Nantucket Baseline Energy Project

Nantucket Project Center December 15th, 2011

An Interactive Qualifying Project Report Submitted to the Faculty of WORCESTER POLYTECHNIC INSTITUTE In partial fulfillment of the requirements for the Degree of Bachelor of Science

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Abstract

Using National Grid data for Nantucket, we constructed a baseline model of electricity use showing the diurnal, seasonal and annual consumption patterns for five municipal facilities, including the Solid Waste Treatment Facility, Waste Water Treatment Facility, Airport, High School, and Elementary School. In addition we conducted energy audits of five small businesses and identified several cost effective options to reduce electricity consumption. These results provide the Town's Energy Studies Committee a scientific basis for formulating actionable plans energy reduction plans.

Acknowledgements

We would like to thank our advisor, Professor Dominic Golding, for his help with our project. We would like to thank him for the opportunity of being able to work with the town of Nantucket towards a better cause.

Thank you to our liaisons, Dr. Whiting Willauer and Dr. Peter Morrison, without their constant support and dedication to our project as a whole, none of what we have achieved could have been possible. Thank you to our sponsoring organization, the Nantucket Energy Study Committee for entrusting our group with a matter so delicate and of great importance to the residents of Nantucket.

We would also like to thank Harvey Young for providing all the WPI students with bikes for our duration on the island. We are also grateful to Harvey for allowing us to perform our first energy audit at his bicycle shop. This first audit helped us to further develop our audit process for later audits.

We would like to acknowledge the assistance of the individuals who took the time to provide our group with information and support. Thank you Lauren Sinatra and George Aronson from the Nantucket Energy Office, town energy consultant Bob Patterson, and assistant town manager Gregg Tivnan for all of their time, support, and patience in helping us with our project. Lastly we would like to thank the business owners that allowed us to conduct energy audits on their businesses. Their cooperation greatly assisted our efforts in collecting information as well as being exemplar for other businesses to look towards conservation.

With the eminent threat of a third cable, Nantucket is prime candidate for the promotion of energy conservation and awareness. It is our wish that the progress made by this report will provide the Nantucket Energy Study Committee and the residents of Nantucket with valuable information, analysis, and the recommendations needed to promote energy conservation for the island as a whole.

Executive Summary

Electricity consumption and expenditures have been rising in the US since the 1960s. Many programs and policies have been put in place at the state and federal level to conserve energy, but these have only slowed the rate of growth in consumption. Nantucket has suffered similar trends. In Nantucket there is a special concern about electricity use. As an island it receives all its electricity from the mainland via two submarine cables. As a result it pays some of the highest rates for electricity in the nation at 18.4cents/kw. Consequently, the Nantucket Energy Studies Committee is exploring various ways to reduce energy consumption in general and electricity use in particular.

The goal of this project was to assist the Nantucket Energy Study Committee in its effort to reduce energy costs on Nantucket. The project had three major objectives: 1) to create a baseline profile of the electricity use on Nantucket by analyzing detailed consumption data held by National Grid; 2) to characterize patterns of energy use among small businesses by performing energy audits; and, 3) to determine the impacts of a variety of conservation techniques to reduce energy among small businesses. Establishing a baseline model of energy use on Nantucket will help the Energy Studies Committee understand better how energy is being consumed on the island and therefore help them make more informed decisions about energy use strategies in the future. The energy audits of small businesses were intended to flesh out this picture of consumption a little more. Although the business sector makes up only a small fraction of the overall island consumption, we focused our audits here because we believe that if local businesses enact conservation strategies they can act as 'catalysts' for residents to follow.

Analysis of the National Grid data clearly reveals the seasonal variation in electricity consumption. Figure 1 shows that the diurnal pattern of electricity for all four seasons is relatively similar. The steep rise in the morning coincides with most people waking up. The curve then proceeds to drop slightly in the afternoon, followed by a rise at dinner time, and finally a drop when people go to sleep. The electrical demand seen in the winter, spring, and fall seasons are all within 3MW of each other. Summer, however, sees a much larger demand. The summer peak is almost 9MW greater than the peak in the winter season and reflects the substantial increase in population at that time.

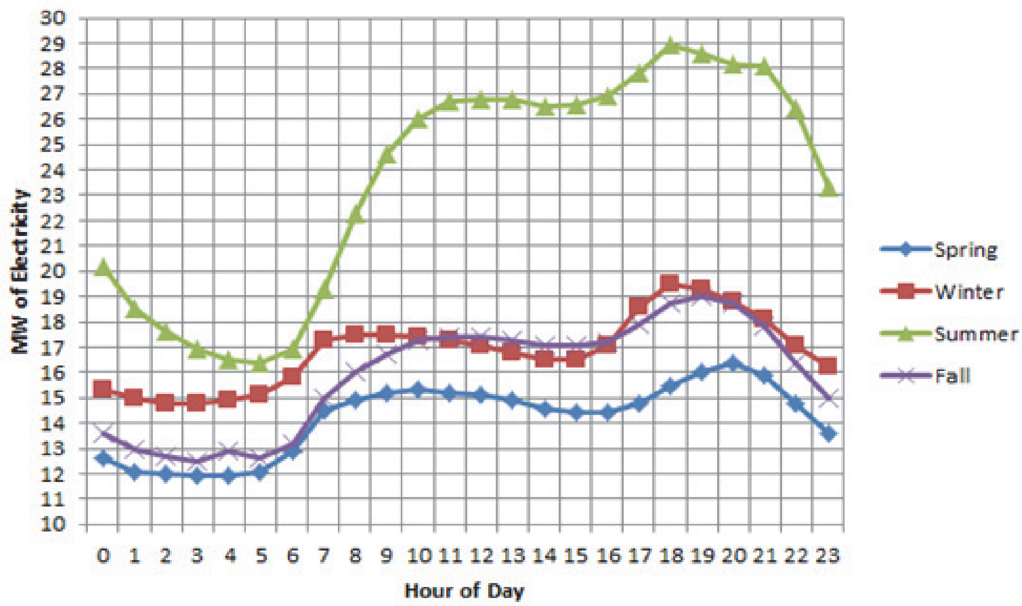

Figure 1 - Nantucket Seasonal Demand 2010-2011

In addition to island wide data, we also looked at the electricity consumption of several G3 and G2 facilities, including three G3 facilities (the Solid Waste Treatment Facility, the Waste Water Treatment Facility, and the Airport) and two G2 facilities (the High School and the Elementary School). The National Grid classifies large users as G3 and moderate users as G2 Figure 2 shows the total kW per day used by the Solid Waste facility in 2010. Overall usage throughout the year is relatively consistent although there is a slight increase in usage during the winter months. While the increased generation (and thus need for disposal) of trash in the summer would be expected to increase electricity consumption at the facility, it appears that the need for winter heating in the composter is a more significant factor. Heating in the building is circulated by large ventilation fans that draw a large amount of electricity and see an increased use during the winter months. The periodic downward spikes are probably related to scheduled or unscheduled maintenance on the composter.

Figure 2 - 2010 Solid Waste Treatment Facility Consumption

The Solid Waste Treatment Facility has experienced an increase in overall consumption since 2006 which is shown in Figure 3. The data show a slight decline in usage from 2005 to 2006, but a relatively steady annual increase between 2006 and 2009. Since 2009 usage has dropped somewhat which may reflect the impact of the recent recession on the generation of trash. This facility is the largest consumer on the island, and any decrease in usage can have a significant impact on the islands total consumption.

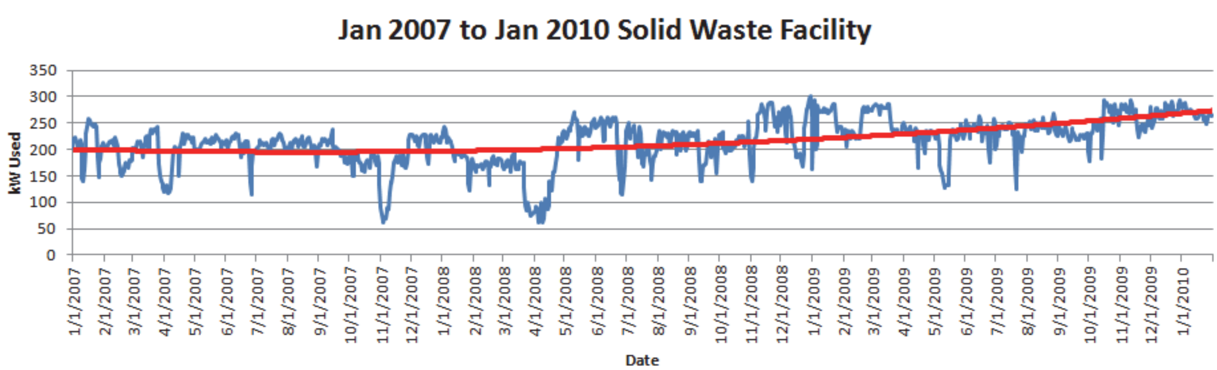

Figure 3 - Jan 2007 to Jan 2010 Solid Waste Treatment Facility Consumption

Another G3 facility we analyzed was the Waste Water Treatment Plant. Figure 4 shows the average diurnal load in a day for the entire data range (January to October 2011). As we can see, the pattern of use throughout the day has an interesting characteristic. Between the hours of 12 AM and 4 AM, the general load varies roughly between 250 and 285 kW. This then starts to increase to a peak of 330 kW and stays in this range until around 6 PM where it slowly starts to drop back down to off peak hours. The green line shows the maximum load during the peak day for 2011, which occurred on July 5. The load reached a peak of 530 kW shortly before noon when it was nearly double than the average weekday or weekend load. These graphs illustrate the nature of the data and types of patterns we observed. The data and patterns for all five facilities are in more detail in the main report.

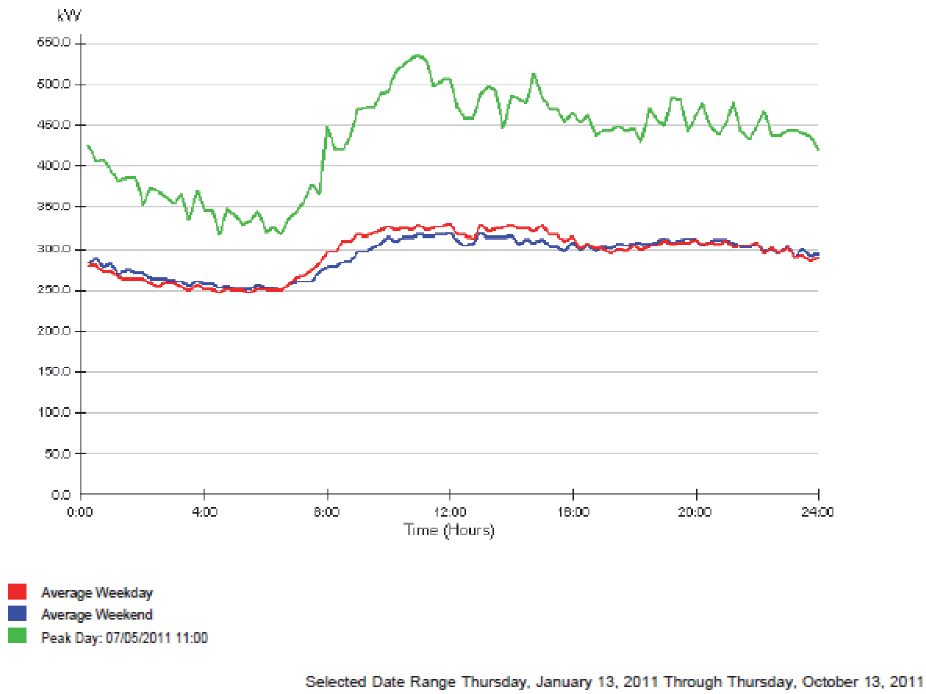

Figure 4 - 2011 Waste Water Treatment Facility Consumption

To supplement our National Grid analysis, we conducted energy audits of select small businesses on the island in order to gain a better understanding of how this sector uses electricity. Figure 5 shows that energy consumption varies among the five businesses, but the seasonal pattern is as expected with a large spike during the summer when the population of Nantucket rises and a steep decline in the winter.

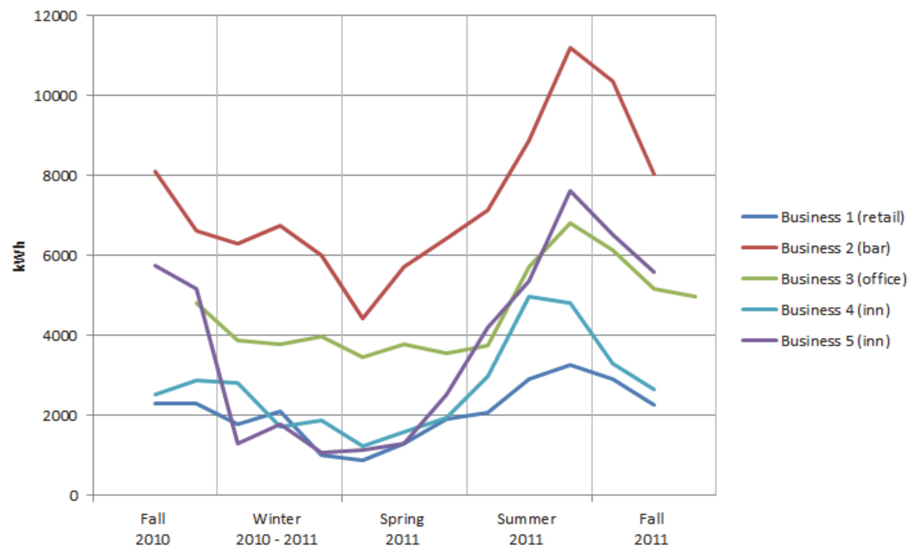

Figure 5 - Business Electricity History

Based on the audit data, we found that the businesses could apply several simple conservation techniques in order to save thousands of dollars each year. Table 1 shows recommendations common to four of the businesses we audited and the savings associated with each. Each type of business shows a slightly different pattern of end-use, but lighting accounts for a substantial fraction of energy use in all of the establishments. Consequently, to compact fluorescent bulbs (CFLs) or light emitting diodes (LEDs) has the potential of saving each business more than $1000 each year. At this point, however, LEDs are still quite expensive, and the payback periods are substantially longer. The second major area of consumption is electronics devices (such as computers, printers and cash registers) especially in retail and office space. Thus, simply turning off electronics in the evening and on weekends, either manually or through timers, can result in substantial energy savings.

	Recommendations	Retail	Bar	Office	Inn	Payback Period
Lighting	Upgrade to CFL	N/A	$1,092	$1,044	**$1,545**	1 – 3 Months
	Upgrade to LED	$1,099	**$1,642**	$1,572	N/A	2 – 6 Years
	Behavioral Changes	**$502**	$501	$79	N/A	0 Months
	Lighting Control Sensors	$351	**$751**	N/A	$149	6 – 12 Months
Heating and Cooling	Programmable Thermostat	**$89**	Plausible	N/A*	N/A	6 – 7 Months
Electronics	Turn off Electronics When Not in Use	$1,005	N/A	**$2,587**	$31	0 – 3 Months

Table 1: Audit Savings

In conclusion we recommend the Nantucket Energy Studies Committee use the data obtained from both National Grid and from our energy audits to help support their efforts to reduce energy consumption and costs on the island. Having a better understanding of how these facilities use energy will lead to more informed decisions about the development of renewable energy or the installation management technologies such as smart grids. We also recommend the town promote energy conservation among both residential homes and commercial establishments as a means to drastically reduce overall consumption on island. Our relatively rudimentary energy audits revealed that by adopting simple energy conservation techniques, business owners can save large amounts of electricity and money. Techniques such as upgrading light bulbs, installing programmable thermostats, and turning off electronics at night are not just limited to commercial businesses. These techniques can be applied to residential homes as well and result in the same kinds of savings. By promoting energy conservation the town can delay the need for a third cable to supply the island with more electricity.

Authorship

This Interactive Qualifying Project was written collaboratively by: Roberto Alvarado, Joseph B. Taleb and Corey Phillips. The entirety of the report including all research, interviews, audits, analysis and conclusions, was completed over the course of 14 weeks during the authors' third year in pursuit of partial fulfillment of Bachelor's degrees at Worcester Polytechnic Institute. The following sections of this were worked on equally by all members of the group: introduction, literature review, methodology, findings, conclusions and recommendations. Afterwards each member took a section, edited it and finalized it for the final product. The final product was lastly reviewed by all authors of the group to ensure it reflected the group's views as a whole.

Disclaimer

This report was completed as a requirement for Worcester Polytechnic Institute and for the benefit of the Nantucket Energy Study Committee. The authors of this report are not professionals or experts in conducting energy audits or conservation, but rather used data acquired from National Grid as well as conducted energy audits to produce this report. The data used to graph the patterns of energy use were acquired from National Grid with the assistance of Lauren Sinatra from the Nantucket Energy Office. Calculations found in the audit reports were all determined based on types of electronics found in each building and hours of use. If hours of use were unknown, a value was estimated based on either business owner statements or past case studies in a similar building. The report does not include any information regarding the concept of ―green, and does not make any assertions about global warming or carbon emissions – the report should not be used as evidence in either context. While this report was completed in conjunction with the NESC, the team's report remained independent from the committee and as objective as possible throughout the entire project. Lastly, it is important to note that the opinions and conclusions made in this report are not reflective of Worcester Polytechnic Institute or any other institution that may have been involved with this independent study, and that all opinions and conclusions are only those of the authors listed above.

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Introduction

The United States currently ranks second only to China as the world's largest electricity consumer. Consumption is expected to rise in the foreseeable future. There is a growing unease among some policy makers and many scientists about the future generation and consumption of electricity in the US, including concerns about fossil fuel depletion, climate change, and the nation's aging power infrastructure. The United States is celebrated as one of the world's most technologically advanced nations; yet, it depends on a power grid that has been around for at least a generation.

Growing demand for power has weakened the electrical grid of the nation. Without significant future investment, brownouts and even blackouts threaten to become more common. Even in a community as small as Nantucket, the mismatch between electricity supply and demand is worrisome, spurring interest in conservation and renewable.

Nantucket is uniquely situated: All its electricity is supplied by two submarine cables from the mainland. Being a seasonal tourist destination, Nantucket's electricity consumption fluctuates immensely according to the season. These realities have highlighted the Island's need for more power and its need to curb its consumption of power through conservation. Nantucket already pays a substantial premium on energy imported to the island, so it is not as simple as just consuming more. Being an island however, Nantucket is small enough such that the development of alternative power including implementation of newer technologies to conserve energy such as smart grids is possible. The citizens themselves can elect to control electricity consumption. Proven conservation could easily be implemented to lower the need and thus, cost of electricity for Nantucket residents.

To reduce consumption, one first must understand the pattern of consumption. Nantucket has a limited electricity supply, and consumption is growing annually, spurred by seasonal tourism. With cooperation between the town of Nantucket and the utility company that supplies the electricity, National Grid, we were able to gain access to 15 minute interval data on 5 of the town's accounts, as well as monthly metered data on other municipalities. What we lacked prior to this project was any information on consumption within the business sector. Although accounting for but a small fraction of Nantucket's total, local businesses are well situated to enact conservation strategies, acting as models for residents to follow.

To inform ourselves about this pattern of use, we conducted energy audits on select businesses that agreed to cooperate with our inquiry. The audits involved analyzing energy bills; walking through the building to note areas where energy efficiency could be improved, and suggesting those improvements. After the walkthrough, we compiled all of this data into detailed reports and shared this information with the business owners themselves. Suggestions were presented in order of priority, supplemented with our calculations and full energy inventory. Appendix G presents our audit checklist and Appendices H through L show our audit reports.

Our baseline model of energy use on Nantucket offers Nantucket's Energy Study Committee a better understanding of how energy is distributed and consumed on the island and an informed basis for decisions about future energy use strategies.

Literature Review

Energy demand in the United States has risen steadily since the 1960s. This rise has prompted numerous conservation measures over the years aimed at slowing the growth of energy usage. Conservation is still a fighting force today as residents, businesses owners, and industrial leaders seek to reduce their energy usage. Nantucket is no exception to this rise in consumption. Trends in electricity use on Nantucket share both similarities and differences when compared to that of the rest of the nation. If nothing is done, Nantucket will soon face the prospect of spending tens of millions of dollars to raise the maximum amount of electricity supplied to the island by adding a third supply cable from the mainland.

Patterns of Energy Use in the United States

Since the 1960s, electricity usage in the United States has risen steadily. Figure 1 depicts the average electricity consumption per capita as gathered by The World Bank. The graph shows that in 1960 electrical consumption was at about 4,050 kWh per capita. However over the course of 50 years, that number has risen to almost 14,000 kWh per capita, a 350% increase in electricity consumption. Demand for electricity will continue to rise unless necessary conservation measures are taken to stop this trend.

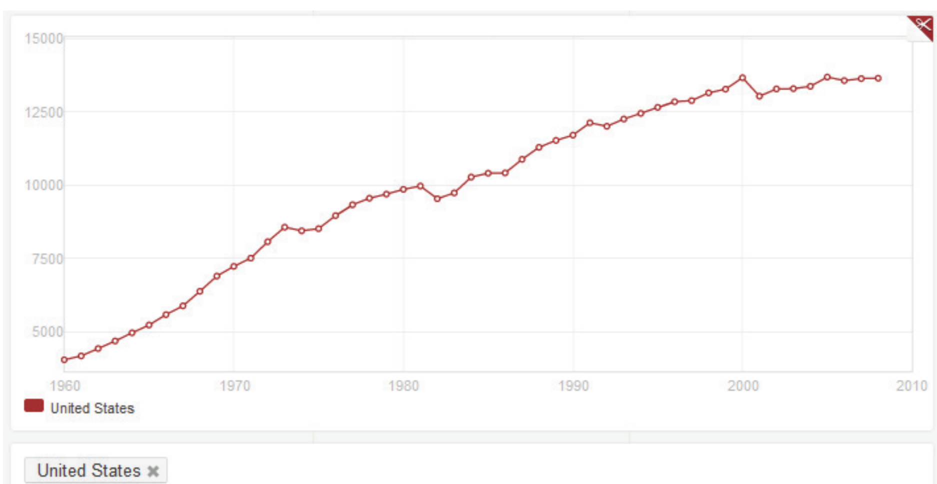

Figure 1: World Bank Electric Power Consumption Per Capita (World Bank, 2011)

In addition to a higher consumption of electricity, prices for electricity have also been rising. According to the U.S. Energy Information Administration, almost every year since 2000 has seen an increase in electricity prices. Figure 2 shows both average price per kilowatt and the annual growth rate for residential homes. Almost every year since 2000 has seen an increase in electricity prices, starting at 9 cents in 2000 and moving up to 12 cents in 2010. In addition to this, "EIA expects average U.S. residential electricity prices to increase by 1.7 percent in 2011 and by 1.2 percent in 2012" (EIA Short-term Energy Outlook, 2011). Rising prices will eventually lead to a stronger need for energy conservation as time goes on.

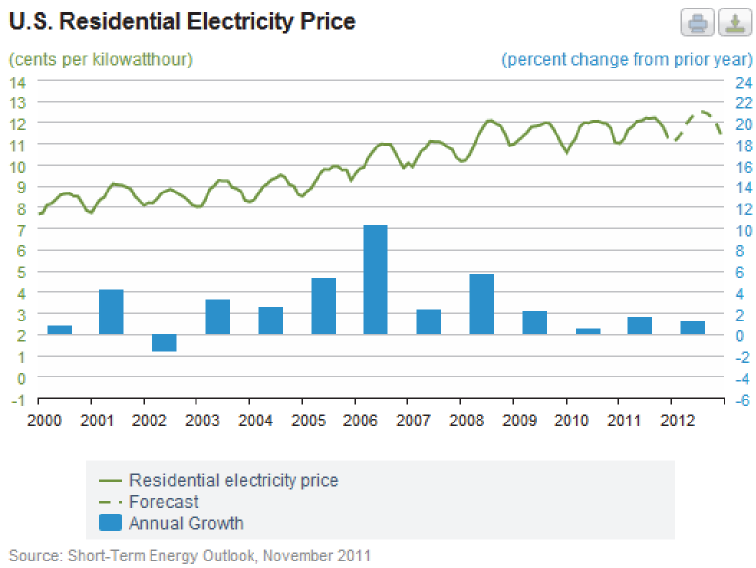

Figure 2: U.S. Residential Electricity Prices (EIA, 2011)

Looking back to the past, there have been many attempts to conserve energy usage in the United States. One example is President Carter's initiatives to reduce oil consumption in the 1970s. In a speech to the nation delivered on April 18, 1977, Carter explained that U.S. oil production could not meet the demands of the country and oil imports had doubled since the previous years. His concern was that the world would soon be demanding more oil than it could produce (Carter, 1977). More recently, efforts at conservation have been driven by concerns about the impacts of fossil fuel consumption on climate, but also by other concerns such as the costs of energy, and the depletion of finite resources. Each one of these concerns plays a role in the stronger emphasis in energy conservation today.

Patterns of U.S. Consumption by End-Use

In order to determine what sort of conservation techniques to put in place, one must be able to determine who is using the electricity and for what purposes. Electricity consumption is broken into four different categories, including residential, commercial, industrial, and transportation. Figure 3 shows this break down for the United States and how much each sector uses in relation to the total electricity usage overall. Residential, commercial, and industrial each make up roughly one third of the total electricity usage with transportation using only 0.2%.

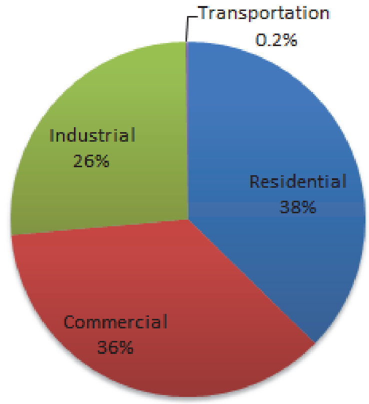

Figure 3: Sales of Electricity to Ultimate Customers, Total by End Use Sector (Based on EIA data)

Within each sector, it is possible to examine energy by end use also (e.g., lighting, heating/cooling, etc.) Figure 4 shows that residential home electricity usage is dominated by HVAC (Heating Cooling Air Conditioner) and kitchen appliances. These two areas account for 58% of electricity consumption in the average home. As homes continue to grow larger in size, the demand to heat this space will grow as well. The square feet of an average residential home has grown from 1,500 sq ft in 1980 up to 2,500 sq ft in 2006 (DoE, 2008). The other major electricity consumer, appliances, has been growing in number over the years as well. Air conditioners, dishwashers, computers, televisions, and small appliances have become increasingly prevalent in American homes over the past twenty years (DoE, 2008). As all these factors continue to rise, so does the growing concern of a larger energy bill for residential homes. Between 2000 and 2005, the average U.S. energy bill was $2,129, a $300 rise since the 1980s (DoE Buildings Energy Data Book, 2010). If not for the environment, home owners should practice good energy conservation methods for the sake of their wallets.

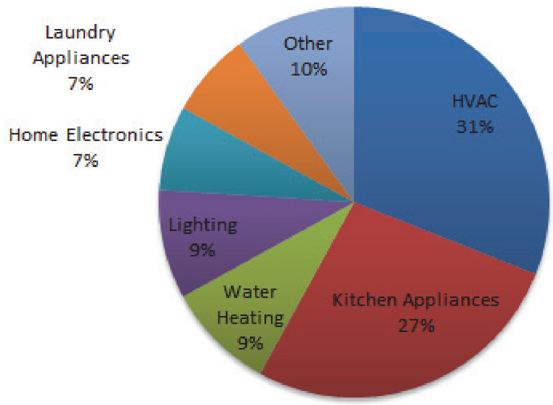

Figure 4: Residential Electricity Consumption by End Use (Based on EIA data)

The commercial sector uses almost as much electricity as the residential sector and consumes about 20% of all energy used in the US (DoE Buildings Energy Data Book, 2010). Figure 5 shows that three types of business (offices, retail stores, and education facilities) account for 48% of all the energy consumed in the commercial sector. When trying to analyze energy usage and promote energy conservation methods in the commercial sectors, these businesses should therefore receive much of the attention, although the picture is a little more complicated. For example, Figure 5 also illustrates that some types of businesses (e.g., food services) are much more energy intensive and it is likely that these offer significant opportunities for energy conservation efforts.

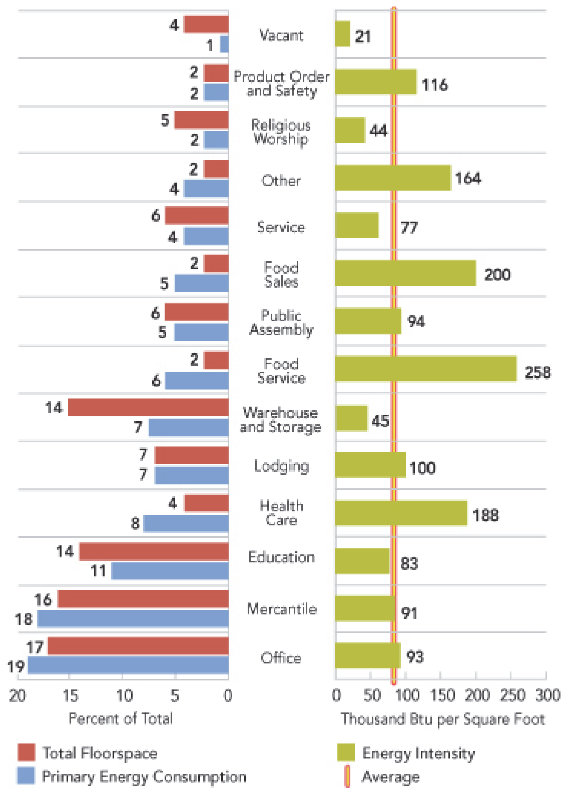

Figure 5: U.S. Commercial Energy Consumption (DoE, 2010)

Electricity usage among the commercial sector shows a few trends that differ from the residential end-use. According to Figure 6, lighting plays a much larger role consuming 38% of commercial electrical usage and would thus be a prime target for energy conservation efforts. Like the residential sector, HVAC is another one of the big users in commercial buildings consuming 30%.

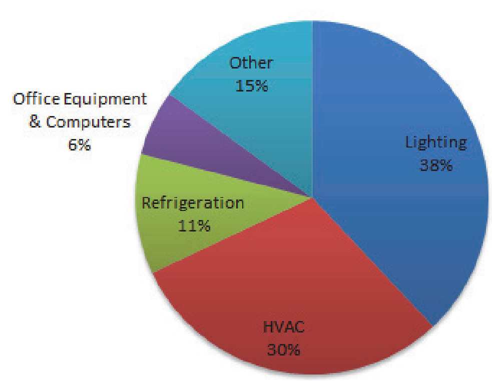

Figure 6: Commercial Sector Electricity Consumption by End Use (Based on EIA data)

Patterns of Energy Use on Nantucket

Nantucket shows both similar and different patterns from the trends seen in the rest of the United States. Nantucket shows a similar increase in electricity consumption seen throughout the United States. In addition to rising demand for electricity, price per kWh is on the rise, giving residents of the island a good reason to conserve energy. Lacking much industry on the island, the primary consumer on the island is the residential sector. Knowing this can assist in where conservation efforts should be focused.

In the past 10 years, Nantucket electricity usage has not shown as strong an upward trend compared to the trend in the rest of the United States. As seen in Figure 7, the peak electricity usage for 2001 was recorded at 13,000,000 kWh. This peak began to rise very slowly reaching 15,000,000 kWh in 2005. Although the 10 year increase has been a relatively slow process, Nantucket may soon be facing the same steep upwards trend that the rest of the U.S. faces. The recent 2011 usage data from National Grid shows a peak of 18,800,000 kWh in the month of August (Massachusetts EEA Migration Reports, 2011). This coupled with the elevated peak in 2010 could be the start of a more rapid increase in peak electricity usage that may present Nantucket with some tough choices to make in the future.

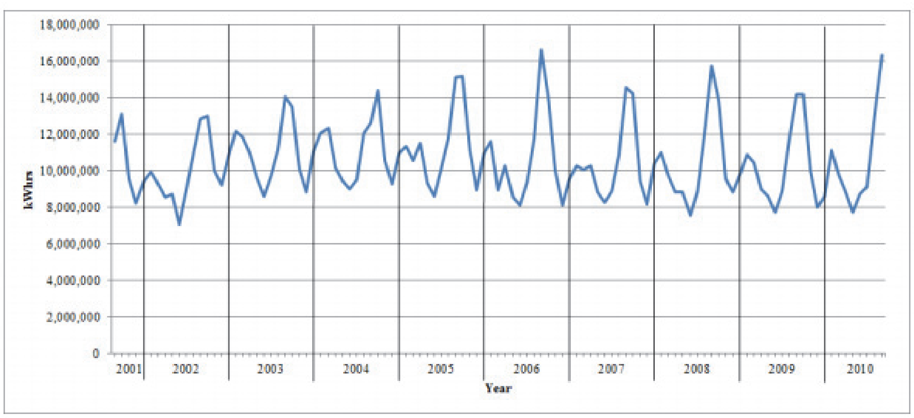

Figure 7: Electricity Usage History for Nantucket (EEA Migration Reports, 2011)

As an island, all of Nantucket's electricity is supplied from the mainland through two underwater cables[1]. These two cables were installed once it became clear that the old 20 MW

[1] Presently, a small fraction of the island's electricity is generated on island through turbines at the High School and Bartlett farm. The town is presently considering the installation of several renewable energy options that may provide substantial sources of power in the near future.

EMD electricity plant on the island would not be able to adequately deliver electricity to the entire island. The first cable was installed in 1996 rated at 35 MW. It soon became clear that a second cable would also be needed which was then subsequently completed in 2006. Noticing the rising demand in consumption, the island realized that at the rate of increase in demand, a third cable would soon be needed, and thus they created the Nantucket Energy Study Committee (NESC). The goal of the committee is to investigate alternative energy and conservation strategies that can be followed in order to delay the installation of a third cable at an estimated cost of $50-$60 million.

In addition to already paying 20% more for electricity than the mainland, cable installations result in an additional delivery charge to all the bills of the residents (Feasibility of a Smart Grid on Nantucket, 2010). This charge is to help pay for the tens of millions of dollars needed to install the cable. As seen in Figure 8, price per kWh jumped after 2006 when the second cable was installed before it settled back down in 2010. It can be expected that if a third cable were to be installed, the spike in price would be higher than that seen in 2006. The NESC is working on renewable energy projects and promoting energy conservation in order to avoid the huge expense of installing a third cable.

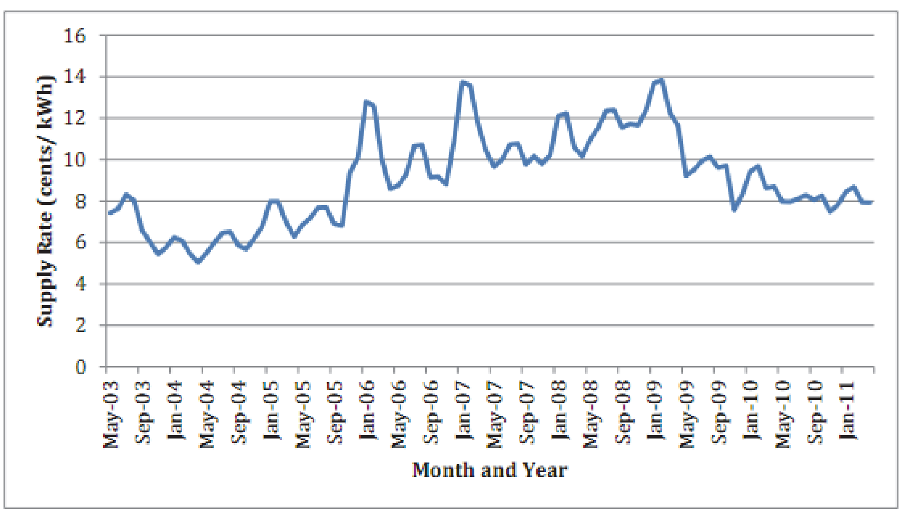

Figure 8: Nantucket Electricity Cost History (Beliveau, Hesler, Jaskolka, & Sigety, 2010)

Another big difference between Nantucket and the rest of the U.S. is the differences in end-use by the various sectors. The market for electricity on Nantucket comprises mostly residential homes and small commercial businesses. There is no real industry on the island, and the biggest single uses are town facilities, including the landfill, airport, and schools. As a result, the majority of the electricity is consumed in residential homes. Figure 9 shows that residential peak usage in the off-season (about 6,000,000 kWh) is far higher than in the commercial sector, and residential peak usage in the summer is dramatically higher, exceeding 12,000,000 kWh in 2010. Peak usage is a key number, since this is what will determine the need for the third cable.

