Energy Audit of Higgins Laboratory

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Abstract

This project consisted of performing an energy audit of Higgins Laboratory in order to address current electric consumption, and provide suggestions towards reducing future electric waste. At the conclusion of the audit, it was decided the first key step that needs to be taken is to develop an ongoing relationship with National Grid, in order to begin taking advantage of their incentive and payback programs for renovations and audits. All the incandescent bulbs should be replaced with LEDs and lighting levels across the building reduced. Occupancy sensors should be installed in all major rooms, and all computer control units should be equipped with a true shutoff mechanism. Conservative estimates on payback periods for the shutoff mechanism is under 5 months, and for the LEDs is 2 months.

Acknowledgments

We would like to thank the following individuals for their invaluable aid. They helped to answer questions, keep us focused, and motivate us to achieve the full potential this project was capable of. Without these people the project would not have been possible.

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Comfy Chairs in Higgins Laboratory!

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Chapter 1 Executive Summary

1.1 Introduction

Energy consumption has become a growing concern for many institutions including Worcester Polytechnic Institute (WPI). The campus has already taken several steps towards reducing its electricity use and becoming a more "greener" campus. These steps are evident in the construction of the new buildings: East Hall and The Bartlett Center. East Hall, the newest residence hall recently constructed, was aimed to achieve Leadership in Energy and Environmental Design (LEED) silver certification, a step above basic LEED certification which certifies a certain level of environmental sustainability. The Bartlett Center, which is registered with the U. S. Green Building Council, uses innovative architectural methods to reduce the load on its lighting and air-conditioning systems. Also, the Sustainability Taskforce, which is comprised of students, faculty, and staff appointed directly by the president of WPI, has launched the availability of Zipcars for faculty, staff, and students, and has equipped the Alumni Field with three large solar powered LED path lights. While this group continues their efforts to monitor, reduce cost, and reduce energy usage at WPI, there is however, much more room to improve the environmental impact of the already present buildings. WPI is a leading technical institution, and as such, should serve as an example for integrating technology with environmental responsibility by tracking its electricity use.

