Green Study for Greeks: The Determination of Environmental Sustainability within the Greek Community of WPI

An Interactive Qualifying Project Report to be submitted to the Faculty of the

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Abstract

Following nationwide trends, the Greek Alumni Council at the Worcester Polytechnic Institute has commissioned a study to raise awareness of environmental issues within the Greek community. The project consisted of a professional energy audit of 2 houses, walk-through audits of all remaining 19 houses Greek houses, a focus group, and substantial background research. The project concluded with a manual of recommendations that was presented to each chapter house ranging from low-cost improvements to capital projects. Overall, the project aimed to contribute to the movement of the academic community towards sustainable energy use.

Executive Summary

Commissioned by the Greek Alumni Council's (GAC) Green Subcommittee, the purpose of this project was to raise awareness within the Greek community of sustainability issues and to find ways in which the chapter houses can reduce energy and thus save money each year. A four-part assessment of the Greek community was performed to aid the beginning of a green transition. These steps are as follows:

1. Conducting energy audits on all 21 Greek houses.
2. Determining cost analysis for potential savings.
3. Creating a manual of recommendations for implementing green improvements.
4. Developing a new GAC award to quantify the future results of the project.

In order to gauge the current energy consumption of the Greek houses, energy audits were performed. A professional audit was first performed on the two Sigma Alpha Epsilon houses by a professional auditor from Comfort Systems USA as a case study of what energy auditing consisted of and to define the limitations of our auditing template. The team then conducted walk-through audits on the remaining 19 Greek houses and collected relevant energy data within the areas of lighting, water, heating, insulation, appliances, and recycling. We used the data collected from the audits in combination with cost analysis techniques from a Microsoft Access Database in determining potential savings and the associated payback period. Based on general trends and energy-saving practices that could be implemented, a manual of recommendations was created and distributed to all house managers and Housing Corporation presidents. The main focus was placed primarily on reducing utility bills through simple, effective, and practical improvements so as to show most efficiently the benefits of green living.

After analyzing the data and calculating the cost savings of quantifiable green transitions, it was found that through many short-term changes, a noticeable amount of money could be saved every year for each Greek house. Based on the cost analysis findings, Table 1 describes the average savings throughout the Greek community as well as the highest possible monetary reduction.

Table 1: Cost Findings

Implementation	Average Savings per Year	Highest Savings per Year
CFLs	$282.90	$1,148.55
T8 Fluorescents	$67.37	$273.01
Motion Sensors	$562.37	$1,657.68
Low-Flow Shower Heads	$305.19	$1,395.34
Low-Flow Aerators	$669.49	$1,959.89

It is the conclusion of the group that the main obstacle to green living in the Greek community is simply poor habits, such as leaving lights on all night and not recycling. This belief was confirmed through the discussion during a focus group of various Greek members that was held. Due to the fact that we were only able to suggest changes and recommendations we created the Sustainability Award to be included as part of the *Chapter Excellence Annual Report* within the GAC Awards Packet. Knowing that competition is a popular medium for inspiring change, we believed that through this award, which includes a monetary prize of $250 to be spent on energy-saving improvements, Greek houses will begin to make environmental changes. Short-term changes determined to reduce energy consumption include:

- Replacing incandescent light bulbs with compact fluorescent light bulbs (CFLs)
- Replacing T12 fluorescent light bulbs with T8 fluorescent light bulbs
- Installing motion sensors for high usage lights
- Reducing water heater temperature to 110°F
- Mounting low-flow water fixtures
- Insulating hot water pipes
- Sealing cracks around doors, windows, and piping fixtures

There are also many energy-saving plans with a longer-term payback that we recommended to the housing corporations to take into account. The purchase or a new boiler and water tank to replace older systems is beneficial in not only having a more efficient unit, but also in purchasing one that has a power output capacity appropriate for the size and needs of the house. The installation of Energy Star-rated appliances will increase efficiency while also greatly reducing energy consumption. The addition of insulation to attics and walls will prevent heat loss. It is necessary with this project to hire a licensed contractor to ensure proper installation. Replacing broken and single-pane windows with Energy Star-rated storm windows will similarly operate to reduce heat loss. However, due to the long payback period associated with cost of the work required from a professional, we recommend that this task be completed in connection with another construction project, such as residing the house, in order to shorten the payback period.

In order to directly present our findings to the greatest number of people, the project group in conjunction with the Green Subcommittee has decided to present our findings at the GAC Leadership Conference in February 2009. This will occur two months after the completion of the project; however, it is predicted to have a great effect in raising awareness of our project's findings as well as reducing poor environmental practices since our audience will be representatives from every house, including all new members, and Housing Corporation Presidents.

Our project was also distributed in two capacities in order to share our findings of energy awareness and conservation. First, our report was shared with the President's Task Force on Sustainability which acts to increase campus-wide interest in energy conservation and behavioral changes throughout the Worcester Polytechnic Institute (WPI). Secondly, in an effort to persuade other Greek houses around the nation to consider their energy habits and become aware of their environmental footprint, our project was circulated throughout each of the national headquarters of those 15 fraternities and sororities settled at WPI. In particular, each Director of Chapter Services was contacted with the pertinent findings. Short-term green transition savings were represented on an annual scale in order to best demonstrate how a transition to green living is both environmentally friendly and financially sound.

Acknowledgements

We would like to begin by thanking the Greek Alumni Council for creating this IQP project in an attempt to raise awareness of sustainability issues and to find way in which the chapter houses can reduce energy and thus save money every year. We would also like to thank the members of the GAC Green Subcommittee for their continual assistance, presence, and enthusiasm throughout our project, in particular: Richard Hooker, Emily Perlow, and Suzanne Peyser.

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Authorship Page

All four team members contributed to and reviewed all sections of this report and therefore we jointly accept responsibility for the project as a whole and decline the option of individual authorships.

Table of Contents

List of Figures

List of Tables

1 Introduction

Going green is a broad term used to describe almost any action that reduces its own environmental impact. Hybrid cars, zero-carbon factories, and planting trees represent a wide range of green initiatives. While the definition of a green lifestyle changes according to opinion, for the purposes of this project, the term “green” will hereby refer to actions that reduce the use of water, electricity, petroleum, and non-recyclable materials, and minimize the environmental footprint left by Greek housing. Common green actions by Greek housing include using efficient lighting, insulating chapter houses well and recycling.

The call for environmentally sustainable consumption is an issue that is being echoed on college campuses worldwide. At the California Polytechnic State University in Southern California, the Lambda Chi Alpha fraternity has already implemented a plan to demolish its existing chapterhouse and to build a new LEED-certified Gold standard residence (Times Press Recorder, 2008). LEED, the Leadership in Energy and Environmental Design rating system, is one the primary rating systems in the United States for green buildings (U.S. Green Building Council [USGBC], 2008c). Similarly, many universities, such as Gloucestershire University in England, are striving towards a completely green campus by implementing environmental action plans while reducing energy consumption and waste creation (Shepherd, 2008). One of the primary reasons for this new movement toward sustainability is that colleges are attracted to the monetary savings and prestige that green buildings afford. For example, building a zero emissions building would save money and act as a unique promoter toward reducing one’s environmental footprint.

The Greek community of Worcester Polytechnic Institute (WPI) is composed of 15 Greek chapters, with 21 houses in total. These houses differ drastically in structural design and infrastructure, as their ages range from 2 to 140 years old. Most houses have not been renovated in recent years and are equipped with inefficient heating systems, outdated plumbing and inadequate insulation. Along with the environmental impact of wasteful utilities, high energy bills are a drain on finances. In order to combat both the environmental and the financial problems of the current Greek lifestyle, the governing body of the Greek community, the Greek Alumni Council (GAC) commissioned research on alleviating the problem. GAC asked for a three-part initiative to assist the Greek community at WPI through its green transition. Their expectations included energy audits to be conducted on the houses, a manual to assist in implementing green improvements, and a rubric by which to quantify future energy savings. The manual is a step-by-step guide on how to make an existing house more environmentally sustainable. The audit rubric is a form that the house manager of a chapter will fill out periodically, detailing their chapter's energy use and gauging the sustainability of their fraternity or sorority.

Our goal was to inform the Greek community about issues relating to environmental sustainability, and to provide green living recommendations to the fraternities with a step-by-step manual to reduce their environmental impact. The first part of our plan was focused on energy audits of the Greek community to gauge current and historical consumption of resources. This provided a benchmark against which the future improvements to the houses can be judged. The second part of our project consisted of creating a manual that details the improvements suggested by the energy audits. Lastly, a rubric was created that will be used to gauge sustainability and identify future areas of improvement within the Greek houses. The main emphasis will be placed on quick and practical improvements in order to most effectively begin the green transition and provide evidence as to its success.

2 Background

In order to foster a green lifestyle in the Greek community, it is necessary to define precisely what "green" means to this project, and why one should live in a sustainable manner. As previously stated, the definition of green, for the purpose of this project, is the set of actions that reduce the use of water, electricity, petroleum, and non-recyclable materials, and minimize the environmental footprint left by Greek housing. Equally important, however, are the *methods* for green living, the techniques for saving energy and the guidelines that consumers can use to grade their own level of consumption. This section addresses the definition of sustainable living, green certification programs, energy-auditing techniques, and incentives for a green lifestyle.

2.1 Sustainability

Lately, due to the concern of an energy shortage and environmental pollution in our country, the issues of wasteful energy consumption are being called into question for reform (Carmichael, Chameau, & Clough, 2006). The development of a sustainable living and working atmosphere depends on three main areas: economy, environment, and society, as seen in Figure 1. For an environment to be truly sustainable, it must take into account and address each of these topics (Dautremont-Smith, Newport, & Walton, 2008). When applying green improvements to a current living situation, the three are interconnected as follows: going green reduces both energy consumption and financial costs which leaves less of an imprint on the environment, and thus successfully addresses social concerns of today's world, i.e. using our resources responsibly, without placing a burden on future generations.

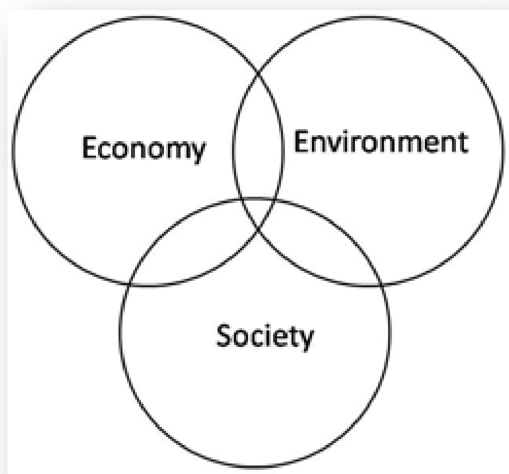


Figure 1: Aspects of Sustainability (Dautremont-Smith et al., 2008)

2.1.1 Sustainability in Higher Education

The significance of the link between education and sustainability was first recognized at the United Nations Stockholm Conference on the Human Environment in 1972. This conference was notable for being "one of the first international documents to recognize the fundamental interdependency between humanity and the environment" (Calder & Clugston, 2002, para. 2). It was believed that by informing students and opening their eyes to the problems and solutions with social and ecological issues, these concerns would be addressed early enough to reduce their significance. Unfortunately, proactive action on the part of higher education has not occurred until as of late, when the issues of energy consumption and the environment have become a more pressing social issue. Derek Bok, former president of Harvard University explains:

> When society recognizes a need that can be satisfied through advanced education or research and when sufficient funds are available to pay the cost, American universities respond in exemplary fashion…. On the other hand, when social needs are not clearly recognized and backed by adequate financial support, higher education has often failed to respond as effectively. (Calhoun, 2006, p. 2)

This explains why colleges and universities have started to take an active interest in environmental sustainability only within the last decade even though this issue was recognized in the early 1970s.

Colleges and universities are now also beginning to tackle and teach green issues from a more profitable business standpoint. As the environment comes to the forefront of American social consciousness, companies are creating initiatives and programs to evaluate and improve their performance from a green perspective. Because of this rapidly evolving movement, manufacturing and energy companies are looking for college graduates who already have at least a basic understanding of green issues and alternative technology (Calhoun, 2006).

2.1.1.1 Campus of WPI

WPI, along with nearly one hundred other universities across the country, is taking part in the Association for the Advancement of Sustainability in Higher Education's (AASHE)

Sustainable Tracking, Assessment & Rating System (STARS) program. This is a voluntary rating program to compare the sustainability performance and trends of colleges and universities across the country. A few of the goals of this program are to form a standard for creating a sustainable campus, to credit those campuses making green advancements, and to share information about the methods and performance of green initiatives across campuses (Dautremont-Smith et al., 2008). The AASHE describes the rating system as follows:

> STARS is comprised of two main types of credits: performance and strategy. Performance credits are based on quantitative measurements of sustainability performance, such as the percentage of new buildings that are built to LEED standards. Strategy credits focus on approaches or processes that can help improve an institution's performance, such as adopting a green building policy. (Dautremont-Smith et al., 2008, p. 7)

The Bartlett Center, built in 2006, was the first building on the WPI campus to address green concerns. The Bartlett Center is considered green in its construction and the ways in which it saves energy while in use. During construction, local and renewable materials were used, and nearly 90% of all waste products produced were recycled. These materials included concrete, brick, cardboard, and metal. The Center’s floor layout and window design allow natural sunlight to reach most areas of the building and drastically reduce the amount of artificial lighting that is necessary to operate on a daily basis (WPI, 2006).

East Hall, the second green building on campus, was completed during the summer of 2008 and is predicted to be LEED-certified with a gold rating by the U.S. Green Building Council. East Hall is a unique and eco-friendly residence hall. The roof is covered by 5,000 square feet of grass which will serve to absorb and collect rainwater, therefore reducing the overflow to the sewers. Being of a drought resistant species,

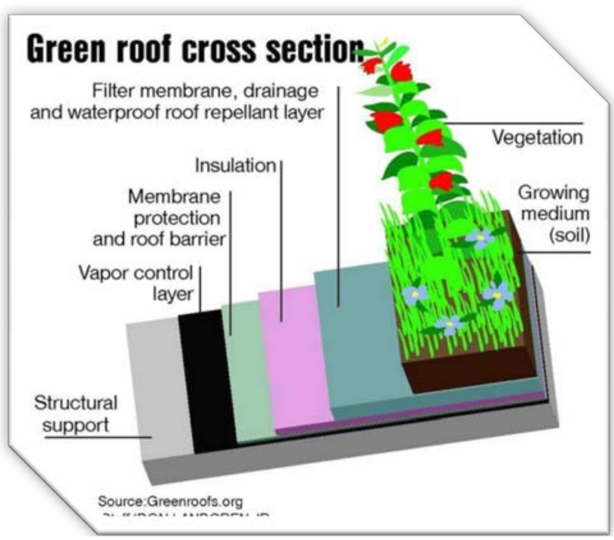


Figure 2: Green Roof Cross Section (Barnes, 2008)

no watering or maintenance will be required of the area. As a whole, the roof system was built in layers, as seen in Figure 2, so as to allow for water filtration and to act as an insulator, therefore reducing the energy required to cool and heat the building. By utilizing a white membrane cover instead of an asphalt roof, the overall temperature of the roof as well as the outside building temperature will be lower. From an educational standpoint, there are also a number of monitors on the roof which will be used by Civil and Environmental classes to track rainfall properties, such as rate and volume, during storms (Barnes, 2008).

2.1.1.2 Colleges Nationwide

Responding to the issue of sustainable campus life throughout the country, many colleges have begun to take a proactive approach to green living. Described below are examples of three and how they are addressing the concerns of a more sustainable campus. Each college is different in how it approaches the idea of going green, yet they are all similar by involving and educating the student body throughout the process.

Ball State University, located in Muncie, Indiana, has created a sustainability council composed of 95 individuals who plan, implement, and educate about green living conditions. These members connect and encompass the campus as a whole by including professors, students, administrators, and student organizations (Calhoun, 2006).

Middlebury College, located in Middlebury, Vermont, with direct support and leadership from its president, has completely redesigned its consumption and recycling habits. By renovating the way the college recycles, manages waste, and makes purchases, they were able to decrease waste by more than 60%, and use local vendors for 30% of its food supply thus reducing carbon emissions by almost 10%, and recycle 300 tons a year from previous waste streams (Calhoun, 2006).

Oberlin College, located in Oberlin, Ohio, is a prime example of how a college was able to obtain complete student involvement in lowering energy consumption. In 2005 the college implemented an energy-monitoring system throughout all of its residential buildings on campus. A competition was then created to see which dormitory could save the most energy over a given period of time. The success of the competition/project was aided by a website that showed livefeed energy usage in each of buildings across campus being monitored (Domask, 2007). Colleges across the country making green initiatives and constructing energy-efficient green buildings use a certification program in order to rate their buildings.

2.2 Certification Schemes

In order to gauge the effects of the green initiatives and to rate the sustainability of buildings, various energy certification programs have been developed in order to provide guidelines and goals for home builders and residents. Certification programs are most often administered by governments or by builder's associations: groups of professionals in the construction industry that are concerned about sustainability in buildings. Different certification programs focus on different aspects of sustainability. Because of this diversity of perspectives, we chose three very different systems to study, in order to give the Greek community as broad a spectrum of ideas as possible. The three systems under consideration are:

- The Leadership in Energy and Environmental Design rating system (LEED)
- The Code for Sustainable Homes (CSH)
- Energy Star

LEED places a great focus on efficient use of water, land and electricity, and is directed towards new buildings and renovations that have LEED certification in mind at the start. CSH is widely used in the United Kingdom and is mandatory for all homes sold in England. Energy Star is an entirely different type of rating system, as it gauges the efficiency of the individual appliances in a house, focusing on each house's energy load rather than the techniques used to build it. The rating systems all share a goal, and that is to ensure that the homes of tomorrow use our world's finite resources in a sustainable manner. Each of these strategies contains a different main focus and has its own particular benefits when viewed in greater depth.

2.2.1 LEED

LEED was developed by the United States Green Building Council (USGBC), a nonprofit consortium of over 15,000 organizations in the construction industry that works to educate builders about green techniques and runs accreditation programs for green builders

(USGBC, 2008e). LEED is an open standard, whose criteria are publicly available and are decided by the member organizations of the USGBC. Buildings are graded on a point system by a variety of criteria, some of which are required, such as erosion control and recyclable collection, and others are optional, such as reuse of building materials and water use reduction. There are several different LEED certifications with separate certifications available for homes, new buildings, existing buildings, universities, and retail buildings, among others. Within each certification, it is possible to earn four levels of certification based upon the number of points the building earns during inspection. An acceptable building can earn a "certified" rating, but upon improvement can move up to a silver, gold, or platinum LEED rating.

LEED criteria change rapidly to incorporate new technologies and techniques, and the standard has become quite popular as a result. According to the USGBC website, buildings as diverse as the Exelon Corporation headquarters in Chicago, the American Embassy in Bulgaria, and the Bronx Library in New York City have received LEED ratings (2008d). In all, over 15,000 building projects worldwide are LEED-certified.

The LEED criteria for existing buildings, as detailed on the LEED for Existing Buildings Registered Project Checklists, are divided into 6 categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation in Operations. The certification is out of 92 possible points, with a minimum rating of 34 points for certification. There are also 10 required criteria that do not contribute to the point total but must be fulfilled in order to receive any LEED rating at all (USGBC, 2008a).

LEED certification is a process that begins before a project starts, and requires documentation to be submitted to the USGBC detailing the building's performance data and operational procedures (USGBC, 2008f). Certification is not free, as the USGBC must retain a staff of 150 in order to perform certifications. The total cost of certification can range from as low as $375 for a single-family house built by a member organization of the USGBC, to over $15,000 for an existing building over 500,000 square feet. The USGBC defends these fees on their website, explaining that "Benefits of a LEED home include lower energy and water bills…The net cost of owning a LEED home is comparable to that of owning a conventional home" (2008b, para. 1).