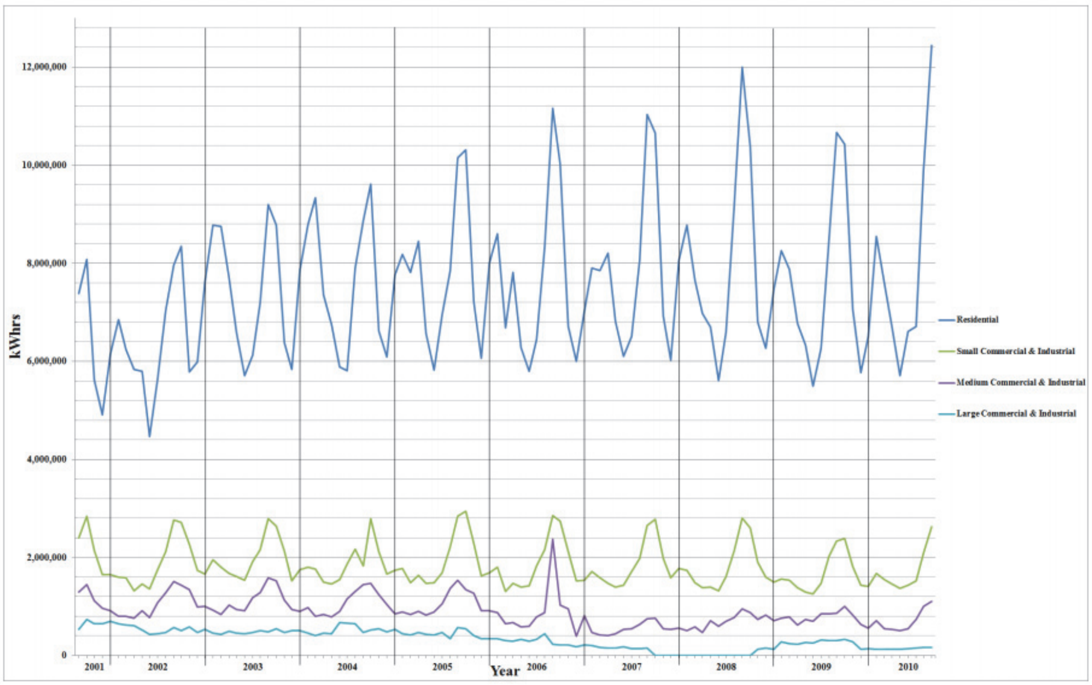

Figure 9: Nantucket Electricity History Broken Into Sectors (EEA Migration Reports, 2011)

Energy Conservation Programs

Many different energy conservation programs have been developed by various state and federal government agencies over the years. Currently, several programs exist that provide consumers with valuable products and suggestions that can significantly reduce electricity consumption with a reasonable initial investment. The cornerstone for these programs is the Energy Star program. Other popular programs are Leadership in Energy and Environmental Design (LEED) and Masco's Environments for Living (EFL).

Energy Star

In 1992, the US Environmental Protection Agency and Department of Energy created a joint program known as Energy Star. This labeling program first started as a way to recognize computers and monitors that used less energy than equivalent models. "The ENERGY STAR label is now on major appliances, office equipment, lighting, home electronics, new homes and commercial and industrial buildings" (Energy Star, 2010). Energy Star covers a wide range of energy saving products, which have applications in the home and in the office. The Environmental Protection Agency conducts a rigorous test of an appliance before giving the product an Energy Star approval. The product must "reduce greenhouse gas emissions and other pollutants caused by the inefficient use of energy, and offer savings on energy bills without sacrificing performance, features, and comfort" (Energy Star, 2010). The Energy Star label can also be applied to new buildings as a whole. It covers a wide range of building types and included 175 Federal buildings as of 2008 (DoE, 2010).

LEED

An energy conservation program that uses the Energy Star Label is the Leadership in Energy and Environmental Design (LEED) program. This program was developed by the US Green Building Council (USGBC) to provide a rating system used to better classify residential and commercial energy use. "LEED promotes a whole-building approach to sustainability by recognizing performance in key areas: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, Locations & Linkages, Awareness & Education, Innovation & Design and Regional Priority" (U.S. Green Building Council, 2011). A building that is certified at one of the LEED certification levels represents an ever growing community of green consumers. The LEED program covers residential homes to commercial warehouses. As of October of 2011, 6092 homes spanning multiple countries are LEED certified. Of that 6092, 169 homes are in Massachusetts and 3 are on Nantucket (U.S. Green Building Council, 2011). Many Federal buildings in the United States are also LEED certified.

Masco's EFL

Masco's Environments for Living (EFL) is a rating system that covers all areas of residential building construction. When a new residential building is being constructed, the contractor can follow either the Gold, Platinum, or Certified Green program. "There are now more than 100,000 homes across the United States that have been constructed by builders under the Environments For Living program. The program starts with a pre-construction plan review of your builder's plans to ensure compliance with the program's stringent requirements" (Environments for Living, 2011). If the plans are compliant with one of the three programs, then the house will be considered as an energy efficient building. An important note on the EFL program is that a significant part of the checklist involves Energy Star rated products. Conditions of the program include energy efficient lighting and appliances. "At least 60% of all hard-wired lights must be compact fluorescent or LED, reducing overall home energy consumption" (Environments for Living, 2011). This can account for a significant reduction in electricity costs.

Trends in Conservation

Numerous energy conservation programs have been established at the state and local levels in the US. These typically focus on reducing the electricity consumed by lighting fixtures, heating and cooling systems, and electronics. While conservation has been effective in some states (especially California), the growth in factors such as housing size and population has counteracted much of the savings. The graph below from DOE shows use increasing in the US as a whole while the very aggressive conservation approaches in California have been able to eliminate the increases if not actually reduce overall total consumption.

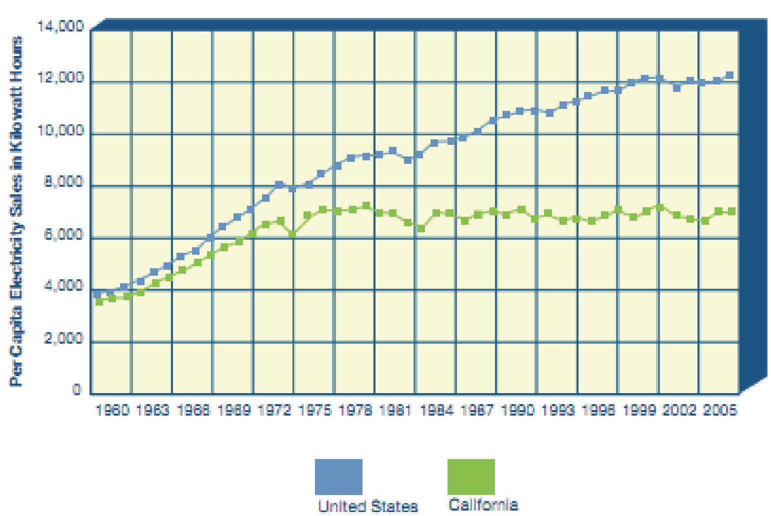

Figure 10 - California Electricity Consumption (DoE, 2008)

The adoption of different energy efficient technologies in the three areas of lighting, heating and cooling, and electronics has shown positive results for anyone who chooses to implement them. Figure 11 depicts the savings that could result from a few simple energy conservation techniques. The conservation techniques used in the savings calculations include upgrading to CFLs, installing programmable thermostats, and turning off unused appliances (Beliveau, Hesler, Jaskolka, & Sigety, 2010). Each of these techniques is relatively simple and the initial investment is either small or nonexistent. Simple techniques such as these can lead to thousands of kWh saved as Figure 11 suggests.

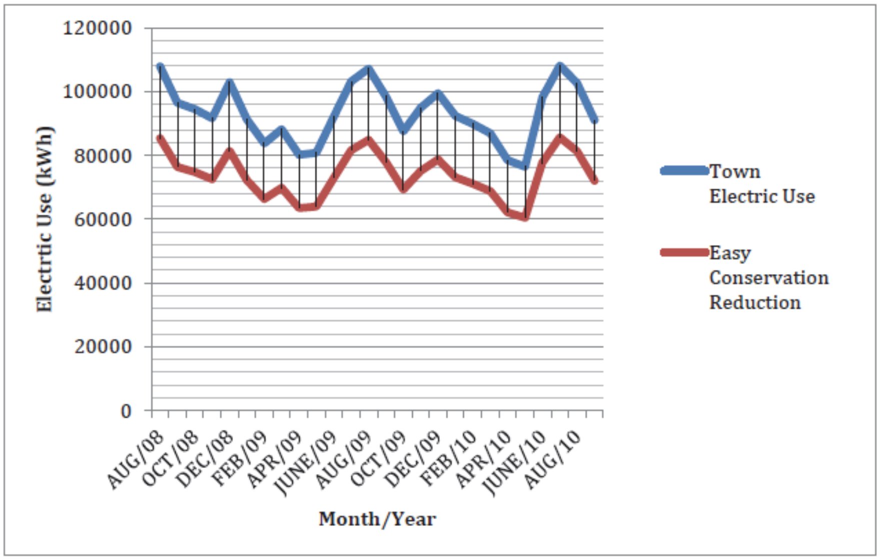

Figure 11 - Town Conservation Savings (Beliveau, Hesler, Jaskolka, & Sigety, 2010)

Lighting

Switching to Compact Fluorescent Light Bulbs (CFLs) from incandescent light bulbs can provide significant electricity savings. Lighting with incandescent light bulbs is costly compared to CFLs. CFLs "can save more than $40 in electricity costs over its lifetime, uses about 75% less energy than standard incandescent bulbs and lasts at least 6 times longer and produces about 75% less heat, so it's safer to operate and can cut energy costs associated with home cooling" (Energy Star, 2010). CFLs are a great alternative to incandescent bulbs, however there are some restrictions. "CFLs are sensitive to extreme temperatures, so place your CFLs in open fixtures indoors. Using them in enclosed fixtures indoors can create a hot environment that reduces the lifetime of your bulbs" (Energy Star, 2010). If a business or residence was interested in switching to CFLs, Energy Star provides a calculator to determine annual and life cycle costs and savings for a bulk conversion to CFLs.

Light Emitting Diodes (LEDs) are another alternative to incandescent light bulbs. LEDs provide the same 75% savings in energy use and produce very little heat. Although they require a little more of an initial investment, they are warranted for three years and last a minimum of 25,000 hours. LEDs are available with motion sensors and automatic daylight shutoff (Energy Star, 2010). The savings on electricity cost and maintenance would outweigh the initial investment if a business chose to switch from incandescent bulbs to either CFLs or LEDs.

In addition to switching to more efficient light bulbs, turning off lights when not in use will result in savings. This can be done manually or by purchasing either a daylight dimming system or an occupancy sensor. Daylight dimming systems will dim the amount of light produced by the bulb depending on the amount of sunlight available. Occupancy sensors will shut off the connected lights when the room is empty. These technologies eliminate the need to constantly switch the lights on and off. Determining when to turn off lights when not using a sensor depends on the type of bulbs used. If the lights are incandescent bulbs, then they should be shut off whenever not in use. Fluorescent bulbs should only be shut off for periods of 15 minutes or more. This is due to the spike needed to turn the light on. This spike is very small, equivalent to a few seconds of normal use, however if lights are switched excessively it might end up costing more in the long run. It is important to note that the more a light is switched, the shorter its life span becomes (DoE, 2011). In general, turning off lights while not in use will result in a reduction of electricity consumption.

LEDs: A SMART ALTERNATIVE FOR RECESSED DOWN LIGHTING

LIGHT SOURCE	LIGHT OUTPUT (LUMENS)			WATTS	LIFETIME (HOURS)	ANNUAL OPERATING COSTS
	TOTAL LIGHT	USEFUL LIGHT	WASTED LIGHT			
Incandescent bulb	1,150	575	575	75.0	1,000	$8.87
Compact fluorescent light bulb (CFL)	1,150	575	575	20.0	10,000	$2.37
ENERGY STAR qualified LED lighting	**575**	**575**	**0**	**16.5**	**25,000 or 35,000**	**$1.95**

Figure 12: Comparison of Downlights (Energy Star, 2009)

"LED manufacturer Cree has been awarded a contract from the U.S. Department of Defense to supply over 4,200 recessed LED lights for the Pentagon. Testing commissioned by the U.S. government determined that Cree's LR24 recessed LED lights would offer a 22 percent energy reduction compared with fluorescent lights, and save the Pentagon 140 tons of carbon dioxide emissions per year." (news.cnet.com). Conservation programs have taken place across the country that focus on lighting. "In May and June 2001, Philips relamped Berkeley businesses (including offices and restaurants) and residences on Telegraph Ave. between Channing and Durant streets with energy-efficient light bulbs. Common household light bulbs and industrial fluorescent bulbs were changed to the most energy-efficient CFL bulbs and linear fluorescents. Mercury vapor fixtures were changed to high-pressure sodium, and incandescent to CFLs" (Philips Lighting Company). The results of this study proved that the replacement was successful. The project saved 45% on consumption, and $20,692 on costs (Philips Lighting Company). The main focus of this program was lighting, and the changes Philips made could be done in any business.

Heating and Cooling

Nantucket experiences summer highs of 75^{o} F and winter lows of 25^{o} F (Weather Channel, 2011). There are many ways that a household or business could save on heating and cooling costs. One of the easier ways to save on cooling costs is to set the air conditioner 5 degrees higher. This can save up to 20% on the bill (Flex Your Power, 2011). Another option is to have air conditioners serviced. This can cut up to 15% off of cooling costs (Flex Your Power, 2011). These options are useful for consumer who already have a cooling system in place, and do not wish to make a large investment. Most ceiling fans use less energy than a light bulb and can be a smart alternative to air conditioners (Flex Your Power, 2011). A combination of these should be used to maximize savings.

Programmable thermostats are a viable option for both households and businesses. Air conditioners and heating systems use a lot of electricity. Programmable thermostats allow the consumer to schedule when their heating or cooling system varies the room temperature. Programmable thermostats can store and repeat multiple daily settings (six or more temperature settings a day) that you can manually override without affecting the rest of the daily or weekly program (DoE, 2011). On an island like Nantucket, a programmable thermostat could save $100 per year, returning the initial investment within 12 months. The Net life cycle savings for a programmable thermostat is $1,807 (energystar.gov). Some skeptics claim that the heating or cooling system will consume more energy returning the room temperature back to its desired setting after the thermostat has been set back. Realistically, leaving the heat or air conditioning system on when not needed will consume more energy due to the system compensation for heat loss or gain depending on the outdoor temperature. Programmable thermostats have shown to be a good return of investment for both businesses and personal residences.

The Glenwood Springs Mall located in Garfield, CO retrofitted their building with programmable thermostats, a new heating and cooling system, and CFL light bulbs. This was done in the winter of 2010. “Electricity bills for the 800-square-foot store show a significant savings in costs and decreases in power use. The highest electricity invoice from January 2009 showed 9,314 kilowatts used at a cost of $778. The highest monthly bill after the work was completed in mid-December showed 5,085 kilowatts used at $425” (Romig). The replacements were made because of the results of an energy audit conducted on the building.

Electronics

Businesses and residences can save electricity costs by reducing the number of appliances plugged in and to turn computers off when possible. Electronics left plugged in when not in use still draw electricity. Unplugging appliances not in use can result in significant electricity savings. More and more technologies are available and most likely run on electricity. Leaving a large number of appliances plugged in constantly uses electricity, even if it is only a small amount. “Taken together, these small items can use as much power as your refrigerator” (Flex Your Power, 2011). Computers are responsible for large amounts of electricity consumption. There are many ways to reduce a computer’s consumption. One solution is to enable "power management" on all computers and make sure to turn them off at night. Another solution is to configure computers to go into hibernate mode after a desired period of time. This allows the user to start the computer back up without reloading everything. “ENERGY STAR® computers power down to a sleep mode that consume 15 Watts or less power, which is around 70% less electricity than a computer without power management features. ENERGY STAR monitors have the capability to power down into two successive "sleep" modes. In the first, the monitor energy consumption is less than or equal to 15 Watts, and in the second, power consumption reduces to 8 Watts, which is less than 10% of its operating power consumption” (DoE, 2011). Depending on the size and structure of the business, switching from desktop computers to laptops may save the business on electricity costs. A laptop computer uses up to 90% less energy than bigger desktop models (Flex Your Power, 2011). If a business runs software that can be run just as efficiently on a laptop as on a desktop, then, depending on the cost of the new laptops vs the savings on electricity that business may want to switch to laptops.

Yale University conducted a study on electricity conservation. This study focused on electronics, specifically computers. “Yale Facilities personnel have been shutting off computers at night since February 2006. In addition to saving $4,700 per year, shutting off the computers: Prevented the emissions of 61,000 lbs CO_2, Saved enough electricity to power 34 homes…” (Yale University Shuts Off Computers to Save Energy). Just by powering down 105 machines the university made a large reduction on electricity costs.

Methodology

The goal of this project is to assist the Nantucket Energy Study Committee in its effort to reduce energy costs on Nantucket. The objectives of this project are 1) to create a baseline profile of the electricity use on Nantucket by analyzing detailed consumption data held by National Grid; 2) to characterize patterns of energy use among small businesses by performing energy audits; 3) to determine the impacts of a variety of conservation techniques to reduce energy among small businesses; and 4) to present the committee and select businesses with our recommendations for energy conservation options and strategies.

Objective 1: Crafting an image of Energy Usage on Nantucket

Our first objective is to create an image of the patterns of energy use on Nantucket. The majority of our data came from National Grid, provided to us through an agreement between the utility and George Aronson, an energy consultant hired by the town, who also cooperated with us in our efforts.

The first set of data that we received was aggregate data for the entire town in 2 week intervals from September 2010 to September 2011. With this information we were able to make an image of the diurnal load pattern of an average day as well as seasonal patterns. This information is displayed in our Findings & Recommendations section.

As the payee on these account, the Town was given access codes that enabled is to download the raw data of five municipal accounts from the National Grid site during a specified ‘window’ of time. National Grid data are not ordinarily available except by request of the payee on any particular account. Three of the five accounts included are the Solid Waste Treatment Facility, the Waste Water Treatment Facility and the Airport which are classified by National Grid as G3 accounts and thus are given ‘large’ business rates. The other two accounts are Nantucket High School and Nantucket Elementary which are classified as G2 accounts and are given “mid-size” business rates. An account is generally considered a G3 or ‘large business’ when their demand exceeds 200kW at any time. (National Grid, 2011).

Table 1 shows the five municipal accounts, their account types and the date ranges for the interval data that were available. Data for the airport and the Waste Water Treatment facility were available for a more limited time period because these facilities were recently reclassified as G3 facilities

Facility	Account Type	Date Ranges
Solid Waste Treatment Plant	G3	12/14/2004 – 10/13/2011
Waste Water Treatment Plant	G3	01/13/2011 – 10/13/2011
Nantucket Airport	G3	09/27/2010 – 10/13/2011
Nantucket High School	G2	11/08/2002 – 10/21/2010
Nantucket Elementary	G2	11/08/2002 – 10/13/2011

Table 1 - National Grid Data Summary

We downloaded the raw interval data from the National Grid website and made back-up copies, for our own use during this project and for the town's use in the future. George Aronson requested that we create load duration curves from these data for the town's use. In addition to this, we also created average profiles for the town on a yearly basis where possible as well as maximum and minimum seasonal data. These graphs are included in our Findings & Recommendations.

Objective 2: Assess Energy Use among Small Businesses

In order to provide the Nantucket Energy Studies Committee (NESC) with certain conservation strategies that can be used in the commercial sector of the island, we conducted energy audits of several small businesses including restaurants, retail stores, lodging, and office buildings. At the time the NESC had little data on patterns of energy use on the island and is still looking to gather more in order to promote energy conservation and reduce energy costs. While businesses on Nantucket account for only a small fraction of the total energy consumption, the ESC hopes that successful examples of energy conservation among small businesses will serve as exemplars to encourage conservation among other businesses as well as residential consumers on the island.

Recruiting Businesses

In recruiting businesses to participate in audits, we wanted to ensure a reasonably representative sample of the various types of businesses on Nantucket. Nantucket's small businesses are mostly dominated by retail stores, restaurants and hotels so they were our main areas of focus. Given their interest in energy and local knowledge, we asked Peter Morrison and Whitey Willauer for suggestions of any businesses they thought might be interested. Harvey Young, owner of a local bike shop, had previously expressed an interest in learning more about energy consumption and conservation options at his store. He obligingly agreed to allow us to conduct the first audit at his building. We used his site as a test of our audit procedures, since he was amendable to us returning to collect any missing or additional data that we did not collect during the first visit. At the end of the audit, we asked him if he could suggest the owners of any other businesses that may be willing to let us conduct an audit. Using this 'snowball' technique, we were able to identify a number of businesses that were interested in and willing to allow us to conduct additional energy audits.

We managed to conduct 5 audits in the retail, restaurant, office space and lodging sectors. We had hoped for a larger sample, but finding willing participants during the 'off season' proved to be more difficult than expected. Recruitment of businesses was handled generally by phone call, explaining in detail the procedure of the audits, how long they would take, what information we would need from them and that the audit was free of charge. In the end, we received 2 rejections and 3 others expressed interest but we were not able to arrange an audit in time. Luck also played a role in recruitment as frequently we encountered owners that were off island or simply unavailable.

During the early stages of our research one of the business owners suggested an improvement in our recruiting strategy. He told us that the term "audit" has a negative connotation by association with Internal Revenue Service (IRS) audits and might scare away potential participants. We decided to refer to our process as energy assessments in our recruiting efforts and changed the wording on a brochure we provided to each owner accordingly. After which we began to receive more positive feedback from the businesses we contacted. However for the purpose of this report, the process will still be referred to as an audit in order to maintain consistency.

Define the Scope of the Audit

Before we began conducting the audit of a select business, we discussed with the owner what the scope of the audit would be. We went over topics such as how much of the building the audit would cover, how long the audit would take, and how the results would be reported. We also provided the business owner with a brochure with more detailed information. A copy of this brochure can be found in Appendix F. Defining the scope of the audit early on prevented either the business owner or our team from having an unrealistic idea of what the audit would entail. Our suggestions focused on modest upgrades that would not require a substantial capital investment, but would result in reasonable savings over a relatively short pay-back period.

Develop Audit Checklist and Conduct the Audit

The audits conducted were a modified Level II audit that consisted of a detailed walk-through of the building in order to identify areas where energy efficiency could be improved and make suggestions for new technology that can be installed or changes in behavior that can be made to reduce energy consumption. These suggestions include a cost analysis detailing how much money will be saved and how long it will take to pay back the investment. Before conducting the walk-through audit, we developed a checklist identifying key things to look for. The team developed a checklist based on several other checklists already created by establishments such as the Carbon Trust and Washington State University. Appendix A shows an example of one of many Carbon Trust checklists that we integrated with others to create a more detailed checklist. Our checklist not only created an inventory of important energy consuming equipment in the areas of lighting, heating and cooling, and other electronics such as office equipment, but also listed questions that can identify possible behavioral changes that can be made. This included an account of the number of items of any one item, the type of item it was (i.e. In terms of lighting, whether they used incandescent or CFLs, etc) as well as any comments about the subject being observed. Wattage information on equipment was also taken down both in written and photographic form. Both of these proved to be useful as there were times where we had only one or the other, they also managed to complement each other well when we did have information in both forms.

Following our pilot audit at Young's Bike Shop, we determined that our checklist was too lengthy and cluttered making it difficult to efficiently record information while walking through the business. We decided to use a more compact template that would still record the same amount of information. By creating a set of guidelines for the audit, we were able to record the data on virtually blank pieces of paper and then transfer the data into tables that we recycled from the previous checklist.

Analyze Results of Audit

The data gathered not only included the results of the walk-through audit, but also previous energy bills spanning over the course of one year. The data from these bills was graphed in order to establish a pattern of energy use. With enough audits conducted, we were able to establish a rough conservation strategy pertaining to certain business sector types such as restaurant, retail, office or lodging. The energy audits conducted acted as a data collection method in order to determine what suggestions can be made to reduce energy consumption.

Objective 3: Analyze Conservation Options

Conservation can be a very attractive proposition for consumers on Nantucket facing high energy costs, given the expanding array of economical energy saving available. The team conducted an extensive review of available energy saving techniques prior to arrival and continued to conduct research on other methods and technologies to meet particular needs identified during the audits. See the literature review for information regarding the current technologies available. The spectrum of electricity conservation technologies ranges from no cost options to expensive ones. It also covers different categories of electricity usage such as lighting, temperature control and electronics. Each conservation technique was researched to determine how much electricity they save.

There are many aspects involved in determining the cost effectiveness of an energy conservation technique. Behavioral changes such as turning off equipment at night and on weekends are not only free, but also can result in high rewards. However, these are sometimes also the hardest to get into given the human factor of forgetfulness. Therefore it is sometimes worth it to introduce technology that can regulate these things for you, such as occupancy sensors that regulate when lights are on or not. Of course there is some initial investment necessary to install certain technologies, but given their relative pay-back periods when compared to the savings, it usually makes this more than worth it.

By analyzing the different conservation techniques, each saving percentage was applied to the different input electricity profiles resulting in a tailored electricity conservation plan. Based on how the selected business is using the most electricity, we determined which conservation techniques will be most effective for the consumer to implement. Additional information on the structure of the business was gathered during the audit. This information includes seasons and hours of operation, whether customers spend a lot of time in the building during transactions and a typical day's schedule. We then presented the owner with a list of our recommendations in the form of an audit report that we viewed as viable options in their current situation.

Objective 4: Presentation of Findings and Recommendations

Generating an Audit Report

The audit report is the document that we used to report back all of our findings as well as our suggestions to each business we audited. It includes the results obtained from the walk-through checklist, highlighting areas of interest where energy efficiency can be improved. The report also details how much energy each area, such as lighting, heating and cooling, etc, is consuming and compares that to the consumption rate of any new technology that is included in our suggestions. The cost and payback periods calculated are shown and prioritized by investment to savings ratio. The report is our way of compiling all of our findings and presenting them in an orderly fashion to the business so that they could then make the decision whether or not to implement our suggestions.

Results

Lastly we talked about what our results were from analyzing both information from National Grid and the Energy Audits. Any pertinent findings were discussed both with the NESC and the business owners as well as providing recommendations on how to address their consumption needs. Through the patterns of consumption determined by compiling the data, it was made easier for both the NESC and small businesses to take note of their consumption given any relevant interval of time, (i.e. seasonal up to hourly). The committee and business owners are now able to move forward in determining what steps to take from here in terms of conservation options suggested from the audits.

Findings

The goal of this project is to assist the Nantucket Energy Study Committee in its effort to reduce energy costs on Nantucket. This involves creating a baseline profile of the electricity use on Nantucket by analyzing detailed consumption data held by National Grid and characterizing patterns of energy use among small businesses by performing energy audits. The audits will allow us to determine the impacts of a variety of conservation techniques to reduce energy among small businesses. Five audits were conducted in total.

National Grid Data Analysis

National Grid granted us access to 15-minute interval data for five major facilities on the island. This included three municipal facilities classified as G3 accounts: the Solid Waste Treatment Facility, Waste Water Treatment Facility and the Airport. Also, the group had access to Nantucket High School and Nantucket Elementary School, which are considered G2 facilities. The date ranges available varies for each consumer. Please refer to Table 1 for exact ranges.

Figure 13 below shows Nantucket's overall consumption from 2010 disaggregated by season. We defined spring as March to May, summer as June to August, fall as September to November and winter as December to February. The data used to create this graph is from hourly data from 2010. We took the interval data and averaged the consumption for each hour of the day for the three months in the season.

There are a few important characteristics to take note of. First, there is an expected diurnal variation regardless of the season, with lower consumption at night. The patterns for winter, spring, and fall are very similar: following a rise in consumption in the morning energy use remains relatively flat during the day until about 4pm; consumption rises through the evening dinner hour and then drops off after about 10pm. The summer pattern is dramatically different: usage rises exponentially around six in the morning and remains high throughout the day. There is a further peak around dinner hours and energy use drops off after 11pm. It is important to note each seasonal characteristic, as the seasonal profiles for each facility below directly influences these curves.

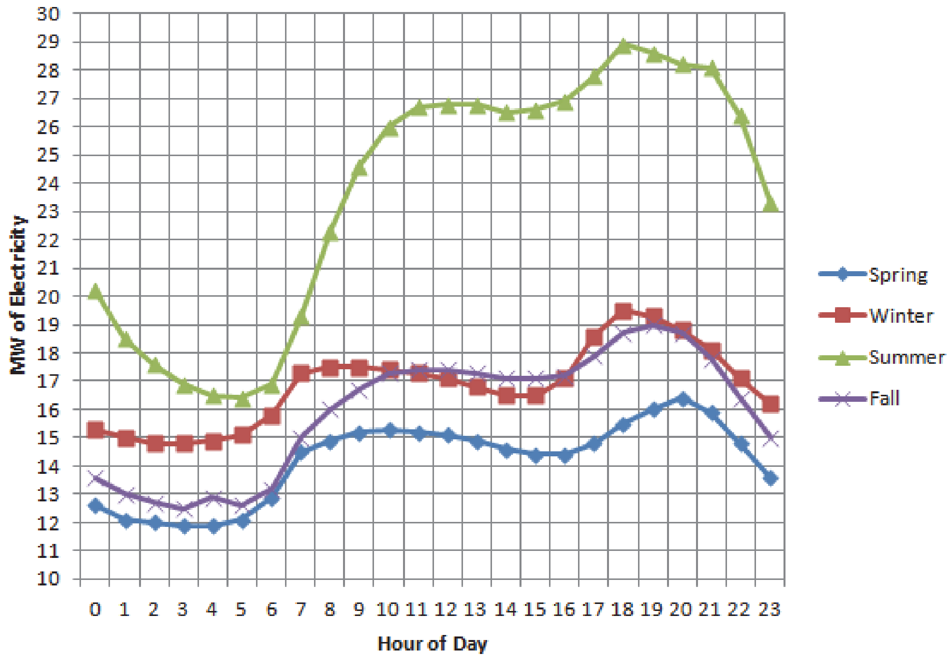

Figure 13: Nantucket Daily Consumption by Season

Solid Waste Treatment Facility

We were granted access to 15-minute interval data from December 2004 until October 2011. To analyze these data, we focused on daily, seasonal, and yearly trends. The Solid Waste Treatment Facility is a G3 facility.

The average electricity profile of the solid waste treatment facility (Figure 14) shows some interesting trends. The town composter operates continuously 24/7, which provides a substantial 'base load' and since 2004 the facility never consumed less than 160kW at any time during the work week or on weekends. The lowest average came in 2006 and the daily profile for that year is shown in Figure 14. In addition to the 'base load' of the composter, we can see that consumption increases at about 7am at the start of the typical work day when staff arrive, turn on lights, computers, and other equipment and then drops off after 4pm when most staff go home.

Another trend shown by the average profile graph is the plateau in usage during the typical work hours. From around 7:30 or 8:00 in the morning until around 3:30 or 4:00 in the evening on a weekday consumption shows a predictable increase. The same increase in usage can be seen on an average weekend within a shorter time window. Since 2004 the daily profile for this facility follows this pattern.

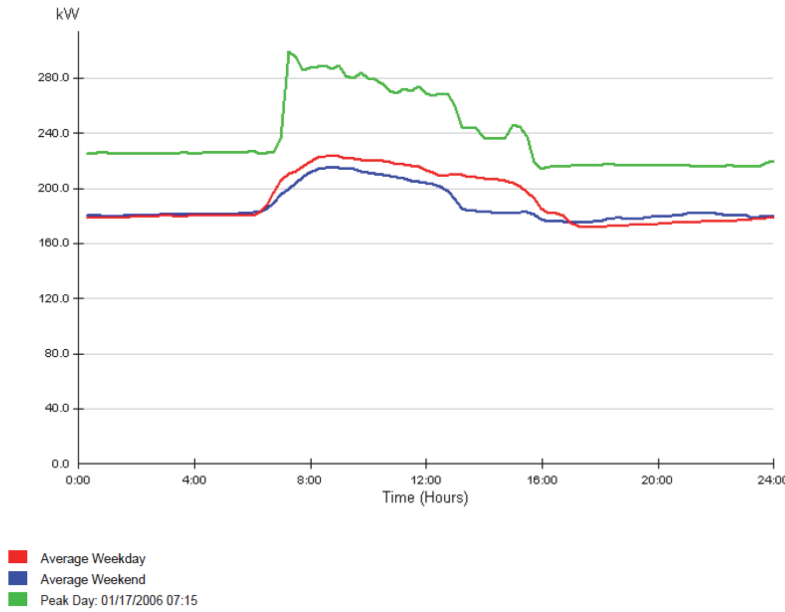

Figure 14: January 2006 Solid Waste Treatment Facility Profile

Figure 15 shows the total kW per day used by the facility in 2010.[2] Evidently, overall usage throughout the year is relatively consistent although there is a slight increase in usage at the Solid Waste Facility during the winter months. During the summer months the total kW used hovers just below 250kW. In the winter months it stays between 250 and 300kW. While the increased generation (and thus need for disposal) of trash in the summer would be expected to increase electricity consumption at the facility, it appears that the need for winter heating in the composter is a more significant factor. Heating in the building is circulated by large ventilation fans that draw a large amount of electricity and see an increased use during the winter months. The periodic downward spikes are probably related to scheduled or unscheduled maintenance on the composter.

[2] We used 2010 data since we did not have data for the entirety of 2011.

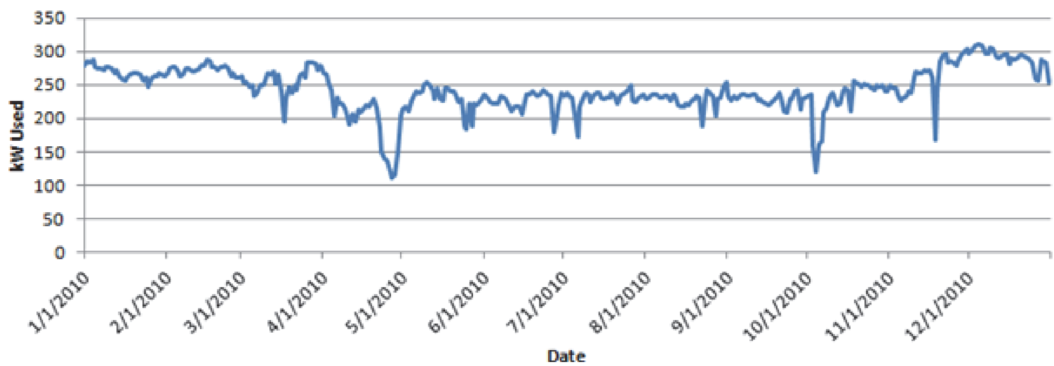

Figure 15: 2010 Solid Waste Treatment Facility Consumption

The Solid Waste Treatment Facility has experienced an increase in overall consumption since 2006 which is shown in Figure 16. The data show a slight decline in usage from 2005 to 2006, but a relatively steady annual increase between 2006 and 2009. Since 2009 usage has dropped somewhat which may reflect the impact of the recent recession on the generation of trash. This facility is the largest consumer on the island, and any decrease in usage can have a significant impact on the islands total consumption.

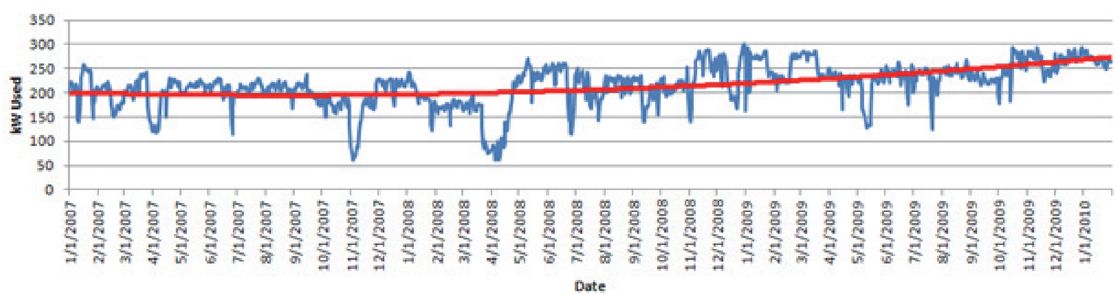

Figure 16: Jan 2007 to Jan 2010 Solid Waste Treatment Facility Consumption

Waste Water Treatment Plant

Unfortunately, the data available for the Waste Water Treatment Plant (WWTP) G3 account cover only January to October 2011, so our analysis is less comprehensive than that presented for the Solid Waste Treatment. The data time frame makes it unavailable to compare to other facilities at the time of this analysis.

Figure 17 shows the average diurnal load in a day for the entire data range (January to October 2011). As we can see, the pattern of use throughout the day has an interesting characteristic. Between the hours of 12 AM and 4 AM, the general load varies roughly between

250 and 285 kW. This then starts to increase to a peak of 330 kW and stays in this range until around 6 PM where it slowly starts to drop back down to off peak hours. The green line shows the maximum load during the peak day for 2011, which occurred on July 5. The load reached a peak of 530 kW shortly before noon when it was nearly double than the average weekday or weekend load.

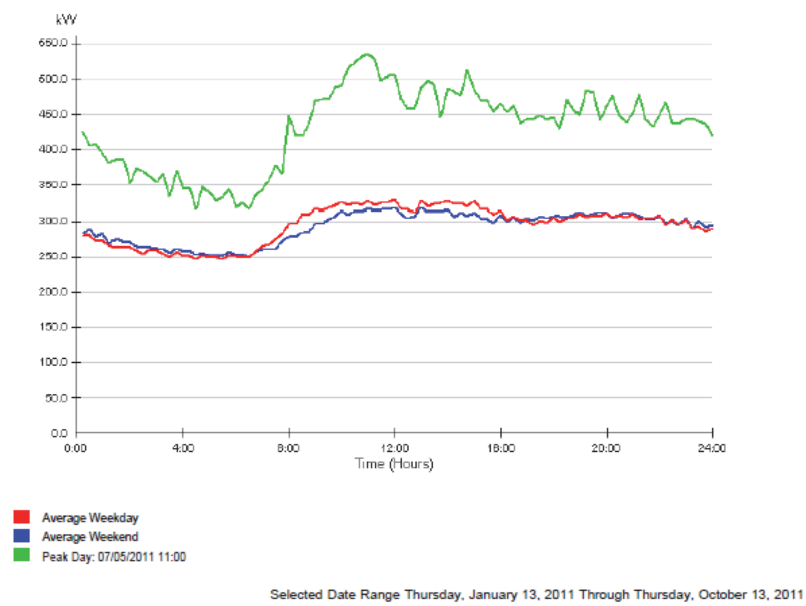

Figure 17: 2011 WWTP Profile

We also analyzed the average daily load by season. Figure 18 shows 2011 consumption for this facility. There is a clear increase during the summer months while tourism is at its peak. During the winter months there is a clear settling around 250 to 300 kW. During the summer months consumption peaks between 400 and 450 kW. The heavy spike in July can most likely be attributed to July 4th weekend.

