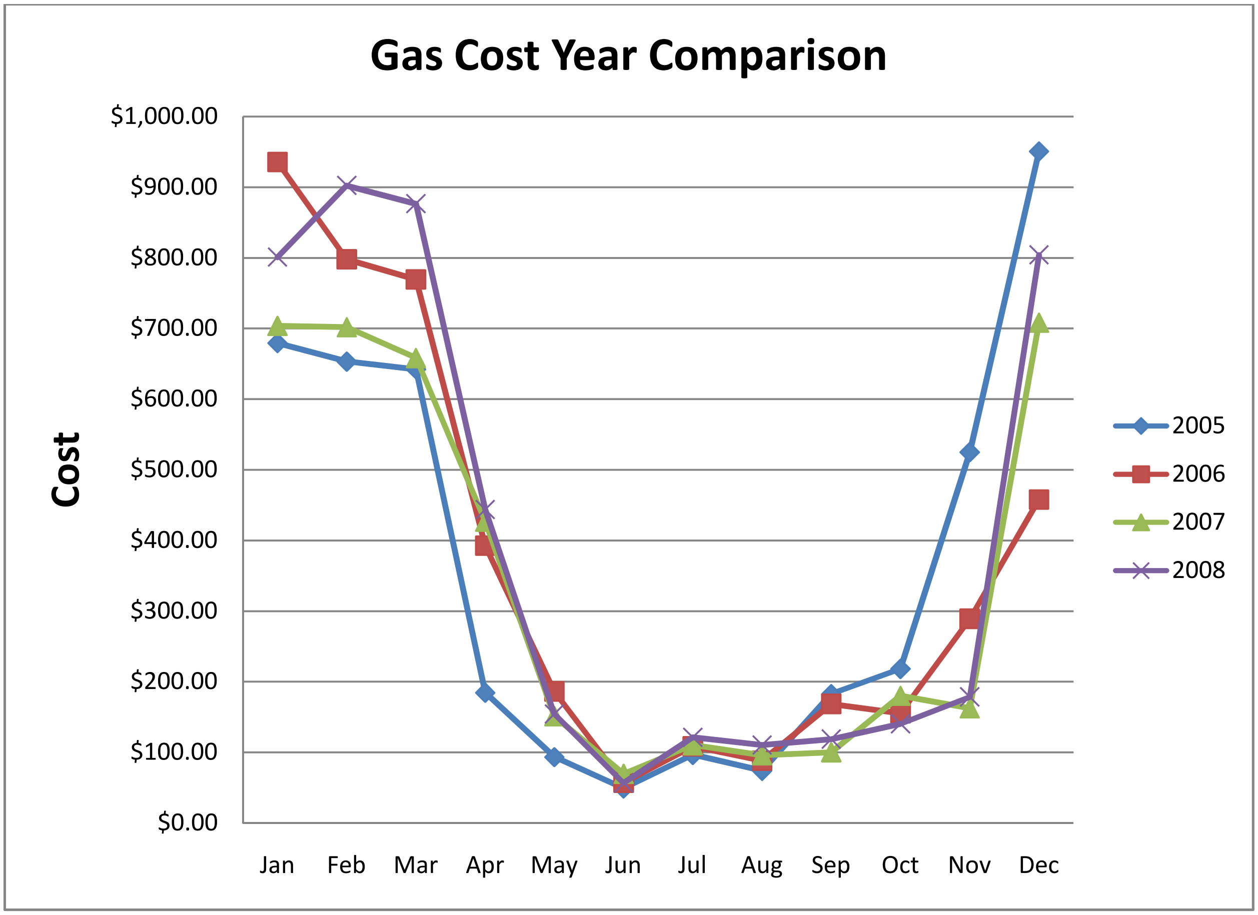


Figure 7.2.13: Gas Therms Year Comparison

Figure 7.2.13 shows the thermo usage trend. Each amount of Therms used per month is shown from January 2005 to December 2008.