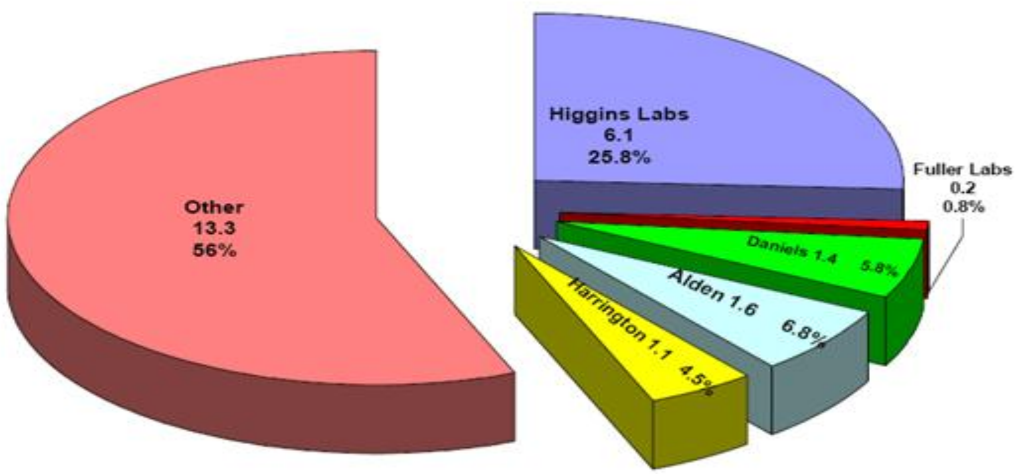
1.2 Background

In the past, there have been a number of groups that have done their Interactive Qualifying Projects (IQP's) focusing on energy issues. A group in 2007 performed a project on "Monitoring Electricity Consumption on the WPI Campus" which covers similar topics to what is being proposed in this paper. The report, which was prepared for the Plant Services Department at WPI, evaluated the present status of WPI's electricity monitoring system on a building-by-building basis. It included a comprehensive report of the electricity meter functionality for several dormitories and academic buildings and also presented a short and long-term plan to improve the school's ability to monitor its electricity consumption. Their project idea never came to full fruition and it was concluded that many of the meters were not functioning properly, and until they were repaired, a breakdown of percent electrical usage by each building was not possible. Unfortunately for them (and us), there was no single point-source for information on WPI's present electricity metering system and there was ambiguity among the administration about which meters were working, what they were recording, and for what buildings they provided data for. Furthermore, no analysis of electricity usage data to observe any emerging trends has been done, so they had to start from scratch. Currently, there is no plan to install up-to-date energy monitoring systems, but it is necessary to install such systems in at least all of WPI's main facilities in order to track WPI's electricity consumption and identify unnecessary expenditure.

1.3 Project Statement

Unlike the project of 2007, which studied the electrical consumption of the entire WPI campus, this project focuses on just one of the buildings: Higgins Laboratories. According to one of the graphs illustrated in the 2007 project, Higgins Labs is shown to be a main consumer of electricity, as can be seen in Figure 1.1, which ultimately led to our decision.

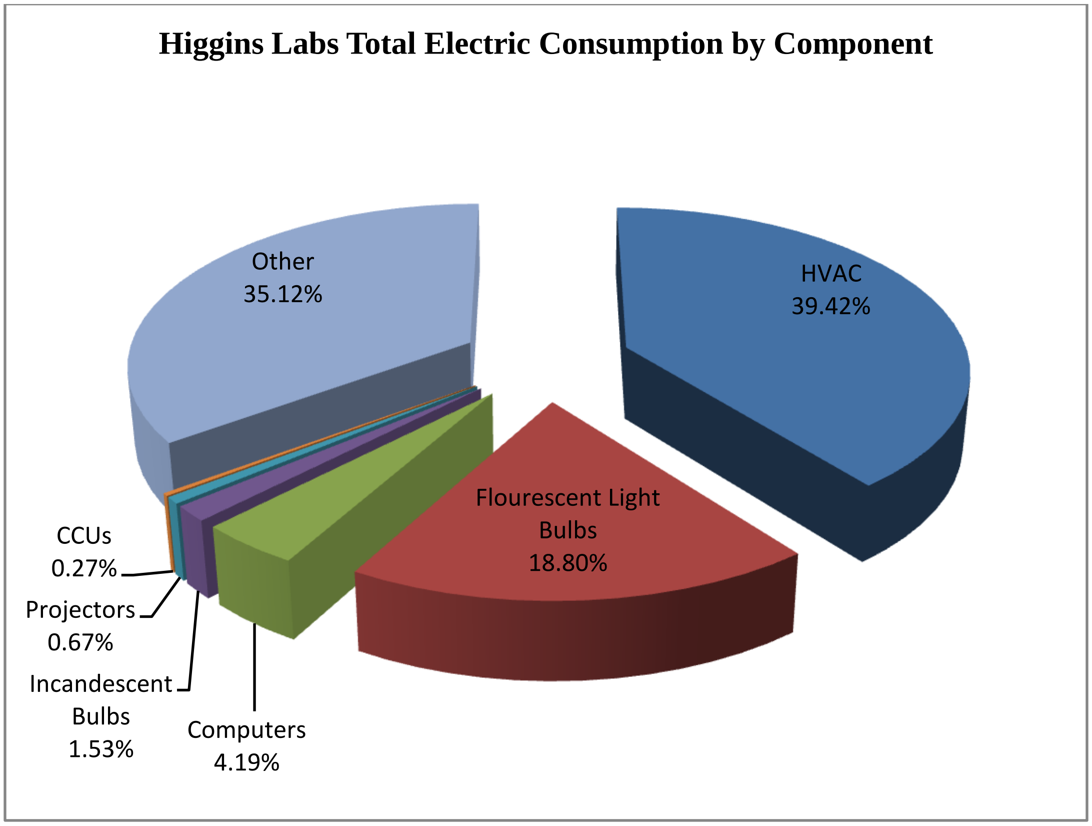
Figure 1.1 Average Usage/Day of WPI's Main campus (Mwh/day)