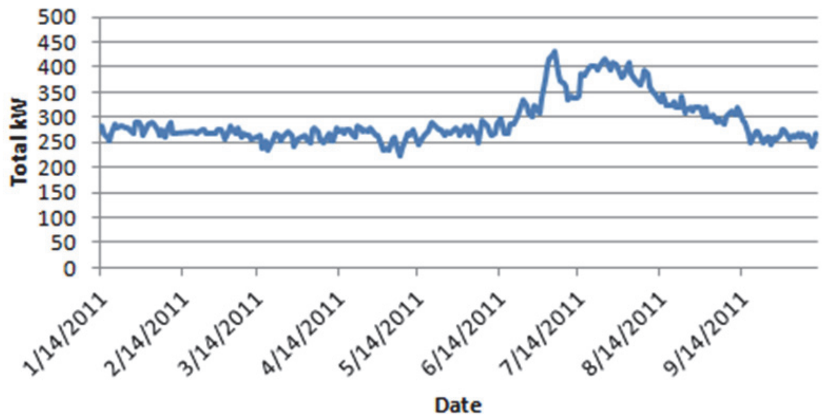

Figure 18: 2011 WWTP Consumption

Figure 19 shows the maximum daily kWh consumption for the Waste Water Treatment Facility broken up months indicative of their season. July's maximum consumption is greater than the other months due to the large amount of tourism on the island during the summer season, expecially July 4th weekend. Maximums for the other months tend to be grouped around the 60 – 80 kWh mark.

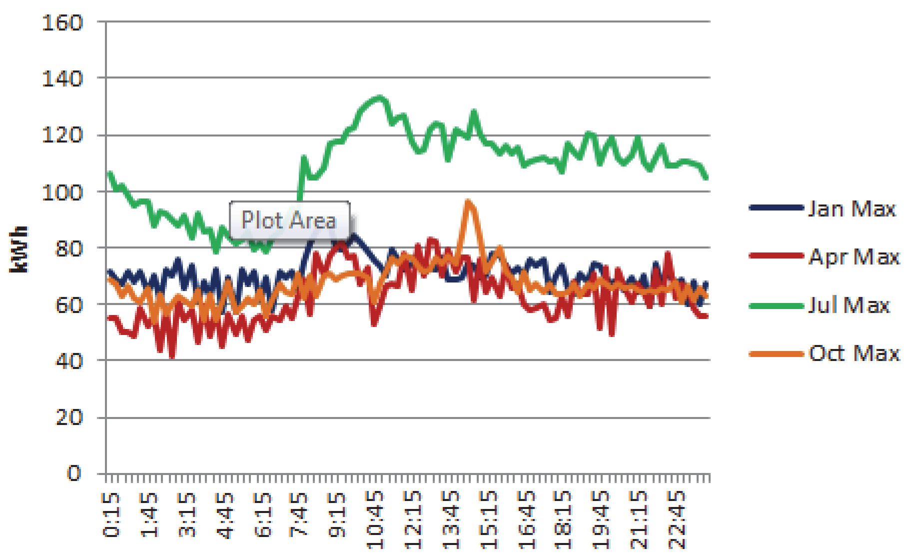

Figure 19: 2011 WWTP Daily Max Consumption

Figure 20 shows the minimum daily consumption for the Waste Water Treatment Plant. Not only does the summer maximum peak surpass the others, the summer minimum consistently stays above the other seasons. July's minimum peaks at about 120 kWh while the maximum consumption for all the other months only goes as high as 80 kWh.

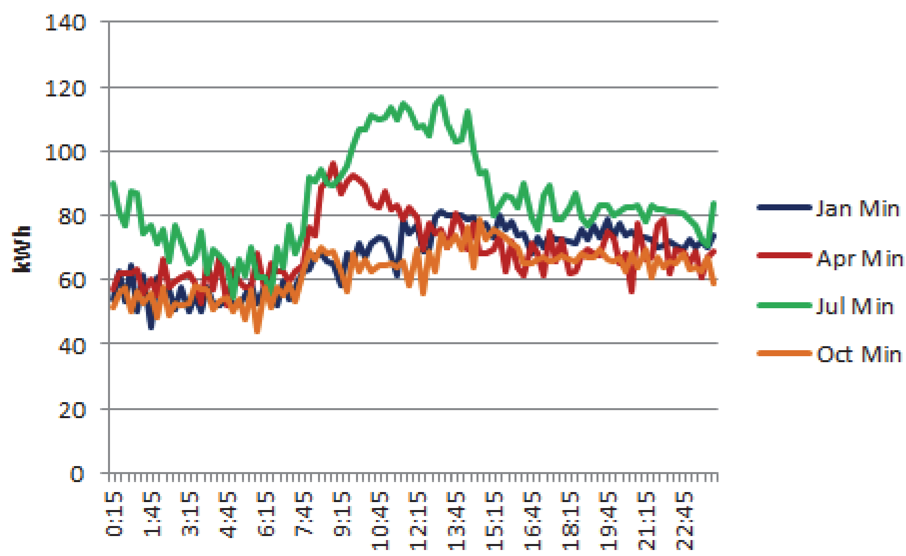

Figure 20: 2011 WWTF Daily Min Consumption

Nantucket Airport

For the G3 Nantucket Airport account, we were able to obtain interval data between September 2010 and Nov 2011. We analyzed this data by looking at both average daily electricity usage as well as comparing seasonal usage.

The green line shown below represents the peak consumption day for the entire data range available (September 2010 to October 2011) which occurred on December 20. Since this is close to Christmas time, there could be large flow of people through the airport. This would account for an increase in consumption. Also it tends to get darker outside earlier in the winter as this would require more electricity for lighting. There tends to be a slight peak in the morning followed by a steady use throughout the day. Peaks could represent high flow of planes through the airport although this remains to be verified.

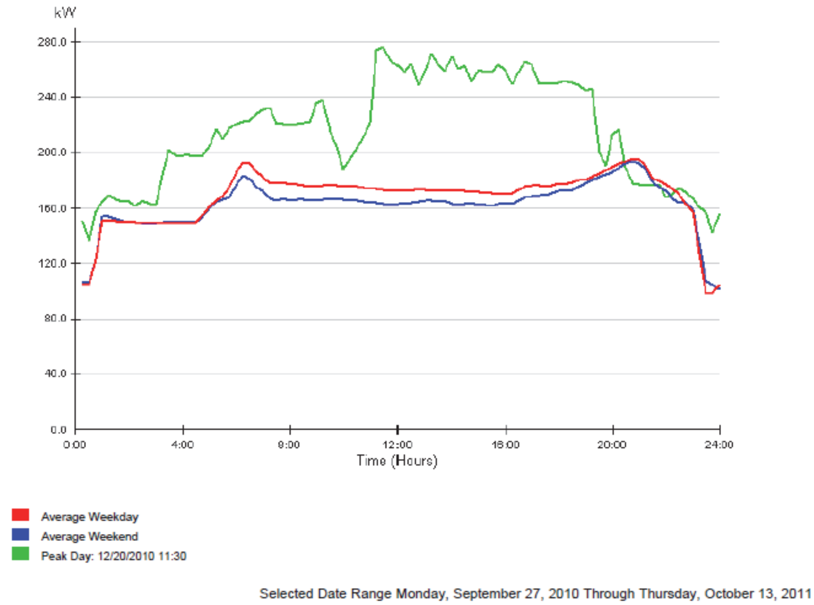

Figure 21: September 2010 to October 2011 Airport Profile

Yearly usage for the Nantucket Airport shows an increase during the summer and winter months, with a slight decrease during the fall and spring. Figure 22 shows just over a year of consumption. There is a sinusoidal pattern with the peaks in the winter and summer. During January usage hovers between 180 and 220 kW. During early June before the summer crowds start consumption drops below 150 kW.

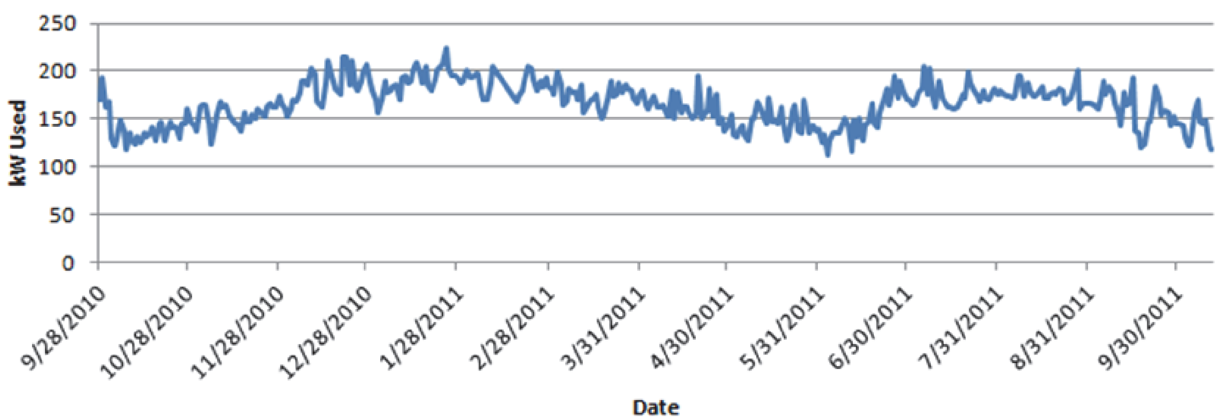

Figure 22: September 2010 to October 2011 Airport Consumption

Nantucket High School

For the G2 Nantucket High School account, we were able to obtain 8 years of 15-minute interval data between the years of 2002 and 2010. We analyzed these data by looking at both average daily electricity usage as well as comparing seasonal usage.

The average electricity use for a typical weekday follows the same pattern for all 8 years of data. In the early hours of the morning between 12AM and 5AM the school remains at a constant 125 kW. Between the hours of 6AM and 8AM, when the school begins its operation, electricity quickly rises to a peak of just over 325 kW. As seen in Figure 23, the school stays at a steady 325 kW throughout the day when the students are in session. After 4PM we begin to see a slow drop in use until it reaches its 125 kW low for the night. The green line represents the peak day which occurred on January 17. This could be due to a special event that occurred that day or there could have been an increase in electricity for heating.

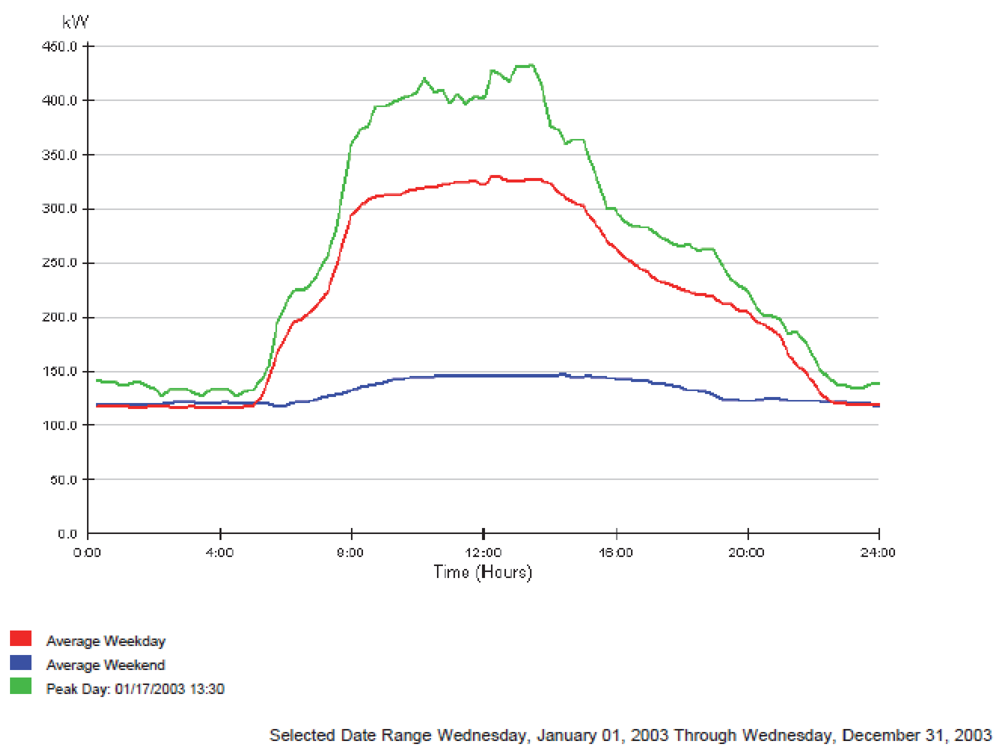

Figure 23: 2003 High School Profile

As one would expect for a school, the average weekend use data is almost a flat line hovering around the 125 kW mark. With minimal to no occupancy during the weekend, it would be strange to see any kind of peak usage during this time. This shows that for all the hours of the day on the weekend, the building maintains an electricity use similar to that of a weekday night. The curve seen in Figure 23 for 2003 is very similar to the curves of all other yearly data plots. Changes only begin to appear in the later years of 2009 and 2010. A slight rise in the power consumed overnight can be seen in Figure 24. Instead of the 125 kW average, we see an increase to about 140 kW. This increase in consumption is met with a decrease in the peak usage during the day. Between 8AM and 4PM the peak reaches about 30 kW less than previous years. Without more detailed investigation we cannot explain these recent trends. They might be related to weather differences, changes in equipment (e.g., additional computers left on overnight), or changes in energy management (e.g., thermostat settings, light controls, etc.).

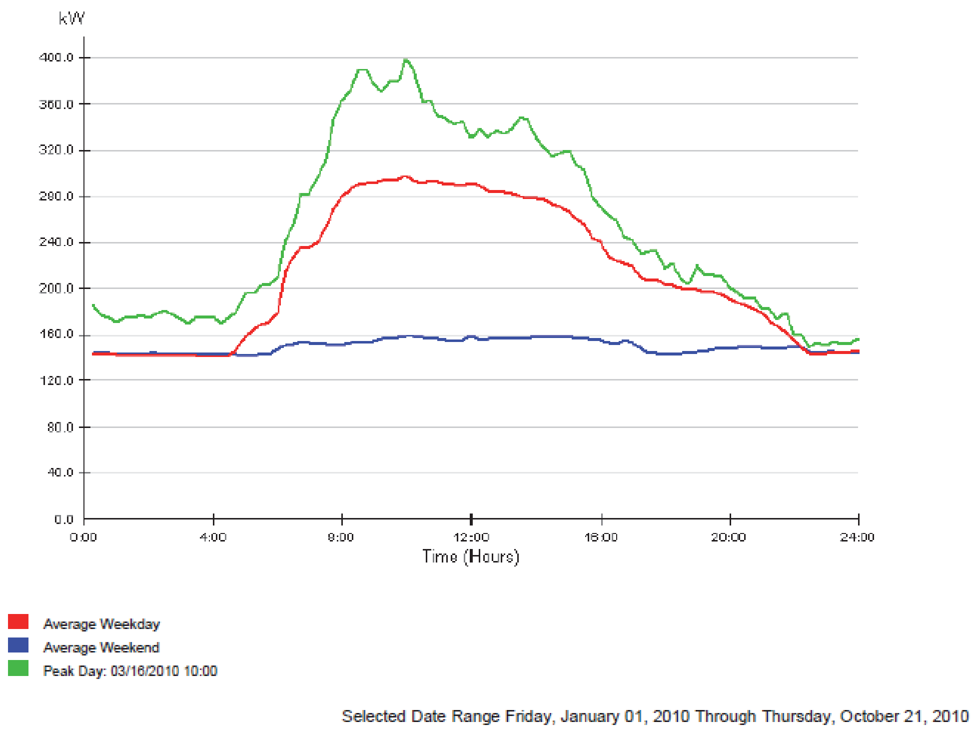

Figure 24: 2010 High School Profile

In addition to looking at the average daily usage, we also looked at the average usage during the different seasons. As our comparisons we chose the months January, April, July, and October to represent the four seasons. For nearly all years, the months of January, April, and October are almost identical to the yearly average with just one exception. The nighttime average for the months of January and April show a 20 kW increase compared to the yearly average. The month that stands out most is July. Figure 25 shows the average use for the month of July in 2009. Since this is a high school, it can be expect that there would be a decrease in electricity usage during the summer months. However the same curve, increase at 8AM and decrease around 4PM, can be seen occurring during the month of July. The kW used are not as high as the yearly average, using between 200 kW and 220 kW during the day, but since the curve is still the same shape, there must still be activities throughout the day.

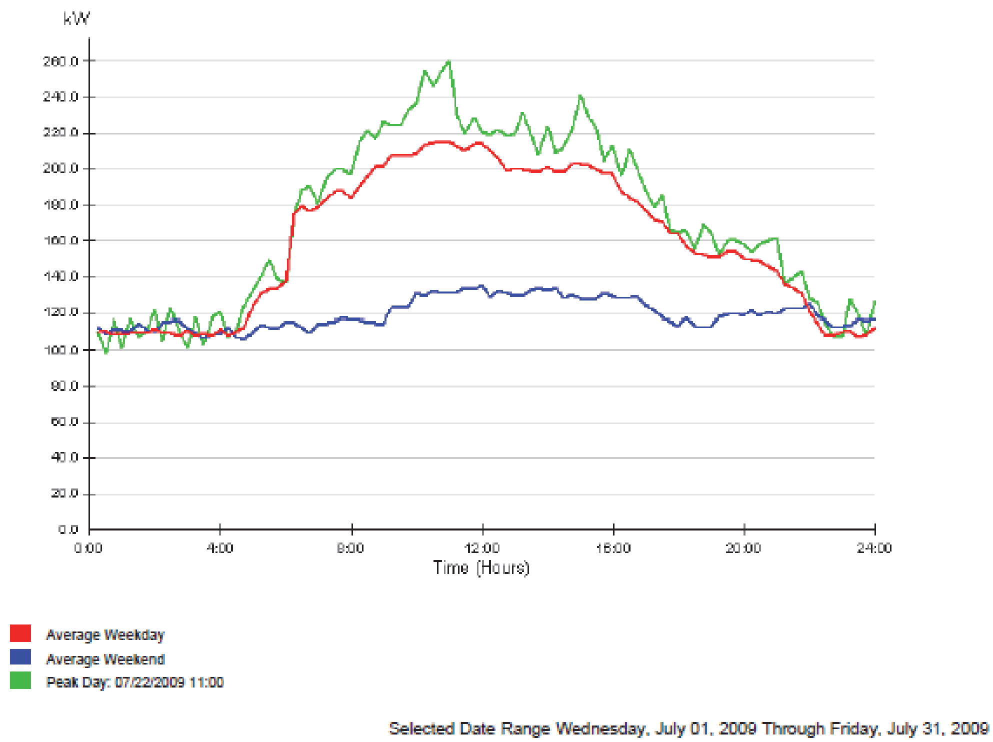

Figure 25: July 2009 High School Profile

Elementary School

For the G2 Elementary school account we had data for the period from January 2002 through October 2011. We analyzed these data by looking at both average daily electricity usage as well as comparing seasonal usage.

The daily profile for the Elementary school depicts a similar general trend to the High school. An expected hump appears on the load starting at the beginning of the school day. This spike in usage continues until it reaches a plateau typically around 100 kW. It then falls back to a baseline level at the end of the day. The average weekend profile follows an expected pattern. Consumption stays at a baseline level during the weekend. It’s actually curious that the consumption even seems to deep lower than the baseline reading.

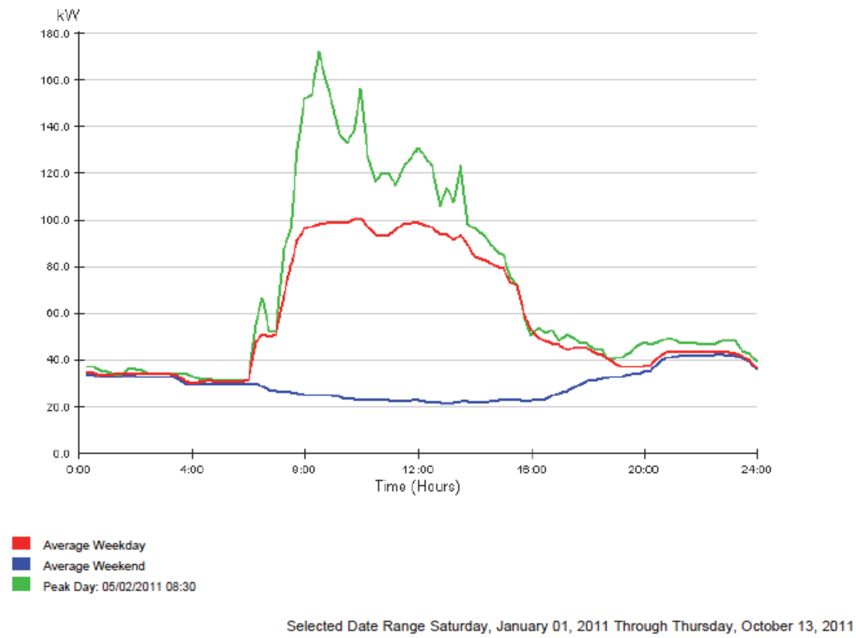

Figure 26: 2011 Elementary School Profile

The Elementary school experiences a significant variation in consumption season to season. This general profile is fairly predictable. January experiences high consumption rates, and accounted for the peak load in 2011 (Figure 27). Average peaks for January 2011 were around 125 kW. Colder, winter months account for high usage at this facility because school is in session and a fair portion of electricity use is devoted to heating.

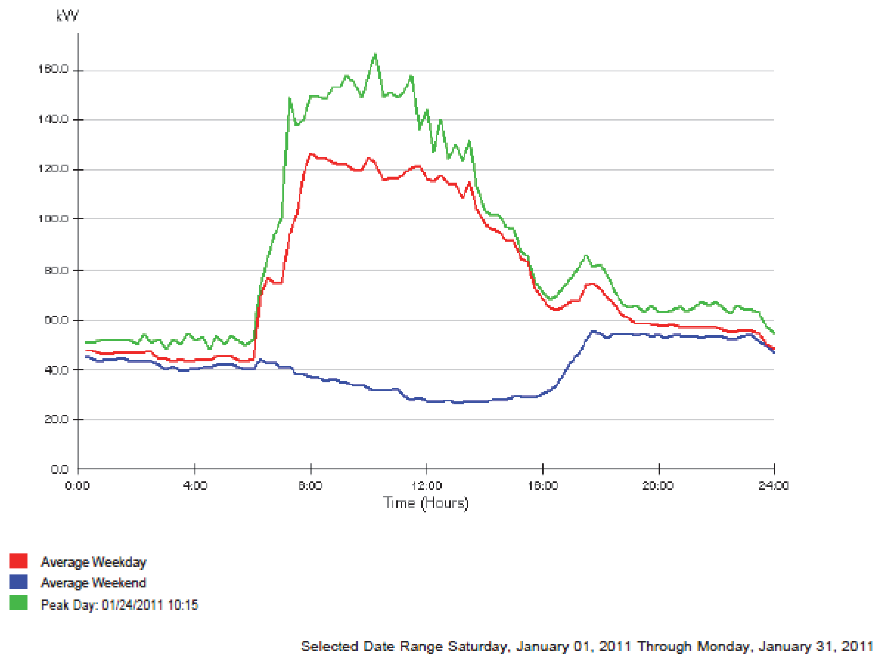

Figure 27: January 2011 Elementary School Profile

April experiences the next significant drop in consumption. This can be attributed to a reduction in heating. School is still in session so the facility uses around 100 kW. The diurnal pattern is still the same as it is in January.

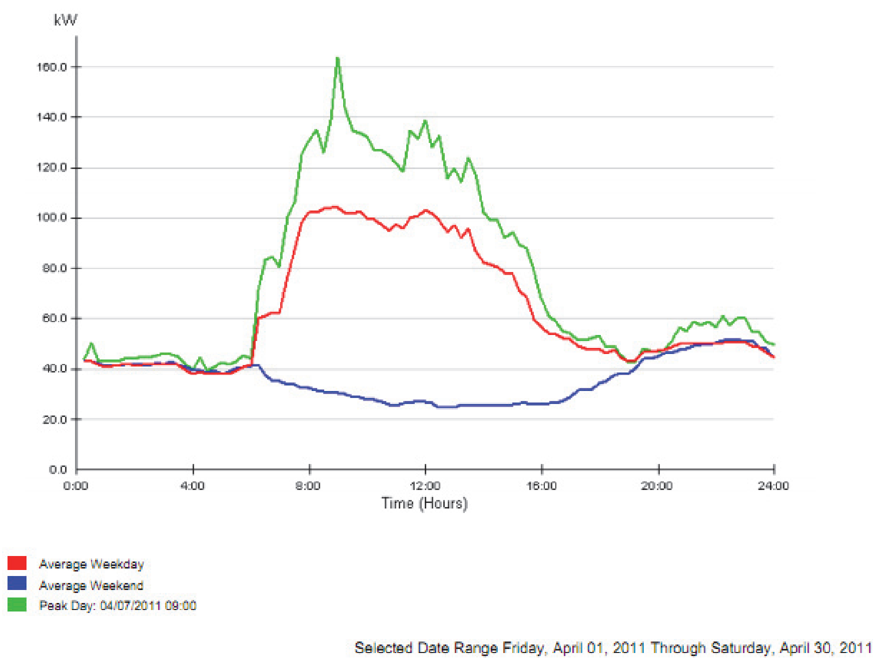

Figure 28: April 2011 Elementary School Profile

Unlike other accounts, July actually enjoys the lowest power loads of the year. School is no longer in session so even the peak day consumption is still less than 75 kW. There is still a similar diurnal pattern, even though most students are not in session. This could be attributed to summer classes, janitorial services, or any events that the school puts on.

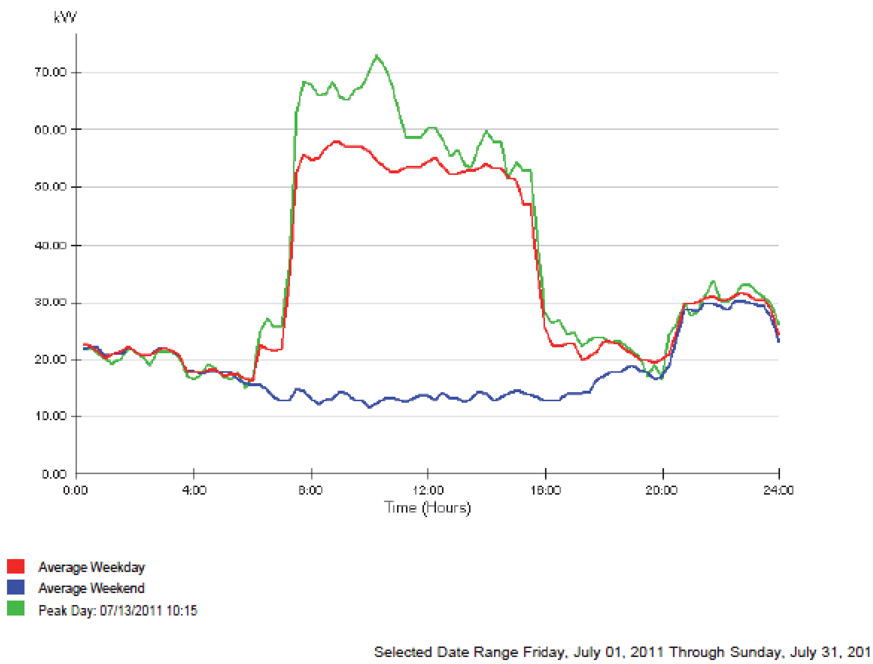

Figure 29: July 2011 Elementary School Profile

October shows similar characteristics to April. School is in session but heating is not yet needed. Figure 30 below shows consumption for 2010. There is a clear decrease right around March when springtime weather is starting to take effect. Right around the end of June or early July there is a large decrease in usage. This coincides with the end of the school year. At the end of August consumption rises again with the beginning of the new school year. Consumption increases as the weather gets colder due to an increase need for heat and light.

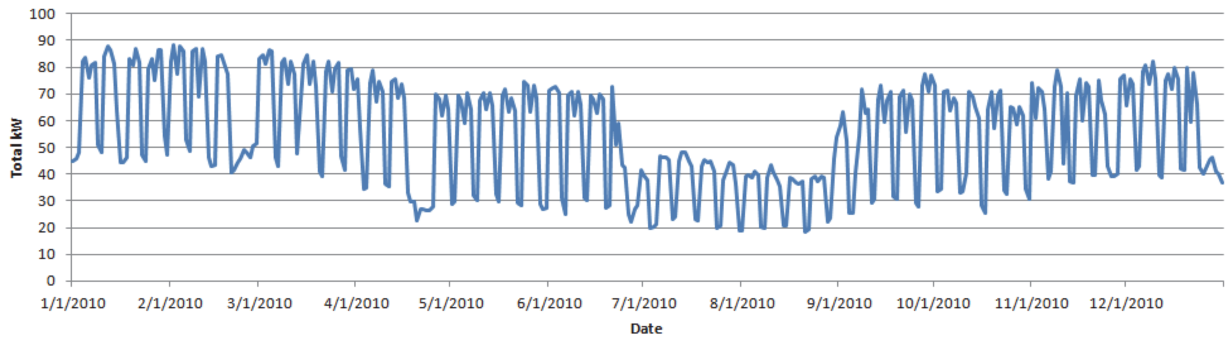

Figure 30: 2010 Elementary School Consumption

Figure 30 clearly illustrates that summer consumption is much higher than any of the other seasons. The most logical explanation of this is the flow of summer vacationers. This tends to raise consumption levels at the Airport and WWTP. More people are flying on and off of the island and since there is such an increase in population the WWTP is working much harder to keep up. However, the Solid Waste Treatment Facility doesn't follow this pattern. Winter consumption is actually higher than summer consumption. This raise cannot be attributed to population, and must be related to the operation of the composter. Both schools show the diurnal and seasonal patterns that would be expected. Throughout the year there is an increase in consumption during normal school hours however total consumption levels peak during the winter months.

Generalizations of Audit Findings and Recommendations

We conducted energy audits on five small businesses, including one retail store, one office, one restaurant, and two inns (Table 2 shows the dates of the audits, the annual consumption of electricity, and the savings to be gained (in energy and dollars) based on the conservation strategies we recommend and discuss later in this section).

Business	Date of Audit	Annual Electricity Consumption	Total Savings	Total Savings
Establishment 1 (Retail)	10/21/2011	24759 kWh	2000-6200 kWh	$90-$1,100
Establishment 2 (Bar)	11/7/2011	87828 kWh	2800-9100 kWh	$500-$1,600
Establishment 3 (Office)	11/11/2011	55054 kWh	3-134.83 kW	$80-$2,500
Establishment 4 (Inn 1)	11/15/2011	35378 kWh	2000-6800 kWh	$90-$2000
Establishment 5 (Inn 2)	11/30/2011	43572 kWh	850-8800 kWh	$150-$1500

Table 2: Businesses Audited

The businesses showed unique annual consumption by sector. Every business type showed an increase during the summer months. The bar used the most electricity, which is most likely due to refrigeration. The inns showed the next highest consumption due to the large influx of patrons in the summer months. Inn 2 shuts down during a portion of the year when there are few visitors which is clearly defined on the graph. The retail establishment shows the lowest energy use overall, but a similar seasonal profile.

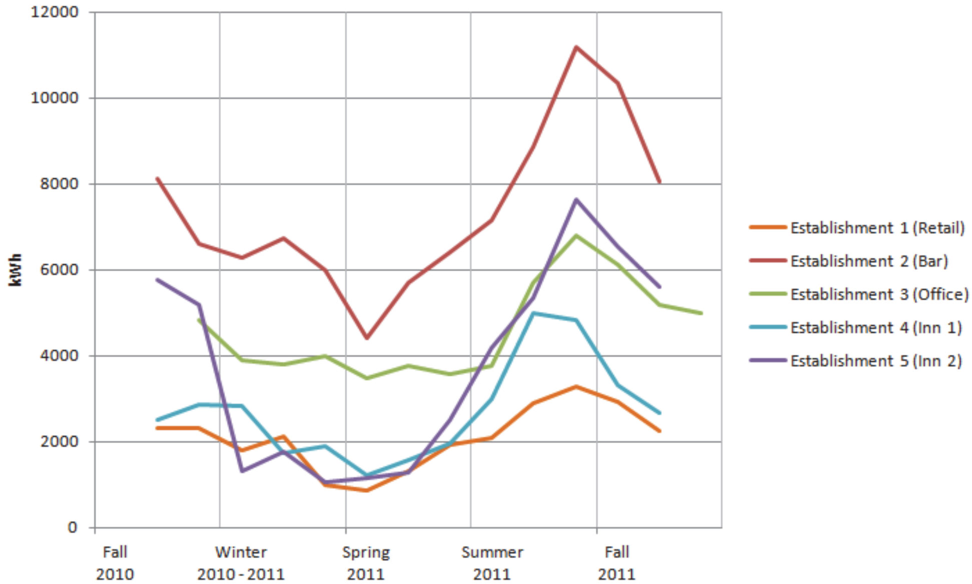

Figure 31: Audited Business Annual Consumption

Figure 32 shows that there is tremendous variation in the end-use of electricity in the different commercial establishments in the sample of businesses we audited. Only Inn 1 is closely comparable with the pattern that is typical in the commercial sector of the US. If these sample establishments are representative of other establishments on the island, the graph has some very powerful messages about potential energy saving measures that might be adopted. Evidently, lighting and electronics are the major consumers in the retail store, so energy saving should focus on these end uses. By contrast, electronics are by far the largest consumer of electricity in the office. The bar is atypical in that refrigeration is a major use of electricity and this inflates the category of 'other' end uses. Inn 2 had engaged in substantial upgrades to some electrical equipment already, so lighting usage was lower than Inn 1. Inn 2 also had substantially more electronic devices (TVs, etc.) in guest rooms, which accounts for the increase in the fraction of electricity used by electronics.

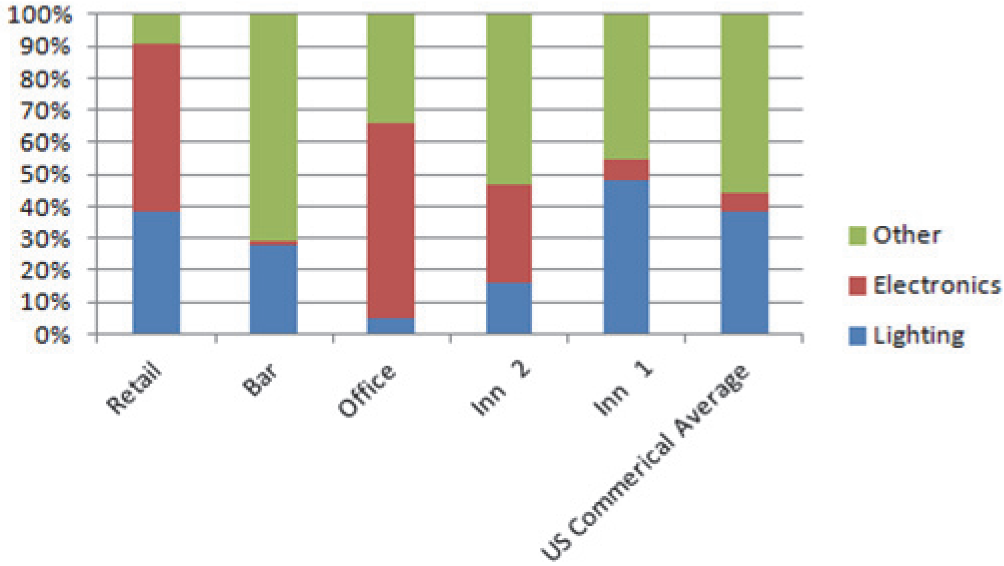

Figure 32: End Use Audited Business Consumption

Based on our assessments of current uses, we made a set of recommendations as to how each establishment might reduce its energy usage. Lighting recommendations account for a large portion of the total savings. Table 3 shown below details all of the lighting recommendations for the five businesses audited. These fell into three major categories: Compact Fluorescent Lighting, LED Lighting and lighting control systems. Behavioral changes are considered as lighting control systems.

For the retail establishment, the first recommendation was to upgrade to newer, more energy efficient bulbs. They were already using CFL bulbs throughout the building so the only step up was LED bulbs. LED bulbs would result in a large savings per year of $1100, but would require a large initial investment (see Table 3). The second path we took was behavioral change with or without technological assistance. In general, a reduction of lighting usage would save $500 a year. Through the use of technology such as motion sensors, a savings of $351 a year could be reached.

Unlike the retail store, much of the lighting of the bar was energy inefficient incandescent bulbs that can be upgraded. Upgrading all incandescent bulbs to CFLs would save $1100 per year. Many of the other lighting recommendations are the same for the retail store as well. Decreasing lighting usage through behavioral changes such as remembering to turn off the lights when leaving a room can save $500 a year. We looked into motion sensors for the bar as well and found several rooms that would benefit from the installation of such devices. This would cut lighting usage by a good amount and save $750 per year. LED bulbs are another route to take, however the payback period is large compared to the period of all other recommendations.

The office building also had the potential to upgrade the bulbs to either CFL or LED bulbs that can end up saving $1000 or $1500 respectively. However we see that once again LED bulbs come with a very large initial investment of over $9000.

Both inns showed potential for significant savings in lighting consumption. Inn 1 could save $500 per year by just reducing usage through behavioral changes. A decrease in lighting even in the off season would help reduce some of the cost impact during tourist seasons. Inn 2 showed a potential to upgrade to CFL bulbs. This could save $1,500 per year. The inns were lit primarily by lamps in each room, which would need a simple switch to CFLs to greatly reduce consumption and costs.

Business Type	Recommendation	$ Savings Per Year	kWh Savings Per Year	Payback Period
Retail	Behavioral Changes with Lighting Usage	$502.55	2839.258 kWh	Immediate
	Occupancy Sensors	$351.24	1984.416 kWh	3 Months
	Upgrade to LED	$1099.20	6210.144 kWh	6.06 Years
Office	Upgrade to CFL	$1044.28	5801.28 kWh	3 Months
	Upgrade to LED	$1571.84	8732.16 kWh	5.8 Years
Inn 1	Lighting Control System	$351.24	1984.416kWh	0.38 Years
	Behavioral Changes	$502.55	2839.258	Immediate
	Upgrade to LED	$1099.20	6210.144	6.06 Years

Inn 2	Occupancy Sensors	$148.75	850.5 kWh	5.6 Years
	Upgrade to CFL	$1545.26	8835.54 kWh	3 Months

Table 3: Audited Business Lighting Recommendations

Electronics also accounted for a decent portion of end use (Table 4). This didn't apply much to the bar, however there are still recommendations for the bar in this area. One piece of electronic equipment that appeared notorious for sucking down power was battery backup systems. These are usually a gateway between computers and outlets and supply around 30 minutes of power in case the electricity goes out unexpectedly. This is great technology if the computer is in use, however if whatever is connected to the backup is not in use then it should be unplugged.