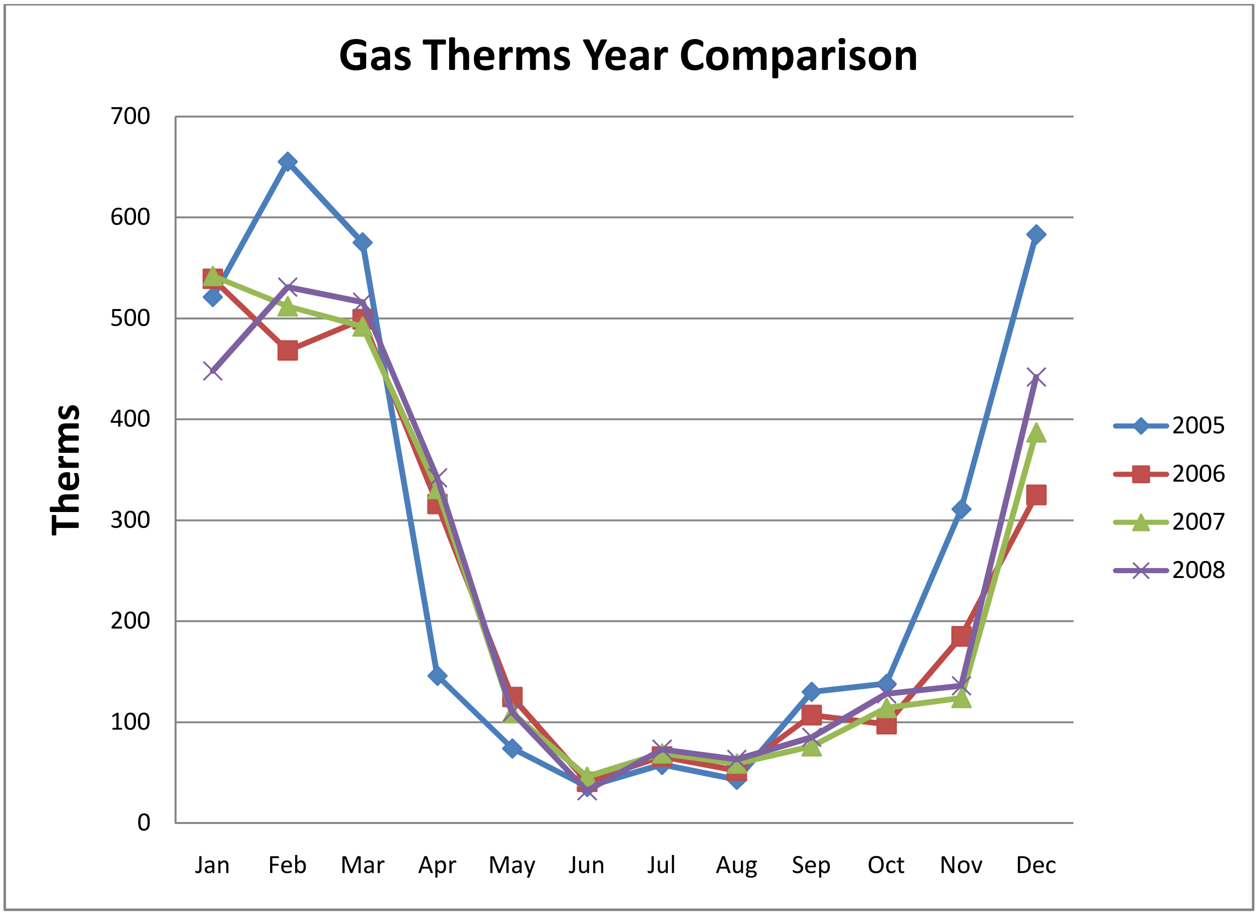


Figure 7.2.14: Average Gas Cost Jan –Dec

Figure 7.2.14 shows the average gas cost per month for years 2005 through 2008.