2.2.2 Energy Star

Energy Star is a program run by the United States Government for the certification of appliances, computers, and lighting as energy efficient. The certification system focuses on the products used to build a home, such as insulation, windows, and air conditioning systems (U.S. Environmental Protection Agency [EPA] & U.S. Department of Energy [DOE], 2008b). Different products have different criteria for being rated by Energy Star. For example, an air conditioning unit needs to be 10% more efficient than the minimum federal guidelines for efficiency to receive an Energy Star rating (EPA & DOE, 2008d). A furnace needs to be approximately 15% more efficient to be rated (EPA & DOE, 2008c), and a standard home ceiling fan must be fully 50% more efficient than the federal minimum standard to be certified as an Energy Star appliance (EPA & DOE, 2008a). Unlike LEED, Energy Star does not certify individual buildings as Energy Star-compliant, but rather focuses on the machines inside that consume resources the most. Energy Star could be considered an ad hoc approach to sustainability where each green decision builds upon others in a highly customizable way, while LEED is a process-based rating system that focuses primarily on the results of building. According to Energy Star, the average home spends approximately $2,000 dollars on energy bills a year (EPA & DOE, 2008e). Using Energy Star-certified appliances can cut that total by a third, or $700 (EPA & DOE, 2008b).

2.2.3 Code for Sustainable Homes

In the United Kingdom, all new homes are required to be rated according to the Code for Sustainable Homes, a rating system much like LEED that grades homes on a point scale of 1 to 6, and judges structures according to a set of nine criteria. These criteria are Carbon Dioxide Emissions, Water Usage, Materials Usage, Surface Water Run-Off, Waste, Pollution, Health & Well-Being, Management, and Ecology (National House Building Council [NHBC], 2008a). The purpose of the mandatory rating is to allow home buyers to make intelligent decisions about the purchase of their homes with regard to energy efficiency and environmental impact. The code is optional for existing buildings in England, but Northern Irish public housing has been required to achieve a score of 3 out of 6 since in April 2008 (NHBC, 2008b). The CSH rating system is owned by the British Government and inspectors are licensed by Stroma Accreditation and the Building Research Establishment (Stroma, 2008). The Code is the successor of the popular Building Research Establishment's Environmental Assessment Method (BREEAM). Unlike LEED's focus on responsible water and land usage, CSH sets the elimination of carbon emissions much higher on its list of priorities, as the British government has set a goal of a reduction of 60% to its carbon emissions by 2050 (WWF-UK, 2006). For this reason, CSH has garnered praise from the World Wildlife Fund, which called the new rating system "a breakthrough for green housing" (2006, para. 1).

While the above certification programs vary in focus, one factor they all have in common is the use of an energy audit. These audits serve to quantify energy usage and efficiency in order to analyze any given building.

2.3 Energy Audits

The most common method for determining energy consumption of a given building or residence is the energy audit. Myer Kutz (2006), noted engineering author, defines energy auditing as "…the practice of surveying a facility to identify opportunities for increasing the efficiency of energy use" (p. 277). In this definition, another important aspect of an audit is to also identify areas of *improvement* to energy usage. Therefore, by combining these two ideas, energy audits can been seen as a tool to determine the overall energy consumption of a facility, as well as a breakdown of how the energy is used, in an effort to reduce overall expenses by using energy more efficiently (Thumann, 1995).

2.3.1 Types of Audits

The type of audit performed can vary greatly depending on the facility being surveyed and the extent of changes perceived to be implemented. Industrial plants and manufacturing facilities have the money for an intensive audit and may be inclined to transition to different heating sources and machinery. Residential homes, on the other hand, generally involve a less in-depth, investigative auditing approach. Since money is a major concern in most households, the energy auditor would try to provide recommendations on practical, inexpensive energy-saving techniques (Thumann, 1995). The three main types of energy audits are as follows:

Walk-Through Audit. The simplest and most straightforward approach, a walk-through audit consists of visual observations that are used to determine energy-saving techniques. These audits generally recommend low-cost conversions that have a quick installation and payback period. After data collection and analysis, a more extensive audit may be recommended.

Mini-Audit. If more auditing is required after the walk-through, a mini-audit can then be conducted. This technique quantifies the efficiency and energy usage of particular systems and operation, such as lighting and heating, in an attempt to predict cost savings through energy conservation.

Maxi-Audit. Taking the mini-audit one step further, the maxi-audit measures energy usage for each individual system by taking into account environmental factors that may vary over the course of a year, as well as machine and equipment efficiencies in order to predict cost savings. The maxi-audit makes various energy usage recommendations depending on the time and season of the year. Generally, this audit is performed on businesses and manufacturing facilities that contain machinery (Thumann, 1995).

We proposed that an audit based on a walk-through evaluation, in conjunction with evaluating some of the systems in the fraternity houses, should provide a solid foundation to recommend many of the energy-saving and cost-saving ideas that would be feasible and cost-effective to implement.

2.3.2 Performing an Audit

It is the responsibility of the auditor to be creative and observant during his visit and analysis of a site. Since the findings in an audit report are only recommendations, it is the goal of an auditor to "find ways to eliminate unnecessary energy-using tasks and ways to minimize the work required to perform the necessary tasks" (Kutz, 2006, p. 286). The general procedure for performing an acceptable audit as stated by Kutz is as follows:

1. Collection of data on energy usage from energy bills and behavior schedules
2. Walk-through inspection of residence
3. Determination of energy-saving techniques
4. Transition cost analysis and payback period
5. Presentation of findings

Energy-saving techniques range from low-cost conversions to capital projects, depending on the facility and the goals of the consumer, and may also range from equipment transitions to behavioral techniques. Examples of low-cost conversions include transitioning to low-flow water devices, or reducing shower durations. Capital projects involve the replacement of entire systems, such as heating systems, and require a price quote from a contractor for the costs of a new system and the labor to install it. Often, capital projects involve construction or renovation of some sort. For these cases, a structural inspection of the house is usually necessary to take into account the feasibility and potential problems when implementing a new system (Kutz, 2006).

In presenting an audit, one cost analysis tool commonly used is the payback period. This figure is used to determine how long it will take to return an initial investment (equipment and transition cost). This term is calculated as follows, $Payback\ Period = \frac{initial\ \ investment}{after\ \ tax\ \ savings}$ (Thumann, 1995).

2.3.3 Presenting an Audit

It is crucial for an auditor to present his findings in a clear and understandable manner. When presenting an audit report to the consumer, Kutz (2006) recommends including these presentation elements:

- Current and historical energy usage/cost
- Energy-saving recommendations and why they are successful
- Cost associated with transition, payback period, and net benefits per year
- Anything else related to change, such as annual maintenance
- Charts and graphs that represent material well and make information easy to understand

In 1986 a case study, *How Important Is Information Format? An Experimental Study of Home Energy Audit Programs,* was performed by professors at Duke University to determine what effect, if any, the formatting of an energy audit had in stimulating homeowners to change over to energy-saving techniques. Social understanding of energy reduction techniques and their benefits during that time are described as follows:

> In particular, many consumers do not possess accurate estimates of the costs, and especially the benefits, of residential energy conservation measures. Some consumers may not know about the existence of some measures, such as [programmable] thermostats…. Even those consumers who possess accurate information about the benefits and costs of alternative energy conservation measures find the time and [initial] costs…to be excessive. (Magat et al., 1986, p. 22)

The case study used a variety of subjects with differences in education, age, income, and race to test the compliance of residential home owners to recommendations of home audits when different presentation formats were used. The audit was conducted by the Duke Power Company on a laboratory house and presented to the participants in one of four formats.

- Control – the standard Duke audit analysis
- Payback period – the payback period was the first statistic stressed
- First year energy savings – emphasis placed on savings per year
- Reduction data – all data in terms of reduction percent in energy usage and cost

The study found that with the control, subjects generally chose a combination of recommendations with a cost-savings ratio of less than half of the most efficient combinations. Each of the other formats stimulated subjects to choose combinations with a higher ratio (Magat et al., 1986). While no one format was found to have a clear advantage over another, the general conclusion is:

> To be effective, information programs must be designed to be useful to consumers…. Knowing what pieces of information are used in reaching decisions and how they are combined determines both what information is most important and how it should be conveyed to consumers. (Magat et al., 1986, p. 29)

2.4 Cost Analysis

The information learned from an energy audit finds form in the Cost analysis. Low-cost improvements, such as low-flow shower heads, cleaning refrigerator coils, and displacing the water in toilet tanks, are stepping stones into bigger programs and renovations. The major home projects suggested by the energy audit are the most beneficial way to save energy and money, and include replacing windows, reinforcing installation and changing of heating style to more sustainable methods. Some of the most cost-effective ways to go green are listed below.

2.4.1 Bathroom

Low-flow shower heads are similar to regular shower heads, but they use much less water. These shower heads have a disk that restricts the flow of water that comes out of the head. This disk can be controlled to block more or less of the orifice dependent on its position in the head (Gullaksen & Jatho, 1974). A low-flow shower head uses as little as 1.5 gallons of water per minute, as opposed to the 1.9 used by the average standard shower head. Changing over to these shower heads can save anywhere from 25%-60% on yearly water bills (DOE, 2008).

Another method to save water is through faucet aerators which are used to bring air into the flow of the water from the faucet. These aerators save water and produce a better stream from the faucet *("*Low-flow aerators*", 2008)*. If a sink indicates that it is producing over 1.5 gallons per minute, the faucet should be changed over to an aerator. This can be such a small fix, yet it can save a family a few hundred dollars a year.

An inexpensive way to create a low-flow toilet is to place a full water bottle it in the back part of the toilet. This acts to displace the water that would be flushed down the toilet with the capped water. The water bottle displaces a percentage of water from the tank and therefore creates a lesser need for water in the refill of the toilet ("Easy peasy tip", 2007).

Finally, using eco-friendly cleaning materials in the bathroom is another way to go green. Not using harmful bleaches and poisons can cut back on the damage to the ecosystem. By eliminating the use of harmful chemicals the household's impact on the environment and atmosphere will be reduced.

2.4.2 Lighting

Another example of a green transition is to switch to compact fluorescent light bulbs, or CFLs. These light bulbs have a mercury gas running through them, producing light when excited by electricity. This is opposed to the incandescent form of lighting which heats up the tungsten inside to produce a white light. The problem with the tungsten is that every time the light bulb is turned off, the tungsten cools down and then must heat up again when the lights are turned back on. The CFL bulbs are up to four times more efficient then the regular incandescent bulbs, and can last up to ten times longer. A switch to CFLs will save money both through the electric bill and consume fewer light bulbs every year. A problem, however, with these bulbs can be difficulty in recycling them since they contain mercury. They cannot simply be thrown away and must instead be brought to a hardware store, such as Home Depot, who will recycle CFLs for free ("Pay to recycle", 2008).

Some lighting fixtures, however, are not compatible with CFLs. Nevertheless, there are some fluorescent lights that are much more energy efficient than others. In particular, four-foot light fixtures that contain fluorescent tubes are not compatible with CFLs and often use bulbs called F40T12 lamps. However, a better technology exists, i.e. F32T8 lamps. These lamps are 10% more efficient, meaning they produce more light per Watt, use 20% fewer Watts, and last 25% longer than typical T12 fluorescents (Oregon Department of Energy, 2007).

The most efficient lighting will still waste energy if used for an unnecessary amount of time. In many homes and office spaces, lights are left on overnight, outdoor lights are used during the day, and lights in low-traffic areas are not shut off for convenience's sake. A simple, inexpensive motion sensor can fix this problem, by turning off the lights when no movement is detected in a room for a set amount of time. This solution is effective both in commercial and domestic applications. In high-traffic areas like public bathrooms, the lights are on for most of the day and are then turned off at night. A motion sensor would keep the lights off during a large part of the day too when the bathroom is unoccupied, saving a great deal of energy. Similarly, in areas of homes where people might be tempted to keep the lights on all night, such as a hallway, a motion sensor keeps the lights off all night, and turns them on if somebody wakes up in the middle of the night.

2.4.3 Kitchen

Small improvements and major capital improvements can be made in the kitchen to reduce energy usage, and to reduce carbon footprint. One such easy fix is as easy as cleaning refrigerator coils in order to reduce heat stored from the insulation of dust. This will increase conversion of the liquid refrigerant, which absorbs the heat from the air around it, and therefore make the process more efficient. Also, moving the refrigerator away from the wall will increase air flow and therefore increase heat absorption.

Inspecting seals on all kitchen appliances is also important. A simple way to do this is to stick a dollar bill in the seal of the refrigerator or freezer door. By checking the ease in pulling it out will determine how well it is sealed. If not properly sealed, a large amount of energy is being lost in cooling the rest of the kitchen instead of just cooling the contents of the refrigerator. Allowing hot leftovers to cool down will decrease the heat added when put into the refrigerator, and will require less energy to cool the refrigerator back to the appropriate temperature (Middlebrooks, 2008).

Energy Star appliances are another way to increase green usage in the kitchen. Changing solid reach-in refrigerator over to an Energy Star one can save close to $400 a year in electricity as well as reducing overall carbon footprint. Similarly, savings of $250 are possible by switching to an Energy Star commercial freezer (EPA & DOE, 2008). Purchasing Energy Star equipment in bulk can produce greater savings from rebates by up to $100 for every appliance purchased.

2.4.4 General Major Improvements

High-efficiency boilers can help houses save close to $8,000 a year by replacing systems that are 10 years or older. The cost for such an improvement is $17,600-$26,400 for the part and the installation. Though the cost of the boiler is high, the resultant savings can make up the initial cost within five years.

Changing windows over to Energy Star windows can produce an annual savings of $1,600 from heating and cooling bills (University of Minnesota, Twin Cities Campus, College of Design, Center for Sustainable Building Research, 2008). These windows are better sealed for maximum ability to insulate the building. Tinting the windows is another way to increase energy-saving capabilities as “reflective coatings and films were developed to reduce heat gain and glare, and more recently, low-admittance coatings have been developed to improve both heating and cooling season performance” (University of Minnesota, Twin Cities Campus, College of Design, Center for Sustainable Building Research, 2008, para. 1).

Some major renovations are not even new green technology, but they still can save money and make a house more energy efficient. The first is reroofing a home. This can be a costly procedure, but with better insulation and newer un-cracked shingles a house can store much more heat. By replacing the house siding with a vinyl or wood material can seal cracks and breaks and stop the outflow of warm air.

Another capital improvement is through solar energy. There are two general ways a homeowner can harness solar energy for use. One of these is by using it to heat usable water. Solar water heating is one of the most cost-effective ways to heat water. This process does not use fossil fuels and requires less energy to heat the water. The water is heated by running through pipes with solar plating on the roof. Then, that water is transferred down into a storage tank where it can be used as needed (DOE, 2008). This same procedure can also be utilized in heating a home.

Solar heating for homes can be classified into two groups: active and passive. An active system heats a liquid or gas and then disperses that heat as needed throughout the house. This dispersion system is aided by fans and pumps to move the heat evenly throughout a home. Passive systems collect heat during the day through windows or floors and then release that energy at night when the temperature begins to decrease. Such improvements, while effective, differ regarding to on-site specific orientation such as window position and seasonal sunlight patterns.

2.4.5 General Low-Cost Improvements

We have also identified many other low-cost improvements that aid in reducing energy usage. First, thermostats are useful in decreasing energy usage. A simple energy-saving technique is to lower the thermostat setting by just a degree or two. This will decrease energy usage and save money over the long term. Homeowners may also choose to completely replace their thermostats. By replacing an outdated thermostat with an electric, programmable one, the heat can be regulated more efficiently so that during hours of vacancy no heat is being produced. A programmable thermostat works by maintaining a normal, comfortable temperature when a home's occupants are awake and in the house, and then automatically adjusts the temperature to a less energy-intensive setting when the occupants are asleep or away. The adjusted temperature depends on the location of the house. In cold climates, a programmable thermostat warms a house during the morning and evening, when people are usually home and active, and cools down the house during the mid-day and at night, when occupants are away or asleep. In warm climates, the thermostat does the same thing, but the house is warmed during off-periods and cooled when the occupants are active. The thermostat automatically begins adjusting the temperature so that occupants of the house never notice a temperature difference. Homeowners can save 15% a year on their heating costs by reducing their energy usage to eight hours a day using a programmable thermostat.

Second, recycling is a green technique that is greatly beneficial to the environment. It not only prolongs the life of resources, but also saves energy and water, and reduces the waste dumped in landfills. One statistic states that "Making recycled paper instead of new paper uses 64 percent less energy and uses 58 percent less water" (Department of Public Works [DPW], 2008, para. 5).

In the city of Worcester, the DPW offers a free curbside recycling program. For convenience, recyclables are collected on the same day as scheduled trash pickup. Due to the "Zero Sort" policy, recyclables do not need to be sorted into categories such as, paper, cardboard, aluminum, plastic, and glass. In order to take part in the recycling program through the city all that is needed is an appropriate recycling bin. These bins are free of charge and are available for pickup through the DPW (DPW, 2008). However, most Greek houses are considered lodging houses and therefore are not eligible for city pickup.

Third, checking the heat pump for clogs and backed-up materials is another way to save on energy bills. If a heat pump is clogged, it can cause serious problems such as flooding and bacterial growth (EPA & DOE, 2008). It is also important to change the air filter in a heat pump to make sure that it is performing at its full potential. If the filter is clogged or dirty it can cause the system to become congested and inefficient.

And finally, sealing air leaks and adding extra insulation are two easy ways to make sure that a house stays at an optimal temperature. You can add insulation as necessary in certain places for the most advantageous performance, such as reinforcing your insulation in the attic and around ceiling fixtures to keep air in. It is also important to keep the cold air out during the winter months. This is best done by adding caulking around windows, doors, outdoor faucets, and other fixtures. Weatherizing cracks and seals all around the house is another way to insulate a home. Performing such tasks can be effective in reducing heat loss as well as reducing energy consumption.

2.5 Incentives

There are also other ways to save money through going green. These include incentives by the government, local communities, and some universities. The government has several grant programs available to help homeowners transition to a green lifestyle, either in the form of tax credits or monetary grants. There are multiple forms of tax credits, which often is the deciding factor for many business owners to go green. The United States Government is very pro-active about these environmental concerns and hopes that these tax credits and benefits will motivate more residential and business owners to change. They also understand that there is usually a higher cost when going green, but hope that these incentives will persuade more people. Since the fraternity houses of WPI are nonprofit organizations, they meet many requirements for government funding and subsidies. For example, Companies that use renewable energy sources such as wind, biomass or geothermal electricity can receive the Renewable Energy Production credit. Usually the tax credit is based on the amount of kilowatt hour of created energy.

The Alternative fuel tax credit is more popular with businesses and individuals. This credit has a major impact on vehicles. Susan Berson, a tax lawyer, says the "Ford Escape Hybrid is popular with clients, partly because their purchase knocks off $3,000 off the buyer's tax bill" (Chilson, 2008, para. 12).

Commercial buildings as well as homes can receive several different types of deductions from taxes. Tax programs are categorized by either federal or state incentives. Most of these financial incentives deal with major changes such as solar water heaters, furnaces and boilers. The "Energy Efficient Commercial Buildings Tax Deduction" states that buildings may receive a deduction anywhere from $0.30-1.80 per square foot for buildings that install the following:

> (1) interior lighting; (2) building envelope, or (3) heating, cooling, ventilation, or hot water systems that reduce the building's total energy and power cost by 50% or more in comparison to a building meeting minimum requirements set by ASHRAE Standard 90.1-2001. (Database of State Incentives for Renewables & Efficiency, 2008, para. 2)

Along with tax credits, there are many federal loan programs available to homeowners who wish to go green. These loans are geared towards homeowners who want to go green but are not adequately financed. This allows homeowners to pursue energy-efficiency improvements. There are two types of mortgages available:

- **Energy Improvement Mortgage** - Finances the energy upgrades of an existing home in the mortgage loan using monthly energy-savings
- **Energy Efficient Mortgage -** Uses the energy savings from a new energy efficient home to increase the home buying power of consumers and capitalizes the energy savings in the appraisal (Residential Energy Services Network, 2008) .