This project built upon some of what the first started and ultimately carried their ideas further. Given the short 6 week time span for this audit, and knowing that performing a detailed energy audit for a building as large as Higgins would be a very time consuming and complex process, it was very important to figure out early on what were the important elements that needed to be addressed. It was decided that the Heating Ventilation and Air Conditioning (HVAC) systems, lighting systems, and computing systems were to get the most attention.

Ultimately, the energy audit of Higgins Labs broke down the electric consumption of the building and is shown in Figure 1.2.

Figure 1.2



1.4 Methods

For the analysis of the present HVAC system, the equipment schedule/specifications schematic was obtained for Higgins Labs. We also met with Norman F. Hutchins, head of the HVAC systems here at WPI, on more than one occasion. He informed us that during weekdays the system is turned on at 6 a.m. and is left running until 9 p.m. when it is completely shut off. During weekends, the system is turned on at 7 a.m. and shut off at 3:30 p.m. and on vacations and holidays the system is completely off. In the equipment schedule, there were over 80 motors listed that ran all of the pumps and ventilation systems. The summation of their individual contributions added up to a total of 1945.34 kWh for a weekday daily power consumption and 1102.36 kWh for a weekend daily power consumption. (Table 1.1).

Table 1.1 HVAC System Motors and Their Corresponding Power Draws

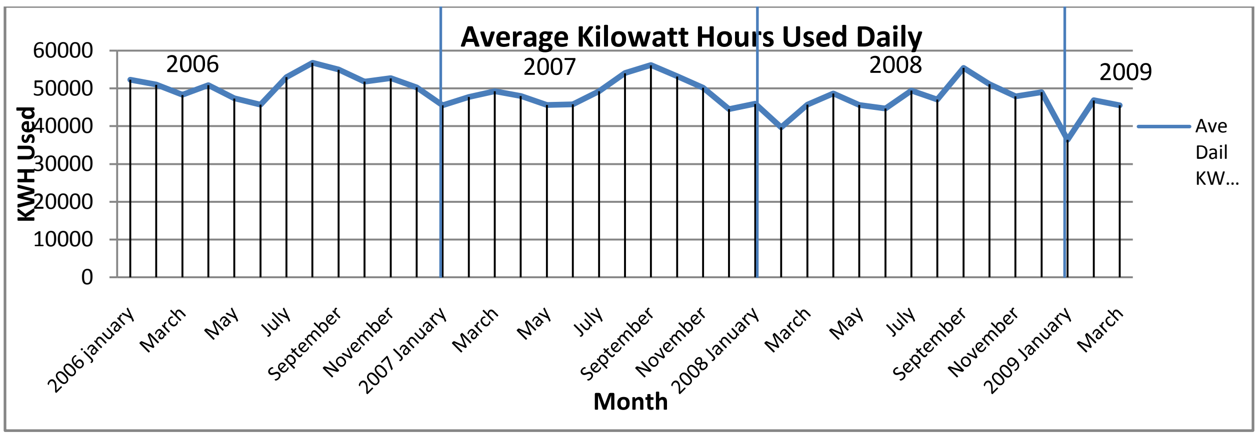
Quantity	HP	Voltage Req. (V)	Instantaneous Power Draw (kW)	Weekday Run Time (hr)	Weekend Run Time (hr)	Weekday Daily Power Draw (kWh)	Weekend Daily Power Draw (kWh)
8	1/3	120	1.99	15	8.5	29.83	16.90
13	3/4	120	7.27	15	8.5	109.06	61.80
6	1	120	4.47	15	8.5	67.11	38.03
6	1 1/2	120	6.71	15	8.5	100.67	57.05
20	1/4	120	3.73	15	8.5	55.93	31.69
4	2	120	5.97	15	8.5	89.48	50.71
1	2 1/2	120	1.86	15	8.5	27.96	15.85
2	3	120	4.47	15	8.5	67.11	38.03
1	20	120	14.91	15	8.5	223.71	126.77
1	5	120	3.73	15	8.5	55.93	31.69
9	1/6	120	1.12	15	8.5	16.78	9.51
6	1	208	4.47	15	8.5	67.11	38.03
3	7 1/2	208	16.78	15	8.5	251.67	142.62
2	5	208	7.46	15	8.5	111.85	63.38
3	20	208	44.74	15	8.5	671.13	380.31
Total Power Draw:			**129.69 kW**			**1945.34 kWh**	**1102.36 kWh**