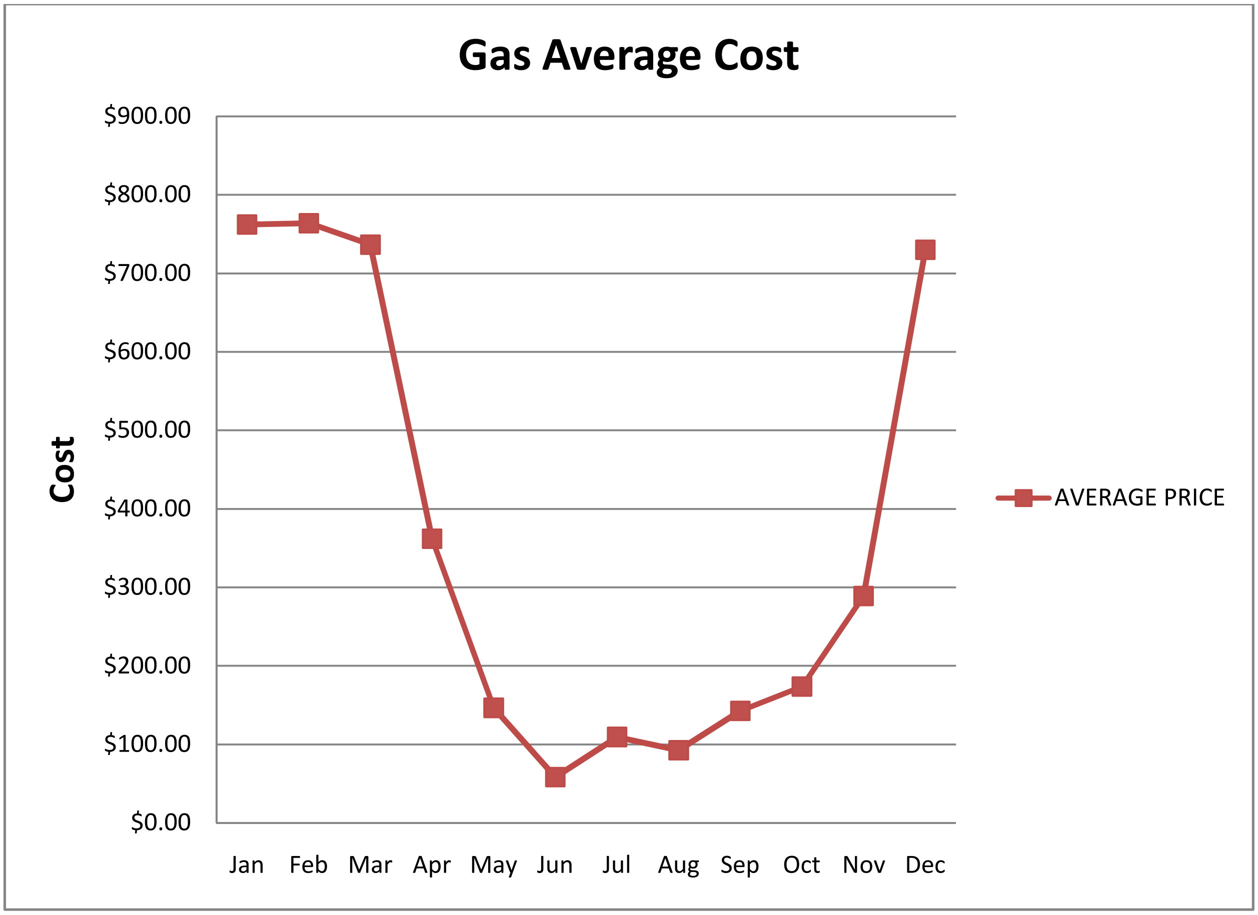


Figure 7.2.15: Average Gas Therms Jan –Dec

Figure 7.2.15 shows the average therms used per month for years 2005 through 2008.

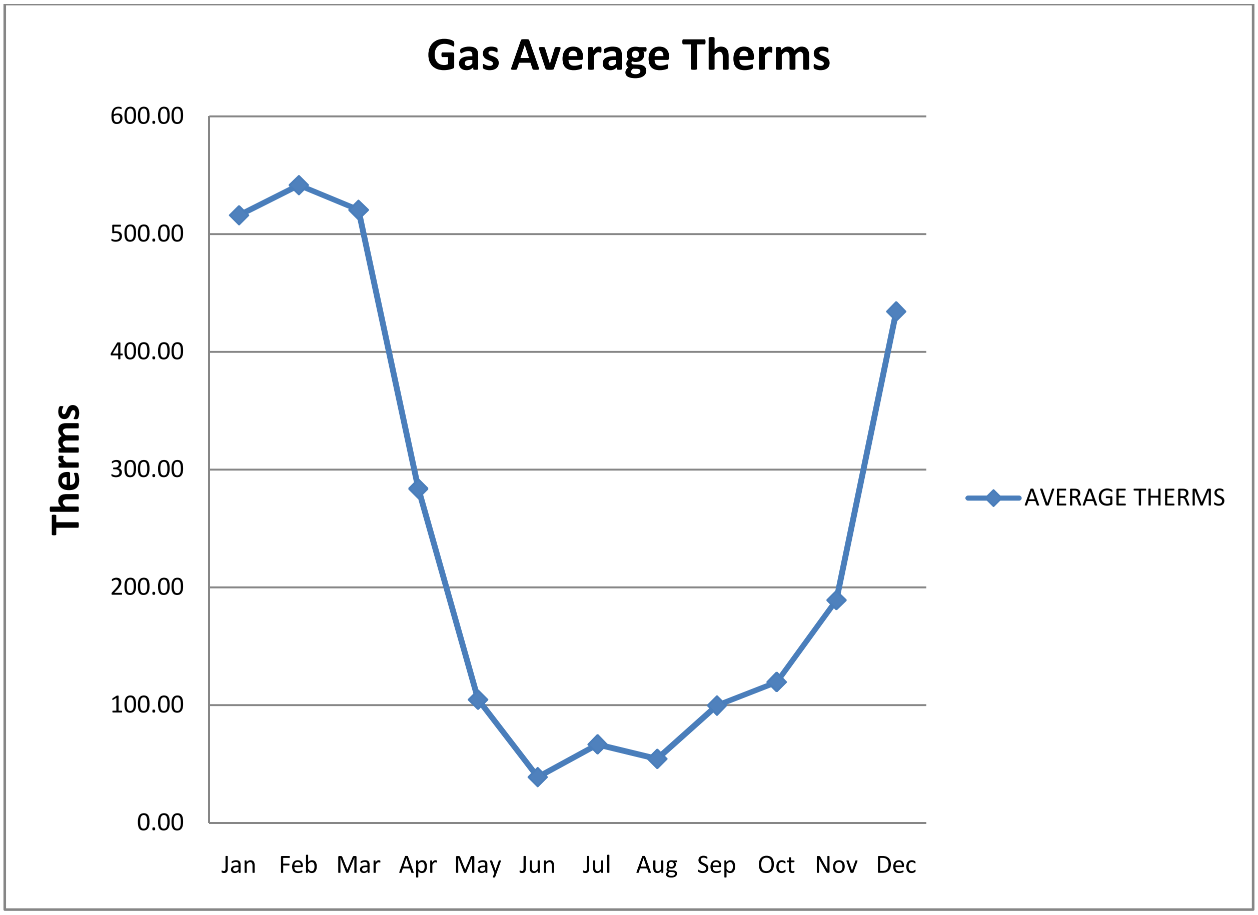


Figure 7.2.16: Gas Cost Trend 2005-2008

Figure 7.2.16 shows the gas cost trend, mapping the cost for each month from January 2005 to December 2008.