States typically provide incentives, loans, and often times many rebate programs. Massachusetts, in particular, has a program called MassSAVE which provides energy information and services to all residential owners. Typically, these services include discounted installation prices, education materials to increase knowledge, and most importantly, reduced costs (MassSAVE, 2008). There are many companies and organizations that are willing to help campuses that show initiative to go green. For example, the National Wildlife Federation has a "Campus Ecology Program" which helps campuses address issues regarding sustainability (National Wildlife Federation, 2008).

Some private institutions have their own organizations regarding environmental sustainability. Often, these organizations will be given grants and funds to make changes to the campus. For example, Harvard University has given grants to their organization, the Harvard Green Campus Initiative, to focus on the environmental impact of the campus. This team continuously works on designs and improvements to the 600 buildings located on campus (Harvard Green Campus Initiative, 2007). On the other hand, Middlebury College located in Vermont has given grants to their study-abroad program to assist with issues related to environmental sustainability. WPI, as well as many other colleges, is also trying to reward their students who use alternative transportation methods. For example, WPI currently has parking incentives through reserved parking spots designated for hybrid cars and began a zip car program providing transportation for students through hybrid cars. Several campuses also provide benefits to students who live in green housing. Campuses are eager to reward students for saving the college money and for using fewer resources.

2.6 Social Impact of Green Living

The issue at the heart of this project is a very old, entrenched attitude that the Earth's resources are effectively limitless, especially in regards to petroleum and water. In raising awareness of the danger of this problematic belief, we aim to shift students' perceptions and attitudes to encourage green habits before society faces a true crisis of resource shortages. By providing the Greek houses with step-by-step instructions on how to live in a sustainable manner, we aim to help the community proactively improve its own sustainability year to year and therefore leave less of a footprint on the environment. When the community realizes that it is responsible for its own consumption, it will become responsible for its own environmental impact.

3 Methodology

The primary goal of this IQP was to raise awareness of green issues in the Greek community of WPI within a project framework of two terms. We successfully completed seven weeks of in-depth research and background gathering, and from October 28 to December 18, 2008 we collected and analyzed our data to achieve the goal of raising awareness of sustainable living in the WPI Greek community. We achieved this goal through four separate initiatives. The first was a comprehensive energy audit, performed by a professional engineer, along with nineteen individual walk-through audits, performed by our groups of two auditors at a time. The second was a detailed cost analysis of a green transition, and the payback period associated with the proposed changes. The third was the creation of a manual for sustainable living for Greek houses and a rubric by which the houses can gauge their own efficiency in the future. Finally, a new GAC award was created to stimulate future competition between the houses as an incentive for implementing green changes.

Our project served as the foundation for creating a sustainable Greek community that will continue to make changes and improvements over the years. We made preliminary recommendations to the Greek houses for low-cost improvements as well as more substantial capital projects. Because of the nature of our project, we cannot guarantee that the Greek community will implement any of the changes that we proposed; we could only raise awareness and make recommendations for improvement. We hope that within a year of our recommendations, the Greek houses will have implemented many of the recommended changes and that they will be able to gauge their own savings using the provided rubric. We fulfilled our sponsor's goal through the following steps:

- Conducted Energy Audits
- Determined Cost Analysis
- Created Informational Manual
- Developed GAC award

Due to the time constraint of the seven week term, all of our objectives were completed within the allotted time. Our timeline is represented in Table 2.

Table 2: Projected Timeline of Project

TASK	Week							
	10/28-10/31	11/3-11/7	11/10-11/14	11/17-11/21	11/24-11/26	12/1-12/5	12/8-12/13	12/15-12/18
Professional Audit	**Professional Audit**							
Interview with Treasurer/schedule audits	**General Interview**							
Pilot Audit		**Pilot Audit**						
Audits of Greek Houses		**Audits of Greek Houses**						
Analysis of Audits		**Analysis of Audits**						
Create Manual		**Create Manual**						
Focus Group with Greek Members					**Focus Group**			
GAC Award						**GAC Award**		
Finalize Product								**Finalize Product**

3.1 Energy Audits

Energy audits are the most viable way for quantifying the amount of energy used in a building. Due to the variety of ways an audit can be performed it is essential to determine what the main focus and objectives will be when performing the audit. For the purpose of this audit we performed one in-depth, professionally aided audit as a case study of what the most advanced audits take into account. The remainder of the houses was evaluated by walk-through audits.

3.1.1 Professional Audit

Through the help of the GAC, we contacted a professional auditor from Comfort Systems USA Energy Services, Albert. G. LaValley. He is a LEED AP program manager and volunteered his time to aid our needs. Because Mr. LaValley is a professional auditor and had access to necessary tools and equipment, more advanced analysis of the building was performed. A Blower Door fan, able to detect air leaks, is just one of the tests he is able to perform with ease. Unfortunately, during the gas emission test to check boiler efficiency the piece of equipment, called a Bacharach, malfunctioned and therefore he could not collect that data.

Due to the cost and time associated with the work, he agreed to perform an audit on one chapter house to demonstrate what an in-depth audit entails. Since he is in fact a Greek alumnus of the institution, he requested that this work be performed on his chapter house, Sigma Alpha Epsilon. While the on-site audit of a building took only a few hours, there was a great amount of background information that was needed before the audit. This information included historical energy data, recent renovations, and structural configuration and dimensions of the house. After the audit was conducted, Mr. LaValley sorted the data and made recommendations justified through cost analysis.

During the audit, we shadowed his work to gain hands-on experience in energy auditing. Shadowing was beneficial to our understanding of the auditing process as we were able to take notes on his work and frequently ask questions relating to his methods and reasoning. Upon completion of the audit, we conducted an interview of Mr. LaValley to gain a better understanding of not only what is involved throughout the audit itself, but what preliminary background information is needed, and how to best interpret the resulting data.

3.1.2 Walk-Through Audits

Based on the results of our interview and shadowing with the auditor, as well as previous research into LEED, we created an evaluation form to be completed during the walk-through audits of the remainder of the Greek houses. Many areas of our audit were inspired by the LEED for Homes Checklist. Such areas include examining Energy Star-rated appliances, insulation of hot water pipes, and water flow rates and temperature. However, LEED is focused not only on reducing energy use, but also on improving the well-being of residents and the environment in less quantifiable ways such as through conservation of open green space and using local suppliers (USGBC, 2008b). The focus of the Green Study for Greeks was primarily on reducing utility bills through simple, effective, and practical improvements. Therefore, we have taken into account those areas of the LEED checklist applicable to improving fraternity housing and refrained from collecting data not warranted for the scope of our project, such as pest control and infrastructure design.

These walk-through audits relied on historical energy usage data as well as observations from around the house. To collect data, such as energy and water bills from the past two years, meetings were scheduled with those people responsible for paying each chapter's bills, either the house treasure or a housing corporation representative. To determine waste habits, we interviewed house managers to establish frequency of trash pickup and waste trends. Current recycling programs were evaluated and capabilities for future efforts were determined.

Areas of focus included water, heating, lighting, insulation, waste management, and appliances. We created a template for performing an audit on a typical Greek house, with fields for each area of focus. Mr. LaValley reviewed our template, and provided feedback on the data that we chose to gather. Namely, he recommended adding space on each sheet to write general comments and observations.

To test the consistency and framework of the evaluation sheet, each auditor performed an independent pilot audit of one house, Phi Kappa Theta. The purpose of the pilot audit was to determine consistency within each auditor's techniques and ease with using the form and to find areas of the form that needed to be corrected. Since the audits lasted for about three hours, we performed the audits at the same time, but had no communication between auditors until all four were done and had compiled and interpreted their data. The purpose of this arrangement was to avoid commandeering the chosen chapter house for 12 hours. This also allowed us to correct any confusion or discrepancies between our auditing methods at the very beginning of the process. We decided not to audit residential rooms to avoid any concerns regarding invasion of privacy.

3.2 Cost Analysis

Cost analysis consists of two elements. The first is calculating the present energy usage of the houses, for use as a baseline for future improvements. Since the houses have dramatically different populations, the statistics were calculated in terms of resource use per person. The second element of the cost analysis used the recommendations from the energy audits in calculating the costs and potential savings of the sustainability improvements. Using this data, we mathematically calculated the payback period ($Payback\ Period = \frac{initial\ \ investmen\ t}{after\ \ tax\ savings}$) of the separate improvements and made projections of the future utility bills of the Greek houses. The predicted cost reduction aided our effort to encourage further green innovation on the part of the Greek Community.

3.2.1 Database

Due to the amount of information gathered during the course of our auditing, a Microsoft Access Database system was needed to format information in an organized way. Professor Diane Strong, an associate professor who specializes in database systems at WPI, assisted the project group by reviewing the database, making suggestions to improve the system. This database allows for others to view, compare, and sift through our findings in an easy-to-use format as well as determine cost analysis data. Based on the information input, automatic queries were created to determine potential savings and payback period for implementing environmental lighting and water changes.

3.3 Manual

In conjunction with the audits and cost analysis of each house, we developed a manual for all of the Greek houses. The methodological considerations for designing the manual include a focus group with males and females in a 3:1 ratio to approximately represent WPIs gender statistics. Also present were members from each representative graduation class and various executive positions, such as house manager, treasurer, and president. The contents of the manual were also discussed with the Greek Advisor, Emily Perlow, the GAC Green Subcommittee, and Albert LaValley. It was determined to include general information that can be applied to every household, how-to procedures for implementing more complex changes, and specific recommendations based on the energy audit and cost analysis for each house. A colloquial tone was used throughout the piece to best suit our audience of the chapter members and to make it easy to read. The manual was made available publically through the GAC/Interfraternity Council (IFC) website, and distributed to each house manager and Housing Corporation President, attached along with an addendum of our walk-through audit findings (see Appendix XII). Lastly, the manual and our findings were distributed to the director of chapter services or the national housing corporations of each fraternity present in an effort to broaden the impact of our project and inspire changes within other chapters around the country. In addition, the project group will present its general findings and recommendations to the houses at the annual GAC Leadership Conference in February 2009. This will occur two months after the completion of the project, but it will have a great effect in raising awareness of our project as our audience will be representatives from every house and Housing Corporation.

3.4 GAC Award

The guidelines for a new GAC award were designed to be compatible with the existing awards packet and create a sense of competition within the Greek community. An existing award was used as a template in creating the questionnaire and scoring system. The contents and focus of the award were discussed with Emily Perlow and the GAC Green Subcommittee. It was determined that a monetary stipend of $250 would be given to the winner to be used for green renovations.

3.5 Summary

Through research and the assistance of a professional auditor a comprehensive walk-through energy audits and cost analysis techniques formed the basis for gathering and analyzing information, which satisfied the project goals. The information collected was ultimately used to create a manual of recommendation which is anticipated to raise awareness of environmental issues within the Greek community of WPI and to begin saving the houses money each year by reducing energy usage. Along with these recommendations, a new GAC award was created to act as a measure of how the Greek houses are implementing green changes throughout the course of the year.

4 Findings and Discussion

This section outlines data collected as stated in the preceding Methodology section. The first subsection describes the analysis of Sigma Alpha Epsilon based on the professional audit. This data is based on both a visual inspection of the house as well as the use of professional equipment. The second subsection describes the findings from each area of the walk-through audit. The third subsection outlines potential cost savings by implementing energy-reducing techniques such as CFLs, low-flow water, insulation, and recycling. The final subsection addresses our experiences while conducting energy audits as well as our opinions on how receptive the Greek community has been to our project. In general, our findings and cost analysis are somewhat limited because the group did not take personal bedroom space into account due to privacy issues. Nevertheless, we still believe the trends we have noticed to be valid throughout the Greek community.

The Greek houses are incredibly diverse in terms of ages, tenancy, and size (see Appendix IV). With the exception of the back house of Sigma Alpha Epsilon, Lambda Chi Alpha, Theta Chi, and Tau Kappa Epsilon, all the houses are at least 60 years old; with nine houses being more than 95 years old. The Greek houses range in population from seven to as many as 47 occupants, with an average residency of 22. Some of the houses were built with the purpose of housing a fraternity in mind, while others are repurposed lodging houses or apartments. It is remarkable that, despite the lack of uniformity among the houses in terms of physical attributes of history, the problems we observed were fairly uniform throughout the Greek community.

4.1 Professional Energy Audit

The following sections outline the simple energy audit and analysis of the professional audit conducted by Mr. LaValley of Comfort Systems USA Energy Services. An examination of the site and utility information allows for three-dimensional modeling and an evaluation of upgrades supported through cost analysis.

4.1.1 The Site

The site consists of two buildings, detached and located adjacent to each other as noted in Figure 3. Following convention, the buildings will be labeled as White House (WH) and Brown House (BH). Front of both buildings are oriented to the Northwestern direction.

Figure 3: Aerial View of the Site

4.1.2 Utility Information

Electricity is provided to both buildings by National Grid, at an average blended rate of $0.115/kWh. Natural Gas is provided by NSTAR at an average cost of $1.36/Therm. The average daily use for each fuel type is shown in Tables 3 and 4 by month. Monthly information is also summarized in Appendix I.

Table 3: Summary of White House Daily Energy Use

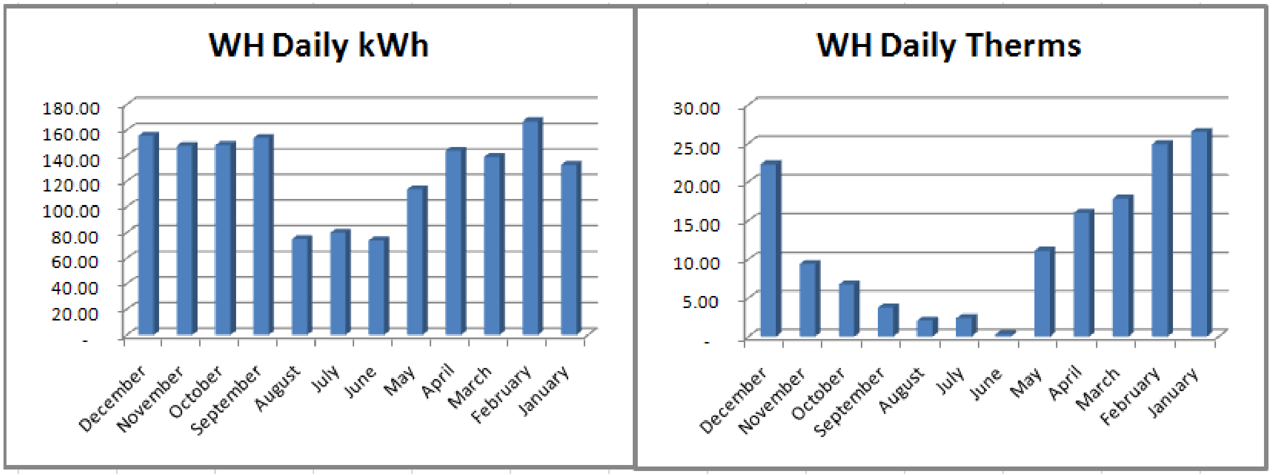
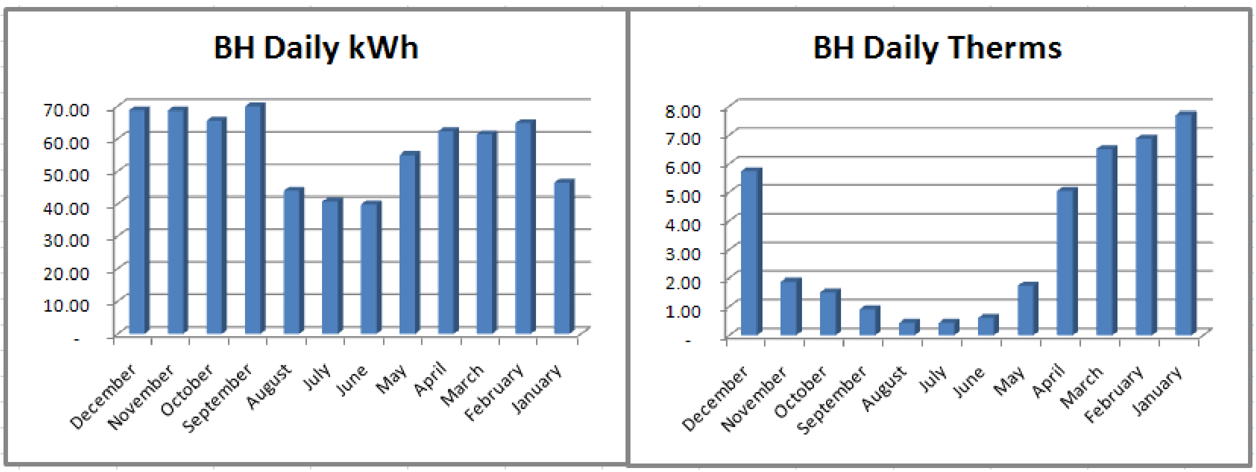


Table 4: Summary of Brown House Daily Energy Use



4.1.3 Modeling

To model the structure of the site the program eQuest 3.63 was used. eQuest is a DOE-II based building simulation engine approved by the Department of Energy and the American Society of Heating and Refrigeration Engineers for use in evaluating energy efficiency improvements to comply with LEED standards and other energy efficiency criteria. Figure 4 shows a computer rendering of the model used to evaluate this building.

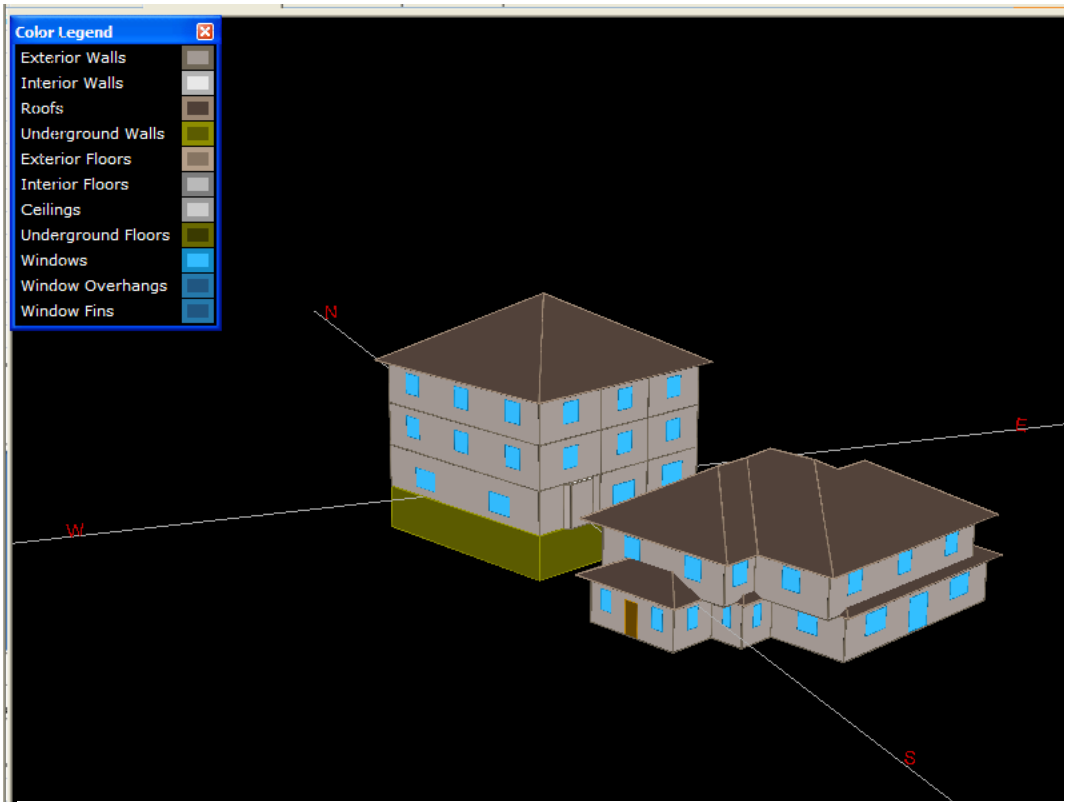


Figure 4: eQuest Model

4.1.4 Evaluated Upgrades

For the purposes of this evaluation, the following Energy Efficiency Measures were analyzed (see Appendix I for simulation output results):

1. Boiler Plant Improvement – Replace existing White House boiler (estimated efficiency – 78%) with high-efficiency condensing boiler containing outdoor air temperature reset. Adjust hot water loop flow accordingly.
2. Insulate White House attic space – Currently the White House attic is poorly insulated. This measure would increase the insulation in the White House attic to R-38 and seal the attic plane.
3. Air-Seal White House – Perform air sealing on the white house to decrease air infiltration by 50%.
4. Insulate Basement Space and Kitchen – Improve thermal performance of basement insulation to R-13.
5. Install high-efficiency compact fluorescents where not already present – Estimated at a 10% reduction in lighting power use.