After performing a general energy audit, this project develops an energy profile of the average class room, lecture hall, office, computer laboratory, and machine shop through several case studies which focuses primarily on their own individual energy consumption and patterns of use. A Kill-A-Watt meter was used in order to determine the electrical consumption, in kilowatts, by each and every device plugged into a 120 volt outlet. Each piece of equipment was classified based upon its electrical consumption. The CAD drawings of the floor plans for Higgins Labs were obtained and used to classify each room as an auditorium, standard classroom, office, computer lab, laboratory, machine shop, conference room, bathroom, hallway, stairway or closet. For each room, all switches, lights, and any electronics or pieces of equipment such as computers and projectors were catalogued by number and by electricity consumption. The intensity of lighting was determined for each room and hallway using a Lux-Meter and compared to Occupational Safety and Health Administration (OSHA) standards to illustrate over lit areas. Simultaneously, readings were taken periodically from the main electricity meter in Higgins' basement for a period of 7 days in order to develop a baseline for the electrical use at Higgins Labs. Additionally, for one day, the electricity meter was monitored every hour on the hour to develop a profile for "A Day in the Life of Higgins Labs." This information was tabulated and used to allocate, with a certain degree of accuracy, the electrical consumption of the HVAC, lighting, and computer systems in Higgins Labs.

WPI uses over 10,000 kWh per month and has a demand of over 200 kW, putting the campus in the G-3 category of billing rates. WPI currently purchases electricity from National Grid, who sends an employee to take a meter reading from 183 West Street once a month. The bills are comprised of a variety of different charges that fluctuate throughout the year. The individual charges that WPI incurs from National Grid are presented here in this paper in detail for your convenience and comprehension. This data helps in evaluating where the campus' money is going and what exactly is being paid for.

The electricity bills from January 2006 to present for WPI's main campus were obtained from records at the Facilities Department. The information on these electricity bills were put into an excel spreadsheet to generate tables and graphs reflecting the patterns of electricity usage and cost for the past three years at WPI as can been seen in Figure 1.3.

Figure 1.3 Average Kilowatt Hours Used Daily



1.5 Recommendations

With the information gathered from the energy audit of Higgins Laboratory, the case studies, electricity bills, and the HVAC system, these are the key recommendations being made. They are arranged in decreasing order of importance.

1). An ongoing relationship with National Grid (NG) needs to be developed and their resources utilized.

2). A full scale professional energy audit should be purchased and performed.

3). Functioning meters should be placed on every building on campus in order to better utilize the Energy Profiler Online program National Grid offers.

4). Replace ALL incandescent bulbs with preferably LED lights, if not, then fluorescent bulbs.

5). Decrease light levels in most all rooms and halls by 20% and up to 70% or more in some areas.

6). Occupancy sensors should be installed in all classrooms and auditoriums.

7). Outfit all CCU's on campus with an on/off outlet switch.