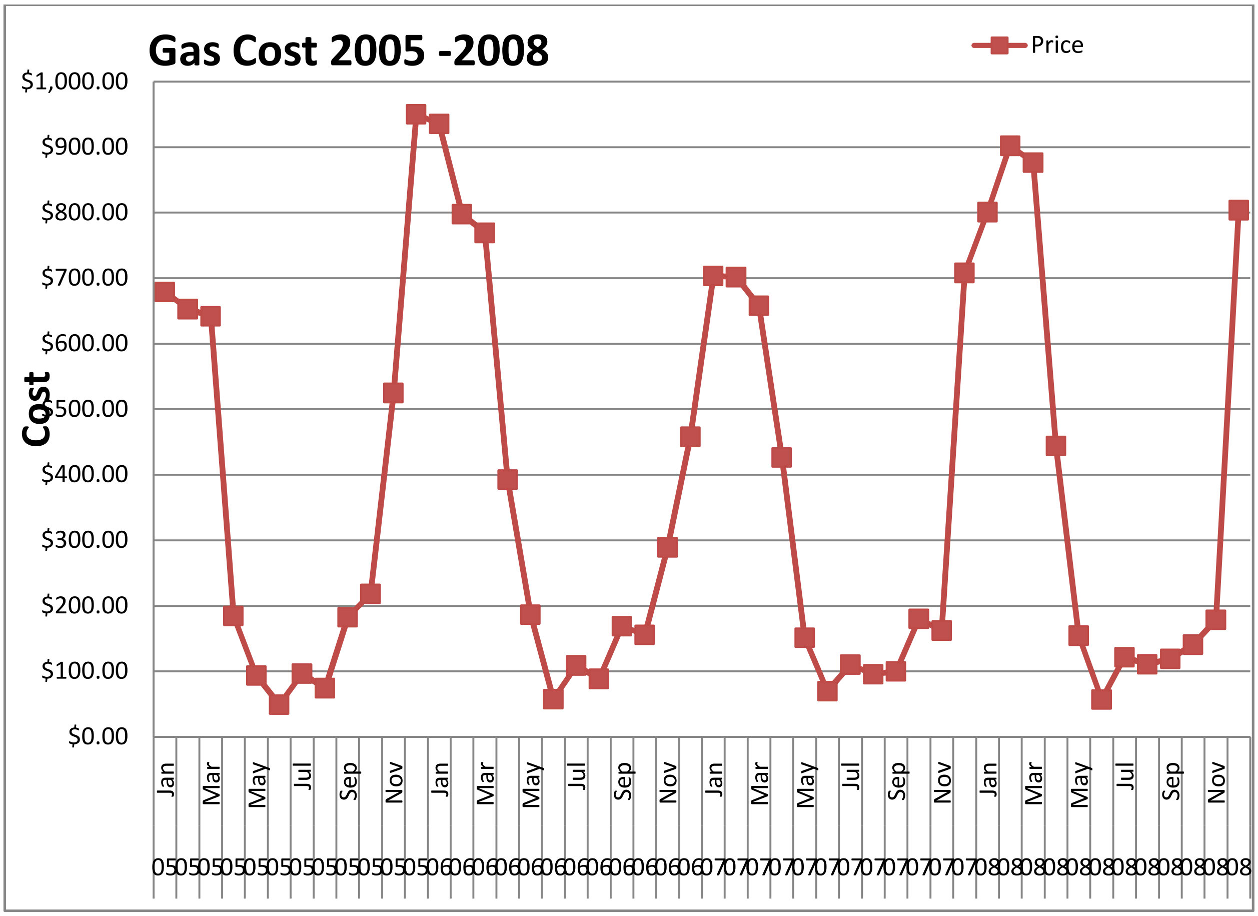


Figure 7.2.17: Gas Therms Trend 2005-2008

Figure 7.2.17 shows the therm usage trend. Each amount of therms used per month is shown from January 2005 to December 2008.