4.2 Walk-Through Energy Audits

The following sections outline the findings based on each area of the walk-through audits that were performed. These audits were necessary in defining the difference between houses. Knowing that information, the best recommendations for each house to reduce energy usage could be determined. For each section general findings are discussed as most of the houses had many aspects in common. Oddities are also described to determine ways in which energy and money were being wasted. Photographs as well as descriptions are used to illustrate such areas of energy loss.

4.2.1 Lighting

The project group was pleasantly surprised to find that the vast majority of lights used in the Greek community are either fluorescent tube lights or CFLs. However, every house still had at least a few incandescent, high-wattage light bulbs. The project group suggested that all lights in the houses be switched to 14W CFLs or higher-efficiency T8 fluorescent tube lights, with the exception of incandescent bulbs used for ornamentation, such as the 60 watt flame-shaped incandescent bulbs used in candelabras and chandeliers. We suggested that fraternities switch their exterior flood lights to CFLs, both to save energy and because CFLs last longer under the conditions that a floodlight must endure, namely extreme temperatures and long operating hours.

The prevalence of green lighting in the fraternities is a sign that the Greek community is open to further green improvements. Although the lights in many of the Greek houses are left on for far longer than necessary, the effect is mitigated by the fact that the bulbs already use as little as one quarter of the electricity of normal incandescent bulbs. Nevertheless, shutting off the lights would be a major improvement to the Greek community's energy usage. This finding naturally led us to consider the use of motion sensors which would automatically shut off the lights when it no longer detected people in a room. Motion sensors were in short supply in the houses, and the ones that were present were found to be broken or disabled. When inquiring about how one motion sensor came to be broken, a brother stated that someone had smashed it during a party. The group still suggests the use of motion sensors, but attempts to steer fraternities away from models mounted in the light switch and towards models mounted in the ceiling, preferably with a protective cage to prevent accidental or purposeful interference with the unit's functioning. For areas where motion sensors are not practical or possible, the houses can only rely on the conscientiousness of their members. It is the purpose of the manual of recommendations (see Appendix III) to raise the awareness of green issues in the Greek community, so that turning off the lights in houses eventually becomes a non-issue.

4.2.2 Water

Water usage is an area where fraternities can make improvements which save money without great effort on the part of the brothers. The first way to save is to reduce the amount of energy required to heat water to the desired temperature. Massachusetts state law requires that hot water be set to between 100°F and 130°F. If the pipes carrying the hot water to the water fixtures are insulated correctly, it is only necessary to heat the water heater to a few degrees above the desired hot water temperature. In several houses, however, the project group found uninsulated hot water pipes. (Figure 5 represents properly insulated pipes.) Not only is this a safety hazard, it is also a tremendous waste of energy. It was not unusual to find boilers set to 140°F, with hot water coming out of the sinks and showers at only 110°F. Those 30 degrees of heat loss, and the significant amount of money wasted thus, could be avoided with a few dollars worth of insulation and duct tape. In an extreme case, a temperature of over 160 degrees was found in one house. This, posing a serious health and safety issue as a potential burn hazard, is wasting a great deal of money on heating, and is in violation of building code.

Figure 5: Properly Insulated Piping

Another improvement to the water system happens at the sinks and showers. In older faucets, it is common to find a water flow rate of 200 milliliters per second or more. This is far more water than people need to wash their hands. For these older faucets, it is recommended to install a low-flow aerator. Low-flow is considered to have a flow rate of 100 milliliters per second. An aerator fits over the opening of most faucets and introduces air into the water stream, cutting the amount of water used by half with no effect on the use of the sink for washing. Another way that chapters can reduce their water flow rate is to dial back the pressure on their water pumps.

4.2.3 Heating

The heating in all houses is handled by at least one of two appliances, the boiler and the water tank/heater. A boiler has several open pipes in the bottom through which natural gas or fuel oil is sprayed and ignited, heating up water that runs through the belly of the machine in pipes. The heated water from the boiler is then directed by pumps into the radiators throughout the building. A water tank/heater stores hot water in an insulated cylinder until it is needed by the showers or sinks in a building. A water tank stores water from the boiler, which feeds the tank hot water at such intervals as to maintain a constant temperature. A water heater has a separate burner underneath it to maintain the temperature of hot water. Use of a water heater gives greater control over the water temperature and takes stress off of the boiler. There are two main heating configurations used in the Greek houses. The first, and most prevalent, is a combination of a boiler and a water heater. The boiler controls the water used to heat the radiators, while a water heater stores and maintains the high temperature of the water used in the showers and sinks. The second configuration is simply a boiler alone. The difference between the two is that with the first configuration, it is possible to lower the temperature of the hot water to save energy.

The most obvious element of heating is of course the temperature to which the thermostat is set. In this respect, the Greek houses were reasonably efficient, keeping their houses at the recommended 68 degrees Fahrenheit. Few houses featured programmable thermostats that could lower the temperature while the house was unoccupied, but only one house was uncomfortably warm. The location and control of the thermostat varied greatly between the houses. Some houses had separate thermostats for every room, others were designated in the hallways of each floor, and others were locked in a separate room where only the House manager had access. We recommend programmable thermostats that are locked away so that only the house managers have access to them.

4.2.4 Insulation

Insulation is the sum of all measures that a house takes to reduce or eliminate the uncontrolled flow of heat between the interior and exterior of a house. Although insulation is essential to heating a house efficiently, especially in the cold climate of New England, the Greek houses very often had serious problems with their insulation. The window frames in most of the houses were wooden, which is normal for the time that these houses were built. However, wooden window frames are harder to seal and are prone to warping, which lead to gaps between the window and the frame, as shown in Figure 6. These gaps allow heat to seep out of the building almost constantly. Figure 7 shows a broke basement window which needs to be replaced as a great amount of heat loss is occurring.

Figure 6: Damaged Window Frame

Figure 7: Broken Window

On metal window frames warping was not an issue, but many of the older frames featured rubber seals that had degraded or been ripped off, allowing cold air into the room. Often, the problem was so severe that a draft was noticeable from over a foot away. Some houses used single-pane windows which act poorly to prevent drafts, but almost all houses examined had used double-pane windows, which have a layer of gas sandwiched between two full sheets of glass to provide superior insulation to a single-pane window. Unfortunately, installing Energy Star-rated windows or storm windows is quite expensive with a long payback period due to the renovations required and relatively low energy savings. Albert LaValley, a professional auditor, estimated the payback to be as many as 20 years. Therefore, transitioning windows is not recommended for as a short-term fix but should be considered by housing corporations if other renovations, such as residing, are already scheduled to occur.

Another insulation problem occurred in the exterior doorways of the houses. Again, wooden door frames are vulnerable to warping, and many houses often have gaps between the floor and the exterior doors or between the door and the door frame, as seen in Figure 8. Rubber or metal skirts exist to fill these gaps, but of the houses that needed them, few had installed them, and fewer still maintained them.

Figure 8: Missing Door Skirt

Figure 9: Missing Attic Hatch

The attics in the houses posed yet another insulation problem. Because heat rises in a building, it is essential to have a well-insulated attic to prevent heat from escaping from the house through the ceiling. Unfortunately, we encountered several houses that lacked any insulation at all in their attics and many others without properly sealed attic hatches. Figure 9 is an extreme case showing a missing attic hatch. Without a hatch, energy is constantly wasted through heating the attic.

This problem is compounded by the architecture of many of the houses. In order to create more room for occupants, the majority of the houses were built on a central pillar system, with one open stairwell leading from the first floor up to the top of the building. This configuration allows a large amount of heat to escape the lower floors and seep into the attic, as shown through Figure 10. If the attic is not insulated properly, the heat in a house can be quite literally "blown out the window." An oft-overlooked insulation problem is the gap that occurs between a pipe that crosses the plane of the ceiling, and the ceiling itself, as shown in Figure 11. This accounts for heat transfer through the stories of the house. In order to fix this problem the entry point of the pipe should be filled with insulating foam or an expanding insulating spray, but this was rarely done.

Figure 10: Open Chimney in

Figure 11: Unsealed Piping

Basements are another area found to have major heat loss areas. Broken windows, unsealed piping fixtures, and uninsulated windows were also present there. Like the attic, a properly insulated basement has a major effect on reducing the heat loss within the rest of the house. Figures 12 and 13 below represent an improperly and properly sealed basement window, respectively. Figure 12 uses a cafeteria tray to cover over an open vent while Figure 13 contains a piece of insulation over the window with expanding foam to stop air leaks around the edges.

Figure 12: Improperly Sealed Window

Figure 13: Properly Sealed Window

4.2.5 Waste Management

Given the amount of trash that a fraternity houses produces, it is surprising that so few houses have instituted recycling programs. Like most issues with environmental sustainability, the main issue preventing change seems to be inconvenience, not cost. Because fraternities are classified as commercial buildings in the city of Worcester, they are not eligible for city trash or recycling pickup. Most fraternities have a dumpster to dispose of trash which is emptied on a weekly or biweekly basis. Very few fraternities drop off their recyclables at a recycling center, opting instead to dispose of them in the dumpsters with their normal trash. This is not only harmful to the environment but fiscally wasteful as well. One fraternity, Sigma Phi Epsilon, was able to save approximately $1,200 a year by recycling their cans, bottles, and cardboard. The reason the house was able to save this money is because trash disposal companies charge by weight to empty their dumpsters. By reducing the amount of material placed in the dumpster, money was ultimately saved and the impact on the environment was lessened. It should be noted that most houses at least recycle bottles and cans by redeeming them for the five-cent deposit. The close proximity of a can and bottle recycling station at the Price Chopper on Park Street made the decision easier. In order to guarantee that recycling occurs, we recommend that it become the responsibility of one of the officers of the house, such as the house manager or assistant house manager. Responsibilities included in this position should be to provide necessary receptacles, ensure members are conscious of recycling, and appropriately dispose of recyclables.

4.2.6 Appliances

Fraternities have a much higher appliance load than a normal house due to the resident capacity. Many fraternities need walk-in freezers and industrial refrigerators to store their food and supplies. Fraternities also use professional-grade washers and dryers that will stand up to the stress of constant use throughout each day. Unfortunately, these appliances are usually extremely inefficient, because of their age. These heavy-duty appliances use a great deal of electricity, but there are ways to reduce the load. Energy Star is a government program that rates appliances' energy efficiency, and gives an Energy Star certification to appliances that meet government criteria for energy use. By purchasing Energy Star-rated appliances chapters can cut their bills substantially, along with getting better performance out of their appliances.

4.3 Cost Analysis

In order to compare the energy usage of each house we employed a Microsoft Access Database to input all the data collected during the walk-through audits. This program was also used to calculate potential savings if green recommendations were implemented by the Greek houses. Due to the inability to quantify certain areas of potential savings, the group focused its efforts on lighting and water cost analysis. Areas such as adding insulation and reducing water heater temperature will greatly reduce energy consumption; but the exact savings are difficult to be predicted. For example, adding insulation around hot water pipes will neglect heat loss and therefore allow for hotter water in faucets and showers to be the same temperature to which the water heater is dialed. This will not only reduce the load on the water heater, but will also allow for House managers to turn down the water heater temperature, again reducing the energy load, without risking the inconvenience of readily available hot water.

4.3.1 Lighting

Based on the current incandescent usage in each house, the potential annual savings from a transition of CFLs were calculated and listed in Appendix V. The annual incandescent operating cost (IOC) and CFL operating cost (COC) were calculated with the equation, $\frac{\sum(usage * Watts * hours)*0.115*365}{1000}$, where usage is the number of lights operating for a high, medium, or low amount of time, represented by 21, 12, and 4 hours respectively. The IOC is calculated using the wattage of incandescent present in the house, whereas the COC reflects the operating cost if each incandescent were transitioned to a 14W CFL.

Table 5: Lighting Comparison

Item	Cost ($)	Lifespan (hr)	Watts
1 kWh electricity	0.115	N/A	N/A
Average CFL	3.50	8,000	14
Average Incandescent	0.50	1,000	60
Average T8	3.50	20,000	32
Average T12	3.50	20,000	34

The sum of the product of these quantities is then multiplied by the cost of electricity per kilowatt hour, $0.115, multiplied by 365 days per year, and then divided by 1,000 to convert watts to kW. Finally, the total savings are calculated by taking the operating cost and including the cost associated with replacing lights through the year. As shown in Table 5, a CFL is seven times more expensive, but it lasts eight times as long and therefore saves $0.50 per year per bulb that is switched to CFL before operating cost is even taken into account.

Similarly, a cost comparison between T12 and T8 fluorescents (see Appendix VI) was conducted using the same equation as previously stated. The T12OC field represents the current annual operating cost based on T12 fixtures. The T8OC field predicts the annual operating cost if the 34W T12s were transitioned to 32W T8s. The total savings again take transition cost and lifespan into account. As shown in Table 3, T8s and T12s cost the same amount and have the same lifespan. The differences between the two bulbs are two-fold. First, T8s use 6% less energy and therefore save $4.60 over the course of the bulb due only to the lower energy consumption. Secondly, a T8 bulb is rated with 25.8 more lumens per Watt than a T12 fluorescent and therefore produces more light.

Finally, the savings pending the installation of motion sensor on high usage lights were estimated for all houses (see Appendix VII). In this calculation, the high usage lights were predicted to fall to a medium usage level due to being turned off overnight or when the space is vacant. To determine the savings, first the cost of operating all high usage lights currently present in the chapter houses was calculated based on current high usage hours. Next, to simulate the operating cost with to motion sensors, the calculation was performed using medium usage hours. The difference in these two values represents the total savings simply by installing motion sensors.

For a transition from incandescent lighting to CFL, the average potential savings per year is predicted to be $282.90. In the most extreme case, the Phi Sigma Sigma Sorority could save $1,148.55, an electricity savings of over 75% by replacing all incandescent lights with 14W CFLs. Through a T8 transition, Fiji had the most significant savings of about 10% with $273.01. Due to the large numbers of lights in the chapter houses and great quantity listed as high usage from being left on overnight, the average savings by installing motion sensors amounted to $562.37. Lambda Chi Alpha has the opportunity for the most savings with an estimated $1,657.68 per annum. Table 6 lists the complete cost savings for all audited houses.

Table 6: Chapter House Lighting Comparison

House	Current Incandescent Cost	CFL Savings	Current T12 cost	T8 Savings	W/O Motion Sensor	Motion Sensor Savings
ΑΓΔ	$274.52	$217.96	$302.56	$50.80	$271.49	$116.35
ΑΤΩ	$20.15	$16.45	$522.34	$50.73	$777.46	$333.20
ΑΞΔ	$506.85	$429.90	$82.77	$8.87	$214.20	$91.80
ΑΧΡ	$372.10	$305.98	$1,207.36	$129.02	$1,695.08	$726.46
Fiji	N/A	N/A	$2,924.23	$273.01	$2,898.29	$1,242.12
ΦΚθ	$33.58	$29.88	$11.42	$2.67	$160.43	$68.76
ΛΧΑ	$342.52	$271.10	$1,555.59	$151.50	$3,867.91	$1,657.68
θΧ	$20.15	$16.45	$29.97	$2.76	$1,158.25	$496.40
ΡΣΚ	N/A	N/A	$459.54	$47.03	$509.49	$218.35
ΡΣΣ	$1,473.32	$1,148.55	N/A	N/A	$2,042.38	$875.30
ΣΦΕ	$298.15	$230.57	$1,003.29	$110.02	$1,971.86	$845.08
ΣΠ	$105.78	$82.10	$59.94	$5.53	$1,124.76	$482.04
ΤΚΕ	$528.89	$370.57	$131.30	$13.72	$935.24	$400.82
ΖΨ	$405.48	$275.23	$308.26	$30.13	$743.96	$318.84
Average	**$365.12**	**$282.90**	**$661.43**	**$67.37**	**$1,312.20**	**$562.37**

4.3.2 Water

Potential savings through the implementation of low-flow aerators and shower heads were calculated for those fixtures currently producing more than the recommended low-flow water level of 1.5 gallons per minute (see Appendix VIII and IX for complete breakdown of data). These calculations take into account both the water savings due to a reduced flow rate and the energy saving based on less water that needs to be heated.

In determining the water savings per year (WSPY) for faucets, first estimated was the current gallons per year (GPY) consumed by each house through the equation, $GPY = GPM * type * 200$. This equation takes into account two different types of faucets: kitchen and bathroom. Kitchen faucets were estimated to be used for 60 minutes per day due to the large number of dishes that must be cleaned every day. In reality, each house has a different system for cleaning dishes so this number is an estimate based on an average personal experience within two houses, Alpha Tau Omega and Sigma Alpha Epsilon. Each resident was estimated to use the bathroom sink for 3.5 minutes a day. This time takes into account washing hands an average of four times a day, washing face once a day, and brushing teeth twice a day. Due to the varying flow rates in each bathroom, the number of residents per bathroom was established to best estimate how often each floors bathroom would be used and therefore better predict the final GPY. The 200 represents the approximate days of residency at the houses. Gallons per year recommended (GPYR) was then calculated using the same equation, except with 1.5 in place of GPM. Next, the cost per year (CPY) of those sinks using more water than the low-flow level was calculated with the equation, $CPY = \frac{GPY * Q * 4.67}{1000}$. Here, the sewage and water cost is represented by $4.67 per 1000 gallons and Q is the quantity of sinks. The cost per year with recommendations (CPYR) was calculated the same way except with GPYR in place of GPY. Finally, the WSPY was determined through the equation, $WSPY = CPY - CPYR$.

The second part of the calculation, energy savings per year (ESPY), was begun by figuring the amount of energy, in therms, required to raise ground water to the maximum output temperature recorded during the walk-through audit. The following equation is the conversion needed to increase the recorded temperature, T, from ground temperature:

$Temp = \frac{3.79*4189*\left[\left(\frac{5}{9}*(T-32)\right)-12.78\right]}{1.05*10^8}$. Using this equation, the overall current energy cost per year (ECPY) is calculated by $ECPY = GPY * Temp * 1.36$, where $1.36 is the average NSTAR cost of one therm of natural gas. Through in installation of low-flow aerators, the energy cost per year recommended (ECPYR) was estimated using the same equation except replacing GPY with GPYR. Lastly, the total energy savings per year (ESPY) were determined from the difference between the ECPY and ECPYR.

Ultimately, in combining the water and energy savings, total savings per year (SPY) can be calculated. The SPY also takes into account the price necessary for purchasing an aerator, determined on average to be $1.75, with the equation, $SPY = WSPY + ESPY - (Q * 1.75)$. Finally, the payback period, in days, was calculated by use of the equation, $Payback = \frac{Q*1.75}{\frac{SPY}{365}}$, to determine how long will be required before the houses regain their initial green investment.

Shower usage was determined in the same fashion and using the same basic equations as for faucets; again just for those shower heads producing more than 1.5 gallons per minute were taken into account with the cost analysis and savings. The only differences in calculation are that the average shower time was estimated to be eight minutes per person, representing the *type* variable, and the cost associated with replacing the current shower heads with low-flow fixtures was standardized at $20.