National Grid has many services available to their clients to aid in creating a more energy efficient world. Mike Thompson, a NG employee who directly handles WPI's energy account, explained that when East Hall was built, NG paid approximately $200,000 dollars for having energy efficient lights, chillers, and ventilation motors installed. He pointed out that there are also many programs that can help defray the costs in retrofitting current lighting and HVAC systems in existing buildings. These programs are called incentive programs. The incentive means that depending on how efficient the new upgraded system is, and as long as the minimum requirements are met for energy savings, NG will pay WPI back a specific amount of money for each change made. Developing a strong relationship with Mr. Thompson, and the NG company will aid greatly in continuing to make positive changes to the campus at a greatly reduced cost.

Once the campus has a professional energy audit performed, NG will pay the campus back a minimum of 45%, and up to 100% of the cost. A professional audit is essential in determining what the best method is for beginning to reduce all around campus electrical waste. The information gathered from the study of Higgins Laboratory's electrical consumption clearly demonstrates that a high percentage of its electricity used is wasted energy.

NG has a program called the Energy Profiler Online (EPO). This program is an online database that catalogs a variety of information regarding the campus' electricity use. Every fifteen minutes this program takes a reading of WPI's instantaneous electrical demand. It has built in tools that will plot consumption from multiple time periods together on one graph. This makes comparing usage from different months and years more convenient. The program can do many different things, and will be a key tool in monitoring electrical patterns. In order for this program to be utilized at its full potential, functioning electrical meters first need to be installed in every campus building.

Higgins Laboratory still contains incandescent bulbs in a number of its rooms. Each of these bulbs consumes almost 6 times the energy of the fluorescent bulbs that would replace them, and up to 75 times the energy a LED light would use. Just replacing the incandescent lights with fluorescent bulbs would result in a conservative savings estimate at minimum of $3,800 a year. With LED bulbs the minimum conservative savings estimate would be $4,500 a year. Installing the latter device would have a payback period of 2 months.

The majority of rooms in Higgins Laboratory are over illuminated. According to the case studies only one room is under illuminated. Every classroom, bathroom, hallway, stairwell, and office is over illuminated. The data shows that these spaces can have their light levels reduced anywhere from 20% to 70%. This reduction in lighting levels would more than qualify WPI for National Grid's incentive programs. This means they would pay for some portion of these renovations, offsetting the initial cost.

After speaking with Norman Hutchins from the Facilities Department, who is in charge of the HVAC systems here at WPI, it can be concluded that there isn't much that can be done to improve the current system without replacing it with a newer system. Certainly there is a more efficient system out there on the market as technology continues to improve over the years, especially since the current system was issued for construction in July of 1994. The payback period and inconvenience to install a new system is costly and unreasonable with a budget of only $30,000 to work with and furthermore there is no immediate reason to do so.

With that being said, your savings with the current system are going to come from the installation of occupancy sensors and CO_2 sensors. So far, there are about a half dozen installed on campus. The success of the CO2 sensor, currently installed in Salisbury Labs 305, has been monitored between the dates of 3/19/09 – 4/23/09 since its installation. The data shows fan run time hours saved as a result of the installation of this device. Initially on 3/19 in this room alone, the ventilation fans were running for 337.59 hours. Now as of 4/23, the fans were running for 152.02 hours. The fan hours saved were 185.57 hours which corresponds to a 54.9% decrease; a substantial save in just one room alone. One can only imagine the amount of savings incurred if these sensors were to be installed throughout the campus. It shows that efforts have been made towards the efficiency matter, but still shy of the ultimate goal.

The research and work performed here will be valuable information for multiple groups of WPI's community such as the Sustainability Task Force which is spearheading WPI's campus wide efforts for energy and resource conservation. The campus savings may prove to help in keeping more consistent tuition costs during these tough economical times. This would directly affect students, and it is therefore important that everyone is made aware.

The information in this project will set the ground work for future IQP's on this subject and will stimulate WPI's awareness on unnecessary energy usage and finally suggests simple and cost effective solutions to major and obvious problem areas to get more “bang for the buck.” This in turn will improve WPI’s environmental impact on society, and possibly set an example for other institutions by integrating technology with environmental responsibility.