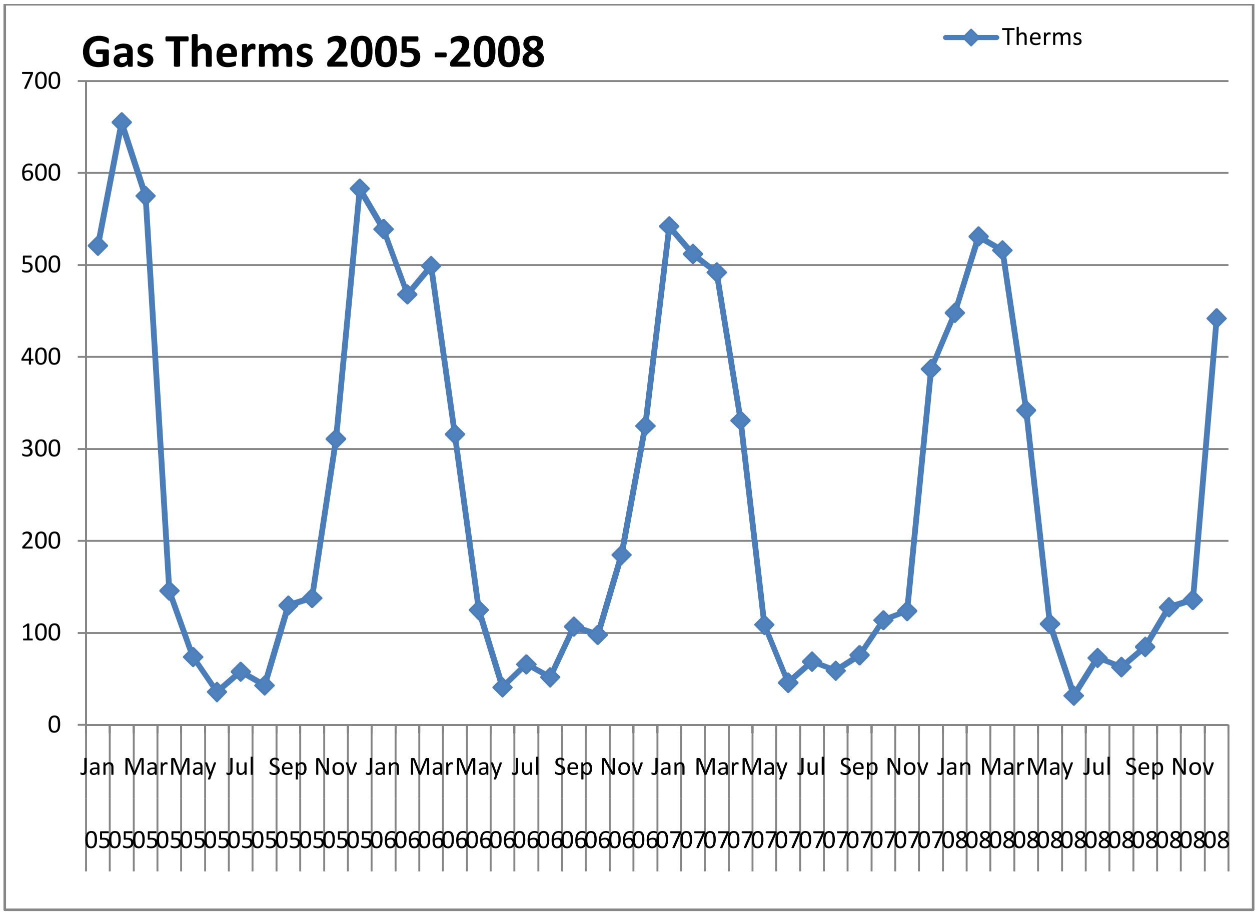


Figure 7.2.18: Carbon Footprint Comparison

Figure 7.2.18 shows the difference between the emissions produced from Gas/heat, Electricity, Wastewater Management, and Recycling before and after the implementation of our emission reduction technique

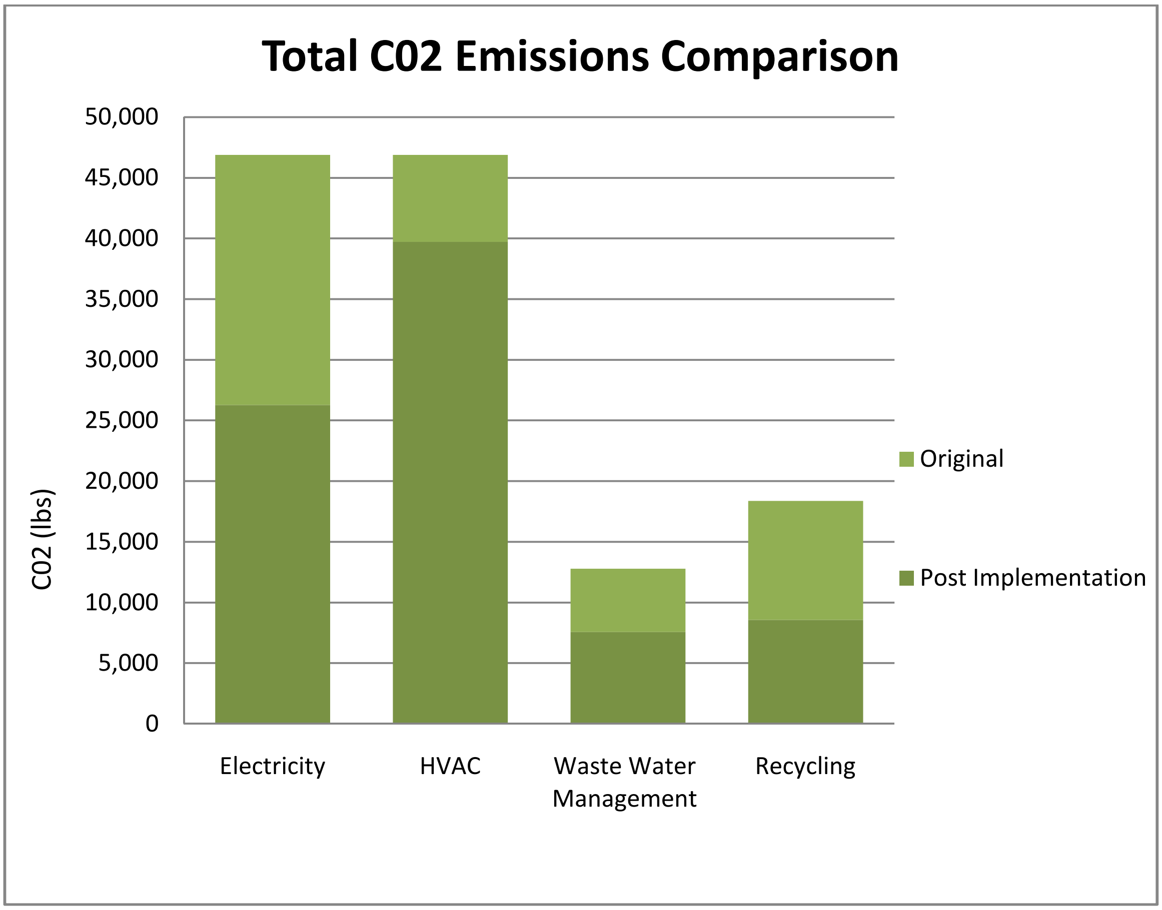


Figure 7.2.19: Percent Savings Comparison

Figure 7.2.19 uses a pie chart to display the potential percent savings in emissions in regards to where the savings are made.