Table 7: Chapter House Water Comparison

	Low-Flow Shower Head				Low-Flow Aerator			
House	**WSPY**	**ESPY**	**SPY**	**Payback (days)**	**WSPY**	**ESPY**	**SPY**	**Payback (days)**
ΑΓΔ	$77.36	$182.06	$199.42	83.26	$111.59	$281.05	$519.44	8.29
ΑΤΩ	$339.95	$541.75	$761.70	49.00	$262.51	$374.52	$892.33	5.56
ΑΞΔ	$45.90	$60.75	$66.64	135.03	$48.23	$98.24	$299.12	6.21
ΑΧΡ	$84.31	$135.30	$139.61	131.14	$774.91	$1,369.82	$1,959.89	1.92
Fiji	$515.32	$960.02	$1,395.34	19.52	$63.27	$119.01	$318.98	13.31
ΦΚθ	$17.68	$24.25	$1.93	343.39	$53.47	$83.94	$282.28	12.91
ΛΧΑ	$240.56	$429.14	$529.70	75.26	$65.32	$119.67	$330.46	16.38
θΧ	$37.20	$48.74	-$154.06	1005.38	$291.84	$462.65	$1,448.45	3.45
ΡΣΚ	$119.78	$212.68	$232.46	108.28	$95.50	$161.48	$390.00	9.44
ΡΣΣ	$34.81	$61.01	-$4.18	375.72	$36.87	$70.32	$244.38	14.83
ΣΦΕ	$115.13	$152.57	$127.69	188.27	$85.13	$120.99	$347.06	15.63
ΣΠ	$32.23	$54.33	$6.57	332.69	$90.26	$158.46	$381.56	12.74
ΤΚΕ	$166.69	$405.45	$412.14	100.67	$453.15	$1,118.03	$1,518.33	6.92
ΖΨ	$294.28	$323.49	$557.76	34.96	$130.79	$176.41	$440.60	4.24
Average	**$151.51**	**$256.54**	**$305.19**	**213.04**	**$183.06**	**$336.76**	**$669.49**	**9.42**

As shown in Table 7, an average savings of $305 can be expected through switching to low-flow shower heads. The house estimated with the highest savings is Fiji with about $1,400. The houses of Theta Chi and Phi Sigma Sigma are both seen to have negative savings after one year. Both these houses have shower heads that produce more than the recommended 1.5 gallons per minute, but do not exceed 2.1 gallons per minute. Also, Theta Chi has 12 shower heads that could be replaced which created a high transition cost. However, the payback period represents that both houses will begin to save every year in the long term.

Likewise, by installing new aerators on all sinks, an average savings of $670 per year can be expected throughout the Greek community. Due to the fact that aerators only cost $1.75, the payback period associated with all chapters is well under one month. Alpha Chi Rho is expected to save nearly $2,000 if all sinks are converted. One probable obstacle seen in this transition is in regards to kitchen sinks. Some houses prefer a higher flow rate because it is more convenient to fill the sinks as fast as possible before cleaning dishes. If Alpha Chi Rho were to leave their kitchen sink non-aerated, currently rated at 11.1 GPM, they would only save about $620 a year opposed to their potential of $2,000.

4.3.3 Washers

In determining the cost savings associated with the transition to Energy Star-rated appliances a comparison was performed to reflect the yearly savings between purchasing a new Energy Star versus non-Energy Star washer (see Appendix X). This calculation, based on an Energy Star template (Energy Star, 2008), was threefold including the savings in gallons, electricity, and therms. Table 8 represents the differences between the two washer types.

Table 8: Washer Data Comparison

Item	Normal	Energy Star
Gallons per Load	32.5	14.77
Cost per Gallon	$0.00467	$0.00467
kWh per Load	0.2090	0.1434
Cost per kWh	$0.115	$0.115
Therms per Load	0.0731	0.0308
Cost per Therm	$1.36	$1.36

First calculated were the gallons per year savings (GPYS) through the equation, $GPYS = (32.5 - 14.77) * (loads * 30 * cost\ per\ gallon)$. The first term represents the difference between gallons used per load. The second term contains the *loads* term, averaged as one load per week per resident, the estimated weeks of usage, and the cost per gallon of water.

The energy per year savings (EPYS) and therms per year savings (TPYS) were determined by use of parallel equations. The equation, $EPYS = (0.2090 - 0.1434) * (loads * 30 * cost\ per\ kWh)$, describes the electricity cost difference. The TPYS is found to be similar as $TPYS = (0.0731 - 0.0308) * (loads * 30 * cost\ per\ therm)$.

The final SPY was found by summing the three separate cost savings due to the Energy Star reduction in overall resource usage. A payback period, in years, for purchasing an Energy Star washer was lastly concluded through the use of the equation, $Payback = \frac{(850-100)*washers}{SPY}$. This payback takes into account the number of washers present in each house as well as the price of purchasing the new appliance while subtracting maintenance fees that would be saved by replacing an old appliance.

Since our comparison is being made to a new, non Energy Star washer, our SPY and therefore payback are underestimated. None of the washers in the Greek Houses were currently Energy Star and most appeared to be ten or more years old. Therefore, they are currently less efficient, which would therefore continue to increase the savings associated with installing an Energy Star appliance. For this, the average SPY of $200 based on this comparison would increase undoubtedly.

4.3.4 Refrigerators

In order to determine the cost savings associated with purchasing a new Energy Star-rated refrigerator, only those commercial refrigerators were taken into account (see Appendix XI). Therefore, residential refrigerator-freezer combinations were not included as they were in the minority of houses. Three different types of refrigerators were found within the Greek houses depending on number of doors. Table 9 lists the differences between the three which were used when calculating savings.

Table 9: Refrigerator Data Comparison

Number of Doors	Average ft^3	Cost	Lifetime Maintenance
1	38.03	$2,715	$200
2	66.17	$3,200	$250
3	122.58	$4,500	$300

In order to determine the current energy per year (EPY) consumed by the appliances the equation, $EPY = \left((0.1 * ft^3) + 3.54\right) * 365$, was utilized, where 3.54 represents the average non-Energy Star energy consumption per kWh. The recommended energy per year (REPY) is calculated in the same fashion except with 1.9 kWh for an Energy Star refrigerator.

The overall savings per year (SPY) is found by the difference, $SPY = EPY - REPY$. Finally, the associated payback period, in years, was determined through the formula, $Payback = \frac{Cost - Maintenance}{SPY}$.

Of all the Greek houses, currently 11 of 15 contain one or more commercial refrigerators. Based on these calculations presented above, an average savings of $1,000 is expected if all were to be switched to Energy Star-rated refrigerators.

4.4 Reception of Sustainability Movement

In performing energy audits on the Greek community, it became apparent that the main obstacle to sustainability was not opposition to the changes, but mere apathy about the state of the chapter houses. Lights are frequently left on at night in most houses, and while some have motion sensors, most of them have been disabled either by vandals or by the residents themselves due to the annoyance of lights turning off while they are still in the room. As stated previously, it is not in the scope of this project to implement any suggestions, only to convey our recommendations to the chapters. That being said, no house was viewed to be a complete loss, and most had some form of green technology already implemented. Based on the feedback received from our focus group as well as the interest shown by house managers during our audits, we believe our manual of recommendations (see Appendix III) including personalized audit addendums (see Appendix XII) will be a success and expect to see many more green changes occurring in the near future. We were able to confirm most of our assumptions about the attitudes of the Greek community in the focus group. We learned that the main motivation for the Greek houses to cut energy use is monetary concerns; one of the participants cited skepticism about global warming as fairly prevalent around his house, making an environmental argument difficult to make. We also noted a general consensus that the support from the university in the form of provided services or other no-cost incentives would go a long way towards convincing chapters to go green. It was also noted that houses that did not pay their own energy bills, but had them paid by their Housing Corporation, felt less personally responsible for energy use and therefore tended to waste more as they pay a fixed rent cost.

5 Conclusions and Recommendations

The project began with the assumption that green improvements to a house are indeed economical. This turned out to be a good assumption, and the project would have gone nowhere had the assumption been proved false. The results, however, were more dramatic than anticipated. The average savings for a house that changes its lighting and water fixtures, and mounts motion sensors on its high usage lights will be approximately $1,887 a year, including the cost of new hardware. That figure does not take into account other energy-saving methods whose savings are difficult to calculate without complicated computer models, such as new insulation and installing new windows.

A recurring theme in the energy audits performed on the Greek community is the existence of problems caused by a lack of conscientiousness, rather than a lack of money or equipment. It is telling that there are some green innovations that are widespread in the Greek community; namely the use of CFLs and aerated sinks that require no effort on the part of the residents of a house. Others, such as maintaining insulation and switching off lights, which require monitoring by the residents of a house, are tragically underutilized. When asked about the primary obstacle to sustainability in their houses, our focus group overwhelmingly cited “laziness” and lack of knowledge of green issues. The tone of our manual of recommendations (see Appendix III) reflects this reality. It is a conversational piece, a non-threatening piece of cajolery intended to educate the average fraternity or sorority member about green issues and to overcome any reluctance towards change by presenting attractive arguments in favor of environmental sustainability in the form of cost analysis. In the end, the house managers, presidents, and housing corporations can only do so much to cut down on utility bills and save energy; the culture of the houses and their attitudes toward the environment and sustainability are far more important. A certain house comes to mind, recently built, whose residents spared no expense in insulating their new dwelling and installing efficient lighting in its hallways and bathrooms. Upon entering, an auditor might expect the house to be rather energy efficient; indeed, the house has done an exemplary job maintaining their door seals and window frames, and uses high-efficiency sink fixtures in every bathroom. The auditor is shocked, then, when he learns that all of the hallway and bathroom lights are left on for nearly twenty hours a day. When the auditor suggests that the residents install motion sensors so that the chore of shutting off their lights is taken off of their shoulders, he is shown to the bathroom where there are vandalized remains of a fixture-mounted motion sensor. This attests to the limitations of technology in solving the energy crisis. Another house comes to mind, also recently built, whose residents pay a fixed tri-monthly rent, encompassing the costs of food, waste management and utilities. In this house, sunlight replaces electric light for most of the day, the insulation is well maintained, and the residents recycle the majority of their waste. These are long-time practices for the residents themselves despite never seeing the utility bills. The culture of the house is such that the residents are encouraged to save energy for the sake of it, despite not seeing the benefits directly.

The purpose of our project was to make recommendations to the Greek community concerning the transition to a green lifestyle on a financial ground. Unfortunately, the manual and its accompanying energy audit alone might not be enough to convince the Greek community to significantly cut back on its energy usage. It is up to the leadership in each house to impress upon their residents the importance of these changes to the future of their chapter, and it is in turn the responsibility of the residents themselves to not only follow these recommendations but to encourage their peers to follow them as well. A brother or sister is much more likely to put forth effort towards a green program if they feel that they are not alone in making the effort towards a more sustainable house.

The outlook, however, is not one of pessimism. Our focus group indicated willingness to make changes to their houses as long as those changes resulted in monetary savings, which we have definitively concluded it will. Our informal conversations with members of the Greek community yielded the same response, and added credence to the idea that a lack of knowledge of green issues was the primary issue, not hostility to environmental reform. Only one member of the focus group cited fairly prevalent skepticism over anthropogenic climate change in his house, but added that the financial argument was very convincing. This makes the financially oriented focus of our manual much more effective because it will help to convince those who would not otherwise take a stand on environmental issues.

On a more practical note, there were several areas not investigated by the scope of our project that form plausible avenues for future IQPs. It was the goal of our sponsor to raise awareness within the Greek community through easy-to-implement recommendations first, and then to address more substantive changes to the infrastructure of the house in future projects. The project did not address alternative energy, for example, such as the use of solar water heating, wind turbines or solar electricity. Though recycling was included as a section in the manual and in our recommendations, far more can be done to address responsible waste management in the Greek community, perhaps in conjunction with WPI or the city of Worcester. Other than the GAC Award (see Appendix XIII), the project also has no way to track the long-term effect of our recommendations, or to gauge the attitude of the Greek community towards green issues as a result of our work. The opinions of the Greek community towards more abstract environmental issues such as land conservation and biodiversity after participating in a green energy use program would be an interesting study, primarily because the two are very different branches of one fundamental philosophy of environmental stewardship.

References

Barnes, G. (2008, Green on top: WPI's new dormitory grows to meet a need. *Worcester Telegram & Gazette,* Retrieved from http://www.telegram.com/article/20080819/NEWS/808190626/1116

BREEAM. (2008). *The code for sustainable homes.* Retrieved September 25, 2008, from http://www.breeam.org/page.jsp?id=86

Calder, W., & Clugston, R. M. (2002). U.S. progress toward sustainability in higher education. In J. C. Dernbach (Ed.), *Stumbling toward sustainability* (pp. 625) Environmental Law Institute. Retrieved from http://www.ulsf.org/dernbach/history.htm

Calhoun, T. (2006). *A (recycled, of course) six-pack of sustainability lessons from the past year in higher education: A report on campus sustainability day III held on october 26, 2005*. Ann Arbor, Michigan: Society for College and University Planning. Retrieved from http://www.scup.org/csd/3/pdf/SCUP-CSD-Report.pdf

Carmichael, C., Chameau, J., & Clough, G. W. (2006, Sustainability and the university. *The Presidency, Winter,* 32. Retrieved from American Council on Education database.

Chilson, M. (2008). Going green: Federal tax breaks provide a green incentive to change. *Kansas City Business Journal, May* Retrieved from http://www.bizjournals.com/kansascity/stories/2008/05/05/focus17.html

"Consumer Information Center: Automatic and Programmable Thermostats." (2008) Retrieved November 5, 2008, from http://www.pueblo.gsa.gov/cic_text/housing/thermo/thermo.htm

Database of State Incentives for Renewables & Efficiency. (2008). *Federal incentives.* Retrieved September 22, 2008, from http://www.dsireusa.org/

Dautremont-Smith, J., Newport, D., & Walton, J. (2008). *Sustainability tracking, assessment & rating system (STARS) for colleges and universities: Guide to pilot phase one*. Lexington, KY: Association for the Advancement of Sustainability in Higher Education. Retrieved from http://www.aashe.org/stars/documents/STARS_0.5.pdf

Department of Public Works and Parks. (2008). *DPW Trash & Recycling - General Information*. Retrieved November 11, 2008, from http://www.ci.worcester.ma.us/dpw/trash_recycling/general.htm

Domask, J. J. (2007). Achieving goals in higher education: An experiential approach to sustainability studies. *International Journal of Sustainability in Higher Education, 8*(1), 53. Retrieved from http://www.ingentaconnect.com/content/mcb/249/2007/00000008/00000001/art00002

"Easy peasy tip: Reduce your toilet's water consumption." (2007). Retrieved September 24, 2008, from http://tinychoices.com/2007/08/25/easy-peasy-tip-reduce-your-toilets-water-consumption/

Energy Star. (2008). *Clothes Washers: Savings Calculator*. Retrieved December 9, 2008, from Energy Star: http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

Gullaksen, G. V., & Jatho, G. W. 1974, Low-*flow volume shower heads,* US Patent 3,831,860.

Harvard Green Campus Initiative. *Campus green loan fund.* Retrieved September 17, 2008, from http://www.greencampus.harvard.edu/gclf/startup.php

Kutz, M. (2006). Energy auditing. *Mechanical engineers' handbook - energy and power* (Third ed., pp. 277) John Wiley & Sons. Retrieved from http://knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=1532&VerticalID=0

"Low-flow aerators." (2008). Retrieved September 24, 2008, from http://www.eartheasy.com/live_lowflow_aerators.htm

Magat, W. A., Payne, J. W., & Brucato, P. F.,Jr. (1986). How important is information format? an experimental study of home energy audit programs. *Journal of Policy Analysis and Management*, *6*(1), 20-34. Retrieved from http://www.jstor.org/stable/3324078

MassSAVE. (2008). *About MassSAVE.* Retrieved September 25, 2008, from http://www.masssave.com/

Middlebrooks, R. (2008). *Tips for making your refrigerator green.* Retrieved September 28, 2008, from http://www.associatedcontent.com/article/575411/tips_for_making_your_refrigerator_green.html

National House Building Council. (2008a). *Code for sustainable homes.* Retrieved September 25, 2008, from http://www.nhbcbuilder.co.uk/Consultancyservices/SustainabilityServices/Codeforsustainablehomes/

National House Building Council. (2008b). *February 2008 announcement - code mandatory in england from may 1st.* Retrieved September 25, 2008, from http://www.nhbcbuilder.co.uk/Consultancyservices/SustainabilityServices/Codeforsustainablehomes/February2008announcement/

National Wildlife Federation. (2008). *Campus ecology.* Retrieved September 16, 2008, from http://www.nwf.org/campusecology/

Oregon Department of Energy. (2007). *Lights and light fixtures.* Retrieved November 10, 2008, from http://www.oregon.gov/ENERGY/CONS/RES/light/lights.shtml

"Pay to recycle CFL program." (2008). *Business & the Environment, 19*(9), 11-12.

Residential Energy Services Network. (2008). *Mortgage information.* Retrieved September 11, 2008, from http://www.resnet.us/ratings/mortgages/default.htm

Shepherd, J. (2008). *And the greenest university is ... gloucestershire.* Retrieved September 11, 2008, from http://www.guardian.co.uk/education/2008/jul/03/highereducation.uk1

Stroma. (2008). *Code for sustainable homes - training and accreditation.* Retrieved September 25, 2008, from http://www.stroma-ats.co.uk/Accreditation/CodeforSustainableHomesCSH.aspx

Thumann, A. (1995). *Handbook of energy audits* (Fourth ed.). Lilburn, GA: The Fairmont Press, Inc.

Times Press Recorder. (2008, New fraternity house seeking LEED certification. *Times Press Recorder,* Retrieved from http://www.timespressrecorder.com/articles/2008/05/24/news/slocounty/news23.txt

U.S. Department of Energy. (2008). *Energy efficiency and renewable energy.* Retrieved September 25, 2008, from http://www.eere.energy.gov/

U.S. Environmental Protection Agency, & U.S. Department of Energy. (2008a). *Ceiling fans.* Retrieved September 25, 2008, from http://www.energystar.gov/index.cfm?c=ceiling_fans.pr_ceiling_fans

U.S. Environmental Protection Agency, & U.S. Department of Energy. (2008b). *ENERGY STAR qualified products.* Retrieved September 25, 2008, from http://www.energystar.gov/index.cfm?fuseaction=find_a_product.