The retail store showed a fair amount of potential electronics savings. Computer equipment being left on overnight created an area of large savings. By properly turning off all computer systems and back up batteries, the store could see a savings of $1000 per year. As compared to the retail store, the bar had much less computers and electronics. There were no electronics recommendations for this establishment. The office space shares similar recommendations as compared to the retail store. The office contains over 15 computer stations and several sever computers consuming a large piece of the overall usage. The biggest saving recommendation is to better manage the amount of time these devices are turned on. Once again many of the computer stations have battery backup systems that consume electricity 24/7. Managing both these backups and making sure each computer station is turned off will result in a $2587 per year savings.

Inn 1 had a lot of electronics that could be hooked up to a power strip and turned off when not in use. These were mostly in common areas and in the office. In inn 2, each room had a television that draws 4W when turned off. This accounts for a fair amount of phantom load to be eliminated. The savings can be seen below.

Business Type	Recommendation	$ Savings Per Year	kWh Savings Per Year	Payback Period
Retail	Connect all Cash Register Equipment to a Power Strip	$1005.25	5679.36 kWh	0.5 – 1.5 months
Office	Electronics Power Management	$2,587.20	20908.8 kWh	0 – 3 months
Inn 1	Connect all Electronics to a Power Strip	$1005.25	5679.36 kWh	0.5 - 1.5 months
Inn 2	Unplug All TVs When Not in Use	$31.44	174.72 kWh	Immediate

Table 4: Audited Business Electronic Recommendations

Each location had the potential for savings recommendations in other areas. These areas depend on the type of business, however heating and cooling recommendations are also included in this section. Table 5 below shows other recommendations that may or may not be applicable to other business sectors. The heating for the retail building is supplied by an oil-fueled furnace which had the potential to be controlled more strictly. The installation of a programmable thermostat could save up to 12% off the oil bill which resulted in about $90 a year. In the bar, refrigeration accounts for a large portion of their electricity bill. For refrigeration, we were able to suggest energy efficient practices to ensure things such as walk in coolers are not consuming as much electricity, however no savings calculations were done. The office already had a programmable thermostat installed, which can lead to a fair amount of electricity savings. One recommendation for the office was better use of the thermostat. The audit was conducted on a holiday when the building was empty yet the thermostat was set to 82^{o}F. This is way above normal room temperatures. Better use of the thermostat would lead to a wide range of savings depending on how many degrees the temperature is changed. The owner of the retail store also asked our group to look into the installation of solar panels on his roof. There is great potential for savings if he were to pursue this option, as there are multiple incentives programs available. This would also cover about 25% of his bill depending on available roof space.

Business Type	Recommendation	$ Savings Per Year	kWh Savings Per Year	Payback Period
Retail	Installation of a Programmable Thermostat	$89.40	N/A	7 Months
Office	Behavioral Changes with Temperature Control	N/A	N/A	N/A
Retail	Solar Power Installation	$1999	6770 kWh	~5 Years with Incentive Programs
Inn 2	Instillation of a Programmable Thermostat	$89.40	N/A	0.55 Years

Table 5: Audited Business Heating and Cooling Recommendations

Overall there were many cost effective conservations techniques that can be applied to the businesses we audited. Moving forward with such conservation techniques creates a potential for a large amount of savings. Lighting is a key aspect for most businesses and is often an easy area for conservation. Techniques can range from upgrading the bulb type to CFLs or LEDs to decreasing overall usage. Overall decreasing of usage can be done by simple habitual changes or with assistance from technology such as occupancy sensors. Electronics also accounted for a large portion of consumption. This usage could be reduced easily by just turning off and unplugging electronics when not in use. Heating and cooling costs can be reduced by using a programmable thermostat to regulate the temperature of a building when it is unoccupied. We were able to find multiple conservation recommendations for the five businesses audited. Many of these recommendations are applicable to the residential sector as well as in other areas of the commercial sector.

Conclusions and Recommendations

The ESC is exploring many options to address the energy issues on the island from conservation to the use of renewable energy sources to the implementation of new technologies, such as smart grids. In order to make informed decisions about possible energy strategies, the ESC needs to have a clear picture of the current patterns and trends in energy use on the Island. One of the objectives of this project was to use NG interval data to help the ESC flesh out this picture.

There is growing concern about the rising cost and consumption of energy in the US. In Nantucket, the cost and growing consumption of energy is a special concern because it depends on two submarine cables for all its electrical power and pays some of the highest rates per kW in the country. Before Nantucket can make any significant progress towards addressing this issue, it first needs to understand just how energy is used on the island. By analyzing interval data from National Grid, we were able to identify the patterns of energy use for the Solid Waste Treatment Facility, Waste Water Treatment Unit, Airport, Nantucket High School, and the Nantucket Elementary School. This analysis is able to visually demonstrate the general increase in consumption over the summer.

Our analysis confirm what the ESC knew in that there is a tremendous seasonal variation in energy consumption on the Island, but the interval data also reveal details that were previously unknown. For example, the Solid Waste Treatment Facility waste management operations consume more electricity in the winter even though more trash is generated in the summer. This is because the facility needs to be heated and ventilated during the winter months. These kinds of patterns may reveal opportunities for future energy saving options, directly or indirectly

The Waste Water Treatment Unit followed a similar pattern to that of Nantucket's overall consumption. During the summer months there was a clear increase due to the tourist crowds and an especially high spike surrounding the July 4th weekend. Spikes like these in addition to an overall increase in consumption for the whole island that could lead to the instillation of a third cable.

In addition to the National Grid data, we collected a wealth of information about the electricity consumption of a small number of commercial enterprises on the island. These energy audits revealed that there is substantial variation among small businesses in terms of the end uses of electricity. Identifying the end use for the electricity reveals opportunities for energy savings. Thus, we were able to identify a number of relatively inexpensive strategies that could save businesses substantial amounts of energy (and thus money). In particular, these included the installation of compact fluorescent bulbs, motion sensitive light controls, and power strips with timers to reduce the amount of energy consumed by lighting and electronic devices. Businesses that engage in energy conservation can serve as exemplars to others in the business community and may even encourage greater adoption of energy conservation measures in the residential sector.

Based on these conclusions we were able to develop the following five recommendations for the town and for the NESC. Firstly, we recommend that data and graphs gathered from National Grid be used to make more informed decisions on future energy conservation projects. This data can be used emphasize the rising electricity consumption of the municipal facilities on the island. More specifically, the Solid Waste Facility data can support the argument for the installation of a wind turbine at that location. The consumption at the Solid Waste Facility sees an increase during the winter months when the suggested wind turbine would be generating the most electricity. Most of the other municipal facilities show a large upwards trend during the summer months corresponding with the large tourism crowds. Spikes in consumption during these months are the primary factor that would lead to the installation of a third cable.

Secondly we recommend that the NESC continue to promote energy conservation among all residents and businesses on Nantucket. Making sure the public is informed and kept up to date on conservation technique that could not only electricity, but also save money off their electricity bills. One possible program to promote is the Mass Save energy audits. Mass Save offers free energy audits for residential homes and identifies measures the homeowner can take to reduce energy consumption. The NESC should also pool together as many willing participants as possible in order to give the Mass Save program more incentive to come to the island and perform the audits.

Next we recommend that the NESC continue tracking their efforts in energy conservation by continuous analysis of National Grid data. Migration reports available on the Mass.gov website can be used to see electricity consumption data for the residential and commercial sectors of Nantucket. Ensuring that these values are decrease can ensure conservation techniques are working. Continued analysis of National Grid interval data is suggested to see the effects of conservation of those facilities.

In order to promote easy and low cost conservation techniques, we recommend the NESC focus on promoting conservation in the lighting and electronics areas of homes and businesses. From our audit findings we saw that these two sections made up a large amount of consumption in most of the buildings. Techniques in these two areas are relatively simple for the average person to implement and technology such as CFL bulbs have a low investment cost. CFL bulbs consume 70% less electricity than incandescent and output the same amount of light. In the electronics section, we found that turning off computers and computer accessories overnight can have a drastic amount of savings.

To promote these conservation techniques, we recommend that the NESC explain the amount of money that can be saved to the public either through newspaper articles or through the ackEnergy website. The NESC could encourage businesses that promote these technique publicly announce it so that can act as an example for others on the island. Getting the information to the public and showing them the amount of savings that could happen are the first steps in promoting conservation across Nantucket.

In order to keep up to date with conservation methods, we recommend the NESC keep an eye on future technologies that have a potential of saving electricity. LED bulb pricing is on a downwards trend and may soon become more viable for residents and business to install in their buildings. Another future technology that can save on electricity costs is cloud computing. Using cloud computing could eliminate the need for businesses to have a server computer running 24/7. These servers can be a huge consumer of electricity. Further research into cloud computing would be needed in order to ensure it will meet the businesses' specifications.

The NESC is currently exploring many different options to help address rising consumption. It is currently trying to push both a wind turbine project at the Solid Waste Treatment Facility and a solar array at the Airport. We hope that the information provided in this report will help the committee be more informed in terms of researching energy conservation techniques to implement in conjunction with the renewable energy sources. Many of the conservation recommendations we provided to small businesses can be applied to a large variety of commercial and residential sectors. If residents of the island would take advantage of these techniques they would not only reduce island wide consumption allowing the island to thrive without a third cable, but lower their electricity costs drastically. Lastly, the committee also is looking towards the future by considering new technologies such as implementing a smart grid on Nantucket. We hope that our efforts will help towards a brighter and more energy friendly Nantucket.

Bibliography

"About the Carbon Trust." Carbontrust.co.uk. Web. 14 Oct. 2011. <http://www.carbontrust.co.uk/about-carbon-trust/pages/default.aspx>.

Average temperatures for Nantucket. (n.d.). Retrieved from http://www.weather.com/weather/wxclimatology/monthly/USMA0271

Beliveau, A., Hesler, M., Jaskolka, S., & Sigety, C. (2010). Feasibility of a Smart Grid on Nantucket. Retrieved from http://www.wpi.edu/Pubs/E-project/Available/E-project-121610-132737/unrestricted/Feasibility_of_a_Smart_Grid_on_Nantucket.pdf

Brown, H (2005). Lighting audit can lead to big energy savings. Real estate Weekly http://www.thefreelibrary.com/Lighting+audit+can+lead+to+big+energy+savings-a0130053346

Buildings energy data book. (n.d.). Retrieved from http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx

Carter, J. (April 18, 1977). Proposed Energy Policy. Retrieved from http://www.pbs.org/wgbh/americanexperience/features/primary-resources/carter-energy/

Center for Climate and Energy Solutions. (2009). Electricity Emissions in the United States. Retrieved from http://www.pewclimate.org/technology/overview/electricity

DoE Energy Efficiency and Renewable Energy. (2008). Energy Efficiency Trends in Residential and Commercial Buildings. Retrieved from http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/bt_stateindustry.pdf

DoE Energy Efficiency and Renewable Energy. (2010). Buildings Energy Data Book. Retrieved from http://buildingsdatabook.eren.doe.gov/

DoE Energy Efficiency and Renewable Energy. (2011). Energy Savers: Thermostats and Control Systems. Retrieved from http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12720

DoE Energy Efficiency and Renewable Energy. (2011). Energy Savers: When to Turn Off Personal Computers. Retrieved from http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10070

DoE Energy Efficiency and Renewable Energy. (2011). Energy Savers: When to Turn Off Your Lights. Retrieved from http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=12280

DoE Energy Efficiency and Renewable Energy. (2010). Federal Energy Management Program: Federal Sustainable Building Case Studies. Retrieved from http://www1.eere.energy.gov/femp/program/sustainable_casestudies.html

Energy Information Administration. (2011). *How old are U.S. power plants?*. Retrieved September 14, 2011, from http://205.254.135.24/energy_in_brief/age_of_elec_gen.cfm

"ENERGY STAR Qualified Products : ENERGY STAR." *Energystar.gov*. Web. 15 Sept. 2011. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup

Energy Star. (2009). Lighting Strategies. Retrieved from http://www.energystar.gov/ia/business/networking/presentations_2009/Aug09_LightingStrategies.pdf

Energy Star. (2010). History of Energy Star. Retrieved from http://www.energystar.gov/index.cfm?c=about.ab_history

Energy Star. (2010). How a Product Earns the ENERGY STAR Label. Retrieved from http://www.energystar.gov/index.cfm?c=products.pr_how_earn

Energy Star. (2010). Learn About CFLs. Retrieved from http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_about

Environment for Living. (2011). Building Solutions for Better Homes and Better Living. Retrieved from http://www.environmentsforliving.com/

"Environments For Living - Program Features." Environmentsforliving.com. Web. 14 Oct. 2011. <http://www.environmentsforliving.com/EFLPublicSite/index.jsp?action=hb_pgm_features>.

Executive Office of Energy and Environmental Affairs. (2011). Electric Customer Migration Data. Retrieved from http://www.mass.gov/eea/energy-utilities-clean-tech/electric-power/electric-market-info/electric-customer-migration-data.html

"Flex Your Power - Residential Energy Saving Tips." *California Energy Efficiency and Conservation*. Web. 15 Sept. 2011. <http://www.fypower.org/res/tools/energy_tips.html>.

Flex Your Power. (2011). Saving Energy, It's a Way of Life. Retrieved from http://www.fypower.org/index.html

GDS Associates. (2008, Jan 08).Connecticut electric conservation programs study. Retrieved from http://www.ctsavesenergy.org/files/Draft Study of CT C&LM Programs 1-8-08.pdf

Historical perspectives of energy consumption. (n.d.). Retrieved from http://www.wou.edu/las/physci/GS361/electricity generation/HistoricalPerspectives.htm

History of energy star. (n.d.). Retrieved from http://www.energystar.gov/index.cfm?c=about.ab_history

How energy star works. (n.d.). Retrieved from http://home.howstuffworks.com/home-improvement/construction/green/energy-star1.htm

HowStuffWorks.com. (2000) *Which appliances use the most power?*. Retrieved Septermber 24, 2011, from http://tlc.howstuffworks.com/home/question272.htm

Jayamaha, L. (2007). Energy-efficient building systems. United States: The McGraw-Hill Companies.

"Learn About CFLs : ENERGY STAR." *Energystar.gov*. Web. 15 Sept. 2011. <http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_about>.

"Lux Meter Helping You Identify Energy Savings." *ResourceSmart*. Sustainability Victoria, Apr. 2010. Web. 25 Sept. 2011. <http://www.resourcesmart.vic.gov.au/documents/lux_meter.pdf >.

Mass save energy efficiency case study brought to you by cape air. (n.d.). Retrieved from http://www.masssave.com/business/building-or-equipment-upgrades/get-the-facts/ci-resources/~/media/Files/Business/Information and Edu Docs/CICaseStudiesCapeAirFINAL.ashx

Melikidze, K. (2010). Energy audit manual. Tbilisi, Georgia: NEW APPLIED TECHNOLOGY, EFFICIENCY AND LIGHTING IMITATIVE.

National Grid. (2011). Demand (G-2). Retrieved from http://www.nationalgridus.com/masselectric/business/rates/4_g2.asp

North American Electric Reliability Corporation (NERC). (2010). Regional and national peak demand and energy forecast bandwidths.Retrieved October 10, 2011, from http://www.nerc.com/docs/pc/lfwg/2010-2019%20NERC%20Regional%20Bandwidth%20Report.pdf

Nuclear Energy Institute. (2011). *U.S. needs new nuclear plants to meet energy demand, maintain supply diversity.* Retrieved September 14, 2011, from http://www.nei.org/resourcesandstats/documentlibrary/newplants/policybrief/usneedsnewplants/

Patrick, D. , Fardo, S. , Richardson, R. , & Patrick, S. (2006). Energy conservation guidebook. (2 ed.). Lilburn, GA: The Fairmont Press.

Philips lighting company business case study. (2007). Retrieved from http://www.fypower.org/pdf/CS_Biz_Philips.pdf

Sitarz, D. (2008). Greening your business: the hands-on guide to creating a successful and sustainable business. Earth Press. Thom Patterson, C. (2010).

Swartz, S & Oster, S. (2010). China Tops U.S. in Energy Use. Retrieved from http://online.wsj.com/article/SB10001424052748703720504575376712353150310.html

"The Lowry Hotel - Case Study." Carbontrust.co.uk. Web. 14 Oct. 2011. <http://www.carbontrust.co.uk/about-carbon-trust/case-studies/carbon-advice/pages/lowry-hotel.aspx>.

The World Bank Group. (2008). [Graph illustrates the average electricity consumption per capita over the last 50 years]. Electric power consumption (kWh per capita) | Graph. Retrieved from http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC/countries/US?display=graph

Town & County of Nantucket Massachusetts. (2011). *Nantucket energy study committee.* Retrieved September 14, 2011, from http://www.nantucket-ma.gov/Pages/NantucketMA_Planning/energycomm

U.S. EIA. (Nov 2011). [Graph illustrated average U.S. electricity price per kW]. Short-Term Energy Outlook. Retrieved from http://38.96.246.204/forecasts/steo/report/electricity.cfm

U.S. electricity blackouts skyrocketing. Retrieved September 14, 2011, from http://www.cnn.com/2010/TECH/innovation/08/09/smart.grid/index.html

U.S. Green Building Council. (2011). LEED for Homes Certified Projects. Retrieved from http://www.usgbc.org/ShowFile.aspx?DocumentID=2683

US Department of Energy. (2008). *The Smart Grid: An Introduction*. Retrieved September 24, 2011 from U.S. Department of Energy: http://www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages(1).pdf

Weather Channel (2011). Nantucket Weather. Retrieved from http://www.weather.com/weather/today/Nantucket+MA+USMA0271

"Why Choose ENERGY STAR LED Lighting? : ENERGY STAR." Energystar.gov. Web. 14 Oct. 2011. <http://www.energystar.gov/index.cfm?c=ssl.pr_why_es_com>.

Willis, H. L., Welch, G. V., & Schrieber, R. R. (2001). *Aging power delivery infrastructures*. New York: M. Dekker.

Zhang, J. (2010, Sept). Technical support document: 50% energy savings for quick-service restaurants. Retrieved from http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19809.pdf

Appendix A: Carbon Trust Checklist for Office Buildings

Walk around checklist CTL048

Business Activities (office based) walk around checklist

Use this walk around checklist to help identify key low or no cost energy saving opportunities within your organisation. Conducting regular housekeeping walk arounds will help form the basis of an action plan to reduce your energy use and carbon footprint.

This checklist should be read in conjunction with the Business Activities Sector Overview (CTV007), downloadable from the website, which provides further detail on most of the topics outlined below.

Heating, ventilation and air conditioning (HVAC)	Complete	Actions/comments
Check that radiators and other heating surfaces are unobstructed.		
Are windows and doors closed where possible when heating or air conditioning is operating?		
Check thermostat settings. The recommended temperature for an office is 19°C. A 1°C drop in average space temperature can cut fuel consumption by about 8%.		
Check thermostatic radiator valve (TRV) settings on radiators. Comfortable temperatures of 19°C are usually maintained when TRVs are set to '3'. If the valve is kept at '5' or 'max', there is no control over the amount of heat emitted from the radiator.		
Undertake regular checks on air conditioning control settings. Air conditioning should not be switched on until temperatures reach 24°C.		
Ensure HVAC time switches are adjusted to match occupancy patterns. Most systems use 7-day time controllers, so varying occupancy patterns can be catered for. Moreover, sufficient heat is often held in the building fabric and radiators to enable heating to be switched off a couple of hours before staff go home.		
Ensure hot water is switched off and time and temperature controls are adjusted over holiday periods. There is no need for water to remain at temperature during this time.		
Check boiler operation during summer walk arounds. In large offices, there are often several boilers for space heating and many of these can be switched off during the summer to save energy.		
Does the office have frost thermostats? These should be tamper-proof and checked regularly. Typically, internal thermostats are set to 4°C and external to 1°C.		

Heating, ventilation and air conditioning (HVAC)	Complete	Actions/comments
Are boilers operating efficiently? Check for warning lights, signs of leakage from pipework, valves and flanges, as well as smells of gas and oil. Look for damage and burn marks to boilers and hot surfaces. Is there undue noise from burners or pumps?		
Check extract fans are switched off after hours. Often, fan operation is linked with light operation and will continue to operate if lights are left switched on. Fans in themselves are expensive to run, and if fans continue to remove heat from the building overnight, this will also increase the amount of heat required to bring the building up to a comfortable temperature the next morning.		
Check filters in ventilation systems. Blocked filters reduce air flow and increase electricity consumption.		
Lighting	**Complete**	**Actions/comments**
Check that lighting in unoccupied areas is switched off and all non-essential lighting is switched off outside of business hours. • Are light switches clearly labelled? • Ensure external lighting is switched off during the day.		
Ensure blinds are open when there is sufficient daylight available. Large items of furniture such as filing cabinets should be moved so as not to obscure daylight.		
Do you still use traditional tungsten light bulbs? If so replace them with energy efficient, compact fluorescent lamps (CFLs) to reduce operating and maintenance costs.		
Review light levels in the office. Often, corridors are over-lit, especially if there have been changes to internal layout. Where appropriate, remove one fluorescent tube from multiple tube fittings in corridors and non-critical areas.		
Are lights switched off in toilets and store cupboards? If not, consider posters and stickers to remind staff to turn lights off, or possibly automatic lighting controls.		
Are windows, skylights, luminaires and sensors being kept clean? Establish a basic lighting maintenance and cleaning schedule to reduce costs as well as improving in-store appearance.		

Office equipment	Complete	Actions/comments
Check hours of operation of all equipment (such as photocopiers and vending machines) and ensure all unnecessary equipment is switched off overnight and at weekends.		
Building fabric	**Complete**	**Actions/comments**
Check whether parts of the building fabric are old or damaged. Cold air and water may infiltrate which can cause damage and lead to increased heating costs.		
Check for draughts and damage to windows, window frames and doors. Repair any damage and install or maintain draught seals.		

For further advice on how to improve existing systems across the above areas, please visit www.carbontrust.co.uk/energy/startsaving/technology.htm

Appendix B: Checklist for Lighting Use

Green Team Lighting Use Survey		
Completed by:	Date:	Business:
Address:	Phone:	Business Sq. Footage:
Lighting is: ❑ Incandescent ❑ Compact Fluorescent ❑ Tube Fluorescent ❑ HID (High Intensity)	Fluorescent ballasts used: ❑ Mechanical ❑ Electronic ❑ Unknown ❑ None	Main Lighting Usages: ❑ Office use ❑ Factory/Commercial ❑ Retail space ❑ Exterior
Number of employees ___________________	Number of visitors/ customers: __________	Total average occupancy _________ ___________

Occupancy Schedule:	Weekdays: ____am to _____pm	Weekends: ____am to _____pm
Existing Lighting Equipment or Fixtures		

Location	Lighting Type	Ballast type (if applicable)	# Units	Energy use in watts/bulb	Total energy use all units	Use/week in hours	KWh/week

Appendix C: Energy Star CFL Savings Calculator

Products that earn the ENERGY STAR prevent greenhouse gas emissions by meeting strict energy efficiency guidelines set by the U.S. Environmental Protection Agency and the U.S. Department of Energy.
www.energystar.gov

CHANGE FOR THE BETTER WITH ENERGY STAR

Life Cycle Cost Estimate for 20 ENERGY STAR Qualified Compact Fluorescent Lamp(s)

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors. CFLs are available in a variety of shapes and sizes, but pricing in this calculator is based on the most common spiral or globe with standard screw-in base.

Enter your own values in the gray boxes or use our default values.

Number of units	20
Electricity Rate ($/kWh)	$ 0.103
Hours used per day	9

	ENERGY STAR Qualified Unit	Conventional Unit
Initial cost per unit (estimated retail price)	$3.40	$0.60
Wattage (watts)	15 *	60
Lifetime (hours)	10,000	1,000

ENERGY STAR wattage is calculated based on the wattage selected for the incandescent unit, user can enter an alternative value if desired.

Annual and Life Cycle Costs and Savings for 20 CFLs

	20 ENERGY STAR Qualified	20 Conventional	Savings with ENERGY
Annual Operating Costs*			
Energy cost	$102	$406	$305
Maintenance cost	$0	$237	$237
Total	**$102**	**$643**	**$541**
Life Cycle Costs*			
Operating cost (energy and maintenance)	$286	$1,808	$1,522
Energy costs (lifetime)	$286	$1,142	$857
Maintenance costs (lifetime)	$0	$665	$665
Purchase price for 20 unit(s)	$68.00	$12.00	-$56.00
Total	**$354**	**$1,820**	**$1,466**
Simple payback of initial additional cost (years)†			**0.1**

* *Annual costs exclude the initial purchase price. All costs, except initial cost, are discounted over the products' lifetime using a real discount rate of 4%. See "Assumptions" to change factors including the discount rate.*
† *A simple payback period of zero years means that the payback is immediate.*

Summary of Benefits for 20 CFLs

Initial cost difference	**$56**
Life cycle savings	**$1,522**
Net life cycle savings (life cycle savings - additional cost)	**$1,466**
Simple payback of additional cost (years)	**0.1**
Life cycle energy saved (kWh)	**9,000**
Life cycle air pollution reduction (lbs of CO_2)	**13,860**
Air pollution reduction equivalence (number of cars removed from the road for a year)	**1.15**
Air pollution reduction equivalence (acres of forest)	**1.43**
Savings as a percent of retail price	**2156%**

Appendix D: Energy Star Programmable Thermostat Savings Calculator

Life Cycle Cost Estimate for 1 Programmable Thermostat(s)

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors.

Enter your own values in the gray boxes or use our default values.

Number of Units*	1
Initial Cost for one programmable thermostat	$92
Initial Cost for one manual thermostat	$73
Unit Fuel Cost (Cooling) ($/kWh)	$0.109
Unit Fuel Cost (Heating) ($/Therm)	$1.05

24 Hour Typical Usage Patterns**

	Weekday	Weekend
Nighttime Set-Back/Set-Up Hours	8	8
Daytime Set-Back/Set-Up Hours	10	10
Hours without Set-Back/Set-Up	6	6

Choose your city from the drop-down menu → City: DC-Washington

Heating Season**

Typical Indoor Temperature w/o Set-Back	70
Nighttime Set-Back Temperature (Average)	62
Daytime Set-Back Temperature (Average)	62
Heating System Type	Gas Furnace

Cooling Season**

Typical Indoor Temperature w/o Set-Up	78
Nighttime Set-Up Temperature (Average)	82
Daytime Set-Up Temperature (Average)	85
Cooling System Type	Central AC

**This calculator is based on an average sized home. For buildings with more than one heating/cooling zone, you may enter the appropriate number of thermostat units to increase the implementation cost, but the number of thermostats entered does not affect the building size or heating/cooling load.*

***All temperatures are in degrees Fahrenheit. Setpoint is defined as the temperature setting for any given time period. Set-back temperature is defined as the lower setpoint temperature for the energy-savings periods during the heating season, generally nighttime and daytime. Set-up temperature is defined as the higher setpoint temperature for the energy-savings periods during the cooling season, generally nighttime and daytime.*

Annual and Life Cycle Costs and Savings for 1 Programmable Thermostat(s)

	1 Programmable Thermostat(s)	1 Manual Thermostat(s)	Savings
Annual Energy Costs			
Heating Energy Cost	$451	$550	$99
Heating Energy Consumption (MBTU)	*43*	*52*	*9*
Cooling Energy Cost	$191	$256	$65
Cooling Energy Consumption (MBTU)	*5.9*	*8.0*	*2*
Total	**$642**	**$806**	**$164**
Life Cycle Costs			
Energy Costs	$7,136	$8,962	$1,826
Heating Energy Costs	*$5,017*	*$6,118*	*$1,101*
Heating Energy Consumption (MBTU)	*645*	*786*	*141*
Cooling Energy Costs	$2,119	$2,844	$725
Cooling Energy Consumption (MBTU)	*89*	*120*	*31*
Purchase Price for 1 Unit(s)	*$92*	*$73*	*-$19*
Total	**$7,228**	**$9,035**	**$1,807**
		Simple payback of initial cost (years)	**0.1**

Summary of Benefits for 1 Programmable Thermostat(s)

Initial cost difference	**$19**
Life cycle savings	**$1,826**
Net life cycle savings (life cycle savings - additional cost)	**$1,807**
Life cycle energy saved (MBTU)-includes both Heating and Cooling	**172**
Simple payback of additional cost (years)	**0.1**
Life cycle air pollution reduction (lbs of CO_2)	**25,546**
Air pollution reduction equivalence (number of cars removed from the road for a year)	**2**
Air pollution reduction equivalence (acres of forest)	**2**
Savings as a percent of retail price	**1965%**

Appendix E: Energy Star Ceiling Fan Savings Calculator

Products that earn the ENERGY STAR prevent greenhouse gas emissions by meeting strict energy efficiency guidelines set by the U.S. Environmental Protection Agency and the U.S. Department of Energy.
www.energystar.gov

CHANGE FOR THE BETTER WITH ENERGY STAR

Life Cycle Cost Estimate for
1 ENERGY STAR Qualified Ceiling Fan(s) with Lighting

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors.

Enter your own values in the gray boxes or use our default values.

Number of units	1	
Electricity Rate ($/kWh)	$0.109	
Percent of Time Spent at Low Speed	40%	
Percent of Time Spent at Medium Speed	40%	
Percent of Time Spent at High Speed	20%	
Choose your location from the drop-down menu	National Average	
	ENERGY STAR Qualified Unit	**Conventional Unit**
Initial Cost per Unit (estimated retail price)	$276	$190
Cost per Replacement Bulb	$3.50	$0.50
Number of Bulbs per Fixture	3	3
Wattage per Bulb	20	60

Annual and Life Cycle Costs and Savings for 1 Ceiling Fan(s) with Lighting

	1 ENERGY STAR Qualified Unit(s)	1 Conventional Unit(s)	Savings with ENERGY STAR
Annual Operating Costs*			
Energy cost	$16	$32	$16
Energy consumption (kWh)	*144*	*295*	*151*
Maintenance cost	$2	$13	$10
Total	**$18**	**$45**	**$27**
Life Cycle Costs*			
Operating costs (energy and maintenance)	$146	$363	$217
Energy cost	$127	$260	$134
Energy consumption (kWh)	*1,436*	*2,949*	*1,513*
Maintenance cost	$19	$103	$84
Purchase price for 1 unit(s)	$276	$190	-$86
Total	**$422**	**$553**	**$131**
Simple payback of initial additional cost (years)†			**3.2**

* *Annual costs exclude the initial purchase price. All costs, except initial cost, are discounted over the products' lifetime using a real discount rate of 4%. See "Assumptions" to change factors including the discount rate.*

† *A simple payback period of zero years means that the payback is immediate.*

Summary of Benefits for 1 Ceiling Fan(s) with Lighting

Initial cost difference	**$86**
Life cycle savings	**$217**
Net life cycle savings (life cycle savings - additional cost)	**$131**
Simple payback of additional cost (years)	**3.2**
Life cycle energy saved (kWh)	**1,513**
Life cycle air pollution reduction (lbs of CO_2)	**2,329**
Air pollution reduction equivalence (number of cars removed from the road for a year)	**0.2**
Air pollution reduction equivalence (acres of forest)	**0.2**
Savings as a percent of retail price	**48%**

Appendix F: Energy Audit Informational Brochure

General Information

Who We Are

We are a group of three students in our third year at Worcester Polytechnic Institute completing our required Interactive Qualifying Project (IQP). The IQP is designed to address a problem that lies at the intersection of science or technology with social issues and human needs and is done under the direct guidance from our advisors. This particular project is sponsored by the Nantucket Energy Studies Committee.

For more information:

http://www.ackenergy.org/WPI_BaselineEnergy.html

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Worcester Polytechnic Institute Interactive Qualifying Project

Energy Assessment Informational Overview

Nantucket Baseline Energy Group

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Energy Assessments

Overview

Costly energy bills have pushed some home and business owners to look for ways to reduce their energy consumption and save money. An energy assessment is a useful way to identify the areas of wasteful energy use in a building. It is designed to identify areas of inefficient energy use and present a variety of suggestions that will reduce energy consumption and save the owner money in the long run.

What it involves

We aim to analyze energy bills and perform a simple walk-through assessment of the building looking for the more obvious inefficient areas. The assessment will also include more detailed measurements taken with specific equipment, such as a lux meter to measure the luminous power per area. The three major focus areas when conducting the walk-through are lighting fixtures, heating and cooling systems, and office equipment. Office equipment can also include any electronics used by the business.

What are the Benefits

The resulting report will contain a cost analysis that includes expected capital investments, operating costs, and payback periods. Suggestions resulting from energy assessment are typically no-cost or low-cost investments that may lead to small or moderate savings in energy consumption.

Our Overall Goal

After conducting multiple assessmentss, a general small business model can be generated. This will show data and recommendations that will be applicable to most small businesses. The information collected will be presented to the Nantucket Energy Study Committee to provide an electricity usage model for this sector of Nantucket. Through the patterns of consumption determined by compiling the data, it will be easier for both the NESC and small businesses to take note of their consumption given any relevant interval of time, (i.e. seasonal up to hourly). The committee and business owners can then move forward in determining what steps to take from there in terms of conservation techniques suggested from the assessments of the businesses.

Nantucket Baseline Energy Group

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Appendix G: Energy Audit Checklist

Preparation

1. Collect past utility bills.
2. Determine rooms / areas to inspect. Tour of facilities.

General Information

Audit Conducted By:
Date:
Business:
Address:
Phone:
Business Sq. Footage:
Number of employees:

Weekday Operation Hours:
Weekend Operation Hours:

Lighting:

- Check that lighting in unoccupied areas is switched off and all non-essential lighting is switched off outside of business hours.
- Ensure external lighting is switched off during the day.
- Ensure blinds are open when there is sufficient daylight available.
- Can the lights be turned off in order to make better use of incoming daylight?
- Are there any inefficient bulbs, such as tungsten, being used?
- Can these be upgraded to LED or CFL?
- Can light sensors be installed in rooms that are not always occupied, such as store rooms or bathrooms?
- Are windows, skylights, etc being kept clean?
- Take Inventory: Lighting Type, Ballast Type (if available), Number of Units, Watts per Bulb, Hours Used per Week, kWh per Week, Lux Reading

Heating and Cooling

- Locate main heating / cooling source, record information.
- Are radiators and other heating surfaces unobstructed?
- Are windows and doors closed where possible when heating or air conditioning is operating?
- What is the temperature in the room? Is the thermostat set to average temperature? The recommended temperature is 70°F.
- Air conditioning should not be switched on until temperatures reach 75°F.
- Is the heating system and air conditioner receiving scheduled maintenance?
- Is the HVAC system run by a programmable thermostat? Heating is switched off after everyone leaves, turned back on before people arrive in the morning.

- Are boilers operating efficiently? Check for warning lights, signs of leakage from pipework, valves and flanges, as well as smells of gas and oil. Look for damage and burn marks to boilers and hot surfaces.
- Take Inventory: Type, Make / Model, Number of Units, Energy Use in Watts, Hours Used per Week, kWh per Week

Office Equipment and Other Electronics

- Check and enable energy saving features on computers and other electrical equipment.
- Is the equipment turned off over night?
- Take Inventory: Equipment, Make / Model, Number of Units, Energy Use in Watts, Hours Used per Week, kWh per Week

Other

Depending on the type of business being audited, emphasis must be placed on other areas. For example a restaurant will need a section regarding cooking equipment in the kitchen. Each building type that is audited could include not only the first three sections but also a section customized to that business.