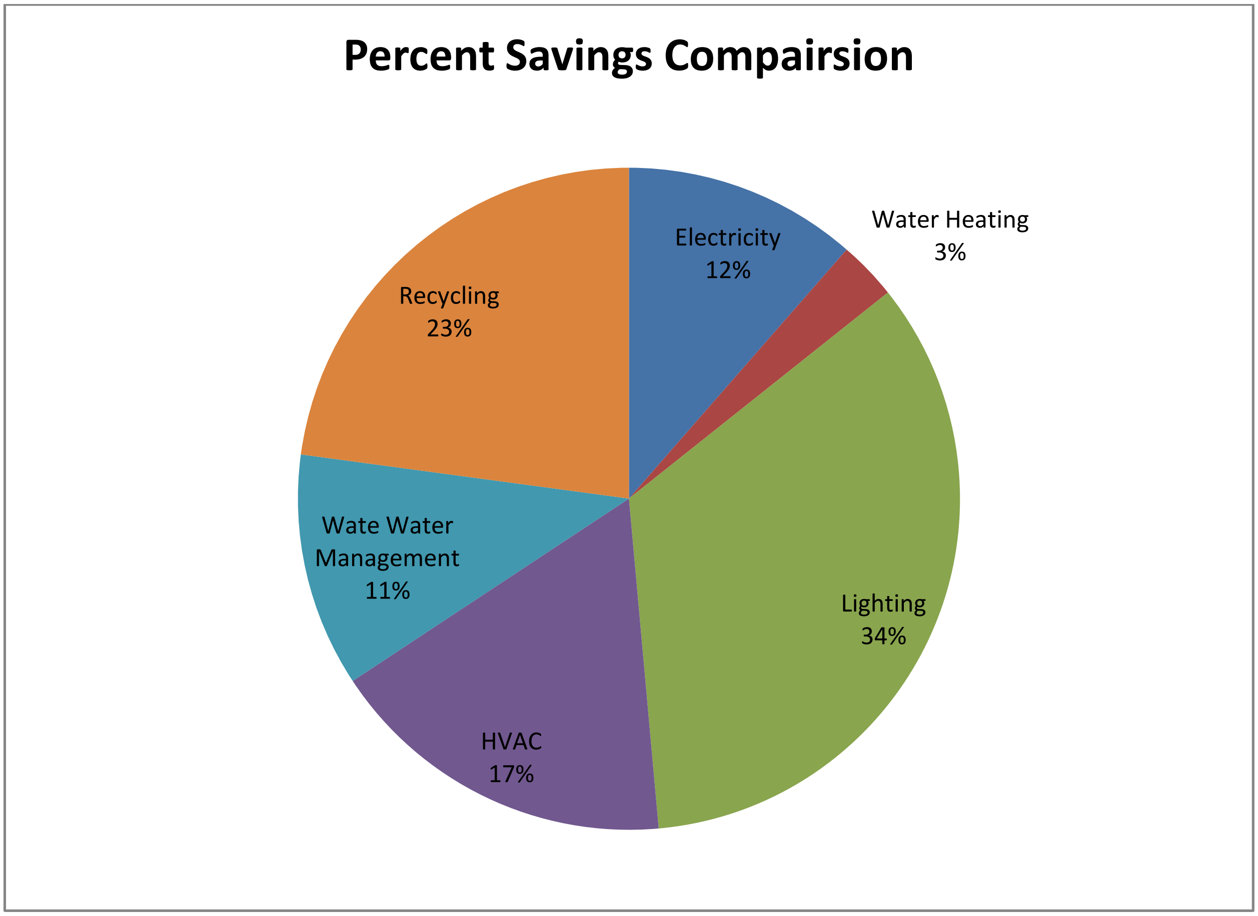


Figure 7.2.20: Break Even Analysis

Figure 7.2.20 uses a Break Even Analysis to look into where a return on investment can be seen from the savings versus the cost.