U.S. Environmental Protection Agency, & U.S. Department of Energy. (2008c). *Furnaces.* Retrieved September 25, 2008, from http://www.energystar.gov/index.cfm?c=furnaces.pr_furnaces

U.S. Environmental Protection Agency, & U.S. Department of Energy. (2008d). *Room air conditioners key product criteria.* Retrieved September 25, 2008, from http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac

U.S. Environmental Protection Agency, & U.S. Department of Energy. (2008e). *Where does my money go?* Retrieved September 25, 2008, from http://www.energystar.gov/index.cfm?c=products.pr_pie

U.S. Environmental Protection Agency, & U.S. Department of Energy. (2008). *ENERGY STAR.* Retrieved September 25, 2008, from http://www.energystar.gov/

U.S. Green Building Council. (2008a). *LEED for existing buildings: Operations & maintenance registered project checklist.* Retrieved September 25, 2008, from http://www.usgbc.org/ShowFile.aspx?DocumentID=4093

U.S. Green Building Council. (2008b). *LEED for homes.* Retrieved September 25, 2008, from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=147

U.S. Green Building Council. (2008c). *LEED rating systems.* Retrieved September 11, 2008, from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222

U.S. Green Building Council. (2008d). *Project profiles.* Retrieved September 25, 2008, from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1721

U.S. Green Building Council. (2008e). *USGBC: About membership.* Retrieved September 25, 2008, from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1716

U.S. Green Building Council. (2008f). *USGBC: Registration.* Retrieved September 25, 2008, from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=65

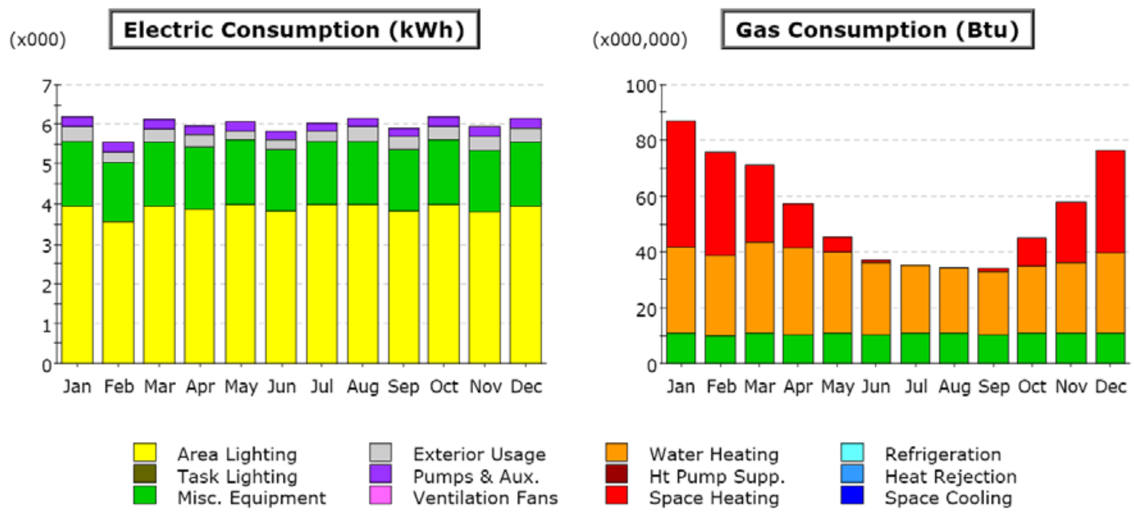
University of Minnesota, Twin Cities Campus, College of Design, Center for Sustainable Building Research. (2008). *Efficient windows collaborative.* Retrieved September 25, 2008, from http://www.efficientwindows.org/gtypes.cfm

Worcester Polytechnic Institute. (2006). *WPI's New Bartlett Center: A "Green" Building.* Retrieved October 6, 2008, from http://www.wpi.edu/About/Bartlett/green.html

WWF-UK. (2006). *Foundations are laid for a more sustainable future.* Retrieved September 25, 2008, from http://www.wwf.org.uk/search_results.cfm?uNewsID=279

Appendix I: Simulation Results

Project/Run: Sigma Alpha Epsilon - Baseline Design   Run Date/Time: 12/13/08 @ 18:15

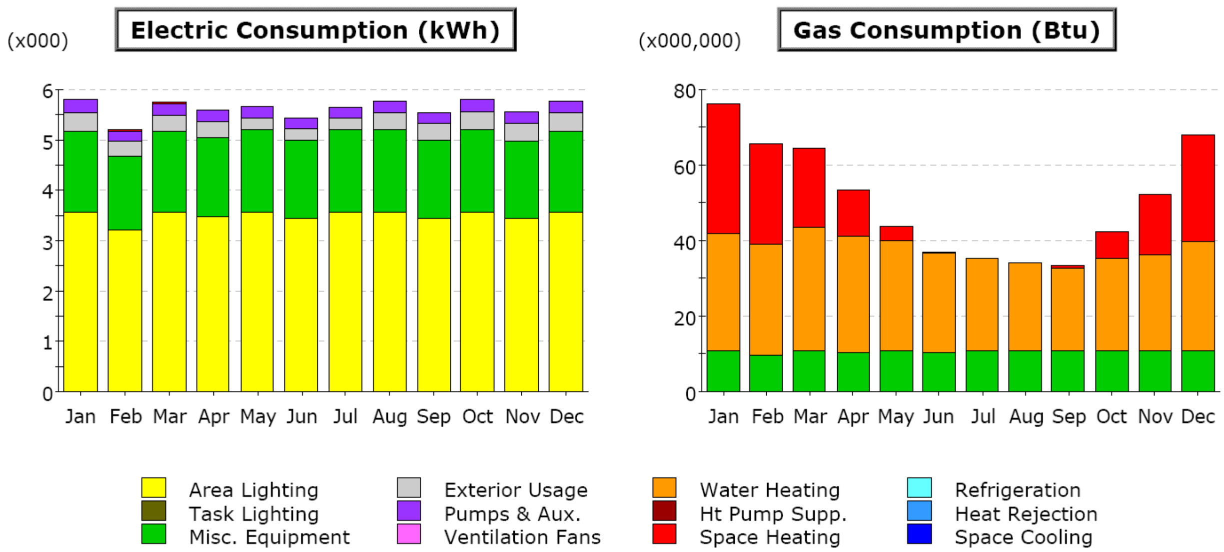


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	0.00	0.00	-	-	-	0.00	0.00	-	0.00
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.25	0.22	0.25	0.23	0.23	0.22	0.23	0.23	0.22	0.24	0.24	0.25	2.79
Ext. Usage	0.36	0.28	0.31	0.30	0.23	0.22	0.23	0.34	0.33	0.34	0.35	0.36	3.67
Misc. Equip.	1.62	1.46	1.61	1.58	1.63	1.55	1.62	1.63	1.55	1.63	1.54	1.60	19.02
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	3.96	3.57	3.96	3.85	3.97	3.82	3.97	3.97	3.82	3.97	3.81	3.96	46.63
Total	6.18	5.54	6.12	5.97	6.07	5.82	6.05	6.16	5.93	6.18	5.94	6.16	72.12

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	45.10	36.93	27.99	16.07	5.11	0.76	0.21	0.26	1.36	9.94	21.45	36.88	202.07
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	30.93	29.19	32.51	30.90	29.28	25.90	24.54	23.30	22.29	24.28	25.49	28.73	327.37
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	10.84	9.78	10.83	10.31	10.73	10.51	10.73	10.72	10.52	10.73	10.62	10.84	127.17
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	86.88	75.91	71.33	57.28	45.13	37.17	35.49	34.28	34.18	44.96	57.56	76.45	656.61



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	0.01	0.00	-	-	-	-	-	-	-	0.00	-	0.01
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.25	0.22	0.24	0.23	0.23	0.22	0.23	0.23	0.22	0.24	0.24	0.25	2.79
Ext. Usage	0.36	0.28	0.31	0.30	0.23	0.22	0.23	0.34	0.33	0.34	0.35	0.36	3.67
Misc. Equip.	1.62	1.46	1.61	1.58	1.63	1.55	1.62	1.63	1.55	1.63	1.54	1.60	19.02
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	3.56	3.22	3.56	3.47	3.57	3.44	3.57	3.57	3.44	3.57	3.43	3.56	41.97
Total	5.78	5.19	5.73	5.58	5.67	5.44	5.65	5.77	5.54	5.78	5.56	5.77	67.46

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	34.51	26.43	20.98	12.18	3.91	0.45	0.08	0.10	0.67	7.43	15.97	28.22	150.91
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	30.93	29.19	32.51	30.90	29.27	25.88	24.51	23.28	22.27	24.28	25.49	28.73	327.25
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	10.84	9.78	10.83	10.31	10.73	10.51	10.73	10.72	10.52	10.73	10.62	10.84	127.17
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	76.28	65.41	64.32	53.38	43.92	36.84	35.32	34.10	33.47	42.44	52.08	67.79	605.34

Electricty	Baseline (kWh)	Baseline Cost	Proposed (kWh)	Proposed Cost	Percent Better
Space Cool	-	-	-	-	0%
Heat Reject.	-	-	-	-	0%
Refrigeration	-	-	-	-	0%
Space Heat	-	-	10.00	1.52	0%
HP Supp.	-	-	-	-	0%
Hot Water	-	-	-	-	0%
Vent. Fans	-	-	-	-	0%
Pumps & Aux.	2,790.00	423.52	2,790.00	423.52	0%
Ext. Usage	3,670.00	557.11	3,670.00	557.11	0%
Misc. Equip.	19,020.00	2,887.24	19,020.00	2,887.24	0%
Task Lights	-	-	-	-	0%
Area Lights	46,630.00	7,078.43	41,970.00	6,371.05	10%
Total	**72,120.00**	**$ 10,947.82**	**67,460.00**	**$ 10,240.43**	**6%**

Natural Gas	Baseline (Therms)	Baseline Cost	Proposed (Therms)	Proposed Cost	Percent Better
Space Cool	-	$ -	-	$ -	0%
Heat Reject.	-	$ -	-	$ -	0%
Refrigeration	-	$ -	-	$ -	0%
Space Heat	2,020.70	$ 3,019.73	1,588.53	$ 2,373.89	21%
HP Supp.	-	$ -	-	$ -	0%
Hot Water	3,273.70	$ 4,892.22	3,444.74	$ 5,147.81	-5%
Vent. Fans	-	$ -	-	$ -	0%
Pumps & Aux.	-	$ -	-	$ -	0%
Ext. Usage	-	$ -	-	$ -	0%
Misc. Equip.	1,271.70	$ 1,900.43	1271.7	$ 1,900.43	0%
Task Lights	-	$ -	0	$ -	0%
Area Lights	-	$ -	0	$ -	0%
Total	**6,566.10**	**$ 9,812.38**	**6,304.96**	**$ 9,422.14**	**4%**

Total Cost		**$ 20,760.20**		**$ 19,662.56**	**5%**

Appendix II: Walk-Through Audit Rubric

House: ________

Date: ________

Auditors: ________________________________

Resident Brothers: ________

Capacity: ________

Received Energy Data: ________

Attic:

How Do we get there?	Do we need a ladder?

Recycling

Notes:

	Y	N
Paper:		
Cardboard:	Y	N
Plastic:	Y	N
Aluminum:	Y	N
Glass:	Y	N
Compost:	Y	N

What could make you recycle:

Waste:

Size of Dumpster:
How often dumpster emptied:
Cost to empty:
Other:

Lighting Left on All the time:

Location:	**Description:**

Heating

Boiler

Serial Number:
Part Number:
Manufacturer:
BTU Rating:

Water Tank

Temperature:
Serial Number:
Part Number:
Manufacturer:
BTU Rating:

Thermostat Settings

Day Temperature:
Day Range:
Night Temperature:
Night Range:

Recommendations:

Check Filter	Y	N
Water Heater Jacket	Y	N
Replace Boiler	Y	N
Programmable Thermostat	Y	N
Regular Heated Temperate:	Day:	Night:
Other:		

Water

Faucet Location	Flow rate	Aerator (Y/N)	Temperature
Basement			
Kitchen			
First Floor			
Second Floor			
Third Floor			
Other:			

Shower Location	Flow rate	Low-flow (Y/N)	Temperature
First Floor			
Second Floor			
Third Floor			
Other:			

Toilet Location	Flow Rate	Low-flow (Y/N)	Higher than 1.6
Basement			
First Floor			
Second Floor			
Third Floor			
Other:			

Recommendation:

Low-flow Aerator	Y	N
Low-flow Shower Head	Y	N
Low-flow Flush	Y	N
Reduce Water Heater Temp	Y	N
Other:		

Lighting

	No bedrooms	Tally	Tally	Tally
Fixture	Watts	High 24-16	Medium 16-8	Low 8-1
CFL				
CFL				
CFL				
CFL				
Incandescent				
Incandescent				
Incandescent				
Flood Light				
T8				
T10				
T12				

Recommendations:

Switch to CFL	Y	N
T8 Fluorescents	Y	N
Motion Sensors	Location	
Other:		

Insulation

Basement Notes:
First Floor Notes:
Second Floor Notes:
Third Floor Notes:
Attic Notes:
Recommendations:

Appliances

Refrigerator

Serial Number:		
Part Number:		
Manufacturer:		
BTU Rating:		
Tally:		
Switch to Energy Star	Y	N
Other:		

Freezer

Serial Number:		
Part Number:		
Manufacturer:		
BTU Rating:		
Tally:		
Walk-In Freezer Notes (If Applicable):		
Energy Star	Y	N
Other:		

Washer

Serial Number:		
Part Number:		
Manufacturer:		
BTU Rating:		
Energy Star	Y	N
Other:		

Dryer

Serial Number:		
Part Number:		
Manufacturer:		
BTU Rating:		
Energy Star	Y	N
Other:		

Appendix III: Manual of Recommendations

Introduction

You've probably noticed that your house has some cracks in the ceiling, or that your sinks use a lot more water than you really need. You've probably been way too cold from the AC during the spring, and everyone's left a light on overnight, right? Well, it may not seem like such a big deal right now, but if you add it all up, that crack in your insulation isn't just letting out heat, it's wasting your chapter's money! Utility bills are a big burden on the Greek community, and any way to reduce them means more money in your pocket. The best part of it is that reducing your utility bills isn't necessarily difficult; you can make changes today that will make a big impact on your bill, immediately.

If there's one thing Greeks know, it's that their actions affect the world around them. Smart use of energy isn't just a good budget decision; it's also good for the environment. A green chapter house uses less oil, water, electricity and non-recyclable materials than a normal one, and that translates into benefits to the environment, as well as your fraternity.

The purpose of the Green Study for Greeks was to find out how much the Greek community was consuming, and find ways to reduce that. You probably noticed a few guys walking through your house with clipboards and flashlights sometime in November. Well, that was us. We were measuring your water flow rates, counting your light bulbs and making sure that your insulation was in good condition, among other things. This manual was made specifically to help the Greek community become greener, and everything in it came from what we observed in your houses, so you can be sure that at least some of what we suggest will apply to your chapter. Best of all, most of the suggestions can be implemented in a few minutes, and don't require a large upfront investment, if any. The ones that do cost money usually pay for themselves within a year. If you want to make really profound changes that'll save you thousands in the long run, we also have some more capital-intensive improvements that need a lot of money upfront but pay for themselves in a couple of years.

We hope you enjoy this manual, learn some things you didn't know about green energy use, and maybe even make some changes around your house. Thanks for letting us audit your houses, guys!

Lighting

Lighting is obviously something that your house can't really do without. Nobody wants to brush their teeth in the dark, or feel their way down the hallway at 3 AM. Lighting takes up about a quarter of your electricity bill, so any way that you can cut down on lighting without compromising your safety and comfort is welcome. There are several ways you can do this:

CFLs:

Normal light bulbs, called incandescent bulbs, are really inefficient; they generate a lot of waste heat and burn out pretty frequently. If you want to save some quick money, start buying compact fluorescent light bulbs. CFLs are the most common way of cutting your energy bill. Unlike incandescent bulbs, close to none of the power put into a CFL is turned into waste heat. This means that not only do CFLs use up to 75% less electricity than incandescent bulbs, but they are also safe to touch, and can be put into any fixture that an incandescent bulb can. Chances are that a good percentage of the lights in your house are already CFLs. You won't be alone switching to CFLs either. Cuba, Brazil, Venezuela, The United States, Canada, The Philippines, Switzerland, Italy and Ireland among others are all in the process of banning the production of incandescent light bulbs.

This is an area where you can make a big impact really quickly. A CFL pays for itself in about three and a half months, and with a lifespan of about 10,000 hours, you don't need to change them as often as incandescent bulbs. According to the EPA, you save around 20 dollars a year for every incandescent you replace with a CFL. Since the average chapter house can have as many as 100 light bulbs, those savings add up to as much as 2000 dollars back into your budget. Another way to save money is to take a look at the fluorescent tube lights in your house. If you look at the end of the bulb, you should find its size rating, or it's T-rating. The T-rating of a fluorescent light is a measure of how thick it is, and this effects the lifetime of the bulb, as well as the energy it uses. Most of you will see "T-12" on your bulbs, and the bulbs will be about as thick around as a D-cell battery. To save money, switch the bulbs out with T-8 bulbs, which are about as thick around as a AA battery, use less energy than a T-12 and have a lifetime of about 20,000 hours, as opposed to the 12,000 hours of a T-12.

A Note On Recycling CFLs:
A CFL works by passing a current through mercury gas. It's a really small amount of mercury, about 4 milligrams per bulb. Still, when it comes time to throw away a CFL, please don't just chuck it in the trash. Take it to a recycling center or to a hardware store like Home Depot for proper disposal. You were really environmentally friendly by buying and using a CFL: don't screw it all up by releasing mercury into the water!

Motion Sensor:

Think about your bathroom for a second. When you walk in, is the light on? It's kind of nice not having to touch the same light switch that everyone else touched on the way out of the bathroom. But think about it; while there's nobody in there, those lights are wasting energy, lighting the room for nobody in particular and sucking the money out of your pocket! Instead of lighting your bathroom for the whole day, you can install a simple motion sensor that will turn off the lights when you're not there and turn them on automatically when you walk in. They're actually pretty cheap; they cost around 25 dollars, and they start saving you money on your electric bill immediately. This quick fix works anywhere lights are left on, be it a bathroom, hallway, living room, or even exterior porch lights. Remember, installing any motion sensor involves rewiring your lights, so get an insured electrician to do it, so that you can be sure that it's done safely and up to code. You generally have two choices of where to install a motion sensor: the ceiling and directly into your light fixture. Sensors mounted into the light fixture are cheaper, but anybody can disable it any time we want. We found one house where someone actually destroyed a fixture-mounted sensor, for unknown reasons. We recommend that you mount the sensors on the ceiling, with a protective mesh metal cage around it, to prevent it from being accidentally broken.

Heating

When winter comes around, your radiator goes from "ugly hunk of metal" to "best friend in the world" really quickly. Heating is one of the most important functions of a house, and one of its biggest energy loads. The state of Massachusetts has laws governing how hot your house must be in the winter; the temperature in a fraternity has to be at least 68 degrees Fahrenheit between 7:00 AM and 11:00 PM, and 64 degrees from 11:01 PM and 6:59 AM. Your house has a constant heating load that it legally has to meet, but there are ways to meet it without bleeding your budget dry.

Boiler:

The vast majority of you use a boiler to heat the water in your radiators. Most of your boilers, with the exception of the new houses, are anywhere from 15 to 30 years old. These boilers run at about 80 percent efficiency. If you want to save a lot of money on your heating bill, talk to your Housing Corp about replacing your boiler with a new, efficient model. Condensation boilers can run at 90 to 92 percent efficiency, saving you a lot of money. The only problem with this fix is a medium-to-high initial investment, which is why you should talk to your Housing Corp about making such a big improvement.

Programmable Thermostat:

An easier fix to save yourself some money on your heating bill is to look at your thermostat. Most of you have an analog thermostat with one set of temperature controls. If you want to squeeze as much money out of your thermostat as possible, consider buying a programmable thermostat. Programmable thermostats can change the temperature of your house automatically, so you don't turn on the heat unless necessary. Turning your heat down to 64 degrees at night greatly reduces your heating load at a time when most of the occupants of a house are either sleeping or away. This is another fix that will show an effect on your next bill, and best of all, it only costs twenty dollars for a basic model. A really fancy model will run you about 45 dollars, but any programmable thermostat is worth it. House managers, you might want to have some control over who can use the thermostat, either by installing a locked cover over it or by keeping it in a locked room.

Insulation

Insulation is something you don't normally think about because you aren't supposed to see it. It's just supposed to hang out in your walls, keeping air from the outside from getting inside, and vice versa. It really is a big deal, though. Your heating load and your comfort level in the house depends a lot on how well insulated it is.

Pipes:

Most of you have a separate water heater in your house to heat the water used in showers and sinks. The tank should have a knob on it to regulate the temperature inside of it, usually set to about 135 to 150 degrees Fahrenheit. By law, the water coming out of your sinks must reach a minimum temperature of 110 and a maximum temperature of 130 degrees Fahrenheit. That means that most of you are losing about twenty degrees of heat from the tank to the sink, a huge amount when you look at how much energy a water heater uses. The way to fix that is by insulating your pipes. Most of that heat loss happens when pipes heat up and radiate it into the walls. This happens a lot more in copper and other metal pipes than it does in newer PVC pipes, so again, new buildings are kind of off the hook on this one, but not entirely. You can buy insulating foam to wrap your pipes in at any hardware store, and you can hire a contractor to insulate the pipes in your walls pretty cheaply. You can expect to save a lot of money on your gas bill with about twenty dollars worth of insulation and duct tape. Another way you can save money is to find where your pipes rise above the ceiling, and seal up the hole in the ceiling made by the pipe.