Appendix H: Retail Audit Report

Retail Audit Report

Nantucket Project Center 2011

A Worcester Polytechnic Institute Interactive Qualifying Project

Authors

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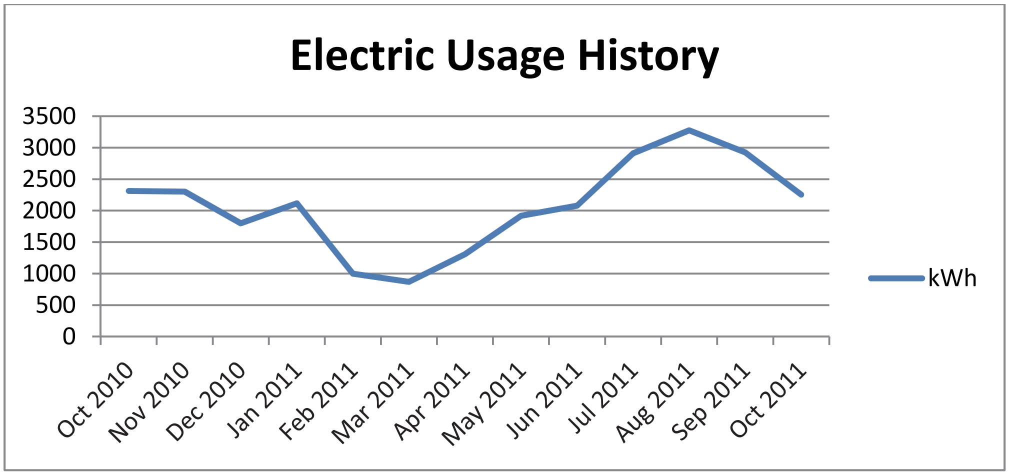
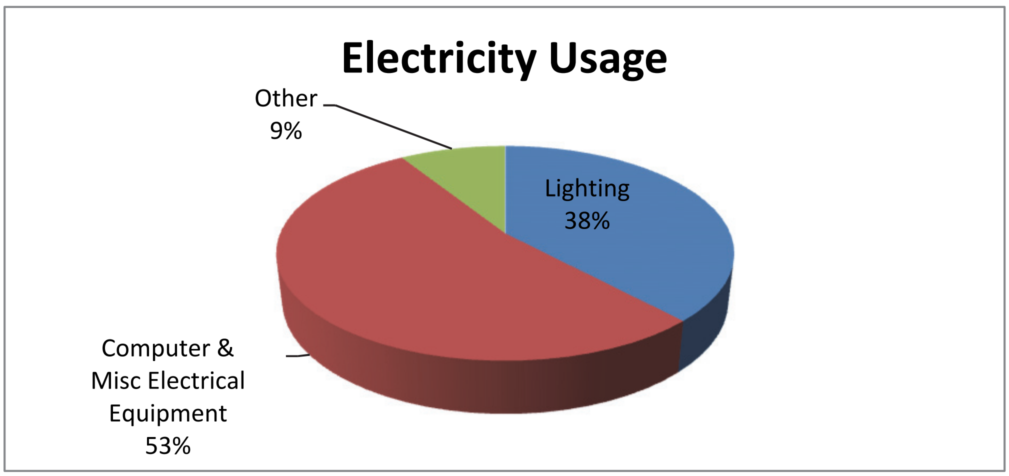
Summary





Recommendation	$ Savings Per Year	kWh Savings Per Year	Initial Cost	Payback Period
Connect all Cash Register Equipment to a Power Strip	$1005.25	5679.36 kWh	$35-100	0.5 month – 1.5 months
Installation of a Programmable Thermostat	$89.40	N/A	$50-70	0.55 Years
Installation of Lighting Control Systems	$351.24	1984.416 kWh	$136	0.38 Years
Decrease Lighting Usage Through Behavioral Changes	$502.55	2839.258 kWh	$0	Immediate
Replace Lighting with LED Lights	$1099.20	6210.144 kWh	$6,666.00 (No Incentives)	6.06 Years
Purchase a New Energy Efficient Server Computer	$628.02	3548.16 kWh	$1,089	1.73 Years

Solar Power Installation	$1999	6770 kWh	Installation Gross Cost: $45,200 Estimated Net Cost after Incentives: $4,707	~5 Years
Total	$5674.66	27031.33 kWh	$53170-53255 (No Incentives) $12677-12762 (After Incentives)	

General Information

Audit Conducted By:	Roberto Alvarado, Corey Phillips, JB Taleb
Date Conducted:	Oct 21, 2011
Areas / Rooms Inspected:	First Floor (Lobby, Small Shop Area, Service Area) Second Floor (Storage and Office) Third Floor (Storage)
Business Hours:	9:00am – 5:00pm, Monday – Saturday Closed Wednesday 10:00am – 4:00pm, Sunday

Retail Report

1. Introduction

The purpose of this energy audit was to identify areas of potential energy reduction and cost savings in the Retail building. The audit conducted was a modified Level 2 audit that consisted of a walk-through of the building as well as cost analysis calculations. The building is a retail and bike service facility composed of a lobby, shop, and service area on the first floor and an office and storage on the upper floors. The operating hours of the building are from 9:00AM to 5:00PM Monday through Saturday, closed Wednesday, and 10:00AM to 4:00PM on Sunday. This results in an estimated 46 hours of occupancy per week.

2. Summary of Findings

During the walk-through portion of our audit of the Retail building, we were able to identify several areas where energy efficiency can be improved.

2.1. First Floor Lobby

Upon entering the main lobby area, we first took note of the number and type of lighting fixtures found there. We counted a total of 28 fixtures each containing 2 fluorescent tubes which consume 32 watts per bulb. The recorded illumination intensity of the front lobby was measured at 725 lux. The recommended value for a show room or greeting area is around 500 lux meaning that this area is being over lit. The building has a wide, open entrance that allows a lot of ambient sunlight to enter the front of the room. This could be used to supplement the amount of lighting in that front area. The front windows are also kept lit by 8 fluorescent flood lights that are on kept on 24/7.

Heat from the oil-fired hot air heating system is only pumped as far forward as the shop area. When we conducted the audit, the lobby was a comfortable 65F despite not having any heating vents in this area. A space heater is located behind the counter in order to provide extra heating during the winter season.

We noticed several computer systems that are used as cash registers running at the time of the audit. These systems are shut down each night after the store has closed, however each system is connected to a Tripp Lite backup battery that will provide the computers with a short battery life should the building lose power. If just the computers are shut down, then these backup systems will still be on and drawing power each night.

2.2. First Floor Shop Area

The shop area behind the lobby is lit by both the same fluorescent tubes as the lobby and a different type of fluorescent flood light. We counted 2 fluorescent tube fixtures for a total of 4 bulbs. In addition to these, there are 14 flood lights that run at 65 watts each bulb. A lux reading of 515 was recorded which is close to that of a display / shop area.

Since the room has a wide opening to the lobby area, the heat from the vents is able to move out and heat the lobby as well as the shop area. By choosing not to pump heat directly into the lobby area, the heating system does not have to work overtime to heat that area.

The electrical system for the shop area is a very similar setup to the lobby area except that there is only one computer cash register.

2.3. First Floor Service Area

Next we moved on to the service area where bikes are worked on and repaired. The lighting in this area consisted of 16 fluorescent tube fixtures each containing 2 bulbs. At the time of our audit, only one of the fixtures was turned on. We then noticed that 7 of the fixtures were on pull cords as opposed to being controlled by a switch. This shows a good behavioral practice of only using extra lighting when working on a bike, and not having the lights stay on all the time.

The temperature of the building is controlled by a single manual thermostat that is located in the service area. It is a good energy saving practice to lower the thermostat temperature when closing up the building for the night. Having a manual thermostat requires a person to always remember to make that adjustment at the end of the day. There is the potential of installing a programmable thermostat that will automatically lower the building temperature at night instead of a person having to do that each night.

The electrical equipment in the area was similar to the shop area, with the exception of some additional power tools that we were told are not used all that often.

2.4. Ramp to Second Floor

Moving up the second floor, we travelled along a small ramp access. The ramp was lit by 4 compact fluorescent bulbs which seemed to be on for the entire business day. The ramp is also closed off from the first floor with a large, sliding door, preventing some of the hot air from leaking into the upper storage areas.

2.5. Second Floor Storage

The lighting of the storage area is minimal, consisting of only 6 fixtures of fluorescent tube bulbs. The recorded lux of the storage area was 150 which match up with the recommended value of a work area where visual tasks are occasionally performed. The lights were always on for the duration of the audit.

The walls of the upper floors are not insulated and heat is not pumped into the storage areas. The room temperature of the storage area was about 56F. Being a low traffic area, it is preferred that this area is not heating as well as the first floor.

2.6. Second Floor Office

Besides just storage, there is also an office room on the second floor. This room is lit by 3 fluorescent tube fixtures that are kept off when no one is in the room. The room has several windows that allow for enough sunlight to enter for us to look around without the need for even turning on the lights.

Additional heating vents are located in this office since it receives more traffic compared to the storage area. The vents can be manually opened or closed to control the temperature of the room. The door to the office is kept closed so that heat cannot escape into the storage area.

The office contains the standard office equipment including things such as computers, phone, printer, and copier. All of the equipment listed was turned off at the time of the audit and is only turned on as it is needed. However there were several pieces of equipment in the office that are left on 24/7. Things such as the mini fridge, water cooler, and server are included in this. The server that is used by the cash register software turns out to be one of the most power hungry pieces of equipment in the entire building.

2.7. Third Floor Storage

Much like the storage area of the second floor, this room receives minimal lighting consisting of 4 fluorescent tube fixtures. In addition to these fixtures, there are windows allowing light in. With regards to heating, it is very similar to that of the second floor storage.

3. Recommendations

The recommendations are organized by priority. The tables below show what should be considered when moving forward.

Priority 1 – Connect all Cash Register Equipment to a Power Strip			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$1,005.25	5679.36 kWh	$35 - $100	0.5 month – 1.5 months
Details:	Despite most of the computers being shut down after business hours, some of the equipment is left on overnight. One of the biggest consumers of electricity being left		

	on is the Tripp Lite backup system that acts as a battery for the computers if the building loses power. At night when the computers are turned off, there is no reason for these to be on and drawing power. In addition to these backup systems, there are also monitors, credit card readers, and receipt printers that can still be drawing power overnight. In order to make sure all these pieces of equipment are properly shut off after business hours, a power strip can be installed in order to control power access to the equipment. Switching off these power strips will have to be incorporated into the closing procedures of the building. The calculations can be found in section 5. There are a large number of different kinds of power strips available for this recommendation. These can range from a simple 6 outlet strip to a more complex power strip with surge protection. In the calculations we used a range of \$7 to \$20 per strip.

Priority 2 – Installation of a Programmable Thermostat			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
\$89.40	N/A	\$50.00	0.55 Years
Details:	While performing our walk-through of the building, we were shown that the heating of the entire building is controlled by one manual thermostat. It is a good practice to lower the temperature of the building overnight while no one is there in order to save money on the heating bill. However it is possible for the last person out of the building to forget to lower the thermostat before they leave. A programmable thermostat is a way to automate this process and make sure that for each and every night the thermostat is lowered, preventing any unnecessary heating. A programmable thermostat is a relatively cheap piece of equipment that can be installed to save a moderate amount of money on heating bills. Since the Retail Building is heated by oil, installing this will save oil and require less refills throughout the year. Since the heating system uses oil as a primary source of energy, we are not able to calculate the exact amount of money that will be saved from implementing this recommendation. Installing a programmable thermostat will reduce the amount of time the heating system has to be run. This will result in having to refill the oil less often. Using a calculator from the Department of Energy we were able to come up with an estimated 12% savings. If the Retail building consumes \$745 worth of oil each year, then this results in a savings of \$89.40 each year. For more information on programmable thermostats visit:		

	http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=TH

Priority 3 – Installation of Lighting Control Systems			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$351.24	1984.416 kWh	$136	0.38 Years
Details:	Lighting accounts for a large chunk of electricity usage in almost all small businesses. At the Retail building, lighting accounts for 276.85 kWh per week. Certain areas inside the building can have a better controlled lighting system. Many sensors are available that will automatically adjust the lighting when it is not needed. There are 2 possible areas of the building where lighting usage can be more controlled. Starting with the Lobby area, we find the flood lights in the front windows of the building. A Daylight Dimming System would be ideal in this situation. Since the display cases see adequate sunlight on certain days, this natural light can be better utilized. Daylight Dimming Systems dim and brighten the lights according to the amount of sunlight present. These would be ideal in the front, since the area needs to be well lit for display purposes at all times. The next area is the second floor storage area, including the ramp leading up to it. These lights are left on, however an Occupancy Sensor would be best suited for this application. These sensors would be ideal since traffic through the storage area is limited. The calculations can be found in section 5. When installing the Daylight Dimming System for the front 8 flood lights, we assumed a 60% reduction of electricity consumption during the day when the dimmer would be active. At night the flood lights will be consuming the full wattage. The occupancy sensors in the upper storage areas would cause the lights to turn off when it detects that no one is in the room. This is similar to the idea of a person making sure they turn off the lights after they leave the room. For this we assumed a 75% reduction in use hours for the fluorescent tube lights found in the upper floors. There are some incentives available to help pay for the cost of the initial investment. See section 4.2. for more information about how much you can save.		

Priority 4 – Decrease Lighting Usage Through Behavioral Changes			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period

$502.55	2839.258 kWh	None	Immediate
Details:	Lighting accounts for a large chunk of electricity usage in almost all small businesses. At the Retail building, lighting accounts for 276.85 kWh per week. Any opportunity to reduce the lighting usage should be taken advantage of. There are 4 possible areas of the building where lighting usage can be more controlled. Starting with the Lobby area, there are two things that were brought to our attention. First were the flood lights in the front windows of the building. These lights are meant to light up and advertise the display area at night, however they were on during the day as well. The second thing we noticed was the above average lux level in the lobby. Some of the fluorescent tube lights could be shut off in order to make better use of the incoming sunlight. The next area is the ramp leading up to the second floor. While we were there the 4 CFLs were on the entire time. A simple behavioral change to save some money would be to make sure these lights are only turned on when someone needs to travel up the ramp. Otherwise it would be best for them to stay off. The same behavioral technique can be applied to the upper storage areas as well. The fluorescent tube lights were always turned on while we were there. Since this is a low traffic area, lighting should only be turned on when it is needed. The calculations can be found in section 5. Three different techniques were taken into effect when calculating the savings. First, for lights that can be shut off when they are not needed, we assumed that these lights would receive a 75% reduction in use. Second, for the flood lights at the front of the building that can be shut off during the day, we subtracted the normal business hours from the total weekly hours of operation. Finally, to decrease the amount of lights in the lobby and make better use of the sunlight, we assumed a 10% reduction in the number of fluorescent tube lights.		

Priority 5 – Replace Lighting with LED Lights			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$1,099.20	6210.144 kWh	$6,666.00	6.06 Years
Details:	LED lighting is currently one of the most energy efficient lighting systems. However, to replace all the lights in the Retail building would require a large initial investment. The main light system already installed in the building consists of energy efficient 32W fluorescent tube bulbs. We estimated that switching to LED lighting would cut the power consumption in half but would have a large payback period. This is why we consider this a priority 4 suggestion. One possible way to go about replacing the fluorescent lights with LED lights is to replace them as they burn out. This would stretch the initial investment out across a long period of time. LED bulbs also have a		

	much longer lifespan than fluorescent bulbs, which may justify the reason to invest in them. LED lights are estimated to have a 30,000+ hour lifespan while fluorescents have about 8,000 hour lifespans. The calculation can be found in section 5. After browsing around the various LED choices available, we came to a conclusion that the wattage of the LED bulbs, on average, are half that of the currently installed fluorescent lights. In terms of pricing, we took the average of several different bulbs that could be used to replace the current ones. This resulted in a $70 average for tube lights and $23 for flood lights. See section 4.1. for a possible incentive that can be used to subsidize some on the initial costs of installing LED lighting.

Priority 6 – Purchase a New Energy Efficient Server Computer			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$628.02	3548.16 kWh	$1,089	1.73 Years
Details:	After we calculated the total kWh consumption of the individual equipment we found during our walk-through, we found that the server in the second floor office is consuming a very large amount of electricity. This server is controlling the cash register system plus more and must be kept on 24/7. This suggestion comes in at number 5 because it will be large hassle to reconfigure a new server with all the data from the old server. The calculations can be found in section 5. For these calculations we chose a single server computer to act as a comparison to the already installed server. We used a PRIMERGY TX100 S2 server from Fujitsu. Another possibility is to switch to an offsite server provider that can provide you with a server that you can remotely connect to. There is a monthly fee involved with this and has a very large range of costs depending upon the needs and the server provider. This setup would require a bit of technical knowledge to setup and manage. This is not included in the calculations, but may be something to consider depending on your needs.		

Solar Power

Besides retrofitting the internal components of the building, renewable energy generation, in the form of solar PV, is also a possibility. With a large surface area on the roof of a building and a good amount of sunlight, solar PV could be a good opportunity to save money on the electric bill. We will be using a solar power calculator to determine the size, cost, and savings of a solar PV setup that will cut electricity bills by 25%.

Solar Power PV Installation on the Roof

Cost Saving Per Year	Energy Production Per Year	Investment Cost	Payback Period
$1,999	6,770 kWh	Installation Gross Cost: $45,200 Estimated Net Cost at Installation: $25,006 Estimated Net Cost after Incentives: $4,707	~5 Years
Details:	For these calculations, we used a setup that would save 25% on electricity bills. In order to save this amount of money, a roof size of 565 sq-ft would be needed. The total cost of such a system would be about $45,200 before any rebates or incentives. There are many incentives available to business owners that would reduce the initial cost of installing renewable energy generation technology. Here is a list of incentives available that would reduce the overall cost of the system to $4,707: MA DOER - Solar Renewable Energy Credits (SRECs) $ 0.30 per kWh x 10 yrs Corporate Excise Tax Deduction for Solar- or Wind-Powered Systems MassCEC - Commonwealth Solar II Rebates (Non-Residential) Federal Tax Credit (30% of Gross Cost at Installation) Modified Accelerated Cost Recovery System (MACRS) Depreciation (5 yr) According to the calculator found at http://www.solar-estimate.org/, a solar panel system that will cover 100% of the electricity bill will require 2,281 sq-ft of space. If the total roof size is 5,200 sq-ft, then this is a possibility. The cost, of course, would greatly increase to roughly $180,000 prior to incentives. However, the same incentives can be applied throughout the lifetime of the system to result in a final cost of $28,000. The savings seen above are for a 565 sq-ft system. More information about how much each of these incentives will reduce the cost of installation can be found in section 5.7. To find out the requirements of each of these incentives, see section 4 or visit the website http://www.dsireusa.org/ to see incentives available for each state.		

4. Available Incentives

There are several incentives available to small business owners who are looking to upgrade existing equipment in order to increase the energy efficiency of the building.

4.1. National Grid Incentives for Lighting: Bright Ideas for Improving Efficiency

Details:

This incentive offered by National Grid is for small businesses seeking to upgrade to more efficient lighting. The can provide financial incentives that covers up to 45% of the cost. The amount of money depends on what lighting system you are upgrading to.

Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706.

For more information you can visit:
http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-retrofit-lighting-national-grid

4.2. National Grid Incentives for Lighting: Retrofit Controls

Details:

This incentive program offered by National Grid focuses on small businesses seeking to upgrade to more efficient lighting control systems. Different incentive amounts are offered per fixture for different control devices that are installed.

Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706. Other lighting control systems may be available, but you must contact your National Grid Representative for details.

For more information you can visit:
http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-lighting-retrofit-controls-national-grid

4.3. MA DOER - Solar Renewable Energy Credits

Details:

The RPS Solar Carve-Out is a market-based incentive program to support residential, commercial, public, and non-profit entities in developing 400 MW of solar photovoltaic (PV) across the Commonwealth.

DOER's goals and objectives for the RPS Solar Carve-Out include:

1. Cultivate solar development through varied generator sizes across multiple sectors (residential, commercial, and utility-scale)
2. Develop a sustainable solar market that reduces dependence on state subsidies and has long-term growth potential

3. Create a smooth transition from upfront, rebate-only incentives to production-based, market-priced Solar Renewable Energy Certificates (SRECs)
4. Minimize impact on ratepayers

Requirements:

1. Have a capacity of 6 MW (dc) or less per parcel of land
2. Be located in the Commonwealth of Massachusetts, which includes municipal light district territories
3. Use some of its generation on-site and be interconnected to the utility grid
4. Have a Commercial Operation Date of January 1, 2008, or later

4.4. Solar and Wind Power Deduction

Details:

In determining net income, a business may deduct the cost of installing any solar or wind powered energy generation system during the taxable year. These units or systems must be in the commonwealth and must be used exclusively in the trade or business of such corporation.

Requirements:

The deduction is allowed only if both conditions are met:

1. The net income for the taxable year and all succeeding taxable years must be computed without any exemption, credit or deduction for such expenditures or depreciation of the property other than the Solar and Wind Power Deduction allowed; and
2. The system or unit must be certified by the Office of Facilities Management, Division of Capital Planning, 617-727-4030.

4.5. MassCEC - Commonwealth Solar II Rebates (Non-Residential)

Details:

Commonwealth Solar II provides rebates for homeowners and businesses in Massachusetts who install solar photovoltaics. Rebates are granted through a non-competitive application process for the installation of photovoltaic projects by professional, licensed contractors at residential, commercial, industrial, institutional and public facilities.

Requirements:

The project site must be a customer of a Massachusetts electric distribution utility that collects the Renewable Energy Systems Benefit Charge from their customers and deposits those funds into MassCEC's Renewable Energy Trust Fund. Further eligibility requirements apply, and potential rebate recipients should read the full program documentation before moving forward.

4.6. Federal Tax Credit (30% of Gross Cost at Installation)

Details:

The American Recovery and Reinvestment Act of 2009 allows taxpayers eligible for the federal renewable electricity production tax credit to take the federal business energy investment tax credit or to receive a grant from the U.S. Treasury Department instead of taking the PTC for new installations. The grant is only available to systems where construction begins prior to December 31, 2011.

Requirements:

The credit is equal to 30% of expenditures, with no maximum credit. Eligible solar energy property includes equipment that uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat. Hybrid solar lighting systems, which use solar energy to illuminate the inside of a structure using fiber-optic distributed sunlight, are eligible. Passive solar systems and solar pool-heating systems are not eligible.

5. Calculations

5.1. Recommendation 1

	A	B	C	D	E	F	G	H	I	J	K
1	**Equipment**	**Number**	**Current kWh Per Week**	**Recommended Upgrade kWh Per Week**		**Electricity Cost**		**Savings**	**$**	**kWh**	
2	Computers	5	64.4	64.4		0.177 Cents Per kWh		**Week**	$20.94	118.32	
3	Monitors	5	40.72	32.2				**Month**	$83.77	473.28	
4	Credit Card Readers	5	5.51	5.51				**Year**	$1,005.25	5679.36	
5	Recipt Printers	5	9.92	9.92							
6	Tripp Lite Backups	5	151.2	41.4							
7		**Week**	271.75	153.43							
8		**Month**	1087	613.72							
9		**Year**	13044	7364.64							
10											
11											
12											

5.2. Recommendation 2

	1 Programmable Thermostat(s)	1 Manual Thermostat(s)	Savings
Annual Energy Costs			
Heating Energy Cost	$1,558	$1,766	$208
Heating Energy Consumption (MBTU)	*54*	*61*	*7*
Cooling Energy Cost	$0	$0	$0
Cooling Energy Consumption (MBTU)	*2.9*	*3.9*	*1*
Total	**$1,558**	**$1,766**	**$208**
Life Cycle Costs			
Energy Costs	$17,322	$19,632	$2,310
Heating Energy Costs	*$17,322*	*$19,632*	*$2,310*
Heating Energy Consumption (MBTU)	*810*	*918*	*108*
Cooling Energy Costs	$0	$0	$0
Cooling Energy Consumption (MBTU)	*44*	*59*	*15*
Purchase Price for 1 Unit(s)	*$50*	*$30*	*-$20*
Total	**$17,372**	**$19,662**	**$2,290**
		Simple payback of initial cost (years)	**0.1**

5.3. Recommendation 3

	A	B	C	D	E	F	G	H	I	J
1	**Lights**	**Number**	**Current kWh Per Week**	**kWh Per Week if - Occupancy Sensor Installed**		**Electricity Cost**		**Savings**	**$**	**kWh**
2	Ramp CFLs	4	7.36	1.84		0.177 Cents Per kWh		**Week**	$7.32	41.342
3	Upper Storage Fluroescent Tube Lights	20	28.83	7.36				**Month**	$29.27	165.368
4				**kWh Per Week if - Daylight Dimming System Installed**				**Year**	$351.24	1984.416
5	Lobby Fluorescent Flood Lights	8	87.36	73.008						
6										
7										
8		**Week**	123.55	82.208		**Sensor Type**	**Cost Per Sensor**			
9		**Month**	494.2	328.832		Occupancy Sensor	$28			
10		**Year**	5930.4	3945.984		Daylight Dimmer	$80			
11										

5.4. Recommendation 4

	A	B	C	D	E	F	G	H	I	J
1	**Lights**	**Number**	**Current kWh Per Week**	**kWh Per Week if - Reduce Hours of Use by 75%**		**Electricity Cost**		**Savings**	**$**	**kWh**
2	Ramp CFLs	4	7.36	1.84		0.177 Cents Per kWh		**Week**	$10.47	59.1512
3	Upper Storage Fluroescent Tube Lights	20	28.83	7.36				**Month**	$41.88	236.6048
4				**kWh Per Week if - Turn off During the Day**				**Year**	$502.55	2839.258
5	Lobby Fluorescent Flood Lights	8	87.36	63.44						
6				**kWh Per Week if - Reduce Number of Lights By 10%**						
7	Lobby Fluorescent Tube Lights	56	82.43	74.1888						
8		**Week**	205.98	146.8288						
9		**Month**	823.92	587.3152						
10		**Year**	9887.04	7047.7824						
11										
12										

5.5. Recommendation 5

	A	B	C	D	E	F	G	H	I	J	K
1	**Floor**	**Lighting**	**Number**	**Current kWh Per Week**	**Recommended LED Upgrade kWh Per Week**		**Electricity Cost**		**Savings**	**$**	**kWh**
2	First	Fluorescent Tube	62	91.264	45.632		0.177 Cents Per kWh		**Week**	$22.90	129.378
3		Fluorescent Flood	22	129.22	64.61				**Month**	$91.60	517.512
4	Second	Fluorescent Tube	18	26.496	13.248				**Year**	$1,099.20	6210.144
5	Third	Fluorescent Tube	8	11.776	5.888						
6			**Week**	258.756	129.378						
7			**Month**	1035.024	517.512						
8			**Year**	12420.288	6210.144						
9											
10							**Light Type**	**Number**	Cost Per Bulb	**Investment**	
11							LED Tube Lights	88	$70.00	$6,160.00	
12							LED Flood Lights	22	$23.00	$506.00	
13										$6,666.00	
14											
15											

5.6. Recommendation 6

	A	B	C	D	E	F	G	H	I	J	K
1	**Equipment**	**Number**	**Current kWh Per Week**	**Recommended Upgrade kWh Per Week**		**Electricity Cost**		**Savings**	**$**	**kWh**	
2	Server	1	184.8	110.88		0.177 Cents Per kWh		**Week**	$13.08	73.92	
3		**Week**	184.8	110.88				**Month**	$52.34	295.68	
4		**Month**	739.2	443.52				**Year**	$628.02	3548.16	
5		**Year**	8870.4	5322.24							
6											
7											
8											

5.7. Solar Power Calculations

Using a calculator found on http://www.find-solar.org/ we were able to determine the size, cost, savings, and various incentives for the installation of a solar power PV setup that saves 25% on electricity bills.

Year of Operation:	at Install	1	2	3	4	5
Gross Cost	($45,200)					
MA DOER - Solar Renewable Energy Credits (SRECs) $ 0.30 per kWh x 10 yrs.	$0	$2,031	$2,031	$2,030	$2,030	$2,030
Corporate Excise Tax Deduction for Solar- or Wind-Powered Systems	$2,396	$0	$0	$0	$0	$0
MassCEC - Commonwealth Solar II Rebates (Non-Residential)	$4,238	$0	$0	$0	$0	$0
Federal Tax Credit (30% of Gross Cost at Installation)	$13,560	$0	$0	$0	$0	$0
Tax savings from MACRS Depreciation	$0	$10,585	$0	$0	$0	$0
Utility Savings	$0	$1,236	$1,282	$1,331	$1,381	$1,433
ANNUAL CASH FLOW	$-25,006	$13,851	$3,313	$3,361	$3,411	$3,463
Cumulative Cash Flow	$-25,006	$-11,155	$-7,842	$-4,481	$-1,070	$2,393 **Breakeven**

Year of Operation:	6	7	8	9	10	11
Gross Cost						
MA DOER - Solar Renewable Energy Credits (SRECs) $ 0.30 per kWh x 10 yrs.	$2,030	$2,030	$2,029	$2,029	$2,029	$0
Corporate Excise Tax Deduction for Solar- or Wind-Powered Systems	$0	$0	$0	$0	$0	$0
MassCEC - Commonwealth Solar II Rebates (Non-Residential)	$0	$0	$0	$0	$0	$0
Federal Tax Credit (30% of Gross Cost at Installation)	$0	$0	$0	$0	$0	$0
Tax savings from MACRS Depreciation	$0	$0	$0	$0	$0	$0
Utility Savings	$1,488	$1,544	$1,602	$1,663	$1,726	$1,791
ANNUAL CASH FLOW	$3,518	$3,574	$3,631	$3,692	$3,755	$1,791
Cumulative Cash Flow	$5,911	$9,485	$13,116	$16,808	$20,563	$22,354

Year of Operation:	12	13	14	15	16	17
Gross Cost				($3,955) Inverter Replaced		
MA DOER - Solar Renewable Energy Credits (SRECs) $ 0.30 per kWh x 10 yrs.	$0	$0	$0	$0	$0	$0
Corporate Excise Tax Deduction for Solar- or Wind-Powered Systems	$0	$0	$0	$0	$0	$0
MassCEC - Commonwealth Solar II Rebates (Non-Residential)	$0	$0	$0	$0	$0	$0
Federal Tax Credit (30% of Gross Cost at Installation)	$0	$0	$0	$0	$0	$0
Tax savings from MACRS Depreciation	$0	$0	$0	$0	$0	$0
Utility Savings	$1,859	$1,929	$2,002	$2,077	$2,156	$2,237
ANNUAL CASH FLOW	$1,859	$1,929	$2,002	$-1,878	$2,156	$2,237
Cumulative Cash Flow	$24,213	$26,142	$28,144	$26,266	$28,422	$30,659

Year of Operation:	18	19	20	21	22	23	24	25
Gross Cost								
MA DOER - Solar Renewable Energy Credits (SRECs) $ 0.30 per kWh x 10 yrs.	$0	$0	$0	$0	$0	$0	$0	$0
Corporate Excise Tax Deduction for Solar- or Wind-Powered Systems	$0	$0	$0	$0	$0	$0	$0	$0
MassCEC - Commonwealth Solar II Rebates (Non-Residential)	$0	$0	$0	$0	$0	$0	$0	$0
Federal Tax Credit (30% of Gross Cost at Installation)	$0	$0	$0	$0	$0	$0	$0	$0
Tax savings from MACRS Depreciation	$0	$0	$0	$0	$0	$0	$0	$0
Utility Savings	$2,322	$2,410	$2,501	$2,595	$2,694	$2,795	$2,901	$3,011
ANNUAL CASH FLOW	$2,322	$2,410	$2,501	$2,595	$2,694	$2,795	$2,901	$3,011
Cumulative Cash Flow	$32,981	$35,391	$37,892	$40,487	$43,181	$45,976	$48,877	$51,888

6. Data Gathered

Lighting

What to Look For	Yes / No	Comments
Is lighting in unoccupied areas switched off and all non-essential lighting is switched off outside of business hours.	Not all are switched off.	Front lights are kept on 24/7. Second and third floor lighting is on during business hours despite low traffic. Bathroom light is often left on.
Ensure blinds are open when there is sufficient daylight available. Can the lights be turned off in order to make better use of incoming daylight?	Yes. Front entrance allows a large amount of ambient light to enter.	Possibility of turning off some lights near front entrance to make better use of sunlight.
Are there any inefficient bulbs, such as tungsten, being used? Can these be upgraded to LED or CFL?	No. Most bulbs are fluorescent. Possibility of LED upgrade.	Most lights are efficient fluorescent bulbs. Possibility of upgrading to LED.
Can light sensors be installed in rooms that are not always occupied, such as store rooms or bathrooms?	Yes.	Lights in bathroom, service area, or upper floors have possibility to be on a motion sensor.
Are windows, skylights, etc being kept clean?	Yes.	
Are any rooms being over lighted or under lighted?	Yes. Front desk over lighted.	The front desk had a lux reading nearly double that of an average reception desk.

Heating / Cooling

What to Look For	Yes / No	Comments
Are radiators and other heating surfaces unobstructed?	Yes.	
Are windows and doors closed where possible when heating or air conditioning is operating?	Yes.	When weather is cold, doors are kept shut. Otherwise front door is open.
Is the air temperature close to the recommended average of 70°F?	Below average.	Air temperature of the first floor ranged from 62-65°F. Slightly below average but was comfortable.
Is the heating controlled by a programmable thermostat?	No.	Heating for the entire building is controlled by a single manual

		thermostat.
Is the heating system / air conditioner receiving scheduled maintenance?	Yes, but late this year.	A typical heating system should be serviced once a year. Last maintenance was 9/30/10 so it is overdue.
If there is a roof space, is it insulated?	No.	Upper floors are not insulated.
Is heating on in unused spaces, such as corridors or low traffic areas.	No.	Hot air from the heating system is only pumped into the first floor and an office on the second floor. Upper storage areas are left unheated.

Electrical Equipment

What to Look For	Yes / No	Comments
Is equipment, such as computers and printers, turned off over night?	Yes.	Computers are shut down each night. However TrippLite backups and server are left on.
Is nonessential equipment, such as printers and copiers, kept shut off until needed?	Yes.	
Can any equipment be switched on later and switched off earlier?	No.	

Existing Lighting Fixtures

Location	Light Type	Number of Units	Watts Per Bulb	Hours Used Per Week	kWh Per Week	Lux Reading
First Floor (Lobby)	Fluorescent Tube	56	32W	46	82.43	725 @ Front Desk 400 @ Back of Lobby
	Fluorescent Flood	8	65W	168	87.36	
	Small Spot Lights	6	55W	46	15.18	
First Floor (Shop Area)	Fluorescent Tube	4	32W	46	5.88	515
	Fluorescent Flood	14	65W	46	41.86	
First Floor (Service Area)	Fluorescent Tube	32	32W	Used as needed. 2 bulbs on 46 hours.	47.10 (32 Bulbs) 2.94 (2 Bulbs)	N/A
Stairs	CFL	4	40W	46	7.36	N/A

(Ramp to 2nd Floor)						
Second Floor (Storage)	Fluorescent Tube	12	32W	46	17.66	150 Under Light 50 In Darkest Area
Second Floor (Office)	Fluorescent Tube	6	32W	23*	4.41	N/A
Third Floor (Storage)	Fluorescent Tube	8	32W	46	11.77	N/A

*estimated value

Existing Extra Heating / Cooling Equipment

Location	Equipment	Make / Model	Number of Units	Wattage	Hours Used Per Week	kWh Per Week	Room Temperature
First Floor (Lobby)	Space Heating	N/A	1	1500W	Used as needed.	Varies.	62-65F
First Floor (Shop Area)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
First Floor (Service Area)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Second Floor (Storage)	N/A	N/A	N/A	N/A	N/A	N/A	56F
Second Floor (Office)	N/A	N/A	N/A	N/A	N/A	N/A	70F
Third Floor (Storage)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Existing Electronic Equipment

Location	Equipment	Make / Model	Number of Units	Wattage	Hours Used Per Week	kWh Per Week
First Floor (Lobby)	Cash Register	Dell Optiplex 740	3	280W	46	38.64
	Monitor	Dell	3	Use = 140W Standby = 14W	46 in use. 122 in standby.	24.44
	Credit Card Reader	Hypercom T7+	3	24W	46	3.31
	Receipt Printer	EPSON	3	43.2W	46	5.96
	Tripp Lite Backup	OmniSmart 300	3	180W	168	90.72
	Printer	HP Color LaserJet 3600dn	1	Use = 335W Standby = 45W	Used as needed.	Varies.
	Fish Tank Filter	N/A	1	7W	168	1.17
First Floor (Shop Area)	Cash Register	Dell Optiplex 740	1	280W	46	12.88
	Monitor	Dell	1	Use = 140W Standby = 14W	46 in use. 122 in standby.	8.14
	Credit Card Reader	Hypercom T7+	1	24W	46	1.1
	Receipt Printer	EPSON	1	43.2W	46	1.98
	Tripp Lite Backup	OmniSmart 300	1	180W	168	30.24
	Printer	HP Color LaserJet 3600dn	1	Use = 335W Standby = 45W	Used as needed.	Varies.
	Copier	Canon PC940	1	Use = 900W	Used as needed.	Varies.
First Floor (Service Area)	Cash Register	Dell Optiplex 740	1	280W	46	12.88
	Monitor	Dell	1	Use = 140W	46 in use. 122 in	8.14

				Standby = 14W	standby.	
	Receipt Printer	EPSON	1	43.2W	46	1.98
	Tripp Lite Backup	OmniSmart 300	1	180W	168	30.24
	Stereo	Kenwood KR-B6080 Panasonic DVD-F87	1	10W	46	0.46
Second Floor (Office)	Computer	Dell Optiplex 740	3	280W	23*	19.32
	Monitor	Dell	3	Use = 140W Standby = 14W	23* in use. 145* in standby.	15.75
	Server	N/A	1	Min = 1000W Max = 1200W	168	184.8
	Mini-Fridge	N/A	1	138W	168	23.18
	Mini-Microwave	Sharp CAROUSEL 2 II Half Pint	1	980W	Used as needed.	Varies.
	Water Cooler	N/A	1	319W	168	53.59
	Stereo	Optimus	1	5.17W	168	0.86
	Phone/Fax	Brother FAX 575	1	Use = 170W Standby = 5W	168 (Standby)	0.84
	Printer	HP Business Inkjet 2280 FN	1	Use = 65W Standby = 8W	Used as needed.	Varies.
	Copier	Canon PC940	1	Use = 900W	Used as needed.	Varies.