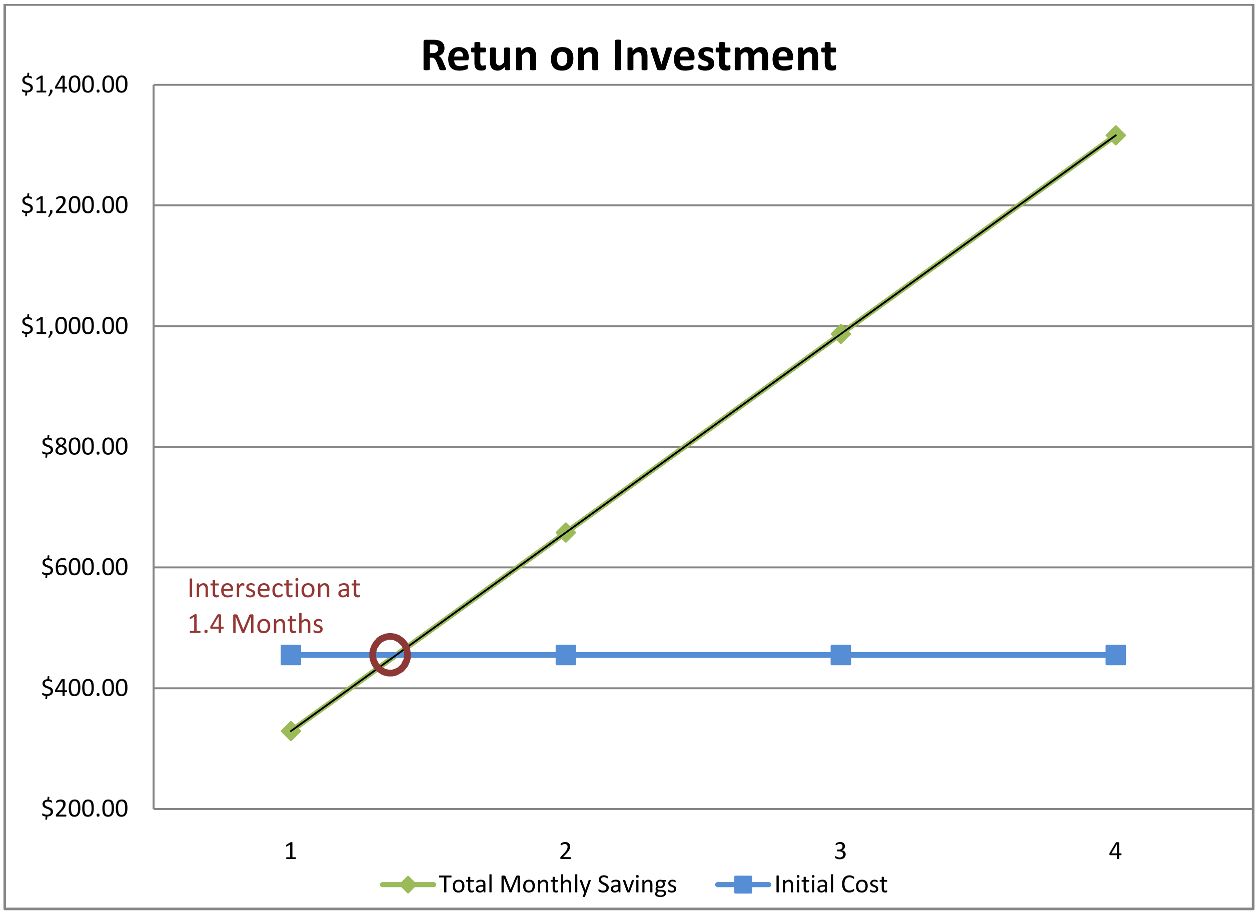


Figure 7.2.21: Pie Chart Carbon Footprint Comparison

Figure 7.2.21 uses a pie chat to demonstrate the new carbon footprint in comparison to the old carbon footprint and the percent emissions reduction