A Note on Water Temperature:

As mentioned above, Massachusetts state habitation law sets a minimum of 110 and a maximum of 130 degrees Fahrenheit for hot water coming out of sinks and showers. We found several houses with hot water coming out in excess of 150 degrees. This is not only a huge waste of money; it's also a real safety hazard. Nobody likes getting burned in the shower, and if you REALLY need water that hot, you can boil it. If you can't stand under your shower for more than ten seconds, turn down your water heater, please.

Attic:

You probably don't go up in your attic a lot; it's hard to get to, dusty, and there may be bats up there. You probably don't think about it too much, either. Still, your attic is actually really important when it comes to how much heat you have to pay for. Think about it: Heat rises, right? Well, if your attic isn't insulated, all the heat that you pump into your house is going to rise up through the ceiling and get blown out of your attic! It doesn't help that most fraternity houses are built around a big, open central stairway. That "central flue" system lets heat go straight to the top floors really easily. This is another inexpensive fix. A few hundred dollars worth of insulation and expanding foam will insulate your attic and keep your house evenly heated during winter. You can call a contractor to do it for you, or just line the floor with insulating foam yourself. How do you know if your attic is insulated? It's really easy, actually. Just go up there. Is it cold? Good, it's probably insulated. Why would you pay to heat a room that nobody wants to be in?

Windows:

Do you feel a draft in the room you're in right now? If you did, you'd probably go close a window, right? Well, what if that didn't help? A lot of the houses have old windows, and this can pose an insulation problem if you're not careful. If your house has wooden window frames, over time those frames could get warped by the elements, creating gaps between the window and the frame. These gaps let in cold air from the outside even when the window is closed. It's important to make sure that these gaps are sealed with either caulk or rubber insulation. Even on metal-framed windows, which are not really subject to warping, a break in the rubber sealing of a window can cause big problems. Also, it should go without saying, but if your window is broken, you need to get that replaced before winter blows a foot of snow into your living room. If you are planning on replacing your windows, be sure to go for double-paned windows. Double-pained windows have two pieces of glass, with a noble gas sandwiched in between them, and are excellent insulators. The payback period of one of these windows is pretty long, so get your Housing Corporation to look into making this improvement.

Appliances

According to the Energy Department, appliances take up about 20% of the energy load of a typical house. Any way to save money here will go a long way, right? Think about your appliances for a second. Your refrigerator is probably an industrial model with enough space to hold all the food that a fraternity house needs. You probably also have either a walk-in freezer or a deep freezer. Some of you might even have washing machines and dryers, too. What do all these appliances have in common? Well, if you live in a Greek house, all four of them are probably really old. It's understandable, of course; if it's not broken, why replace it? Well, these old appliances, especially refrigerators, use a lot of electricity to run. For example, an old refrigerator can use up to 2500 kilowatt–hours per year, compared to the less than 1000 kilowatt-hours of new refrigerators. You can save a lot of money in the long run by switching to an Energy Star-certified version of the appliance that you're replacing. Energy Star is a program that rates the efficiency of appliances, and an Energy Star appliance is usually much cheaper to operate than a less efficient model, with only a small increase in initial price. That translates into big savings for your house, and a payback period of only a few years. This is something you should talk to your Housing Corp about, since replacing that old refrigerator is going to be a little expensive, and getting that thing out your front door is going to be pretty near impossible.

Water Use

How often do you use the running water in your house? Washing your hands, showering, drinking and rinsing dishes all add up to a lot of water when it's twenty people in a house doing it. Running water isn't something you can do without, obviously, but there are ways to make it more efficient without inconveniencing you. One of the things you can look at is the use of low-flow shower heads and sink aerators. These cheap devices screw in to pretty much any sink and shower, and add air into the water stream coming out. The result is that you feel about the same force of water coming out, but only about half the water gets used. On most new sinks, the aerator is already installed, but older sinks might need one to be installed. We've seen older sinks in some houses that have a water flow rate of 400 milliliters per second, or over 6 gallons per minute. A low-flow showerhead or sink will normally use one quarter of that, 1.5 gallons per minute. The sinks in East Hall, the first "green" dorm on campus, use 0.63 gallons per minute, and there is little to no difference in perceived strength of the water stream. Another way you can save money related to water use is to make sure that the temperature of your hot water is in the correct range, as mentioned above. Finally, if you have access to your house's water pump system, you might want to ask your Housing Corp about turning down the pressure in the pumps themselves. This not only saves water by reducing the flow rate in your sink, it also saves electricity by not making the pump work as hard. Please ask your Housing Corp about this first, though; if your hot water pumps are connected into your radiator system, you do not want to tamper with them in any way, so make sure that it's okay.

Recycling

You might not think that recycling is a way to save money, since you have to pay to get it hauled away, just like trash. However, it turns out that you can save money by recycling. We looked at one fraternity which instituted a house-wide recycling program, and ended up saving $1,200 dollars a year. If you keep your aluminum cans, glass, cardboard, paper, and plastic out of your dumpster and in a recycling bin, there really isn't that much left for the garbage company to take away! Recycling companies usually charge a lot less than garbage companies, and if you drive the stuff to a recycling drop-off point once every two weeks or so, you'll save even more money! Another way to make a little money from recycling, which a lot of houses have already implemented, is to recycle aluminum cans for their deposits. Each can only gives you five cents back, but that money adds up quickly if you recycle most or all of your cans. Think about how many cans you have left over after a party or a social; wouldn't you want to make a few bucks off that bag of "trash?"

Conclusion

What we noticed most of all in the Greek houses was not any one serious problem, but actually the opposite; you guys are actually doing pretty well when it comes to being sustainable. Most of you use compact fluorescent light bulbs and low-flow sinks and shower heads. The thing is, the secret to being a truly green house isn't buying something. If you want an energy-efficient house, every brother or sister needs to be behind that goal, and work to change their habits for the good of the fraternity. All the CFLs in the world don't mean a thing if you leave them on all night! The number one factor in making your house green is the habits of its residents, and the best ways to save you money won't cost you a bit.

We want to thank the Greek community for letting us audit your houses and for answering our questions. We realize that wandering around someone's house for four hours and criticizing the way they live isn't the best way to make friends, but we're glad that you all were behind us, and we hope that this manual is a good jump-off point for you guys to start thinking of your own ways to use less and spend less.

Appendix IV: Description of Sample

House	Year Built	Residents	Capacity	Area (ft^2)
ΑΓΔ	1910	24	26	5,028
ΑΤΩ1	1920	23	27	8,839
ΑΤΩ2	1920	14	18	N/A
ΑΞΔ	1905	7	12	2,003
ΑΧΡ1	1869	22	22	N/A
ΑΧΡ2	N/A	10	13	N/A
Fiji	1899	31	44	9,491
ΦΚθ	1897	11	16	7,483
ΛΧΑ	1994	47	51	N/A
θΧ	1965	28	63	15,393
ΡΣΚ1	1904	7	12	3,899
ΡΣΚ2	1914	13	21	3,414
ΡΣΣ	1910	20	20	4,032
ΣΑΕ1	1894	18	18	6,841
ΣΑΕ2	2006	15	20	5,334
ΣΦΕ1	1910	21	21	6,300
ΣΦΕ2	1910	25	25	4,119
ΣΠ	1914	30	38	6,617
ΤΚΕ1	2006	43	58	4,776
ΤΚΕ2	1910	16	22	2,703
ΖΨ	1900	18	18	3,801

Appendix V: Cost Comparison for Transition to CFL

Incandescent			
houseID	IOC	COC	TotalSavings
AGD	$274.52	$64.05	$217.96
ATO1	$20.15	$4.70	$16.45
AXiD	$506.85	$83.45	$429.90
AXP1	$261.29	$48.77	$215.52
AXP2	$110.81	$25.86	$90.46
KAP	$33.58	$4.70	$29.88
LCA	$342.52	$79.92	$271.10
OX	$20.15	$4.70	$16.45
PSS	$1,473.32	$343.78	$1,148.55
SigEp1	$292.15	$67.58	$230.57
SigPi	$105.78	$24.68	$82.10
TKE1	$518.81	$163.95	$362.36
TKE2	$10.07	$2.35	$8.22
Zete	$405.48	$135.75	$275.23

Appendix VI: Cost Comparison for Transition to T8 Fluorescents

T8-T12			
houseID	T12OC	T8OC	TotalSavings
AGD	$302.56	$284.76	$50.80
ATO1	$239.76	$225.66	$22.10
ATO2	$282.58	$265.95	$28.62
AXiD	$82.77	$77.91	$8.87
AXP1	$620.81	$584.29	$61.52
AXP2	$586.56	$552.06	$67.50
Fiji	$2,924.23	$2,752.22	$273.01
KAP	$11.42	$10.75	$2.67
LCA	$1,555.59	$1,464.09	$151.51
OX	$29.97	$28.21	$2.76
psk1	$425.29	$400.27	$43.02
PSK2	$34.25	$32.24	$4.01
SigEp1	$405.31	$381.47	$44.84
SigEp2	$597.98	$562.80	$65.18
SigPi	$59.94	$56.41	$5.53
TKE2	$131.30	$123.57	$13.72
Zete	$308.26	$290.13	$30.13

Appendix VII: Cost Comparison for Installing Motion Sensors

Motion Sensor				
houseID	TotalHighUsage	W/O MS	W MS	TotalSavings
AGD	11	$271.49	$155.14	$116.35
ATO1	37	$597.64	$341.51	$256.13
ATO2	6	$179.82	$102.75	$77.07
AXiD	4	$214.20	$122.40	$91.80
AXP1	56	$1,196.16	$683.52	$512.64
AXP2	19	$498.91	$285.09	$213.82
Fiji	102	$2,898.29	$1,656.17	$1,242.12
KAP	13	$160.43	$91.67	$68.76
LCA	178	$3,867.91	$2,210.24	$1,657.68
OX	41	$1,158.26	$661.86	$496.40
PSK1	21	$435.45	$248.83	$186.62
PSK2	6	$74.04	$42.31	$31.73
PSS	52	$2,042.38	$1,167.07	$875.30
SigEp1	58	$1,574.31	$899.61	$674.71
SigEp2	14	$397.55	$227.17	$170.38
SigPi	37	$1,124.76	$642.72	$482.04
TKE1	26	$705.18	$402.96	$302.22
TKE2	10	$230.06	$131.47	$98.60
Zete	27	$743.96	$425.12	$318.84

Appendix VIII: Cost Comparison for Low-Flow Aerators

WaterUsage							
HouseID	type	Location	GPY	WSPY	ESPY	SPY	Payback
AGD	Faucet	First Floor	21,302.40	$75.95	$194.81	$267.25	4.72
AGD	Faucet	Kitchen	22,824.00	$22.53	$56.69	$216.52	8.06
AGD	Faucet	Third Floor	6,497.23	$6.81	$16.46	$19.76	54.91
AGD	Faucet	Second Floor	6,390.72	$6.31	$13.10	$15.91	65.83
ATO1	Faucet	Kitchen	76,080.00	$187.17	$274.34	$727.31	2.77
ATO1	Faucet	Third Floor	15,311.10	$48.95	$50.22	$95.66	12.88
ATO1	Faucet	First Floor	7,655.55	$13.20	$24.18	$35.62	17.09
ATO1	Faucet	Second Floor	7,655.55	$13.20	$25.79	$33.73	49.16
AXiD	Faucet	Kitchen	20,922.00	$13.65	$28.33	$198.13	15.22
AXiD	Faucet	Second Floor	10,096.45	$29.99	$60.80	$89.04	7.04
AXiD	Faucet	Third Floor	4,659.90	$4.60	$9.10	$11.95	46.62
AXP1	Faucet	Kitchen	133,140.00	$537.70	$985.16	$1,283.27	0.42
AXP1	Faucet	First Floor	11,390.87	$17.24	$32.42	$47.91	12.86
AXP1	Faucet	Third Floor	8,949.97	$5.84	$10.98	$15.07	37.98
AXP1	Faucet	Second Floor	8,787.24	$5.08	$9.30	$10.88	88.84
AXP2	Faucet	Kitchen	62,766.00	$209.06	$331.95	$602.76	1.18
Fiji	Faucet	Kitchen	22,824.00	$22.53	$46.78	$216.52	9.22
Fiji	Faucet	Second Floor	22,356.43	$28.40	$52.03	$75.18	23.82
Fiji	Faucet	Third Floor	18,916.98	$12.34	$20.19	$27.28	58.90
KAP	Faucet	Kitchen	24,726.00	$31.41	$49.88	$234.91	7.86
KAP	Faucet	Third Floor	7,322.70	$16.22	$24.96	$37.68	31.03
KAP	Faucet	Second Floor	4,881.80	$4.82	$7.53	$8.85	103.43
KAP	Faucet	First Floor	4,068.17	$1.02	$1.57	$0.84	246.92
LCA	Faucet	Kitchen	20,922.00	$13.65	$25.00	$198.13	16.53
LCA	Faucet	Third Floor	14,601.02	$22.09	$40.48	$60.82	10.21
LCA	Faucet	Second Floor	14,601.02	$22.09	$40.48	$57.32	30.62
LCA	Faucet	First Floor	11,472.23	$7.48	$13.71	$14.19	120.57
OX	Faucet	Kitchen	83,688.00	$222.70	$353.62	$800.88	2.22
OX	Faucet	Kitchen	68,472.00	$67.58	$107.31	$649.55	10.96
OX	Faucet	First Floor	6,213.20	$1.56	$1.71	($1.98)	586.63
PSK1	Faucet	Kitchen	34,236.00	$75.82	$109.28	$326.87	3.45
PSK1	Faucet	Third Floor	3,106.60	$3.07	$4.27	$5.59	87.07

WaterUsage							
HouseID	type	Location	GPY	WSPY	ESPY	SPY	Payback
PSK1	Faucet	Second Floor	2,588.83	$0.65	$0.87	($0.23)	420.38
PSK2	Faucet	First Floor	6,009.79	$6.82	$20.82	$25.88	23.11
PSK2	Faucet	Second Floor	5,769.40	$5.69	$16.97	$20.92	28.18
PSK2	Faucet	Third Floor	5,288.62	$3.45	$9.27	$10.97	50.22
PSS	Faucet	Kitchen	23,965.20	$27.86	$53.76	$227.55	7.83
PSS	Faucet	Second Floor	8,136.33	$5.31	$9.59	$11.40	85.74
PSS	Faucet	First Floor	7,396.67	$1.85	$3.57	$3.68	117.69
PSS	Faucet	Third Floor	7,396.67	$1.85	$3.39	$1.75	243.50
SigEp1	Faucet	Kitchen	26,628.00	$40.29	$58.07	$253.30	6.49
SigEp1	Faucet	Second Floor	10,251.78	$27.28	$36.65	$56.93	39.96
SigEp1	Faucet	Third Floor	5,824.88	$6.61	$8.88	$11.99	82.50
SigEp2	Faucet	Second Floor	11,095.00	$10.95	$17.39	$24.84	45.08
SigPi	Faucet	Kitchen	26,628.00	$40.29	$67.92	$253.30	5.90
SigPi	Faucet	Second Floor	13,979.70	$35.86	$67.46	$92.83	37.09
SigPi	Faucet	First Floor	9,319.80	$14.10	$23.08	$35.43	17.18
TKE1	Faucet	Kitchen	110,316.00	$347.06	$890.22	$1,058.38	1.03
TKE1	Faucet	Basement	15,505.26	$19.70	$51.49	$64.18	35.89
TKE1	Faucet	Third Floor	13,119.84	$8.56	$21.95	$27.01	41.88
TKE1	Faucet	Second Floor	13,119.84	$8.56	$21.95	$25.26	62.81
TKE1	Faucet	First Floor	13,119.84	$8.56	$18.60	$23.66	47.03
TKE2	Faucet	Kitchen	24,726.00	$31.41	$52.94	$234.91	7.57
TKE2	Faucet	Second Floor	15,385.07	$19.54	$40.58	$56.63	21.25
TKE2	Faucet	First Floor	7,692.53	$9.77	$20.29	$28.31	21.25
Zete	Faucet	Kitchen	39,942.00	$102.47	$142.68	$382.05	2.61
Zete	Faucet	First Floor	12,981.15	$16.49	$18.13	$32.87	18.45
Zete	Faucet	Second Floor	11,982.60	$11.83	$15.60	$25.68	23.29

Appendix IX: Cost Comparison for Low-Flow Shower heads

WaterUsage							
HouseID	type	Location	GPY	WSPY	ESPY	SPY	Payback
AGD	Shower	First Floor	17,041.92	$25.79	$63.63	$69.41	81.64
AGD	Shower	Third Floor	17,041.92	$25.79	$59.85	$65.63	85.25
AGD	Shower	Second Floor	17,041.92	$25.79	$58.59	$64.37	86.52
ATO1	Shower	Third Floor	18,664.96	$35.61	$34.79	$50.40	103.69
ATO1	Shower	Second Floor	17,498.40	$30.16	$58.21	$28.37	247.83
ATO2	Shower	First Floor	92,310.40	$274.18	$448.75	$682.93	20.20
AXiD	Shower	Second Floor	14,201.60	$27.09	$36.40	$43.50	114.97
AXiD	Shower	Third Floor	12,426.40	$18.80	$24.34	$23.15	169.19
AXP1	Shower	Third Floor	21,944.85	$20.29	$34.20	$34.49	133.97
AXP1	Shower	Second Floor	23,246.67	$26.37	$43.16	$29.53	209.98
AXP2	Shower	Second Floor	16,061.33	$37.65	$57.94	$75.58	76.37
Fiji	Shower	Second Floor	133,647.20	$450.41	$825.22	$1,215.63	17.17
Fiji	Shower	Third Floor	51,100.40	$64.91	$134.79	$179.71	36.55
KAP	Shower	Second Floor	11,158.40	$11.01	$14.80	$5.81	282.82
KAP	Shower	Third Floor	10,228.53	$6.67	$9.45	($3.88)	452.76
LCA	Shower	Third Floor	42,909.12	$95.03	$162.50	$217.53	56.69
LCA	Shower	Second Floor	42,909.12	$95.03	$174.11	$189.14	108.49
LCA	Shower	First Floor	33,373.76	$50.50	$92.52	$123.03	51.04
OX	Shower	First Floor	18,462.08	$23.45	$31.51	$34.96	132.81
OX	Shower	Second Floor	14,201.60	$3.56	$3.04	($93.40)	5532.42
OX	Shower	Third Floor	15,621.76	$10.19	$14.19	($95.62)	1796.85
PSK1	Shower	Second Floor	13,018.13	$34.64	$48.24	$62.88	88.08
PSK1	Shower	Third Floor	8,876.00	$15.30	$20.56	$15.85	203.60
PSK2	Shower	Third Floor	15,385.07	$23.28	$58.58	$61.86	89.18
PSK2	Shower	Second Floor	15,385.07	$23.28	$43.79	$47.07	108.84
PSK2	Shower	First Floor	15,385.07	$23.28	$41.52	$44.80	112.66
PSS	Shower	First Floor	18,597.33	$12.13	$22.22	$14.35	212.50
PSS	Shower	Third Floor	19,949.87	$18.45	$31.54	$9.99	292.07
PSS	Shower	Second Floor	16,906.67	$4.23	$7.24	($28.53)	1272.38
SigEp1	Shower	Third Floor	12,781.44	$12.62	$16.95	($10.43)	493.82
SigEp1	Shower	Second Floor	12,781.44	$12.62	$16.95	($10.43)	493.82

WaterUsage							
HouseID	type	Location	GPY	WSPY	ESPY	SPY	Payback
SigEp2	Shower	First Floor	29,586.67	$44.77	$49.21	$73.98	77.67
SigEp2	Shower	Third Floor	26,416.67	$29.97	$46.12	$56.08	95.95
SigEp2	Shower	Second Floor	23,246.67	$15.16	$23.33	$18.50	189.63
SigPi	Shower	Second Floor	21,302.40	$32.23	$54.33	$6.57	337.31
TKE1	Shower	Third Floor	51,797.80	$121.41	$311.42	$392.83	33.73
TKE1	Shower	Second Floor	29,988.20	$19.56	$50.17	$9.73	314.07
TKE2	Shower	First Floor	17,582.93	$22.34	$37.65	$39.99	121.70
TKE2	Shower	Second Floor	13,525.33	$3.39	$6.21	($30.41)	1521.88
Zete	Shower	First Floor	63,907.20	$197.57	$217.19	$394.76	17.60
Zete	Shower	Second Floor	41,083.20	$90.99	$100.02	$171.00	38.22
Zete	Shower	Second Floor	22,824.00	$5.72	$6.28	($8.00)	608.36