*estimated value

Appendix I: Bar Audit Report

Bar Audit Report

Nantucket Project Center 2011

A Worcester Polytechnic Institute Interactive Qualifying Project

Authors

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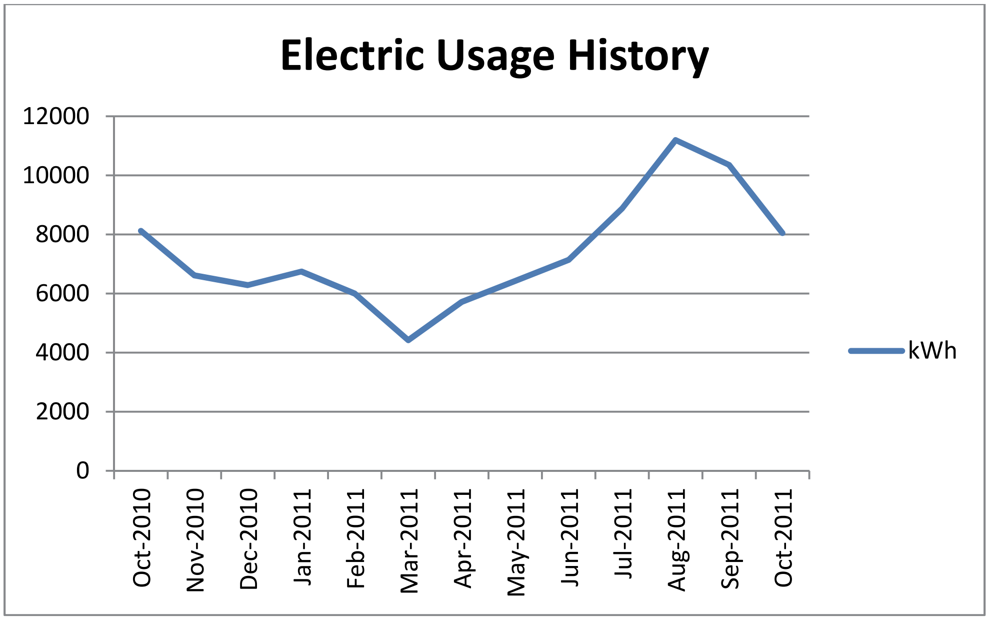
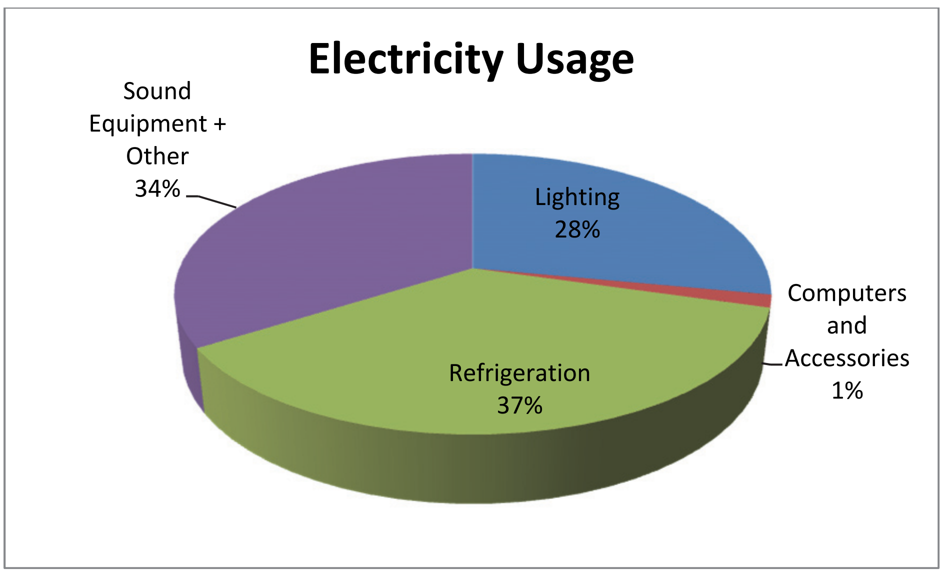
Summary





Recommendation Name	$ Savings Per Year	kWh Savings Per Year	Initial Cost	Payback Period
Upgrade All Incandescent Bulbs to CFL	$1,091.66	6064.8 kWh	$84.66	1 Month
Decrease Lighting Usage Through Behavioral Changes	$500.77	2782.08 kWh	None	Immediately
Install Occupancy Sensors to Control	$751.16	4173.12 kWh	$168	2.64 Months

Lighting in Low Traffic Areas				
Upgrade All Incandescent Bulbs to LED	$1,641.95	9121.92 kWh	$2,210	1.34 Years
Upgrade Stages Lights to LED	$176.08	978.24 kWh	$2,352	13.36 Years

General Information

Audit Conducted By:	Roberto Alvarado, Corey Phillips, JB Taleb
Date Conducted:	Nov 7, 2011
Areas / Rooms Inspected:	Stage, Stage Floor, Bar, Game Floor, Smoking Deck, Bathrooms Back Storage, Ice Machine Room, Cooler Room, Office Underneath Storage
Business Hours:	12pm – 1am Last Call, Everyday

Bar Report

1. Introduction

The purpose of this energy audit was to identify areas of potential energy reduction and cost savings in the Bar. The audit conducted was a modified Level 2 audit that consisted of a walk-through of the building as well as cost analysis calculations. The building is a bar composed of a stage, stage floor, bar, game floor, smoking deck, bathrooms, back storage, ice machine room, Cooler Room, and underneath storage. The operating hours of the building are from 12:00PM to 1:00AM every day. This results in 84 hours of occupancy each week.

2. Summary of Findings

During the walk-through portion of our audit of the Bar, we were able to identify several areas where energy efficiency can be improved.

2.1. Stage Floor

Upon entering the area just before the stage, we first took note of the lighting situation. This area is being kept lit by 36 small spot lights and an additional 4 incandescent bulbs above the entrance. There are also several larger spot lights used as needed during a stage performance. In order to determine the intensity of the light in this area, we took lux readings throughout the stage floor. The reading ranged from 40 to 100 lux. This result is below average for wide open area such as this, however due to the nature of the establishment it is understandable. One thing we look for when performing the walk-through is any opportunity to reduce lighting usage and instead make use of the incoming sunlight, but due to the small number of windows, this would not be possible.

This area also features several other pieces of electrical equipment including 2 Samsung TVs, a Sharpvision projector, a handful of neon signs, and a large soundboard used during performances. Besides the TVs, all the other equipment is only used when needed.

2.2. Stage

Moving onto the stage, we saw a large amount of sound equipment used during a performance. Having little experience with such equipment and the minimal savings associated with making any changes to them, we decided to only take a look at the stage lighting. The stage is primarily lit by 24 Par 56 spot lights which average about 300w each. Switching these to LED lighting using a lower wattage bulb is viable only if the stage is actively used a lot. The recommendations section goes into this in more detail.

2.3. Bar

The bar area is kept lit by 4 overhead lamps each fitted with an incandescent bulb. These lamps are also controlled by a dimmer switch allowing for more control over the amount of light produced. To chill the bottled beverages, there are 2 true value coolers located on the floor of the center area. Also behind the bar are the 4 Positouch touchscreen cash registers controlled by the server found in the office.

2.4. Game Floor

Moving on to the right side of the building, this area has relatively few light fixtures. We noted a total of 10 fluorescent bulbs throughout all the fixtures. The lux readings were slightly lower than that of the other side of the building, coming in at between 30 and 80 lux.

This area also has several other pieces of equipment that draw power. There were 3 Great American Pool Tables and a Champion Shuffleboard Table, all of which were unplugged at the time of the audit. In addition to these games, there was an electronic casino game and a mini-bank ATM which were plugged in all the time. Like the other side of the building, there were also 2 TVs and a handful of neon signs.

2.5. Smoking Deck

The smoking deck had very little in terms of pieces of equipment that draw electricity. This included 12 incandescent lamps that are only used at night, as well as a large fan towards the top of the roof. These incandescent, along with the rest of the incandescent bulbs throughout the building, have the potential of being upgrade to either CFLs or LED bulbs.

2.6. Bathrooms

Both male and female bathrooms are almost identical in terms of electricity use so we only examined the men’s room. The lighting includes 4 incandescent bulbs that are kept on all the time for the duration of the business hours. The only other pieces of equipment we noticed that draw electric power are the hand drier and the fan. Since these two rooms are low traffic areas, it may not be best to leave the lights on all the time.

2.7. Back Storage

Moving on to the area behind the bar, we found several of the same incandescent bulbs that are used to light up a majority of the other parts of the building. The area also has a single Ecolab dish washer, 2 laundry washers, and a Jenn-Air refrigerator. We also noticed that as we moved into the back area, the temperature began to rise from 73F in the open lobby up to over 80F in the back.

2.8. Ice Machine Room

Next was the room that contained several ice machines, only one of which was turned on. The same incandescent bulbs as the rest of the building can be found lighting up the room. This room was by far the hottest of all the areas we went into. The ice machine generates a substantial amount of heat causing the room to be heated to over 90F.

2.9. Cooler Room

Most of this room was devoted to a large walk in cooler that housed several kegs connected to the glycol cooling system as well as other miscellaneous beverages. We were informed that occasionally the door to this cooler would be left open while employees go in and out. Based on the Glycol system in the basement of the building, the cooler is kept chilled by two Tecumseh cooling compressors. The two units consume 1403w and 3082w when being used to chill the cooler. On average, a cooler kept at 32F will require 30 minutes of cooling for every 10 minutes the door is left open. Based on this, a 10 minutes period of the door being open would result in 2.24 kW/h used in the 30 minute cooling phase. At a cost of $0.18 per kW/h, this would cost $0.40. However this assumes an average outside temperature of 70F. The Cooler Room at the Bar was around 80F, meaning the cooling phase will probably be longer than 30 minutes. See Appendix A at the end of the report for more information about maintaining an energy efficient walk-in cooler.

2.10. Office

The office consists of two small rooms lit by 3 fluorescent tubes and 2 more incandescent bulbs in the hallway just outside the office. The office contains the standard office equipment including things such as computers, phone, and printer. One of the computers acts as a server for the cash register software in the bar area and must remain on.

2.11. Underneath Storage

Lastly we looked at a small storage area underneath the building. This small room was lit by 3 60w incandescent light bulbs that are kept off when no one is there. Also housed in this area is the Glycol Beer Cooling System that is being run all the time.

3. Recommendations

The recommendations are organized by priority. The tables below show what should be considered when moving forward.

Priority 1 - Upgrade All Incandescent Bulbs to CFL			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$1,091.66	6064.8 kWh	$84.66	1 Month

Details:	Currently, a majority of the lighting used in the Bar is 60w incandescent bulbs. These types of bulbs have been surpassed in efficiency by the more common compact fluorescent (CFL) or the uncommon LED bulbs. In this recommendation, we took a look at the savings incurred if all incandescent bulbs are switched out for CFLs. For our calculations, we used an Eiko 00031 SP13/27K 13 Watt Compact Fluorescent Spiral Light Bulb that can be purchased online for $2.50 per bulb. The light produced by this bulb is identical to that of a 60w incandescent. Assuming all the incandescent lights in the building are left on for a full 12 hours per day, a total savings of just over $1,000 can be saved per year for only an $85 investment. This situation would be ideal, however in reality not all of these lights are left on for a full business day. Even if this is the case, if all the incandescent bulbs are left on for 50% of a business day or about 6 hours per day, the savings would still be over $500 a year. There is also an incentive program offered by National Grid that can help cover the initial cost of changing bulbs. The details of this incentive can be found in section 4.1. The calculations can be found in section 5. There you can find all the incandescent bulbs we looked at and how much power they each consume.

Priority 2 - Decrease Lighting Usage Through Behavioral Changes			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$500.77	2782.08 kWh	None	Immediately
Details:	One comment the owner made is that employees that go into the back storage area will often leave the lights on after they leave the room. For the duration of our audit, the lights in several of the back rooms were on all the time. Behavioral changes such as remembering to turn off the lights when you leave a room are often the hardest ones to put into motion, however these type of changes have no initial investment and will end up saving money on the electric bills. Once again for our calculations we assumed the worst case scenario in which all the lights in the bathrooms, back storage, ice machine room, cooler room, and office are left on for a full business day. Of course these rooms will need to be accessed for normal business operations, so for our calculations we assumed that these lights would only be turned on for 50% of the business day. Based on this, if the lights are shut off for 50% of the day, then you can see a $500 savings per year. But as we all know, not everyone will remember to turn off the lights every time they leave the room, so even if the lights are kept off for 25% of the day, you can still see a savings of up to $250 per year. The calculations can be found in section 5. There you can see the location of the bulbs		

	used in the calculation as well as how much power they consume if left on for 12 hours per day.

Priority 3 - Install Occupancy Sensors to Control Lighting in Low Traffic Areas			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$751.16	4173.12 kWh	$168	2.64 Months
Details:	Another way to decrease lighting usage in low traffic areas is to install motion sensors that will automatically make sure the lights are turned off when no one is in the room. This gets rid of the human element of remembering to turn off the lights when leaving a room. In the end this would result in a greater reduction of lighting use because it has been automated. Shopping around online, we took an average of the prices and came up with $28 per occupancy sensor. The areas in which these sensors could be installed include the bathrooms, back storage, ice machine room, cooler room, and office. The best case scenario for these rooms would be a 75% reduction in lighting use which would result in a savings of $750 per year. Due to several different factors, the percent reduction could be lower than this. This would result in a lower saves as well as a larger payback period. National Grid also has an incentive program directed towards the installation of these types of motion sensors. For more details about this incentive, see section 4.2. The calculations can be found in section 5.		

Priority 4 - Upgrade All Incandescent Bulbs to LED			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$1,641.95	9121.92 kWh	$2210	1.34 Years
Details:	LED lighting is currently one of the most energy efficient lighting systems. However, to replace all the lights in the Bar would require a large initial investment. This would involve swapping out both the 60w incandescent bulbs and the fluorescent tube lighting. We estimated that switching to LED would reduce power consumption to only 9w per bulb and 16w per tube but would have a large payback period. This is why we consider this a low priority suggestion. One possible way to go about replacing the fluorescent lights with LED lights is to replace them as they burn out. This would stretch the initial investment out across a long period of time. LED bulbs also have a much longer lifespan than fluorescent bulbs, which may justify the reason to invest in them. LED lights are estimated to have a 30,000+ hour lifespan while fluorescents have about 8,000 hour lifespans.		

<table>
<tr><td></td><td>The calculation can be found in section 5. After browsing around the various LED choices available, we came to a conclusion that the wattage of the LED bulbs were around 9w for a standard bulb and 16w for a larger tube light. In terms of pricing, we took the average of several different bulbs that could be used to replace the current ones. This resulted in a $70 average for tube lights and $30 for the standard bulb.

See section 4.1. for a possible incentive that can be used to subsidize some on the initial costs of installing LED lighting. The calculations can be found in section 5.</td></tr>
</table>

<table>
<tr><td colspan="5">Priority 5 - Upgrade Stages Lights to LED</td></tr>
<tr><td colspan="2">Cost Saving Per Year</td><td>Energy Savings Per Year</td><td>Investment Cost</td><td>Payback Period</td></tr>
<tr><td colspan="2">$176.08</td><td>978.24 kWh</td><td>$2352</td><td>13.36 Years</td></tr>
<tr><td>Details:</td><td colspan="4">We looked at the possibility of upgrading the 24 Par 56 stages lights to LED bulbs. A typical Par 56 bulb will consume about 300w of power. Unsure of the average hours of use for these lights, our calculations assumed that they would be used for 12 hours a month, or 4 3-hour long shows a month. If they are used more than that, then the savings will continue to grow larger. For example, if the lights are used 24 hours a month the savings would be $350 a year.

In order to determine the initial cost, we used the website http://www.bulbamerica.com/ to find an LED bulb used in Par 56 lights. We found a 17w Optima LED bulb that costs $98 per bulb. This would result in a $2352 investment in order to change all the lights.

At this time, we do not think that it is worth it to upgrade to LED Par 56. The steep initial investment places the payback period at over 13 years. Keep in mind that this calculation assumes that the lights are used 12 hours a month. If, for example, they are used 24 hours a month, then the payback period gets reduced to 6 years. It would be best to wait till the price of these bulbs begins to drop before considering making the change.

Calculations used can be found in section 5.</td></tr>
</table>

4. Available Incentives

There are several incentives available to small business owners who are looking to upgrade existing equipment in order to increase the energy efficiency of the building.

4.1. National Grid Incentives for Lighting: Bright Ideas for Improving Efficiency

Details:

This incentive offered by National Grid is for small businesses seeking to upgrade to more efficient lighting. The can provide financial incentives that covers up to 45% of the cost. The amount of money depends on what lighting system you are upgrading to.

Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706.

For more information you can visit:

http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-retrofit-lighting-national-grid

4.2. National Grid Incentives for Lighting: Retrofit Controls

Details:

This incentive program offered by National Grid focuses on small businesses seeking to upgrade to more efficient lighting control systems. Different incentive amounts are offered per fixture for different control devices that are installed.

Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706. Other lighting control systems may be available, but you must contact your National Grid Representative for details.

For more information you can visit:

http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-lighting-retrofit-controls-national-grid

5. Calculations

5.1. Recommendation 1 – CFL Upgrade

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Room	Light	Number	kWh Per Week	kWh Per Week After Upgrading to CFL		Electricity Cost		Savings	$	kWh			
2	Stage Floor	Small Spot Light	36	151.2	151.2		0.18		Week	$22.74	126.35			
3		Incandescent Bulb	5	25.2	5.46				Month	$90.97	505.4			
4	Bar	Incandescent Bulb	4	20.16	4.36				Year	$1,091.66	6064.8			
5	Game Floor	Fluorescent Tube	10	33.6	33.6									
6		T4 Lamp	4	33.6	33.6									
7	Smoking Deck	Incandescent Bulb	4	10.08	2.18									
8		Small Lamp	8	33.6	33.6									
9	Men's Bathroom	Incandescent Bulb	4	20.16	4.37									
10	Women's Bathroom	Incandescent Bulb	4	20.16	4.37									
11	Back Storage	Incandescent Bulb	4	20.16	4.37									
12	Ice Machine Room	Incandescent Bulb	2	10.08	2.18									
13	Freezer Room	Incandescent Bulb	5	25.2	5.46									
14	Office	Fluorescent Tube	3	10.08	10.08									
15		Incandescent Bulb	2	10.08	2.18				Light	Number	Watts Per Bulb	$ Per Bulb	Total	
16			Week	423.36	297.01				CFL Bulb	34	13	$2.49	$84.66	
17			Month	1693.44	1188.04									
18			Year	20321.28	14256.48									
19														

5.2. Recommendation 2 – Decrease Usage

	A	B	C	D	E	F	G	H	I	J	K	L
1	Room	Light	Number	kWh Per Week	kWh Per Week - No Reduction		Electricity Cost		Savings	$	kWh	
2	Stage Floor	Small Spot Light	36	151.2	151.2		0.18		Week	$10.43	57.96	
3		Incandescent Bulb	5	25.2	25.2				Month	$41.73	231.84	
4	Bar	Incandescent Bulb	4	20.16	20.16				Year	$500.77	2782.08	
5	Game Floor	Fluorescent Tube	10	33.6	33.6							
6		T4 Lamp	4	33.6	33.6							
7	Smoking Deck	Incandescent Bulb	4	10.08	10.08							
8		Small Lamp	8	33.6	33.6							
9					kWh Per Week - Reduce Usage By 50%							
10	Men's Bathroom	Incandescent Bulb	4	20.16	10.08							
11	Women's Bathroom	Incandescent Bulb	4	20.16	10.08							
12	Back Storage	Incandescent Bulb	4	20.16	10.08							
13	Ice Machine Room	Incandescent Bulb	2	10.08	5.04							
14	Freezer Room	Incandescent Bulb	5	25.2	12.6							
15	Office	Fluorescent Tube	3	10.08	5.04							
16		Incandescent Bulb	2	10.08	5.04							
17			Week	423.36	365.4							
18			Month	1693.44	1461.6							
19			Year	20321.28	17539.2							
20												

5.3. Recommendation 3 – Occupancy Sensors

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Room**	**Light**	**Number**	**kWh Per Week**	**kWh Per Week**		**Electricity Cost**		**Savings**	**$**	**kWh**		
2	Stage Floor	Small Spot Light	36	151.2	151.2		0.18		**Week**	$15.65	86.94		
3		Incandescent Bulb	5	25.2	25.2				**Month**	$62.60	347.76		
4	Bar	Incandescent Bulb	4	20.16	20.16				**Year**	$751.16	4173.12		
5	Game Floor	Fluorescent Tube	10	33.6	33.6								
6		T4 Lamp	4	33.6	33.6								
7	Smoking Deck	Incandescent Bulb	4	10.08	10.08								
8		Small Lamp	8	33.6	33.6								
9					**kWh Per Week - Occupancy Sensors Installed (75% Reduction)**								
10	Men's Bathroom	Incandescent Bulb	4	20.16	5.04								
11	Women's Bathroom	Incandescent Bulb	4	20.16	5.04								
12	Back Storage	Incandescent Bulb	4	20.16	5.04								
13	Ice Machine Room	Incandescent Bulb	2	10.08	2.52								
14	Freezer Room	Incandescent Bulb	5	25.2	6.3								
15	Office	Fluorescent Tube	3	10.08	2.52				**Sensor**	**Number**	**$ Per Sensor**	**Total**	
16		Incandescent Bulb	2	10.08	2.52				Occupancy	6	$28.00	$168.00	
17			**Week**	423.36	336.42								
18			**Month**	1693.44	1345.68								
19			**Year**	20321.28	16148.16								
20													

5.4. Recommendation 4 – LED Upgrade

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Room**	**Light**	**Number**	**kWh Per Week**	**kWh Per Week After Upgrading to LED**		**Electricity Cost**		**Savings**	**$**	**kWh**			
2	Stage Floor	Small Spot Light	36	151.2	151.2		0.18		**Week**	$34.21	190.04			
3		Incandescent Bulb	5	25.2	3.78				**Month**	$136.83	760.16			
4	Bar	Incandescent Bulb	4	20.16	3.02				**Year**	$1,641.95	9121.92			
5	Game Floor	Fluorescent Tube	10	33.6	13.44									
6		T4 Lamp	4	33.6	5.37									
7	Smoking Deck	Incandescent Bulb	4	10.08	3.02									
8		Small Lamp	8	33.6	33.6									
9	Men's Bathroom	Incandescent Bulb	4	20.16	3.02									
10	Women's Bathroom	Incandescent Bulb	4	20.16	3.02									
11	Back Storage	Incandescent Bulb	4	20.16	3.02									
12	Ice Machine Room	Incandescent Bulb	2	10.08	1.51									
13	Freezer Room	Incandescent Bulb	5	25.2	3.78									
14	Office	Fluorescent Tube	3	10.08	4.03									
15		Incandescent Bulb	2	10.08	1.51				**Light**	**Number**	**Watts Per Bulb**	**$ Per Bulb**	**Total**	
16			**Week**	423.36	233.32				LED Bulb	34	9	$30.00	$1,020.00	
17			**Month**	1693.44	933.28				LED Tube	17	16	$70.00	$1,190.00	
18			**Year**	20321.28	11199.36								$2,210.00	
19														

5.5. Recommendation 5 – LED Stage Lights

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Room**	**Light**	**Number**	**kWh Per Week**	**kWh Per Week After Upgrading to LED**		**Electricity Cost**		**Savings**	**$**	**kWh**		
2	Stage	Par 56	24	21.6*	1.22*		0.18		**Week**	$3.67	20.38		
3			**Week**	21.6	1.22				**Month**	$14.67	81.52		
4			**Month**	86.4	4.88				**Year**	$176.08	978.24		
5			**Year**	1036.8	58.56								
6													
7													
8													
9	*Assuming an Average Use of 12 Hours a Month												
10	or 4 3-Hour Long Shows a Month												
11													
12									**Light**	**Number**	**Watts Per Bulb**	**$ Per Bulb**	**Total**
13									LED Par 56	24	17	$98.00	$2,352.00
14													

6. Data Gathered

Lighting

What to Look For	Yes / No	Comments
Is lighting in unoccupied areas switched off and all non-essential lighting is switched off outside of business hours?	No.	The lights in several low traffic areas are kept on during all business hours.
Ensure blinds are open when there is sufficient daylight available. Can the lights be turned off in order to make better use of incoming daylight?	No.	Windows are small and do not allow in enough sunlight to be used as a primary lighting source.
Are there any inefficient bulbs, such as tungsten, being used? Can these be upgraded to LED or CFL?	Yes.	Many of the bulbs used are inefficient incandescent bulbs. Possibility of replacing with CFL or LED.
Can light sensors be installed in rooms that are not always occupied, such as store rooms or bathrooms?	Yes.	Rooms such as bathrooms and storage areas have the potential for light sensors.
Are windows, skylights, etc being kept clean?	Yes.	
Are any rooms being over lighted or under lighted?	No.	

Heating / Cooling

What to Look For	Yes / No	Comments
Are radiators and other heating surfaces unobstructed?	No.	
Are windows and doors closed where possible when heating or air conditioning is operating?	Yes.	
Is the air temperature close to the recommended average of 70°F?	Above average.	Customer area is above average. The back storage areas are very overheated due to the heat given off by the equipment.

Electrical Equipment

What to Look For	Yes / No	Comments
Is equipment, such as computers and printers, turned off over night?	Yes.	
Is nonessential equipment, such as printers and copiers, kept shut off until needed?	No.	
Can any equipment be switched on later and switched off earlier?	No.	

Existing Lighting Fixtures

Location	Light Type	Number of Units	Watts Per Bulb	Hours Used Per Week	kWh Per Week	Lux Reading
Stage	Par 56	24	300w	Varies.	Varies.	
Stage Floor	Small Spot Light	36	50w	84	151.2	40-100
	Incandescent Bulb	5	60w	84	25.2	
	Par 56	6	300w	Varies.	Varies.	
Bar	Incandescent Bulbs	4	60w	84	20.16	
Game Floor	Fluorescent Tube	10	40w	84	33.6	30-80
	T4 Lamp	4	100w	84	33.6	
Smoking Deck	Incandescent Bulb	4	60w	42 (On at Night)	10.08	
	Small Lamp	8	100w	42 (On at Night)	33.6	
Men's Bathroom	Incandescent Bulb	4	60w	84	20.16	
Women's Bathroom	Incandescent Bulb	4	60w	84	20.16	
Back Storage	Incandescent Bulb	4	60w	84	20.16	
Ice Machine Room	Incandescent Bulb	2	60w	84	10.08	
Cooler Room	Incandescent Bulb	5	60w	84	25.2	
Office	Fluorescent Tube	3	40w	84	10.08	
	Incandescent Bulb	2	60w	84	10.8	
Underneath	Incandescent	3	60w	Varies.	Varies.	

Storage	Bulb					

Existing Electronic Equipment

Location	Equipment	Make / Model	Number of Units	Wattage	Hours Used Per Week	kWh Per Week
Stage Floor	Projector	Sharpvision	1	340w	Varies.	Varies.
	TV	Samsung	2	90w	12	2.16
	Cash Register	N/A	1	48w	Varies.	Varies.
Bar	Cable Box	Comcast	6	5w	24	0.72
	Cable Box	Direct TV	4	5w	24	0.48
	Amp	Crown Power Tech 2	1	320w	Varies.	Varies.
	Cash Register	Positouch	4	90.25	12	4.33
	Receipt Printer	Epson TMT88 III	4	28.8	12	1.38
	Cooler	True Value	2	1253.5w	24	60.16
Game Floor	Casino Machine	Vortex JVL	1	70w	24	1.68
	Pool Table	Great American	3		Varies.	Varies.
	Shuffleboard Table	Champion	1		Varies.	Varies.
	Minibank ATM	RBS WorldPay	1		24	
	TV	Multisync LCD	2		12	
Men’s Bathroom	Hand Dryer	N/A	1	2400w	Varies.	Varies.
Women’s Bathroom	Hand Dryer	N/A	1	2400w	Varies.	Varies.
Back Storage	Washer	Whirlpool LSR 7233F	2	120v/240v, 23a	Varies.	Varies.
	Washer	Ecolab ES-1000W	1	1518w	Varies.	Varies.
	Fridge	Jenn-Air	1	1081w	24	25.94
Ice Machine Room	Ice Machine	Manitowoc 400	1	2200w	0	0
	Ice Machine	Manitowoc 5570	1	2200w	0	0
	Ice Machine	Hoshizaki C	1	3200w	24	76.8

Cooler Room						
Office	Computer	Dell Optiplex 755	1	280w	12	3.36
	Computer	Dell Optiplex 330	2	280w	12	6.72
	Fax	Brother Intellifax 775	1	Max = 170w Standby = 5w	24 (Standby)	0.12
	Printer	HP Deskjet 6940	1	50w	12	0.6
	Printer	Epson Stylus C120	1	Max = 15w Standby = 2w	12	0.18
	Cable Box	Motorola	1	5w	24	0.12
	TV	Sharp	1	90w	Varies.	Varies.
	Monitor	Dell	2	140w	12	3.36
Underneath Storage	Beer Cooling System	Glycol	1	805w	24	19.32

Appendix A – Energy Efficiency Walk-in Cooler Checklist

AHRI Air-Conditioning, Heating, and Refrigeration Institute

Energy Efficient Walk-In Coolers and Freezers Checklist

To optimize the performance of walk-in coolers and freezers, a new federal law prescribes a series of measures to improve their efficiency. To be compliant with the law, the checklist below lists those measures that should be followed for equipment manufactured after Jan. 1, 2009.

The federal regulation only applies to walk-in coolers and freezers that have a total chilled storage area of less than 3,000 square feet. Regulated coolers also must achieve temperatures above 32 degrees Fahrenheit and regulated freezers must achieve temperatures at or below 32 degrees. The regulation does not apply to products that are designed and marketed exclusively for medical, scientific or research purposes. It also does not apply to units manufactured prior to Jan. 1, 2009, but equipment owners interested in boosting the efficiency of their existing walk-ins can use the checklist to identify opportunities to make energy-saving improvements.

DESIGN STANDARDS:

Doors

☑ Automatic door closers that firmly close all walk-in doors if they are within one inch of the closed position. This requirement does not apply to doors wider than 3 feet 9 inches or taller than 7 feet.

☑ Strip doors, spring-hinged doors or other measures to minimize air infiltration when doors are open.

Insulation

☑ Insulation of walls, ceiling and doors of at least R-25 for coolers and R-32 for freezers.

☑ Floor insulation of at least R-28 for freezers.

Motors

☑ For evaporator fan motors under one horsepower and less than 460 volts, use either electronically commutated motors (brushless direct current motors) or three-phase motors.

☑ For condenser fan motors under one horsepower, use either electronically commutated motors, permanent split capacitor-type motors or three-phase motors.

Lighting

☑ Lighting with an efficiency of 40 lumens per watt or more, including ballast losses or occupancy sensors that turn lights off within 15 minutes if the walk-in is unoccupied.

Glass

☑ For coolers, use double-pane with heat-reflective treated glass and gas fill or triple-pane with either heat-reflective treated glass or gas fill.

☑ For freezers, use triple-pane with either heat-reflective treated glass or gas fill.

Anti-sweat Heater on Transparent Reach-in Doors

☑ Walk-ins with anti-sweat heaters on transparent reach-in doors, but without anti-sweat heat controls, must have a total door rail, glass and frame heater power draw of no more than 7.1 watts per square foot of door opening for freezers and 3.0 watts per square foot of door opening for coolers.

☑ Anti-sweat heat controls on walk-ins with anti-sweat heaters on transparent reach-in doors and a total door rail, glass and frame heater power draw of more than 7.1 watts per square foot of door opening for freezers, and 3.0 watts per square foot of door opening for coolers — must reduce the units energy use in an amount corresponding to the relative humidity in the air outside the door or to the condensation on the inner glass pane.

Appendix J: Office Audit Report

Office Audit Report

Nantucket Project Center 2011

A Worcester Polytechnic Institute Interactive Qualifying Project

Authors

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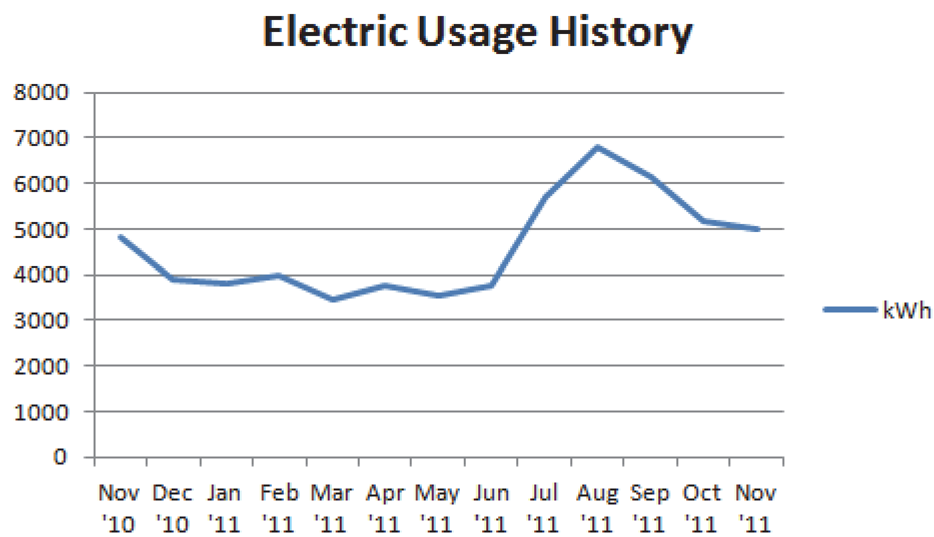
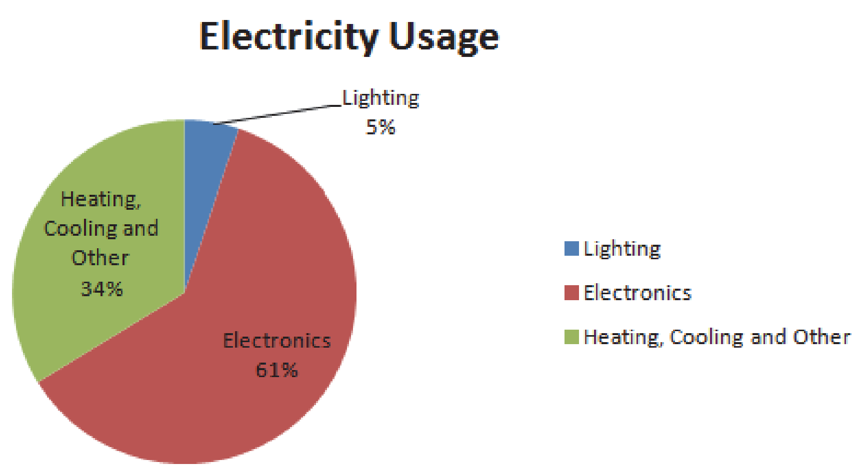
Summary





Recommendation	$ Savings Per Year	kW Savings Per Year	Initial Cost	Payback Period
Electronics Power Management	$2,587.20	134.83kW	$0-500	Immediate to 3 months
CFL Upgrade	$1,044.28	37.41	$204.18	3 months
Lighting Control System	$78.63 +	2.817 +	$0-28	Immediate to 5 months
Temperature Control System	N/A	N/A	N/A	N/A
LED Upgrade	$1,571.84	56.31	$9,110.00	6 Years
Total	$5281.95	231.367	$9314.18-9842.18 (Before Incentives)	

General Information

Audit Conducted By:	Roberto Alvarado, Corey Phillips, JB Taleb
Date Conducted:	Friday, November 11, 2011
Areas / Rooms Inspected:	Basement, 1st Floor Office Space and bathroom, 2nd Floor Office Space, 2nd Floor Small Office, 2nd Floor Server Room and bathroom, Attic
Business Hours:	Mon-Thurs: 8:30am-4:30pm Fri: 8:30am-4:00pm

Office Report

1. Introduction

The purpose of this energy audit was to identify areas of potential energy reduction and cost savings in the Office building. The audit conducted was a modified Level 2 audit that consisted of a walk-through of the building as well as cost analysis calculations…

2. Summary of Findings

During the walk-through portion of our audit of the Office building, we were able to identify several areas where energy efficiency can be improved.

2.1 1st Floor Office Space

Lighting was the first concern in the main office space on the first floor. The office space is lit by 38 fixtures, each housing 2 fluorescent tubes. The fixtures were in rows of 3, where the first 9 rows were controlled by 3 switches, and the remaining lights are controlled by 1 switch. In order to determine the intensity of the light in various areas throughout the room, we took lux readings for 2 different scenarios. In the front of the room with the first 3 rows of lights turned off the reading was about 175 lumens. This area sees a decent amount of sunlight from the front windows. Throughout the room with the lights turned on the lux reading was about 500 lumens. This is normal for an office environment.

There is a considerable amount of office equipment in this area, and was the next focus of the audit. This room contained 18 monitors, 14 printers and scanners, 14 computers, 15 phones, 1 shredder and 1 typewriter.

This temperature is controlled by forced hot water and 2 air conditioning units installed on the wall.

2.2 1st Floor Bathroom

This was a small, single person bathroom being lit by 2 incandescent bulbs. The lights were turned off during the audit.

2.3 Basement

The basement is used for storage, and is lit by 4 incandescent bulbs and 9 fixtures housing 2 fluorescent tubes each. The stairs leading down to the basement are lit by another incandescent bulb. The lux reading was 100 lumens in the brightest area, however dropped dramatically as we moved towards the back of the space. The lights were turned off before and after we left.

The basement contained some important electrical equipment for normal business operation. This includes telephone system equipment with a backup, and a modem with an Ethernet switch.

2.4 2rd Floor Stairwell and Hallway

The stairs leading to the 2nd floor and the main hallway on that floor are lit by 3 incandescent spotlight bulbs plus an additional incandescent bulb at the bottom of the stairs. The additional bulb is individually controlled. The hallway also contains 2 lamps using a total of 4 incandescent bulbs. The lamps were kept off during the audit.

2.5 2nd Floor Back Office/Server Room

The back office area on the second floor that contained the servers was lit by 12 incandescent spotlight bulbs. These were on 3 switches and are equipped with dimmers. The lux reading in the room was about 173 lumens. There was also a fluorescent tube above the servers which was double the normal length.

This room contains electronic equipment that has high consumption. This includes 2 computers, 3 monitors, 3 phones, 1 printer, 2 Ethernet switches, 4 servers, and 3 backup systems. Out of all of these components, the servers and the backup systems consume the most electricity.

2.6 2nd Floor Bathroom and Adjacent Hallway

Directly outside of the bathroom is a small hallway lit by 2 incandescent spotlight bulbs. The bathroom itself is lit by a total of 4 incandescent spotlight bulbs. These 4 bulbs are spread out throughout the sink and toilet area and are on separate switches respectively. These lights were turned off during the audit, while the 2 bulbs outside the bathroom were on.

2.7 2nd Floor Small Office

This is the single office that connects the server room with the front office space on the 2nd floor. This room was lit by 4 ceiling fixtures. 3 of these fixtures had incandescent spotlight bulbs, while 1 had a standard incandescent bulb. There was also a desk lamp which uses 2 incandescent bulbs. The lux reading in this room was about 75 lumens.

As this office was small, there was not a lot of office equipment to account for. The room has 1 computer, 1 monitor, 1 phone, 1 printer, 1 backup system, 1 internet modem, and 2 Ethernet switches.

2.8 2nd Floor Front Office Space

This office area is lit by 15 incandescent spotlights controlled by 3 switches. 2 walls of the room are covered with windows. When the row of lights closest to one of the walls of windows is turned off the lux reading was about 30 lumens. When all the lights are on the reading was between 80 and 100 lumens. There were also four desk lamps each housing 3 incandescent bulbs, and one desk lamp with a single incandescent bulb, which are used as needed.

Similar to the first floor office space, this room contains a multitude of electronic equipment. The room had 1 water cooler, 2 servers, 8 monitors, 7 computers, 7 phones, and 6 backup systems. These computers are left running during non business hours.