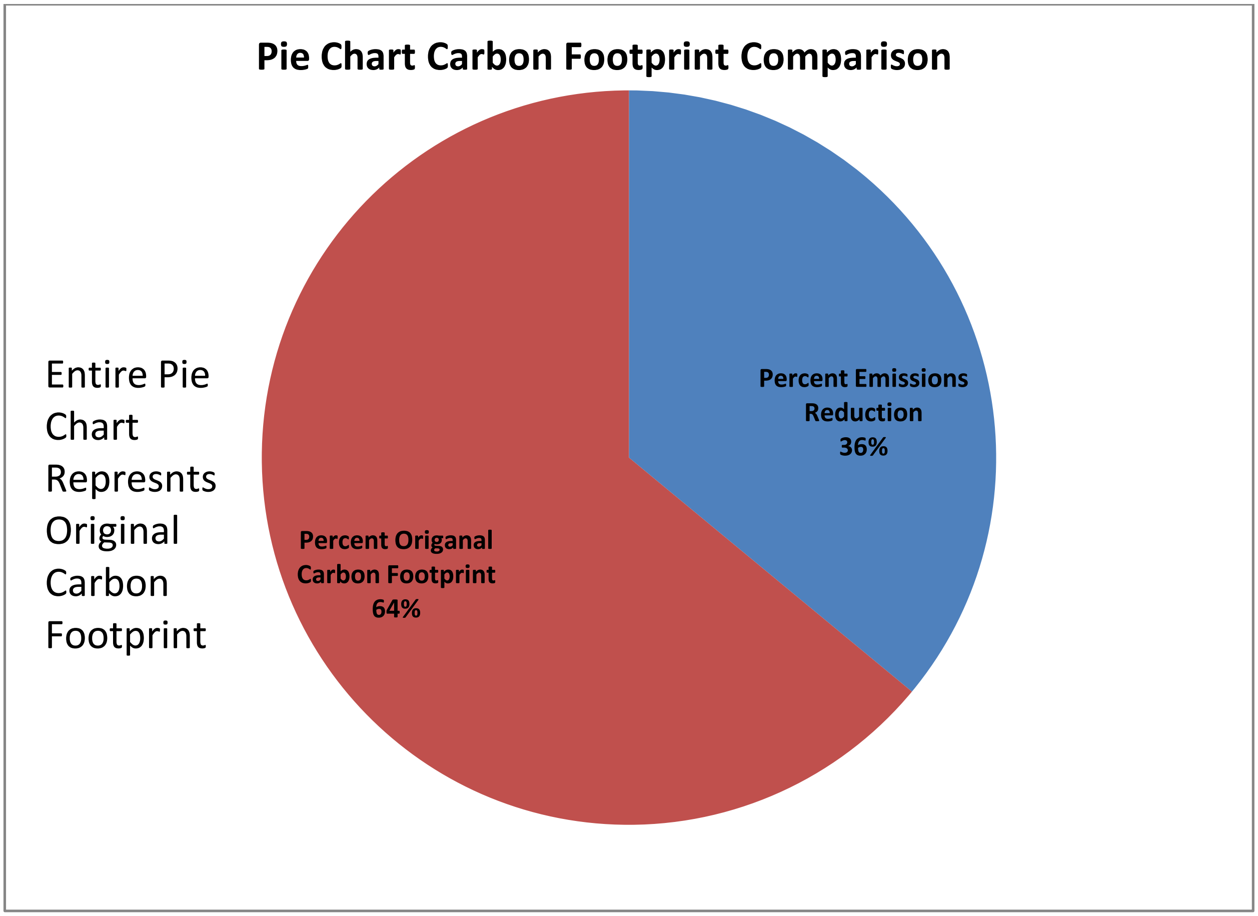


Figure 7.2.22: Green Process House

Figure 7.2.22 uses the image of a house to demonstrate the foundation and pillars of facility operation and green process.

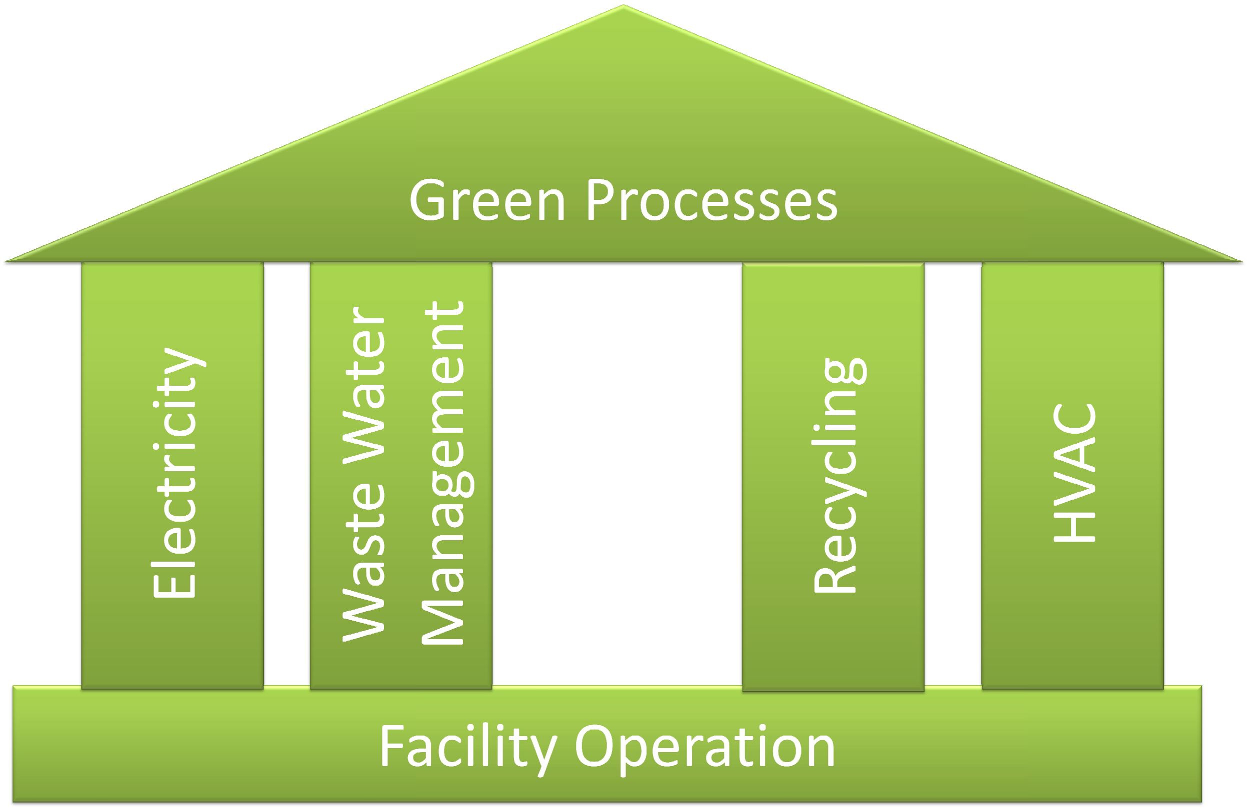


Figure 7.2.23: Benefit Analysis

Figure 7.2.23 the image of a scale and weights to illustrate the benefits and justification for our green implementation