Appendix X: Cost Comparison for Energy Star-Rated Washer

Washer									
HouseID	Type	EnergyStar	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	PayBack
AGD	Washer	0	24	2	$59.62	$65.00	$41.37	$165.98	9.04
ATO1	Washer	0	37	2	$91.91	$100.21	$63.78	$255.89	5.86
AXiD	Washer	0	7	1	$17.39	$18.96	$12.07	$48.41	15.49
AXP1	Washer	0	22	2	$54.65	$59.58	$37.92	$152.15	9.86
AXP2	Washer	0	10	2	$24.84	$27.08	$17.24	$69.16	21.69
Fiji	Washer	0	31	1	$77.00	$83.96	$53.44	$214.40	3.50
KAP	Washer	0	11	1	$27.32	$29.79	$18.96	$76.08	9.86
LCA	Washer	0	47	2	$116.75	$127.29	$81.02	$325.05	4.61
OX	Washer	0	28	1	$69.55	$75.83	$48.27	$193.65	3.87
PSK2	Washer	0	20	1	$49.68	$54.17	$34.48	$138.32	5.42
TKE1	Washer	0	43	1	$106.81	$116.45	$74.12	$297.39	2.52
TKE2	Washer	0	16	2	$39.74	$43.33	$27.58	$110.66	13.56
Zete	Washer	0	18	1	$44.71	$48.75	$31.03	$124.49	6.02

Appendix XI: Cost Comparison for Energy Star-Rated Refrigerators

Refrigerator						
HouseID	EnergyStar	Notes	EPY	REPY	SPY	Payback
AGD	0	2 Door	$4,176.07	$3,400.67	$775.41	3.80
ATO1	0	2 Door	$4,176.07	$3,400.67	$775.41	3.80
ATO1	0	3 Door	$7,324.42	$6,470.87	$842.60	4.92
AXP1	0	2 Door	$4,176.07	$3,400.67	$775.41	3.80
AXP2	0	2 Door	$4,176.07	$3,400.67	$775.41	3.80
Fiji	0	3 Door	$7,324.42	$6,470.87	$842.60	4.92
LCA	0	2 Door	$4,176.07	$3,400.67	$775.41	3.80
PSK1	0	2 Door	$4,176.07	$3,400.67	$775.41	3.80
SigEp1	0	2 Door	$4,176.07	$3,400.67	$775.41	3.80
SigEp1	0	3 Door	$7,324.42	$6,470.87	$842.60	4.92
SigPi	0	2 Door	$4,176.07	$3,400.67	$775.41	3.80
TKE1	0	1 Door	$2,680.20	$2,081.60	$598.60	4.20
Zete	0	3 Door	$7,324.42	$6,470.87	$842.60	4.92

Appendix XII: Audit Reports

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
AGD			
	$274.52	$64.05	$217.96

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
AGD			
	$355.95	$284.76	$104.19

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
AGD				
	11	$271.49	$155.14	$116.35

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
AGD							
	Faucet	First Floor	21,302	$75.95	$194.81	$267.25	4.718
	Faucet	Kitchen	22,824	$22.53	$56.69	$216.52	8.064
	Faucet	Third Floor	6,497	$6.81	$16.46	$19.76	54.914
	Faucet	Second Floor	6,391	$6.31	$13.10	$15.91	65.830
	Shower	First Floor	17,042	$25.79	$63.63	$69.41	81.643
	Shower	Third Floor	17,042	$25.79	$59.85	$65.63	85.247
	Shower	Second Floor	17,042	$25.79	$58.59	$64.37	86.520

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
AGD							
	24	2	$59.62	$65.00	$41.37	$165.98	9.04

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
AGD				
	$4,176.07	$3,400.67	$775.41	3.804

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
ATO1			
	$20.15	$4.70	$16.45

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
ATO1			
	$282.07	$225.66	$64.41
ATO2			
	$332.44	$265.95	$78.49

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
ATO1				
	37	$639.95	$365.69	$274.26
ATO2				
	6	$211.55	$120.89	$90.67

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
ATO1							
	Faucet	Kitchen	76,080	$187.17	$274.34	$727.31	2.768
	Faucet	Third Floor	15,311	$48.95	$50.22	$95.66	12.883
	Faucet	First Floor	7,656	$13.20	$24.18	$35.62	17.092
	Faucet	Second Floor	7,656	$13.20	$25.79	$33.73	49.156
	Shower	Third Floor	18,665	$35.61	$34.79	$50.40	103.690
	Shower	Second Floor	17,498	$30.16	$58.21	$28.37	247.829
ATO2							
	Shower	First Floor	92,310	$274.18	$448.75	$682.93	20.196

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
ATO1							
	37	2	$91.91	$100.21	$63.78	$255.89	5.86

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
ATO1				
	$7,324.42	$6,470.87	$842.60	4.921
	$4,176.07	$3,400.67	$775.41	3.804

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
AXiD	$506.85	$83.45	$429.90

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
AXiD	$97.38	$77.91	$23.48

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
AXiD	4	$224.78	$128.44	$96.33

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
AXiD							
	Faucet	Kitchen	20,922	$13.65	$28.33	$198.13	15.215
	Faucet	Second Floor	10,096	$29.99	$60.80	$89.04	7.035
	Faucet	Third Floor	4,660	$4.60	$9.10	$11.95	46.622
	Shower	Second Floor	14,202	$27.09	$36.40	$43.50	114.969
	Shower	Third Floor	12,426	$18.80	$24.34	$23.15	169.185

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
AXiD	7	1	$17.39	$18.96	$12.07	$48.41	15.49

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
AXP1	$261.29	$48.77	$215.52
AXP2	$110.81	$25.86	$90.46

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
AXP1	$730.37	$584.29	$171.07
AXP2	$690.07	$552.06	$171.01

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
AXP1	56	$1,275.49	$728.85	$546.64
AXP2	19	$578.25	$330.43	$247.82

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
AXP1							
	Faucet	Kitchen	133,140	$537.70	$985.16	$1,283.27	0.419
	Faucet	First Floor	11,391	$17.24	$32.42	$47.91	12.863
	Faucet	Third Floor	8,950	$5.84	$10.98	$15.07	37.981
	Faucet	Second Floor	8,787	$5.08	$9.30	$10.88	88.838
	Shower	Third Floor	21,945	$20.29	$34.20	$34.49	133.965
	Shower	Second Floor	23,247	$26.37	$43.16	$29.53	209.981
AXP2							
	Faucet	Kitchen	62,766	$209.06	$331.95	$602.76	1.181
	Shower	Second Floor	16,061	$37.65	$57.94	$75.58	76.372

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
AXP1	22	2	$54.65	$59.58	$37.92	$152.15	9.86
AXP2	10	2	$24.84	$27.08	$17.24	$69.16	21.69

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
AXP1	$4,176.07	$3,400.67	$775.41	3.804
AXP2	$4,176.07	$3,400.67	$775.41	3.804

Incandescent/CFL Cost Analysis

IOC	COC	TotalSavings

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
Fiji			
	$3,440.27	$2,752.22	$789.05

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
Fiji				
	102	$3,390.15	$1,937.23	$1,452.92

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
Fiji							
	Faucet	Kitchen	22,824	$22.53	$46.78	$216.52	9.216
	Faucet	Second Floor	22,356	$28.40	$52.03	$75.18	23.824
	Faucet	Third Floor	18,917	$12.34	$20.19	$27.28	58.904
	Shower	Second Floor	133,647	$450.41	$825.22	$1,215.63	17.168
	Shower	Third Floor	51,100	$64.91	$134.79	$179.71	36.553

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
Fiji							
	31	1	$77.00	$83.96	$53.44	$214.40	3.50

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
Fiji				
	$7,324.42	$6,470.87	$842.60	4.921

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
KAP			
	$33.58	$4.70	$29.88

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
KAP			
	$13.43	$10.75	$4.69

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
KAP				
	13	$160.43	$91.67	$68.76

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
KAP							
	Faucet	Kitchen	24,726	$31.41	$49.88	$234.91	7.858
	Faucet	Third Floor	7,323	$16.22	$24.96	$37.68	31.025
	Faucet	Second Floor	4,882	$4.82	$7.53	$8.85	103.425
	Faucet	First Floor	4,068	$1.02	$1.57	$0.84	246.924
	Shower	Second Floor	11,158	$11.01	$14.80	$5.81	282.821
	Shower	Third Floor	10,229	$6.67	$9.45	($3.88)	452.757

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
KAP							
	11	1	$27.32	$29.79	$18.96	$76.08	9.86

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
LCA			
	$342.52	$79.92	$271.10

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
LCA			
	$1,830.11	$1,464.09	$426.02

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
LCA				
	178	$4,132.35	$2,361.35	$1,771.01

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
LCA							
	Faucet	Kitchen	20,922	$13.65	$25.00	$198.13	16.528
	Faucet	Third Floor	14,601	$22.09	$40.48	$60.82	10.208
	Faucet	Second Floor	14,601	$22.09	$40.48	$57.32	30.624
	Faucet	First Floor	11,472	$7.48	$13.71	$14.19	120.568
	Shower	Third Floor	42,909	$95.03	$162.50	$217.53	56.692
	Shower	Second Floor	42,909	$95.03	$174.11	$189.14	108.493
	Shower	First Floor	33,374	$50.50	$92.52	$123.03	51.040

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
LCA							
	47	2	$116.75	$127.29	$81.02	$325.05	4.61

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
LCA				
	$4,176.07	$3,400.67	$775.41	3.804

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
OX			
	$20.15	$4.70	$16.45

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
OX			
	$35.26	$28.21	$8.05

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
OX				
	41	$1,163.55	$664.88	$498.66

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
OX							
	Faucet	Kitchen	83,688	$222.70	$353.62	$800.88	2.217
	Faucet	Kitchen	68,472	$67.58	$107.31	$649.55	10.956
	Faucet	First Floor	6,213	$1.56	$1.71	($1.98)	586.630
	Shower	First Floor	18,462	$23.45	$31.51	$34.96	132.815
	Shower	Second Floor	14,202	$3.56	$3.04	($93.40)	5532.417
	Shower	Third Floor	15,622	$10.19	$14.19	($95.62)	1796.853

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
OX							
	28	1	$69.55	$75.83	$48.27	$193.65	3.87

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
PSK			
	$1,473.32	$343.78	$1,148.55
PSK			
	$1,473.32	$343.78	$1,148.55

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
PSK1			
	$425.29	$400.27	$43.02
PSK2			
	$34.25	$32.24	$4.01

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
PSK				
	21	$435.45	$248.83	$186.62
PSK				
	6	$74.04	$42.31	$31.73

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
PSK1							
	Faucet	Kitchen	34,236	$75.82	$109.28	$326.87	3.451
	Faucet	Third Floor	3,107	$3.07	$4.27	$5.59	87.071
	Faucet	Second Floor	2,589	$0.65	$0.87	($0.23)	420.382
	Shower	Second Floor	13,018	$34.64	$48.24	$62.88	88.079
	Shower	Third Floor	8,876	$15.30	$20.56	$15.85	203.604
PSK2							
	Faucet	First Floor	6,010	$6.82	$20.82	$25.88	23.114
	Faucet	Second Floor	5,769	$5.69	$16.97	$20.92	28.180
	Faucet	Third Floor	5,289	$3.45	$9.27	$10.97	50.222
	Shower	Third Floor	15,385	$23.28	$58.58	$61.86	89.179
	Shower	Second Floor	15,385	$23.28	$43.79	$47.07	108.840
	Shower	First Floor	15,385	$23.28	$41.52	$44.80	112.661

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
PSK2							
	20	1	$49.68	$54.17	$34.48	$138.32	5.42

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
PSK1				
	$4,176.07	$3,400.67	$775.41	3.804

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
PSS			
	$1,473.32	$343.78	$1,148.55

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
PSS				
	52	$2,042.38	$1,167.07	$875.30

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
PSS							
	Faucet	Kitchen	23,965	$27.86	$53.76	$227.55	7.826
	Faucet	Second Floor	8,136	$5.31	$9.59	$11.40	85.740
	Faucet	First Floor	7,397	$1.85	$3.57	$3.68	117.689
	Faucet	Third Floor	7,397	$1.85	$3.39	$1.75	243.500
	Shower	First Floor	18,597	$12.13	$22.22	$14.35	212.500
	Shower	Third Floor	19,950	$18.45	$31.54	$9.99	292.067
	Shower	Second Floor	16,907	$4.23	$7.24	($28.53)	1272.380

Washer Cost Analysis

LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
SigEp1			
	$292.15	$67.58	$230.57

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
SigEp1			
	$476.84	$381.47	$116.37
SigEp2			
	$703.50	$562.80	$170.70

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
SigEp1				
	58	$1,616.63	$923.79	$692.84
SigEp2				
	14	$455.72	$260.41	$195.31

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
SigEp1							
	Faucet	Kitchen	26,628	$40.29	$58.07	$253.30	6.494
	Faucet	Second Floor	10,252	$27.28	$36.65	$56.93	39.962
	Faucet	Third Floor	5,825	$6.61	$8.88	$11.99	82.499
	Shower	Second Floor	12,781	$12.62	$16.95	($10.43)	493.815
	Shower	Third Floor	12,781	$12.62	$16.95	($10.43)	493.815
SigEp2							
	Faucet	Second Floor	11,095	$10.95	$17.39	$24.84	45.078
	Shower	First Floor	29,587	$44.77	$49.21	$73.98	77.673
	Shower	Third Floor	26,417	$29.97	$46.12	$56.08	95.947
	Shower	Second Floor	23,247	$15.16	$23.33	$18.50	189.629

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
SigEp1				
	$7,324.42	$6,470.87	$842.60	4.921
	$4,176.07	$3,400.67	$775.41	3.804

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
SigPi	$105.78	$24.68	$82.10

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
SigPi	$70.52	$56.41	$16.10

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
SigPi	37	$1,135.34	$648.77	$486.57

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
SigPi							
	Faucet	Kitchen	26,628	$40.29	$67.92	$253.30	5.903
	Faucet	Second Floor	13,980	$35.86	$67.46	$92.83	37.091
	Faucet	First Floor	9,320	$14.10	$23.08	$35.43	17.178
	Shower	Second Floor	21,302	$32.23	$54.33	$6.57	337.308

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
SigPi	$4,176.07	$3,400.67	$775.41	3.804

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
TKE1			
	$518.81	$163.95	$362.36
TKE2			
	$10.07	$2.35	$8.22

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
TKE2			
	$154.47	$123.57	$36.89

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
TKE1				
	26	$705.18	$402.96	$302.22
TKE2				
	10	$251.22	$143.55	$107.67

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
TKE1							
	Faucet	Kitchen	110,316	$347.06	$890.22	$1,058.38	1.033
	Faucet	Basement	15,505	$19.70	$51.49	$64.18	35.893
	Faucet	Third Floor	13,120	$8.56	$21.95	$27.01	41.877
	Faucet	Second Floor	13,120	$8.56	$21.95	$25.26	62.815
	Faucet	First Floor	13,120	$8.56	$18.60	$23.66	47.033
	Shower	Third Floor	51,798	$121.41	$311.42	$392.83	33.731
	Shower	Second Floor	29,988	$19.56	$50.17	$9.73	314.074
TKE2							
	Faucet	Kitchen	24,726	$31.41	$52.94	$234.91	7.572
	Faucet	Second Floor	15,385	$19.54	$40.58	$56.63	21.247
	Faucet	First Floor	7,693	$9.77	$20.29	$28.31	21.247
	Shower	First Floor	17,583	$22.34	$37.65	$39.99	121.695
	Shower	Second Floor	13,525	$3.39	$6.21	($30.41)	1521.878

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
TKE1							
	43	1	$106.81	$116.45	$74.12	$297.39	2.52
TKE2							
	16	2	$39.74	$43.33	$27.58	$110.66	13.56

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
TKE1				
	$2,680.20	$2,081.60	$598.60	4.201

Incandescent/CFL Cost Analysis

	IOC	COC	TotalSavings
Zete			
	$405.48	$135.75	$275.23

T12/T8 Cost Analysis

	T12 Operating Cost	T8 Operating Cost	Total Savings
Zete			
	$362.66	$290.13	$84.53

Motion Sensor Cost Analysis

	TotalHighUsage	Cost w/o Motion Sensor	Cost w/ Motion Sensor	Total Savings
Zete				
	27	$786.28	$449.30	$336.98

Water Usage Cost Analysis

	type	Location	GPY	WSPY	ESPY	SPY	Payback (Days)
Zete							
	Faucet	Kitchen	39,942	$102.47	$142.68	$382.05	2.606
	Faucet	First Floor	12,981	$16.49	$18.13	$32.87	18.451
	Faucet	Second Floor	11,983	$11.83	$15.60	$25.68	23.287
	Shower	First Floor	63,907	$197.57	$217.19	$394.76	17.601
	Shower	Second Floor	41,083	$90.99	$100.02	$171.00	38.219
	Shower	Second Floor	22,824	$5.72	$6.28	($8.00)	608.357

Washer Cost Analysis

	LoadsPerWeek	Quantity	GPYS	EPYS	TPYS	SPY	Payback (Days)
Zete							
	18	1	$44.71	$48.75	$31.03	$124.49	6.02

Refrigerator Cost Analysis

	EPY	REPY	SPY	Payback
Zete				
	$7,324.42	$6,470.87	$842.60	4.921

Appendix XIII: GAC Award

Greek Life @ Worcester Polytechnic Institute

Worcester Polytechnic Institute
Chapter Excellence Annual Report

Chapter Name

Sustainability

Please answer each question honestly and to the best of your ability. Provide documentation where a "D" appears.

	Does your chapter recycle: aluminum, cardboard, glass, paper, or plastic? *2 points per item*	/10
	Are recycling responsibilities the duty of one of your elected positions? *No=0 points* *Yes=10 points*	/10
	A programmable thermostat controls the day/night temperature setting for each floor. *No=0 points* *Yes=10 points* *Yes, and secured access=15 points*	/15
	Your chapter utilizes energy-saving light bulbs (14W CFLs and T8 fluorescents). *No=0 points* *Yes, some=5 points* *Yes, all=10 points*	/10
	Motion sensors are installed in areas of frequent usage. *No=0 points* *Yes=10 points*	/10
	What is the temperature (°F) setting on your hot water tank? *140+=0 points* *130=5 points* *120=10 points* *110=15 points*	/15
	How old (in years) is your boiler? *20+=0 points* *11-20=5 points* *0-10=15 points*	/15
"D"	Boiler has filter check and calibration once per year. *No=0 points* *Yes=5 points*	/5
"D"	Percent gas/electricity reduction between the timeframe of January 2007-January 2008 and January 2008-January 2009 $\left(\left[\frac{Difference\ \ in\ Therms}{Therms\ from\ 2007-2008}+\frac{Difference\ \ in\ kWh}{kWh\ from\ 2007-2008}\right]*100\right)$. *No reduction=0 points* *1-5%=10 points* *6-10%=15 points* *11-15%=20 points* *16%+=25 points*	/25
"D"	Percent water reduction between the timeframe of January 2007-January 2008 and January 2008-January 2009 $\left(\frac{Difference\ \ in\ gallons}{Gallons\ \ from\ 2007-2008}*100\right)$. *No reduction=0 points* *1-5%=10 points* *6-10%=15 points* *11-15%=20 points* *16%+=25 points*	/25
	TOTAL (of 140 total possible points)	**/140**

In a short paragraph, describe your recycling program and all energy-saving techniques implemented since January 2008.

In a short paragraph, describe how your chapter would spend the $250 monetary award on green improvements if chosen as the winner of the Sustainability Award.