2.9 2nd Floor Conference Room

This small room is lit by 4 incandescent spotlight bulbs. During the audit, lights in this room were on. The lux reading in this room was normal, however the lights were left on even when the room was not in use.

There is limited electronic equipment inside the conference room. There was 1 computer, 1 printer, and 1 phone. The air conditioning units installed in the building do not affect this room, however there was a fan installed on the wall.

2.10 3rd Floor Stairwell and Attic

The stairwell leading to the attic was lit by 2 incandescent spotlight bulbs. The attic space contained 10 incandescent bulbs. All lights in the attic were controlled by one switch with the exception of one light controlled by a pull cord. These lights were turned off, and only used when access to the attic or roof is necessary.

3. Recommendations

The recommendations are organized by priority. The tables below show what should be considered when moving forward.

Priority #1 – Electronics Power Management			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$2,587.20	134.8332 kW	$0-$500	Immediate to 3 months
Details:	The computers in the 2nd floor office area are left on all day. Shutting down these computers when not in use can provide significant savings. By turning off these computers and the backup systems supporting them electricity consumption can be reduced by 134.83kW per year. This requires no initial investment, so the payback period would be immediate. Another power management option is to completely unplug all computers, monitors, and printers, as well as any backup systems associated with them at the end of the work day. This would be most easily completed by purchasing power strips; one for each computer station. All of the electronics mentioned should be plugged into these strips, and the strips switched off at night. All of these devices have a ‘phantom load,’ which is a constant draw of power even when a device is turned off. The only way to avoid this is to completely unplug the equipment. There is no data on the phantom load for calculations. Please see calculations for more power strip cost information.		

	Backup systems for computers account for significant electricity consumption. Although it is not advised to unplug backups associated with servers, those connected to computers should be unplugged when the computer is not in use. Please refer to calculations for an example of backup system savings.

Priority #2 – Upgrade to CFL Light Bulbs			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$1,044.28	37.4109 kW	$204.18	3 months
Details:	Most of the lighting in the building was fluorescent tubes, which are already fairly efficient. This upgrade applies to all of the other bulbs in the building, including desk lamps. This recommendation would have a significant effect on the electricity bill with a reasonably short payback period. We took a look at the savings incurred if all incandescent bulbs are switched out for CFLs. For our calculations, we used an Eiko 00031 SP13/27K 13 Watt Compact Fluorescent Spiral Light Bulb that can be purchased online for $2.50 per bulb. The light produced by this bulb is identical to that of a 60w incandescent. There is also an incentive program offered by National Grid that can help cover the initial cost of changing bulbs. The details of this incentive can be found in the incentives section		

Priority #3 – Lighting Control Systems			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$78.63 plus	2.816914286 kW plus	$0 to $28	5 Months
Details:	Lighting accounts for a large chunk of electricity usage in almost all small businesses. At the Office building, lighting accounts for 254.552 kWh per week. Certain areas inside the building can have a better controlled lighting system. Many sensors are available that will automatically adjust the lighting when it is not needed. There are a few possible areas of the building where lighting usage can be more controlled. Starting with the 1st floor office space, we will examine the front 3 rows of lights, which are controlled by 1 switch. A sensor would be unnecessary here, however behavioral changes could have a significant effect. The front of the building sees a decent amount of sunlight that could be better utilized. Turning off the front section of lights on a sunny day would provide immediate savings. The amount saved varies depending on the amount of off time, but a 60% reduction in use would provide $78.63 a year in savings. The 2nd floor front office space also provides an opportunity for lighting reduction. Turning off the row of lights closest to the window would produce slightly lower savings than the 1st floor, but the idea is the same.		

	The next area of focus is the 2nd floor back office area. These lights are already controlled by dimmers. More efficient use of this feature will provide in immediate savings. The lights should be dimmed whenever there is adequate sunlight. The amount saved will depend on how often and to what extent the lights are dimmed. The final area is the 2nd floor conference rooms. These lights were on during the audit, although the room was not in use. This would be an acceptable space for an occupancy sensor. Lighting usage could also be controlled manually, but a sensor would make things easier. An occupancy sensor costs around $28 and is easy to install. The amount saved will depend on how often the room is used. The calculations can be found in section 5. For lights that can be shut off when they are not needed, we assumed that these lights would receive a 60% reduction in use.

Priority #4 – Temperature Control Systems				
Cost Saving Per Year		Energy Savings Per Year	Investment Cost	Payback Period
N/A		N/A	N/A	N/A
Details:	The building is already equipped with programmable thermostats to regulate the temperature. During the audit, we noticed that the temperature was set pretty high. Even a 5% change in temperature can result in up to 20% reduction in the electricity bill. Having the air conditioning and heating system serviced regularly can also provide savings. For more information of programmable thermostat operation, please visit http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=TH			

Priority #5 – Upgrade to LED Lighting				
Cost Saving Per Year		Energy Savings Per Year	Investment Cost	Payback Period
$1,571.84		56.31043 kW	$9,110.00	6 Years
Details:	LED lighting is currently one of the most energy efficient lighting systems. However, to replace all the lights in the building would require a large initial investment. The main light system already installed in the building consists of energy efficient fluorescent tube bulbs. We estimated that switching to LED lighting would cut the power consumption in half but would have a large payback period. This is why we consider this a priority 5 suggestion. One possible way to go about replacing the fluorescent lights with LED lights is to replace them as they burn out. This would stretch the initial investment out across a long period of time. LED bulbs also have a much longer lifespan than fluorescent bulbs, which may justify the reason to invest in them. LED lights are estimated to have a 30,000+ hour lifespan while fluorescents have about 8,000 hour lifespan. The calculation can be found in section 5. After browsing around the various LED			

	choices available, we came to a conclusion that the wattage of the LED bulbs, on average, are half that of the currently installed fluorescent lights. In terms of pricing, we took the average of several different bulbs that could be used to replace the current ones. This resulted in a $70 average for tube lights and $30 for bulbs. See section 4 for a possible incentive that can be used to subsidize some on the initial costs of installing LED lighting.

4. Available Incentives

There are several incentives available to small business owners who are looking to upgrade existing equipment in order to increase the energy efficiency of the building.

4.1. National Grid Incentives for Lighting: Bright Ideas for Improving Efficiency

Details:

This incentive offered by National Grid is for small businesses seeking to upgrade to more efficient lighting. The can provide financial incentives that covers up to 45% of the cost. The amount of money depends on what lighting system you are upgrading to.

Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706.

For more information you can visit:

http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-retrofit-lighting-national-grid

4.2. National Grid Incentives for Lighting: Retrofit Controls

Details:

This incentive program offered by National Grid focuses on small businesses seeking to upgrade to more efficient lighting control systems. Different incentive amounts are offered per fixture for different control devices that are installed.

Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706. Other lighting control systems may be available, but you must contact your National Grid Representative for details.

For more information you can visit:

http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-lighting-retrofit-controls-national-grid

5. Calculations

5.1 Recommendation 1

	A	B	C	D	E	F	G	H	I	J
1	**Equipment**	**Number**	**Current kWh Per Week**	**Recommended Upgrade kWh Per Week**	**kWh Savings**	**Savings/Week**	**Savings/Month**	**Savings/Year**	**kW Savings/Year**	
2	Computers	7	312.48	73.47	239.01	$43.02	$172.09	$2,065.05	73.97929	
3	Backups	5	257.04	60.435	196.605	$10.88	$43.51	$522.16	60.85393	
4										
5	Total	12	569.52	133.905	435.615	$53.90	$215.60	$2,587.20	134.8332	
6										
7	Power Strips Range		$7-$20							
8	Number of Strips Needed		25							
9	TotalPrice Range		$175-$500							

5.2 Recommendation 2

	A	B	C	D	E	F	G	H	I	J
1	**Light Type**	**Number**	**Current kWh Per Week**	**CFL kWh Per Week**	**kWh Savings**	**Weekly $ Savings**	**Monthly $ Savings**	**Yearly $ Savings**	**kW Savings/Year**	
2	Tube	95	100.738	100.738	0	$0.00	$0.00	$0.00	0	
3	Bulbs	82	153.814	32.948	120.866	$21.76	$87.02	$1,044.28	37.4109	
4	Electricity Rate: $0.18/kWh									
5										
6	**Light**	**Number**	**Watts Per Bulb**	**$ Per Bulb**	**Total**					
7	CFL Bulb	82	13	$2.49	$204.18					
8										
9										
10	**Total Cost to switch to CFL bulbs**			$204.18						
11	**Payback Period (Months)**			2.346262252						
12										
13	* usage average of 4 hours per week for basement and attic access									
14	*usage of bathroom about 10 minutes per day per employee, divided umungst 2 bathrooms									

5.3 Recommendation 3

	A	B	C	D	E	F	G	H	I	J	K
1		**Light Type**	**Number**	**Wattage**	**Hours Less Used Per Week**	**kWh Per Week**	**kWh Savings**	**Savings/Week**	**Savings/Month**	**Savings/Year**	**kW Savings/Year**
2	1st Floor Office Space										
3	Turn off Front Light Switch	Fluorescent Tube	18	32	23.7	13.6512	9.1008	$1.64	$6.55	$78.63	2.816914286

5.4 Recommendation 4

No calculations used for Recommendation 4

5.5 Recommendation 5

	A	B	C	D	E	F	G	H	I
1	**Light**	**Number**	**Current kWh Per Week**	**LED kWh Per Week**	**kWh Savings**	**Weekly $ Savings**	**Monthly $ Savings**	**Yearly $ Savings**	**Yearly kW Savings**
2	Fluorescent Tube	95	100.738	49.816	50.922	$9.17	$36.66	$439.97	15.76157143
3	Bulbs	82	153.814	22.81	131.004	$23.58	$94.32	$1,131.87	40.54885714
4									
5	Total	177	254.552	72.626	181.926	$32.75	$130.99	$1,571.84	56.31042857
6									
7	Electricity Rate: $0.18/kWh								
8									
9	**Light**	**Number**	**Watts Per Bulb**	**$ Per Bulb**	**Total**				
10	LED Bulb	82	9	$30.00	$2,460.00				
11	LED Tube	95	16	$70.00	$6,650.00				
12									
13									
14	**Total Cost to switch to LED Lighting**			$9,110.00					
15	**Payback Period (Years)**			5.795752933					
16									
17	* usage average of 4 hours per week for basement and attic access								
18	*usage of bathroom about 10 minutes per day per employee, divided umungst 2 bathrooms								

6. Data Gathered

Lighting

What to Look For	Yes / No	Comments
Is lighting in unoccupied areas switched off and all non-essential lighting is switched off outside of business hours.	Yes	All lights are turned off during non-business hours. Some unnecessary lights were on in unoccupied rooms
Ensure blinds are open when there is sufficient daylight available. Can the lights be turned off in order to make better use of incoming daylight?	Yes	Blinds were open. Possibility of turning off lights in main office spaces near windows to utilize sunlight more.
Are there any inefficient bulbs, such as tungsten, being used? Can these be upgraded to LED or CFL?	No	Most light bulbs used were incandescent or fluorescent tubes, which could be upgraded to LED or CFL
Can light sensors be installed in rooms that are not always occupied, such as store rooms or bathrooms?	Yes	Motion sensors could be utilized in the server room and second floor conference room, as traffic in there is limited.
Are windows, skylights, etc being kept clean?	Yes	None
Are any rooms being over lighted or under lighted?	Yes	All rooms are equipted with either dimmers or multiple switches, some of which can be turned off.

Heating / Cooling

What to Look For	Yes / No	Comments
Are radiators and other heating surfaces unobstructed?	Yes	Radiators are located under windows, unobstructed.
Are windows and doors closed where possible when heating or air conditioning is operating?	No	Windows upstairs and front door were left open while heat was on.
Is the air temperature close to the recommended average of 70°F?	No	Air temperature in all areas was above average.
Is the heating controlled by a programmable thermostat?	Yes	Separate thermostats for heating and cooling units.

Is the heating system / air conditioner receiving scheduled maintenance?	Yes	Boiler was last serviced on 11/7/11.
If there is a roof space, is it insulated?	No	Attic is used just for storage, insulation is not necessary.
Is heating on in unused spaces, such as corridors or low traffic areas.	Yes	Heating is on in entire building.

Electrical Equipment

What to Look For	Yes / No	Comments
Is equipment, such as computers and printers, turned off over night?	Some	Some of the machines are powered down overnight, while some remain on all the time.
Is nonessential equipment, such as printers and copiers, kept shut off until needed?	No	Printers and scanners are left on all day during business hours.
Can any equipment be switched on later and switched off earlier?	Yes	Printers and scanners can be turned off until needed.

Existing Lighting Fixtures

Location	Light Type	Number of Units	Watts Per Bulb	Hours Used Per Week	kWh Per Week	Lux Reading
Basement	Incandescent Bulb	5	100	As Needed	Varies	100
	Fluorescent Tubes	18	32	As Needed	Varies	
1st Floor Office Space	Fluorescent Tubes	76	32	39.5	96.064	Varies from 175-675 depending on location
1st Floor Bathroom	Incandescent Bulbs	2	100	As Needed	Varies	N/A
2nd Floor Server Room	Incandescent Spotlights	14	60	39.5	33.18	173
	Fluorescent Tube	1 (double length)	60	39.5	2.37	
2nd Floor Bathroom	Incandescent Spotlights	4	60	As Needed	Varies	N/A
2nd Floor Hallway and	Incandescent Bulbs	2	71	As Needed	Varies	N/A

Stairwell	Incandescent Spotlights	3	60	39.5	7.11	
	Incandescent Bulbs	1	60	39.5	2.37	
		2	60	As Needed	Varies	
2nd Floor Small Office	Incandescent Spotlights	3	60	39.5	7.11	75
	Incandescent Bulbs	3	60	39.5	7.11	
2nd Floor Office Space	Incandescent Spotlights	15	60	39.5	35.55	Varies from 30-100 depending on location
	Incandescent Bulbs	12	60	As Needed	Varies	
	Incandescent Bulbs	1	40	As Needed	Varies	
2nd Floor Conference Room	Incandescent Spotlights	4	60	39.5	9.48	80
3rd Floor Stairwell	Incandescent Spotlights	2	60	39.5	4.74	N/A
Attic	Incandescent Bulbs	10	60	As Needed	Varies	8

Existing Extra Heating / Cooling Equipment

Location	Equipment	Make / Model	Number of Units	Wattage	Hours Used Per Week	kWh Per Week	Room Temperature
Roof	Air Conditioning Unit	Mitsubishi Electric	1	6205.5-7969.5	As Needed	Varies	N/A
1st Floor Office Space	AC Unit	Mitsubishi Electric Mr. Slim	2	3515.97 - 10547.91	As Needed	Varies	76°-79° F
Basement	Boiler	Weil-McLain	1	N/A	As Needed	Varies	N/A
	Water Pump	Emerson SA55JXFSN-3748	1	391W	As Needed	Varies	N/A
Attic	Heating Pump	ARUF060-00A-1A	1	811.2W	As Needed	Varies	68°F

Existing Electronic Equipment

*Printers and scanners kWh were calculated using 1 hour of running and 38.5 hours of standby

Location	Equipment	Make / Model	Number of Units	Wattage	Hours Used Per Week	kWh Per Week
Basement	Telephone System Component	Lucent Technology Partner	1	480W	168	80.64
	Telephone System Component	Oneac ON1300A	1	Input= 1800W Output= 1296W	168	302.4
	Telephone Back-up System	APC Back-UPS RS 1500	1	1440W	168	241.92
	Ethernet Switch	SMC SMCD3G	1	24W	168	4.032
1st Floor Office Space	Printer	Panasonic UF-7200-AU	2	Max=1000W Standby=9.5W	39.5	2.732
	Scanner	Panasonic KV-S3065C	1	Sleep=8W Standby=72W Scanning=168W	39.5	2.94
	Printer	Konica Minolta Model 200	1	Operation=1380W Standby=20W	39.5	2.15
	Printer	HP LaserJet 4100	1	Printing=465W Standby=21W PowerSave=20W	39.5	1.2735
	Shredder	GBC Shredmaster 1036S	1	652W	1	0.652
	Printer	HP LaserJet 1012	9	Operational=250W Standby/Sleep=2W	39.5	2.961
	Type Writer	IBM Wheelwriter 1000	1	80W	39.5	3.16
	Calculator	Canon MP21D	1	1W	39.5	0.0395
	Computer	Dell Optiplex GX620	5	280W	39.5	55.3
	Computer	Dell Optiplex GX270	3	210W	39.5	24.885
	Computer	Dell Optiplex GX260	4	180W	39.5	28.44
	Computer	Dell Optiplex 320	2	280W	39.5	22.12
	Monitor	Dell	12	Operational = 20W	39.5	9.48

				Standby = 1W		
	Monitor	ViewSonic	3	25W	39.5	2.96
	Monitor	KDS Radius	1	Operational=40W Standby/Sleep=5W	39.5	1.58
	Phone	Avaya Partner-18D	8	25W	168	33.6
	Phone	Lucent Merlin ETR-34D	7	25W	168	29.4
	Window Monitors	Dell	2	150W	168	50.4
Server Room	Computer	Dell Optiplex 360	2	255W	39.5	20.145
	Monitor	Dell	1	Operational = 20W Standby = 1W	39.5	0.79
	Monitor	ViewSonic	1	25W	39.5	0.9875
	Monitor	AccuSync LCD Monitor 52VM	1	23W	39.5	0.9085
	Phone	Avaya Partner-18D	3	25W	168	12.6
	Printer	HP LaserJet 1012	1	Operational=250W Standby/Sleep=2W	39.5	0.327
	Backup	APC Back-UPS ES550	1	330W	168	55.44
	Backup	APC Back-UPS ES750	2	450W	168	151.2
	Server	Poweredge 840	1	420W	168	70.56
	Server	Poweredge 1800	2	650W	168	218.4
	Server	DocStar Server Series 3 Workgroup Pro Edition	1	450W	168	75.6
	Ethernet Switch	IOGear Miniview Ultra PS/2 KVM	1	1.08W	168	0.181
	Ethernet Switch	Linksys SR2016	1	6W	168	1.008
	Mini Fridge	Gorenje	1	144W	168	24.192
	Printer	HP LaserJet 8550	1	862.5W	39.5	34.07
	Printer	HP LaserJet 2300	1	690W	39.5	27.26
	Shredder	GBC Shredmaster	1	920W	1	0.92

		5200S				
2nd Floor Small Office	Computer	Dell Optiplex GX780	1	255W	168	42.84
	Monitor	Samsung	1	20W	39.5	0.79
	Phone	Avaya Partner-18D	1	25W	168	4.2
	Printer	HP Deskjet 6940	1	Operating=50W Standby=3W	39.5	0.1655
	Backup	APC Back-UPS 725	1	450W	168	75.6
	Modem	Comcast	1	24W	168	4.032
	Ethernet Switch	Westell Wirespeed	1	30W	168	5.04
	Ethernet Switch	Xincom VPN Gateway	1	7.5W	168	1.26
2nd Floor Office Space	Server	Poweredge 1900	1	800W	168	134.4
	Server	Poweredge T610	1	870W	168	146.16
	Monitor	KDS Radius	3	Operational=40W Standby/Sleep=5W	39.5	4.74
	Monitor	Dell	4	Operational = 20W Standby = 1W	39.5	3.16
	Monitor	Acer	1	55W	39.5	2.1725
	Computer	Dell Optiplex 380	4	255W	168	171.36
	Computer	Dell Optiplex GX520	1	230W	168	38.64
	Computer	Dell Optiplex 745	2	305W	168	102.48
	Backup	APC Back-UPS 750	1	450W	168	75.6
	Backup	APC Back-UPS 350	2	210W	168	70.56
	Backup	APC Back-UPS 550	2	330W	168	110.88
	Backup	Minuteman UPS Pro 1500E	1	1500W	168	252
	Phone	Avaya Partner-18D	5	25W	168	21
	Phone	Lucent Merlin ETR-34D	2	25W	168	8.4
	Water Cooler	N/A	1	319W	168	53.59
	Printer	Canon PC940	1	720W	39.5	28.44
	Hole Punch	Swingline	1	120W	1	0.12

		Electronic Punch				
	Printer	HP LaserJet 4050N	1	Operation=330W Standby=20W	39.5	1.1
	Fax machine	Brother Intellifax 2820	1	1056W	39.5	41.712
	Printer	HP LaserJet 4200tn	1	Operational=580W Standby=23W	39.5	1.466
	Printer	RICO Aficio MP C3300	1	1500W	39.5	2.27
	Printer	HP Scanjet 4370	1	0.48W	39.5	0.019
2nd Floor Conference Room	Computer	Dell Vostro 200	1	690W	39.5	27.255
	Printer	HP Deskjet 6988	1	Operating=50W Standby=3W	39.5	0.1655
	Phone	Lucent Merlin ETR-34D	1	25W	168	4.2
Attic	Computer	Dell Optiplex 390	1	240W	39.5	9.48
	Phone	Avaya Partner-18D	1	25W	168	4.2

Appendix K: Inn 1 Audit Report

Inn # 1 Audit Report

Nantucket Project Center 2011

A Worcester Polytechnic Institute Interactive Qualifying Project

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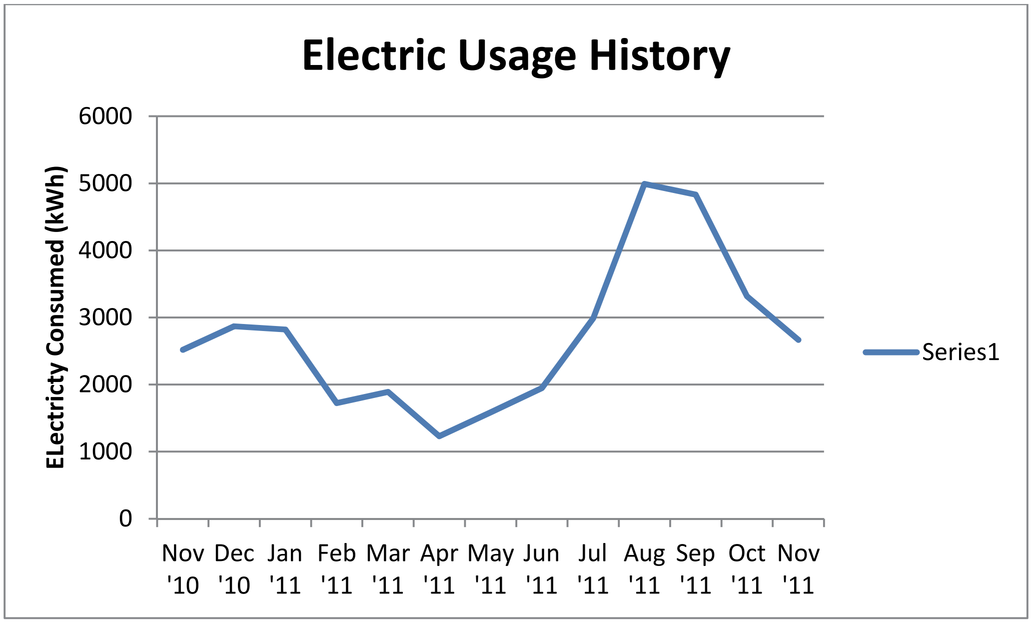
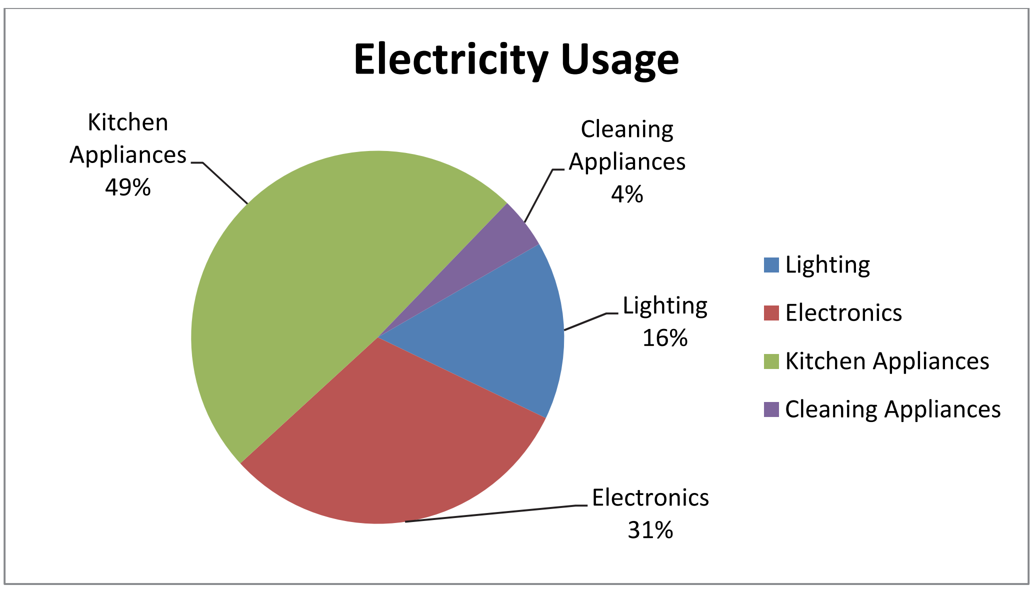
Summary





Recommendation	$ Savings Per Year	kWh Savings Per Year	Initial Cost	Payback Period
CFL Upgrade	$455.44	2741.076 kWh	$200 - $250	5 month – 7 months
Total	$455.44	2741.076 kWh	$200 - $250 (No Incentives) $110 – $137.50 (After Incentives)	

General Information

Audit Conducted By:	Roberto Alvarado, Corey Phillips, JB Taleb
Date Conducted:	Nov 15, 2011
Areas / Rooms Inspected:	First Floor (Foyer, Common Area, Dining Room, Kitchen, Suite, Owner's Room) Second Floor (6 rooms) Third Floor(5 rooms) Basement (Laundry Area, Mini Kitchen, Bed Room)
Business Hours:	…..

Inn # 1 Report

1. Introduction

The purpose of this energy audit was to identify areas of potential energy reduction and cost savings in the Inn # 1 building. The audit conducted was a modified Level 2 audit that consisted of a walk-through of the building as well as cost analysis calculation. The building is a lodging facility mostly in service during the tourist/holiday seasons. While there aren't customers year round, the high influx of tourists during the winter and summer months make this facility a prime example to study the fluctuation of consumption on the island.

2. Summary of Findings

During the walk-through portion of our audit of the building, we were able to identify several areas where energy efficiency can be improved.

2.1 First Floor Foyer, Common Room and Dining Room

This area is the entrance to the facility. Upon walking in we noticed that the only things using electricity at the time were the lights. Although there are other types of electronics and things that could use electricity, these were left off so already we were given the impression that energy is indeed conserved in the facility at least to some degree.

2.2 First Floor: Kitchen, Room behind kitchen, and Suite

The first floor kitchen had a collection of appliances that we recorded. The appliances of most interest to us were the refrigerator and the ice maker because of their constant use. Other appliances like the Bunn coffee maker, the microwave and the toaster were also taken in to account because of their high load capacity when they are in use.

The room behind the kitchen had a few lights on but nothing major running. A computer was running but the computer only runs during the day. There was also a printer along with the computer that was always on. A small amount of savings could be gained from turning it off but nothing substantial. The suite was a large room with a few lights and shades drawn. The lights were on but the TV and stereo system in the room were off. This is the only guest room that actually had a TV.

2.3 Second and Third Floor Guest Rooms

The guest rooms were rather simple. Other than an air conditioner, and an alarm clock, there were really no other electronics in the room that could consume electricity. Lights were off in every room and usually this consisted of a desk lamp, a floor lamp and room lights. The air conditioners were the only things that could consume a significant amount of power at any one time.

2.4 Basement

The basement had three distinct areas. The first area is considered to be the laundry room. The washers and dryers are all brand new and carry the Energy Star seal so those are fine as they are. The second area was a room in the basement used by staff. Nothing that consumed a substantial amount of electricity was left on so good conservation behavior is already practiced here. The last main area was the small kitchen in the basement. A refrigerator was recorded as a major appliance.

3. Recommendations

Upon completion of the Inn # 2 Energy Audit it was determined that the facility already practices good conservational techniques merely through behavior. In addition, the facility does not have many electronics in their inventory that would result in a rise in consumption. Normally multiple recommendations are given based on the results of the report and are listed by suggested priority. However, this report can only find one recommendation to present at this time. Details on the recommendation are listed below.

Priority #1 – CFL Upgrade			
Cost Saving Per Year	Energy Savings Per Year	Investment Cost	Payback Period
$455.44	2741.076 kWh	$200 - $250	5-7 months
Details:	Although it only makes up 16 percent of the overall usage, a CFL upgrade for this facility has the potential for high savings. Most of the lighting comes from 60W incandescent bulbs. However, by merely replacing the bulbs with CFLs which on average use 13W, when multiplied onto the numerous fixtures in the facility, one has the potential to gain a sizable amount of savings. LED lighting was considered at first yet given the high investment cost and the bright white light that emanates from the bulbs. We felt that this upgrade did not fit the inn's needs. The investment cost from LEDs does not justify the savings for this facility nor do we believe that the light from the bulbs reflect the lighting the inn wishes to have. Installation is as simple as replacing a bulb and can even be done by an incentive		

	program, See details in section 4. Calculations for this recommendation can be found in section 5.

4. Available Incentives

There are several incentives available to small business owners who are looking to upgrade existing equipment in order to increase the energy efficiency of the building.

4.1. National Grid Incentives for Lighting: Bright Ideas for Improving Efficiency

Details:

This incentive offered by National Grid is for small businesses seeking to upgrade to more efficient lighting. The can provide financial incentives that covers up to 45% of the cost. The amount of money depends on what lighting system you are upgrading to.

Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706.

For more information you can visit:

http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-retrofit-lighting-national-grid

4.2. National Grid Incentives for Lighting: Retrofit Controls

Details:

This incentive program offered by National Grid focuses on small businesses seeking to upgrade to more efficient lighting control systems. Different incentive amounts are offered per fixture for different control devices that are installed.

Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706. Other lighting control systems may be available, but you must contact your National Grid Representative for details.

For more information you can visit:

http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-lighting-retrofit-controls-national-grid

5. Calculations

5.1 Recommendation 1

	A	B	C	D	E	F	G	H	I	J
1	**Light Type**	**Number**	**Current kWh Per Week**	**CFL kWh Per Week**	**kWh Savings**	**Weekly $ Savings**	**Monthly $ Savings**	**Yearly $ Savings**	**kWh Savings/Year**	
2	Tube	8	0.64	0.64	0	$0.00	$0.00	$0.00	0	
3	Bulbs	99	54	1.287	52.713	$9.49	$37.95	$455.44	2741.076	
4	Electricity Rate: $0.18/kWh									
5										
6	**Light**	**Number**	**Watts Per Bulb**	**$ Per Bulb**	**Total**					
7	CFL Bulb	99	13	$2.49	$246.51					
8										
9										
10	**Total Cost to switch to CFL bulbs**			$246.51						
11	**Payback Period (Months)**			6.495077116						
12										
13										
14										

6. Data Gathered

Lighting

What to Look For	Yes / No	Comments
Is lighting in unoccupied areas switched off and all non-essential lighting is switched off outside of business hours.	No (Hallway only)	Business hours cannot really be taken into account here since the facility is an inn. Lighting in hallways should be on a majority of the time, unused rooms had lighting that was off.
Ensure blinds are open when there is sufficient daylight available. Can the lights be turned off in order to make better use of incoming daylight?	Yes and no	Some rooms had blinds open, others had them closed. Blinds could generally be opened to let in light, however, the decision to do this usually lies on the guests of each room. Other rooms had the issue that sunlight did not provide enough illumination so lights had to be used.
Are there any inefficient bulbs, such as tungsten, being used? Can these be upgraded to LED or CFL?	Yes	A good majority of the bulbs used were indeed incandescent bulbs. It is possible that most of the savings can be made here.
Can light sensors be installed in rooms that are not always	Yes/No	This may be difficult to actually implement since it cannot be

occupied, such as store rooms or bathrooms?		used in areas like the hallway, foyer or rooms.
Are windows, skylights, etc. being kept clean?	Yes	Windows are being kept clean
Are any rooms being over lighted or under lighted?	No	It seemed that none of the rooms were being over lit which is a good indicator. One room in particular did score an above recommended lux reading, however, this was due to sunlight in the room; no other lights were on at that time.

Heating / Cooling

What to Look For	Yes / No	Comments
Are radiators and other heating surfaces unobstructed?	Yes	
Are windows and doors closed where possible when heating or air conditioning is operating?	Yes	Certain doors have poor closings
Is the air temperature close to the recommended average of 70°F?	Yes	
Is the heating controlled by a programmable thermostat?	Yes	
Is the heating system / air conditioner receiving scheduled maintenance?	N/A	
If there is a roof space, is it insulated?	Yes	
Is heating on in unused spaces, such as corridors or low traffic areas.	No	

Electrical Equipment

What to Look For	Yes / No	Comments
Is equipment, such as computers and printers, turned off over night?	Yes	
Is nonessential equipment, such as printers and copiers, kept shut	Yes	Computer only on during day, no other major appliances were on

off until needed?		when not in use.
Can any equipment be switched on later and switched off earlier?	No	Most appliances not needed were already off to being with; facility already seems to have a good sense of energy conservation.

Existing Lighting Fixtures

Location	Light Type	Number of Units	Watts Per Bulb	Hours Used Per Week	kWh Per Week	Lux Reading
First Floor (Foyer)	CFL Bulbs	2	13	12	0.312	50-170
	Incandescent	1	60	12	0.720	
	Chandelier Candle Bulbs	8	40	12	3.840	
First Floor (Dining Room/Lounge)	Chandelier Bulbs Incandescent	8	40	12	3.840	
	Floor Lamp Incandescent	4	60	12	2.880	
	Table Lamps CFL	2	23	12	0.552	
First Floor (Room 2)	Desk Lamps CFL	2	23	6	0.276	
	Floor Lamp Incandescent	4	75	10	3.000	
	Mini Lamp Incandescent	2	60	6	0.720	
	Bed Side Lamp Incandescent	2	60	6	0.720	
Second Floor (Room 21)	Desk Lamp Incandescent	3	60	6	1.080	
	Mini Lamp Incandescent	1	60	6	0.360	
Second Floor (Room 22)	Lamp Incandescent	1	75	8	0.600	
	Sconce Incandescent	1	40	6	0.240	
	Lamp Incandescent	5	60	8	2.400	
	Bathroom Light Incandescent	1	60	1	0.060	
Second Floor (Room 23)	Lamp Incandescent	2	60	6	0.720	
	Floor Lamp	4	60	8	1.920	

	Incandescent					
Second Floor (Room 24)	Lamp Incandescent	2	60	6	0.720	
	Floor Lamp Incandescent	4	60	8	1.920	
Second Floor (Room 25)	Lamp Incandescent	2	60	8	0.960	
	Floor Lamp Incandescent	4	60	8	1.920	
Second Floor (Room 26)	Lamp Incandescent	2	60	8	0.960	
	Floor Lamp Incandescent	4	60	8	1.920	
Second Floor (Hallway)	Wall Lamp Incandescent	2	40	18	1.440	
	Ceiling Fixtures	2	40	18	1.440	
	Chandelier Bulbs	8	40	18	5.760	
Third Floor (Room 34)	Floor Lamp Incandescent	1	40	8	0.320	
	Wall Lamp Incandescent	2	40	6	0.480	
	Ceiling Fixtures Incandescent	2	40	6	0.480	
Third Floor (Room 33)	Lamp Incandescent	1	60	8	0.480	
	Ceiling Lights Incandescent	2	60	6	0.720	
	Lamp Incandescent	1	60	8	0.480	
Third Floor (Common Area)	Lamp Incandescent (Candle Flame)	3	40	8	0.960	
	Ceiling Lights Incandescent	4	60	6	1.440	
Third Floor (Room 35)	Lamp Incandescent	1	40	8	0.320	
	Wall Lamp Incandescent	1	60	6	0.360	
	Lamp Incandescent	1	60	8	0.480	
Third Floor (Room 31)	Lamp Incandescent	2	60	8	0.960	
	Floor Lamp Incandescent	1	60	8	0.480	
Third Floor (Hallway)	Ceiling Lights Incandescent	3	60	6	1.080	

Basement	Florescent Tubes (Short)	2	20	4	0.160	
	Florescent Tubes (Regular)	4	20	4	0.320	
	Florescent Tubes (Regular)	2	20	4	0.320	
Kitchen	Incandescent Bulbs (Candle)	6	40	8	1.920	
	CFL Bulbs	2	13	8	0.208	
Room Behind Kitchen	CFL Bulbs	3	13	5	0.195	
	Incandescent	4	60	5	1.200	
	Flood Light	1	N/A	3	N/A	

Existing Electronic Equipment

Location	Equipment	Make / Model	Number of Units	Wattage (W)	Hours Used Per Week	kWh Per Week
First Floor (Dining Room/Lounge)	Flat screen TV	Sharp	1	63/4 when off(phantom load)	20/148	1.260-1.852
	Old Toaster	N/A	1	1745	1	1.745
	Mini-Fridge	Kenmore Elite	1	90	168	15.120
	Ice Maker	U-line echelon	1	350	168	58.800
	Printer	HP LaserJet 3330	1	330/300/14 Variable Usage	2/166	2.324-2.984
	Amp and Speakers	Sharp	1	250	10	2.500
First Floor (Room 2)	Flat screen TV	Magnavox	1	95/4 when off(phantom load)	10/158	0.950-1.582
	Stereo System	Sony CMT-HP7	1	180	8	1.440
Second Floor (Room 21)	Alarm Clock	Sony	1	5	168	0.840
	Hair Dryer	Conair	1	1200	2	2.400
	Air Conditioner	Samsung AW1001M	1	1070	4	4.280
Second Floor (Room 22)	Alarm Clock	Sony	1	5	168	0.840
	Hair Dryer	Conair	1	1200	2	2.400
	Air Conditioner	Samsung AW1001M	1	1070	4	4.280
Second Floor (Room 23)	Alarm Clock	Sony	1	5	168	0.840
	Hair Dryer	Conair	1	1200	2	2.400
	Air Conditioner	Culus SCK5200M	1	515	6	3.090

Second Floor (Room 24)	Alarm Clock	Sony	1	5	168	0.840
	Hair Dryer	Conair	1	1200	2	2.400
	Air Conditioner	Samsung AW1001M	1	1070	4	4.280
Second Floor (Room 25)	Alarm Clock	Sony	1	5	168	0.840
	Hair Dryer	Conair	1	1200	2	2.400
	Air Conditioner	Samsung AW1001M	1	1070	4	4.280
Second Floor (Room 25)	Alarm Clock	Sony	1	5	168	0.840
	Hair Dryer	Conair	1	1200	2	2.400
	Air Conditioner	Samsung AW1001M	1	1070	4	4.280
Third Floor (Room 31)	Alarm Clock	Sony	1	5	168	0.840
	Hair Dryer	Conair	1	1200	2	2.400
	Air Conditioner	Friedrich CP06F10	1	1758	4	7.032
Third Floor (Room 32)	Alarm Clock	Sony	1	5	168	0.840
	Hair Dryer	Conair	1	1200	2	2.400
	Air Conditioner	Friedrich CP06F10		1758	4	7.032
Third Floor (Room 33)	Hair Dryer	Conair	1	1200	2	2.400
	Alarm Clock	Sony	1	5	168	0.840
	Air Conditioner	Friedrich CP06F10	1	1758	4	7.032
Third Floor (Room 34)	Air Conditioner		1	535	6	3.210
	Alarm Clock	Sony	1	5	168	0.840
Third Floor (Room 35)	Air Conditioner	Friedrich CP06F10	1	1758	4	7.032
	Alarm Clock	Sony	1	5	168	0.840
Basement	Washer	Kenmore HE5T Steam	1	400	15	6.000
	Dryer	Kenmore	1	650	15	9.750
	Refrigerato r	Frigidaire Electrolux FRT18G4AW A	1	455	168	76.44 0
Kitchen	Coffee Maker	Bunn	1	1800	10	18.00 0
	Microwave	Sharp Carousel	1	1600	2	3.200
Room Behind Kitchen	Computer	HP Desktop HP Pro	1	120	12	1.440
	Printer	HP Officejet 4500	1	2.8(power save)/9.6(active)	168	0.470-0.489
	TV	Curtis	1	~150	28	4.200

Appendix L: Inn 2 Audit Report

Inn # 2 Audit Report

Nantucket Project Center 2011

A Worcester Polytechnic Institute Interactive Qualifying Project

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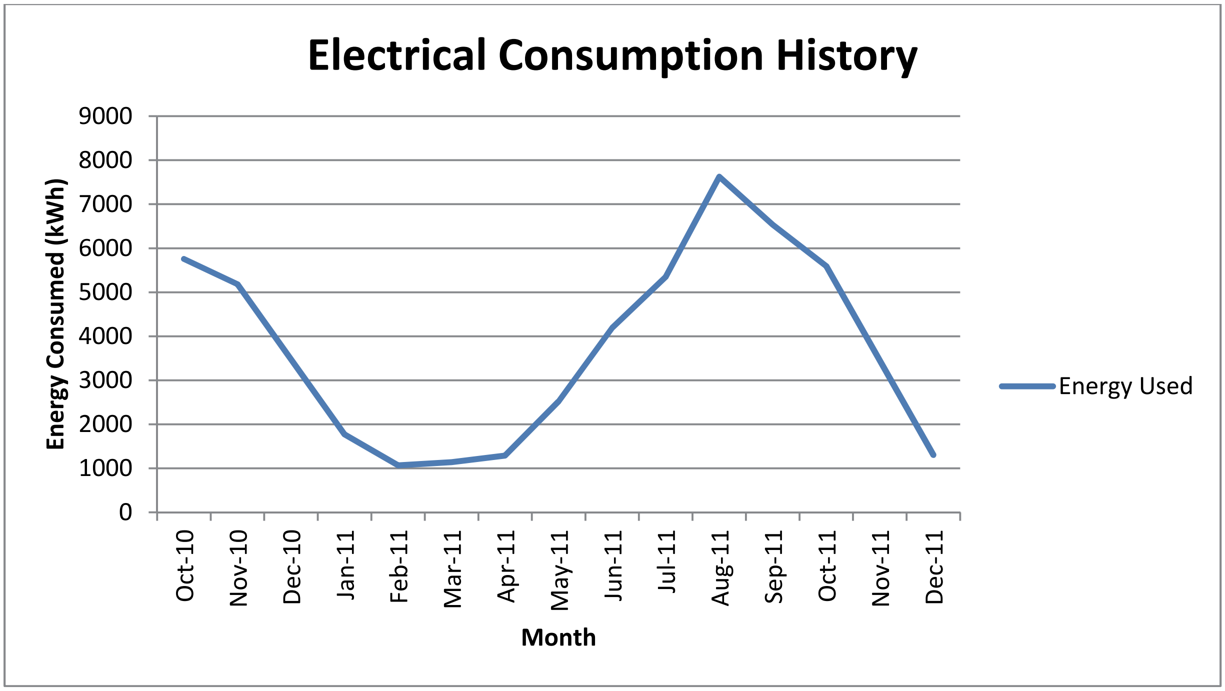
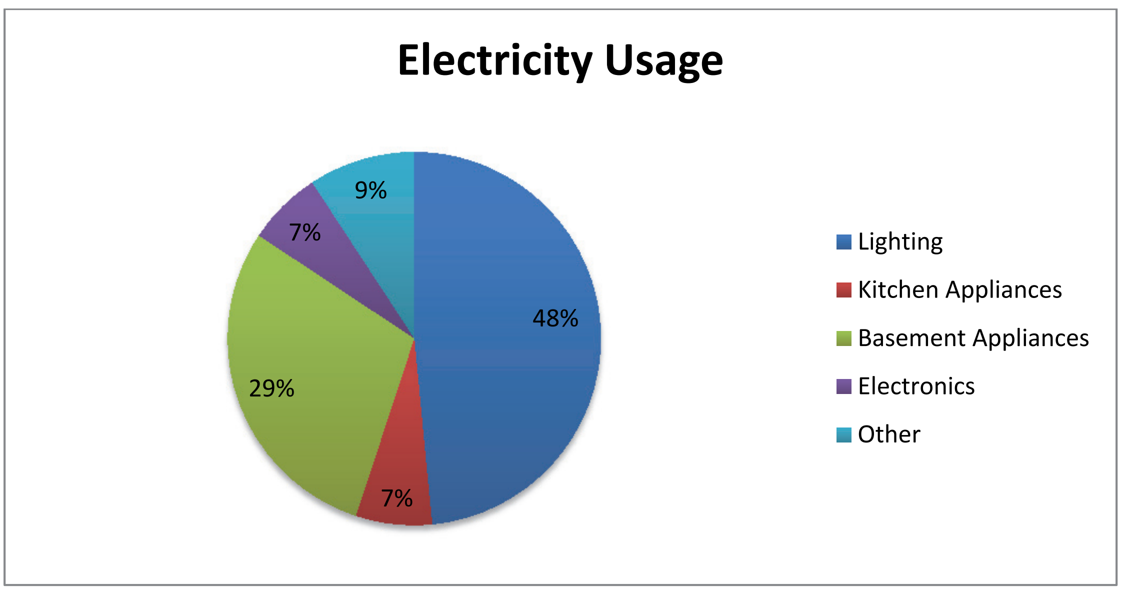




Recommendation Name	$ Savings Per Year*	kWh Savings Per Year*	Initial Cost	Payback Period
Upgrade All Incandescent Bulbs to CFL	$1545.26	8835.54 kWh	$358.56	3 Months
Install Occupancy Sensors to Guest	$148.75	850.5 kWh	$828.00	5.6 Years

Bathrooms				
Unplugging TVs During Offseason**	$31.44	174.72 kWh	None.	Immediately.

*Savings per year are on a 7 month scale to correspond with the time period the inn is open.

**Savings per year are on a 5 month scale to correspond with the time period the inn is closed.

General Information

Audit Conducted By:	Roberto, Corey, JB
Date Conducted:	November 30, 2011
Areas / Rooms Inspected:	Basement 1st Floor (Lobby, Kitchen, Office, Guest Rooms) 2nd Floor (Guest Rooms)
Business Hours:	Open April through October

Inn # 2 Report

1. Introduction

The purpose of this energy audit was to identify areas of potential energy reduction and cost savings in the Inn # 2 building. The audit conducted was a modified Level 2 audit that consisted of a walk-through of the building as well as cost analysis calculations…

2. Summary of Findings

During the walk-through portion of our audit of the Inn # 2 building, we were able to identify several areas where energy efficiency can be improved.

2.1. Basement

Starting in the basement of the building, we recorded the number and types of light bulbs used. The primary source of lighting was 24 fluorescent tube bulbs with several incandescent bulbs scattered throughout. The fluorescent tubes consume 32w of power as compared to the 60w consumption of the incandescent making them a good choice for primary lighting.

The basement housed all of the washers and dryers used for the inn's linens. We found 2 commercial dryers and 4 commercial washers. We were told these are run for about 8 hours a day during the 7 months they are open.

2.2. Kitchen

Moving up into the kitchen, we saw once again a mixture of both fluorescent and incandescent bulbs. A total of 8 incandescent bulbs and 5 fluorescents were found. The appliances in the kitchen looked new and consisted of mostly commercial grade equipment including a refrigerator, stove, and dishwasher. There were other miscellaneous appliances including a coffee machine, ice maker, and microwave.

2.3. Common Area

Connected to the kitchen was a small common area lit by 6 incandescent bulbs. Using a lux meter we recorded the number of lumens the lights of this room produces. Throughout the area the lux readings came to between 30 and 115 lumens. This falls into the category of a working area where visual tasks are only occasionally performed. As we begin to see more and more incandescent bulbs, this brings up the possibility of upgrading the bulbs to either CFLs or LED bulbs. More information about this can be found in the recommendations section.

2.4. Office

Another room connected to the common area is a small office space. Once again we see the use of 5 incandescent bulbs to light the room. Also in the room are two laptop computers and a Cannon printer.

2.5. Entrance Way / Lobby

The lobby area seen after entering through the front door is lit by 8 incandescent candle bulbs and 3 standard incandescent bulbs. CFL bulbs today can fit in almost any kind of fixture that the incandescent bulbs can fit into. In addition to the standard 60w incandescent bulbs, the 25w candle bulbs also have the potential to be replaced by 5w CFL candle bulbs, an 80% reduction in electricity consumption.

2.6. Guest Rooms

There are a total of 12 guest rooms in the building that span across both the first and second floors. The first floor has 4 rooms, while the second floor has 8. The lighting and electronic setup is almost the same for each of the guest rooms. Each room is lit by 3 to 5 incandescent bulbs and has several windows that allow in a lot of ambient sunlight. Each room is fitted with a Samsung TV and either a Sony alarm clock or Westclox alarm clock.

2.7. Guest Bathrooms

Each guest room has an accompanying bathroom. Lighting in these rooms ranged from 1 to 3 incandescent bulbs, however a few of the bathroom had fixtures with a CFL bulb. Being a low traffic area, bathrooms are often a prime target for the installation of occupancy sensors that will automatically turn off the lights when no one is in the room.

3. Recommendations

The recommendations are organized by priority. The tables below show what should be considered when moving forward.

Note: The cost savings and energy savings will be calculated on a 7 month scale instead of the full 12 months. The calculations will only be focusing on when the inn is open to guests.

Priority 1 – Upgrade All Incandescent Bulbs to CFLs			
Cost Saving Per	Energy Savings	Investment Cost	Payback Period

<table>
<tr><td>Year</td><td>Per Year</td><td></td><td></td></tr>
<tr><td>$1545.26</td><td>8835.54 kWh</td><td>$358.56</td><td>3 Months</td></tr>
<tr><td>Details:</td><td colspan="3">Currently, a majority of the lighting used in Inn # 2 consists of 60w incandescent bulbs. These types of bulbs have been surpassed in efficiency by the more common compact fluorescent (CFL) or the uncommon LED bulbs. In this recommendation, we took a look at the savings incurred if all incandescent bulbs are switched out for CFLs. For our calculations, we used an Eiko 00031 SP13/27K 13 Watt Compact Fluorescent Spiral Light Bulb that can replace the standard 60w incandescent. The light produced by this bulb is identical to that of a 60w incandescent. We also used the 7w Conserv-energy CFL Flame Tip to replace the incandescent candle bulbs.

To estimate the average hours of use for lighting in guest rooms we used a case study done by Iresearch on the Redondo Beach Crowne Plaza Hotel in 1999. The study focused on monitoring how long lights are kept on within a group of guest rooms. Bathroom lights seem to be left on the longest at 7 hours per day, while the desk lamps are left on for 5 hours a day. We used these two figures to estimate the kWh of guest room and bathroom lights. In addition to this, we assumed a 75% occupancy rate during the 7 months the inn is open.

Using this case study as a baseline, we estimated that by replacing all incandescent bulbs with energy efficient CFL bulbs a savings of $1,500 could be achieved during the 7 month period the inn is open. Using the light bulbs mentioned above, an initial investment of $350 would be needed to make the switch. CFL bulbs today fit into most of the standard ballasts that incandescent bulbs fit into so the installation would be quite easy.

General Electric published a short informational brochure for CFL recommendations. Appendix A at the end of this report shows a page of that brochure that focused specifically on hotels. It includes several different comparisons between incandescent and CFLs as well as a lamp selection guide. Although page is targeted at larger hotels, the savings can still benefit smaller businesses.

There is also an incentive program offered by National Grid that can help cover the initial cost of changing bulbs. The details of this incentive can be found in section 4.1.

The calculations can be found in section 5. There you can find all the incandescent bulbs we looked at and how much power they each consume.</td></tr>
</table>

<table>
<tr><td colspan="4">Priority 2 – Installation of Occupancy Sensors in Guest Bathrooms</td></tr>
<tr><td>Cost Saving Per Year</td><td>Energy Savings Per Year</td><td>Investment Cost</td><td>Payback Period</td></tr>
<tr><td>$148.75</td><td>850.5 kWh</td><td>$828.00</td><td>5.6 Years</td></tr>
<tr><td>Details:</td><td colspan="3">The installation of motion sensors is a good way to reduce lighting usage in low traffic</td></tr>
</table>

<table>
<tr><td></td><td>areas such as bathrooms. For the calculations done, we looked at a case study done by the California Energy Commission’s Public Interest Energy Research. The details of the case study can be found in Appendix B at the end of this report. The researchers tested a group of hotel bathrooms that were retrofitted with occupancy sensors and observed a 50% decrease in lighting usage. We used this same percentage to calculate the savings that would be seen in Inn # 2. We found that with a 50% reduction in lighting usage in the bathrooms, a savings of $150 would occur. Keep in mind this uses the assumption of a 75% occupancy rate, same as the previous recommendation. Installation of these sensors will require an electrician and thus a larger investment cost. The sensors cost about $39 each so for 12 rooms that totals to $468. With an addition of $360 for installation costs, that brings the total investment cost to $828.

National Grid also has an incentive program directed towards the installation of these types of motion sensors. For more details about this incentive, see section 4.2. If you are interested in installing motion sensors, this incentive should be considered a priority. The incentive grants a $35 rebate for wall mounted occupancy sensors that would bring the total cost per sensor down to only $4. The initial investment would then drop down to $408.

The calculations can be found in section 5.</td></tr>
</table>

<table>
<tr><td colspan="4">Priority 3 – Unplug All TVs During the Offseason</td></tr>
<tr><td>Cost Saving Per Year*</td><td>Energy Savings Per Year*</td><td>Investment Cost</td><td>Payback Period</td></tr>
<tr><td>$31.44</td><td>174.72 kWh</td><td>None.</td><td>Immediately.</td></tr>
<tr><td>Details:</td><td colspan="3">TVs are constantly drawing power even if they are turned off. Phantom load is the term used to describe this type of situation. TVs are one of the largest phantom load consumers out of all home appliances. On average, a TV will continuously draw 4w of power as part of the phantom load.

The inn is closed for 5 months out of the year and would thus result in wasted electricity if the TVs are left plugged in. Simply remembering to unplug all the TVs in the guestrooms when the inn closes for the season will save about $31 during that 5 month period.</td></tr>
</table>

*Savings per year are on a 5 month scale to correspond with the time period the inn is closed.

4. Available Incentives

There are several incentives available to small business owners who are looking to upgrade existing equipment in order to increase the energy efficiency of the building.

4.1. National Grid Incentives for Lighting: Bright Ideas for Improving Efficiency

Details:

This incentive offered by National Grid is for small businesses seeking to upgrade to more efficient lighting. The can provide financial incentives that covers up to 45% of the cost. The amount of money depends on what lighting system you are upgrading to.
Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706.
For more information you can visit:
http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-retrofit-lighting-national-grid

4.2. National Grid Incentives for Lighting: Retrofit Controls

Details:

This incentive program offered by National Grid focuses on small businesses seeking to upgrade to more efficient lighting control systems. Different incentive amounts are offered per fixture for different control devices that are installed.
Requirements:

There are three steps required in order to apply for this incentive. You must first fill out an application form and a device code and rated wattage table form that explains exactly what upgrades you will be making and what light bulbs you will be using. Finally you must contact your National Grid Representative at 1-800-787-1706. Other lighting control systems may be available, but you must contact your National Grid Representative for details.
For more information you can visit:
http://www.masssave.com/business/building-or-equipment-upgrades/find-incentives/incentive-details-business-lighting-retrofit-controls-national-grid

5. Calculations

5.1. Recommendation 1 – Upgrade to CFL

	A	B	C	D	E	F	G	H	I	J	K	L
1	Room	Lighting	Number	Current kWh Per Week	Recommended CFL Upgrade kWh Per Week		Electricity Cost		Savings	$	kWh	
2	Basement	Standard Incandescent	2	20.16	4.36		0.174891829		Week	55.188	315.555	
3	Common Area	Standard Incandescent	1	10.08	2.18				Month	220.752	1262.22	
4		Incandescent Candle Bulb	5	21	5.88				Year***	1545.26	8835.54	
5	Kitchen	Standard Incandescent	2	20.16	4.36							
6		Incandescent Candle Bulb	6	25.2	7.05							
7	Office	Standard Incandescent	5	12	2.6							
8	Lobby	Standard Incandescent	2	20.16	4.36							
9		Incandescent Candle Bulb	6	25.2	7.05							
10	Guest Rooms*	Standard Incandescent	42	66.15	14.33							
11		Incandescent Candle Bulb	2	0.875	0.24							
12	Guest Bathrooms**	Standard Incandescent	27	59.53	12.89							
13		Incandescent Candle Bulb	2	1.22	0.34							
14	Second Floor Hallway	Standard Incandescent	8	80.64	17.47							
15		Incandescent Candle Bulb	12	50.4	14.11							
16			Week	412.775	97.22							
17			Month	1651.1	388.88							
18			Year***	11557.7	2722.16							
19												
20												
21	*Guest room calculations assume that 75% of total rooms are occupied and,								Light Type	Number	Cost Per Bulb	Investment
22	based on the 1999 Iresearch study, assumes an average lighting use of 5 hours per day.								13w CFL Spiral Bulb	89	$2.49	$221.61
23									7w CFL Candelabra Bulb	33	$4.15	$136.95
24	**Based on the same study, lighting use in bathrooms is assumed to be 7 hours per day.										Total	$358.56
25												
26	***Yearly energy usage only accounts for the 7 month period the inn is open to guests.											

5.2. Recommendation 2 – Installation of Occupancy Sensors in Guest Bathrooms

	A	B	C	D	E	F	G	H	I	J	K	L
1	Room	Light	Number	kWh Per Week	kWh Per Week - Occupancy Sensors Installed (50% Reduction)		Electricity Cost		Savings	$	kWh	
2	Guest Bathroom*	Standard Incandescent Bulb	27	59.53	29.765		0.174891829		Week	$5.31	30.375	
3		Incandescent Candle Bulb	2	1.22	0.61				Month	$21.25	121.5	
4			Week	60.75	30.375				Year	$148.75	850.5	
5			Month	243	121.5							
6			Year**	1701	850.5							
7												
8												
9												
10												
11	*Based on the 1999 Iresearch study, lighting use in bathrooms is assumed to be 7 hours per day.											
12												
13	**Yearly energy usage only accounts for the 7 month period the inn is open to guests.											
14												
15									Sensor	Number	$ Per Sensor	Investment
16									Occupancy	12	$39.00	$468.00
17											Installation Cost	$360.00
18											Total	$828.00

6. Data Gathered

Lighting

What to Look For	Yes / No	Comments
Is lighting in unoccupied areas switched off and all non-essential lighting is switched off outside of business hours.	No.	However because it is an inn, some lights need to be left on all the time.
Ensure blinds are open when there is sufficient daylight available. Can the lights be turned off in order to make better use of incoming daylight?	Yes.	Each room has a good amount of sunlight coming in through windows. However it is up to the guest to turn off the lights and make better use of sunlight.
Are there any inefficient bulbs, such as tungsten, being used? Can these be upgraded to LED or CFL?	Yes.	Most of the bulbs used are 60w incandescent.
Can light sensors be installed in rooms that are not always occupied, such as store rooms or bathrooms?	Possibility.	Possibility of installing motion sensors in bathrooms and hallways however may not be plausible.
Are windows, skylights, etc being kept clean?	Yes.	
Are any rooms being over lighted or under lighted?	No.	

Heating / Cooling

What to Look For	Yes / No	Comments
Are radiators and other heating surfaces unobstructed?	Yes.	
Are windows and doors closed where possible when heating or air conditioning is operating?	Yes.	
Is the air temperature close to the recommended average of 70°F?	Yes.	Air temperature throughout the building was always around 70F.
Is the heating controlled by a programmable thermostat?	No.	
Is the heating system / air	Yes.	

conditioner receiving scheduled maintenance?		

Electrical Equipment

What to Look For	Yes / No	Comments
Is equipment, such as computers and printers, turned off over night?	Yes	None
Is nonessential equipment, such as printers and copiers, kept shut off until needed?	Yes	None
Can any equipment be switched on later and switched off earlier?	No	None

Existing Lighting Fixtures

Location	Light Type	Number of Units	Watts Per Bulb	Hours Used Per Week	kWh Per Week	Lux Reading
Basement	Incandescent Bulb	2	60W	168	20.16	175-330 Lumens
	Fluorescent Tube	24	34W	168	137.088	
	Incandescent Bulb	1	60W	As Needed	N/A	
	Incandescent Bulb	2	60W	As Needed	N/A	
1st Floor Common Area	Incandescent Candle Bulb	5	25W	168	21	30-115 Lumens
	Incandescent Bulb	1	60W	168	10.08	
Powder Room	Fluorescent Lamp Bulb	1	18W	As Needed	N/A	
Kitchen	Incandescent Candle Bulb	6	25W	168	25.2	200 Lumens
	Fluorescent Tube	1	20W	168	3.36	
	Incandescent Bulb	2	60W	168	20.16	
	Fluorescent Lamb Bulb	4	20W	168	13.44	
Office	Incandescent Bulb	5	60W	40	12	80 Lumens
1st Floor Hallway	Incandescent	6	25W	168	25.2	

	Candle Bulb					
	Incandescent Bulb	2	60W	168	20.16	
Front Room	Incandescent Bulb	3	60W	168	30.24	
	Incandescent Candle Bulb	8	25W	168	33.6	
Room 1	Incandescent Bulb	4	60W	84	20.16	
Room 1 Bathroom	Incandescent Bulb	2	60W	As Needed	N/A	
	Fluorescent Lamp Bulb	1	18W	As Needed	N/A	
Room 2	Incandescent Bulb	5	60W	84	25.2	
Room 2 Bathroom	Incandescent Bulb	3	60W	As Needed	N/A	
Room 3	Incandescent Bulb	4	60W	84	20.16	
Room 3 Bathroom	Incandescent Bulb	2	60W	As Needed	N/A	
Room 4	Incandescent Bulb	3	60W	84	15.12	
Room 4 Bathroom	Incandescent Bulb	2	60W	As Needed	N/A	
Room 5	Incandescent Bulb	3	60W	84	15.12	
Room 5 Bathroom	Incandescent Bulb	3	60W	As Needed	N/A	
Room 6	Incandescent Bulb	4	60W	84	20.16	
Room 6 Bathroom	Incandescent Bulb	3	60W	As Needed	N/A	
Room 7	Incandescent Bulb	4	60W	84	20.16	
Room 7 Bathroom	Incandescent Bulb	2	60W	As Needed	N/A	
	Fluorescent Lamp Bulb	1	18W	As Needed	N/A	
Room 8	Incandescent Bulb	4	60W	84	20.16	
Room 8 Bathroom	Incandescent Bulb	1	60W	As Needed	N/A	
Room 9	Incandescent Bulb	3	60W	84	15.12	
	Incandescent Candle Bulb	3	25W	84	6.3	

Room 9 Bathroom	Incandescent Bulb	1	60W	As Needed	N/A	
	Incandescent Candle Bulb	2	25W	As Needed	N/A	
Room 10	Incandescent Bulb	3	60W	84	15.12	
	Incandescent Candle Bulb	2	25W	84	4.2	
Room 10 Bathroom	Incandescent Bulb	2	60W	As Needed	N/A	
Room 12	Incandescent Bulb	2	60W	84	10.08	
Room 12 Bathroom	Incandescent Bulb	3	60W	As Needed	N/A	
Room 14	Incandescent Bulb	3	60W	84	15.12	
Room 14 Bathroom	Incandescent Bulb	3	60W	As Needed	N/A	
2nd Floor Stairwell and Hallway	Incandescent Bulb	8	60W	168	80.64	
	Incandescent Candle Bulb	12	25W	168	50.4	
Location	Light Type	Number of Units	Watts Per Bulb	Hours Used Per Week	kWh Per Week	Lux Reading

Existing Extra Heating / Cooling Equipment

Location	Equipment	Make / Model	Number of Units	Wattage	Hours Used Per Week	kWh Per Week	Room Temperature
Basement	Boiler	Buderus Logano G215	1				
	Water Pump	Taco 007-F5	5	81.65	168	68.59	

Existing Electronic Equipment

Location	Equipment	Make / Model	Number of Units	Wattage	Hours Used Per Week	kWh Per Week
Basement	Commercial Linen Dryer	Speed Queen 70115601	1	1608 W	56	90.04
	Commercial Linen Dryer	IDC	1	989 W	56	55.38
	Commercial Washer	Speed Queen LTS90AWN	2	1176 W	56	131.71
	Commercial Washer	Estate	1	720 W	56	40.32
	Commercial Washer	Continental Girbau H5020LCA1061P	1	1200 W	56	67.2
	Telephone System	Panasonic KX-TA824	1	145W	168	24.36
	Refrigerator	Whirlpool	1	unknown	168	?
	Food Freezer	White Westinghouse	1	2875W	168	?
	Battery Back up	APC Back Ups LS 500	1	315W	168	52.92
Kitchen	Coffee Maker	Bunn CWTF-15	1	1.8 kW	As Needed	
	Ice Maker	Hoshizaki AM-50BAE	1	244 W	168	40.99
	Commercial Toaster	Waring	1	2028-2700W	As Needed	
	Coffee Grinder	Bunn LPG 20580-0001	1	360 W	As Needed	
	Sanitizer	Hobart	1	2400W	As Needed	
	Microwave	General Electric	1	1.5 kW	As Needed	
	Refrigerator	Delfield/Alco	1	63.84W	168	10.72
	Freezer	True	1	1253.5W	168	?
	Stove	Franklin Chef Stove	1	402.97W	As Needed	
Office	Printer	Cannon MX882	1	Operational=23W Off=0.4W	As Needed	
Rooms 1-14	TV	Samsung CN02	13	Operational=90W Phantom=4W		
	Alarm Clock	Sony Dream Machine	10	20W	168	33.6
	Hair Dryer	Vidal Sasoon VS402	7	1675W	As Needed	

	DVD Player	Sony Progressive Scan DVPN5575P	1	11W	As Needed	
	Fridge	Whirlpool	1	1725W		?
	Iron	Sunbeam 3017	3	1200W	As Needed	
	Alarm Clock	Westclock	2	5W	168	1.68

Appendix A – GE CFL Lighting Brochure

Hotels Turn to CFLs to Ensure Guest Satisfaction

Guest satisfaction is a key driver of profitability in the hospitality industry— and CFLs can play an important role in creating a favorable impression. CFLs are energy-efficient, long-lasting, have great quality of light and are environmentally preferable. In the lobby, corridors, and guest rooms, well-functioning lighting powerfully conveys the message that the property is clean and well maintained. And given the number of fixtures and table lamps in a typical hotel, savings from self-ballasted CFLs can be substantial.

Consider a hotel operator with 10 large, airport properties of 350 guest rooms each. Just converting four guest room lamps from incandescent to CFLs produces an annual saving of $83,055.

Benefits of a project like this:

- *Only a 5-month payback*
- 237% ROI
- Equivalent to planting 89 acres of trees every year

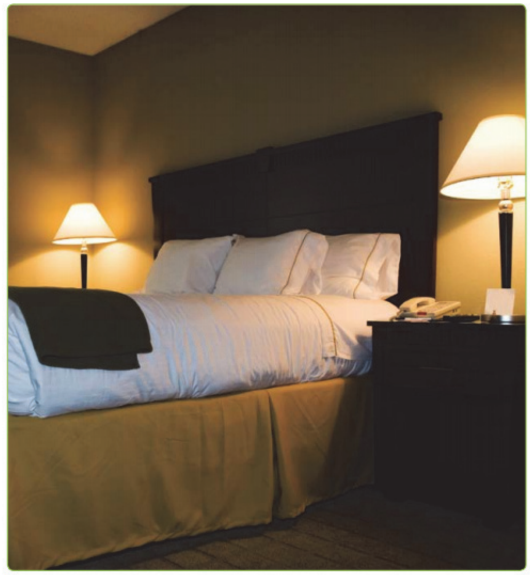
(See the Cost of Light Illustration to the right).

Guest Room Table Lamp– Cost of Light Illustration

Lamp Type	41034 100W A-line 100A/W 120V	80890 26W - CFL Spiral FLE26HT3/2/XL827
Lamp Life	750 hrs	12,000 hrs
End User Lamp Price	$0.49	$2.99
Wattage @ 120V	100	26
Lumens	1690	1700
Annual Operating Hours	628.53	628.53
Labor $ Per Lamp, Relamp Only	$0.00	$0.00
Average Electric Rate	$0.110	$0.110
Total Number of Lamps	14,000	14,000
Lamp Costs	$5,749	$2,193
Labor Costs	$0	$0
Electricity Costs	$96,794	$25,166
HVAC Savings– HVAC Coefficient	0.33	$7,871
Total Annual Operating Cost	$102,542	$19,488
Annual Savings		$83,055
Annual Savings per Hotel		$8,305
Simple Payback		0.4
Return on Investment		237%

ecomagination

Annual kWh's	879,942	228,785
kWh's Reduction		(651,157)
kWh's Reduction %		-74.0%
Carbon Dioxide– Global Warming: CO_2 Reduction (lbs)		(906,411)
Sulfur Dioxide– Acid Rain: SO_2 Reduction (lbs)		(3,935)
Nitrogen Oxide– Smog: NO Reduction (lbs)		(1,932)
Equivalent number acres of trees planted per year		(89)
Equivalent number of cars removed from the road per year		(56)



Lamp Selection Guide– Hotel Application

Lamp Description	Spiral T2	Spiral T3	Spiral T4	Spiral 3-Way	GU24	covRguard®	Reflector R20	Reflector R30	Reflector R40	Reflector PAR38	Reflector Genura®	Decorative Candle	Decorative A-line	Decorative Glass Covered	Decorative Globe	Decorative Post/Bullet Shape
Interior																
Bathroom								● R	● R			●	●	● R	●	
Wall sconce	●	● R	●		●	●						●	●			
Corridor	●	● R	●		●	●	● R	● R	● R	●	●	●	●		●	
Ceiling/Decorative							● R	☼ R	☼ R	●	●	●	●	● R	●	
Guest rooms	●	● R	●	● R	●	●							●	● R		
Exterior																
Entryway	●	● R	●		●	●	● R	● R	● R	●	●					
Pathway										●						●
Security										●						●

☼ Dimmable lamp available   R Reveal® lamp available

6

Public Interest Energy Research Program ***Case Study***

Hotel Bathroom Lighting Control System

"A real win-win with 50% savings, reduced maintenance, fewer customer complaints!"

– Bob Hughes, DoubleTree Hotel Director of Operations

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Energy Savings Opportunity

Many hotel bathroom lights operate during unoccupied times, wasting electricity, and increasing maintenance costs. Research has shown that many guests do not turn off the bathroom lights when they leave their room and more than 40% use the bathroom light as a nightlight.

As Lawrence Berkeley National Laboratory (LBNL) lighting researcher Michael Siminovitch found, "More than 75% of the energy used by these fixtures occurs when bathroom fixtures are left on for more than two hours at a time and most often during the overnight hours."

The Watt Stopper Inc., LBNL, and the Sacramento Municipal Utility District (SMUD) partnered in research to develop a Bathroom Lighting Control System, the WN-100 Motion Sensor Nightlight, to address the inefficient use of hotel bathroom lighting.

The result is a wall-mounted light switch with a built in occupancy sensor and an LED nightlight. While these technologies are not new, the WN-100 Motion Sensor Nightlight combines them in an innovative system which saves electricity and decreases maintenance costs.

DoubleTree Hotel Test Site

The DoubleTree Hotel in Sacramento, California was chosen as a test site for the new WN-100 Motion Sensor Nightlight technology. Staff electricians replaced 448 standard wall switches with the new sensors. Prior to installation, LBNL researchers measured the light usage in 15 guest bathrooms for two months to establish baseline usage. The researchers then monitored the same bathrooms for two months after installation to quantify energy savings.

WN-100 Motion Sensor Nightlight Highlights

Energy Savings
Minimizes lighting overuse and achieves 50% energy savings!

Operation & Maintenance
Cuts O&M costs by 33% by reducing lighting use, resulting in extended lamp life and fewer burned-out lamp complaints!

Occupant Comfort & Safety
Supports nighttime vision with energy saving, low-level LED illumination.

Manufacturer: The Watt Stopper Inc.

Market: Widespread application in hotel bathrooms, military housing, and healthcare facilities.

Site: DoubleTree Hotel in Sacramento, California

Installation-related Costs

New Construction: The WN-100 Motion Sensor Nightlight requires the same labor to install as any wall mounted switch and costs $38 per device when purchased in large quantities.

Retrofit: The Watt Stopper Inc. estimates that installation requires about one half hour, costing about $68 per room using a standard electrician rate of $60/hr and a cost of $38 for the device.

Payback

Providing night lighting and occupancy-based lighting control, the WN-100 Motion Sensor Nightlight delivers both energy and non-energy benefits. Using the above costs, the simple payback from energy savings alone was calculated to be 5½ years for retrofits and 2½ years for new construction using 64W bathroom luminaires. At the DoubleTree Hotel, as lamp usage decreased, so did energy use, lamp replacement, and customer complaints. Facility managers estimated that the product reduced operation and maintenance costs by 33%, further shortening the payback by as much as a year.

Study Results

The DoubleTree's pre- and post-installation data shows a 50% reduction in energy use! As expected, most savings occurred from 10:00pm to 3:00am and from 7:00am to 1:00pm supporting previous findings that bathroom lights frequently operate during unoccupied times and are used as nightlights.

The DoubleTree study achieved the following significant cost savings:

- Number of Rooms 448
- Retro-fit cost per Room ~$45 (including utility incentive)
- Project cost ~$20,000 (including labor)
- Annual energy savings ~ 66,500 kWh
- Annual cost savings ~ $8,000
- **Simple payback ~ 2.5 years**

Equally impressive were the non-energy cost savings resulting from decreased lamp replacement and associated O&M maintenance. Lamp replacement costs were reduced from ~$1500/month to ~$1000/month, a 33% reduction resulting in an additional $6000/year savings!

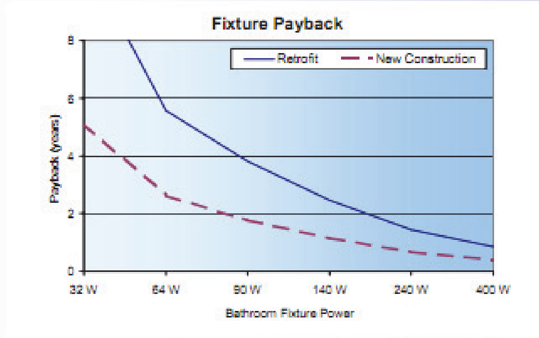

Figure 1-Simple payback in years for new and retrofit applications, assumes $0.14/kWh, not including O&M savings.

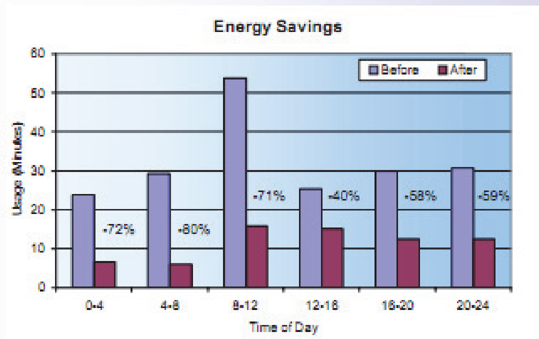

Figure 2- Average energy reduction in a typical room before and after retrofit. The greatest savings are seen between 8 a.m. and 12 p.m. when occupants vacate the room and leave the lights on.

Conclusion

At the Sacramento DoubleTree Hotel, the WN-100 demonstrated significant electricity and O&M cost savings, resulting in a two and a half year payback. The nightlight feature was well received, with no complaints on the customer comfort questionnaires and a number of positive responses specifically mentioning the added comfort provided by the nightlight. By installing the WN-100 Motion Sensor Nightlight, the DoubleTree Hotel reduced bathroom luminaire energy use by 50%, reduced customer complaints, and decreased O&M costs.

Availability

The Motion Sensor Nightlight is currently being offered for sale through The Watt Stopper catalog (www.wattstopper.com). The expected retail cost is $58 per individual unit or approximately $38 per unit for large volume purchases. Utility incentives may also be available.

About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) program. PIER supports public-interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

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