WPI has 36 Computer Control Units (CCUs). These units are not capable of a true shutdown, where the electricity being pulled is less than 1 watt. Equipping each of these systems with an outlet switch that has an on/off button will take care of this issue (Figure 1.4). The payback period is estimated for one CCU by purchasing one switch. If the switches were bought in bulk the price would drop as well as the time for payback. In order to keep the estimate conservative, it is assumed the CCU is in its lowest power state of 50 watts when not being used. In actuality, the CCU’s have a program that puts them into a sleep/standby mode after about fifteen minutes. People utilizing the rooms have been advised by Network Operations not to shut the computers down during the week, since they have this standby program. Due to this fact, the computers are almost always found in their nominal 140 watt-drawing stage.

Figure 1.4 Outlet Switch

In a worst case scenario, the CCU will be in use from 7am until 10pm. This would mean that it is not in use eleven hours a day. This assumes that every professor and group using the room will need the CCU for their entire hour, and that none are teaching from the whiteboards. This was done to make sure the payback calculation is conservative. Shutting the CCU off for eleven hours a day, assuming it is pulling 50 watts and WPI is paying 14 cents a kWh, equates to a payback period of just less than 5 months. The warranty on the switch covers a full year, which is over double the conservative payback period estimate.

Chapter 2 Background

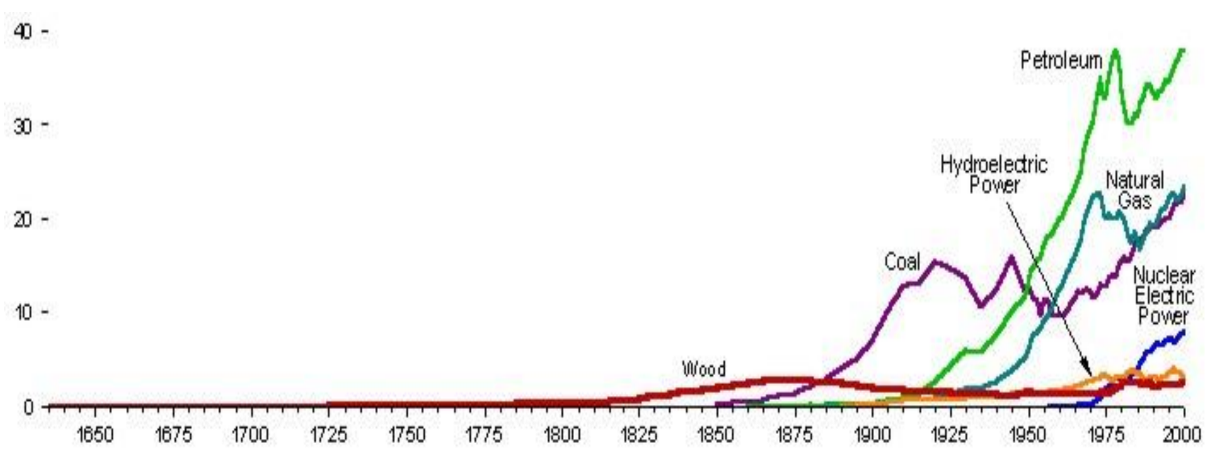
2.1 Intro

The background contains historical and current information regarding energy related research, laws, and technologies. United States Energy Act of 2005 and OSHA standards for lighting are explored. Federal committees such as LEED, Leadership in Energy and Environmental and Design, and FERC, the Federal Energy Regulatory Commission, are explained. WPI Sustainability Task Force and demographics are discussed, along with campus energy projects. A detailed method for performing a full scale energy audit is provided, and grant and funding opportunities are covered.

2.2 United States Energy Use History

Since the 20th century, there has been an increasing demand in the United States for industrial and residential electricity. The earliest large scale energy production was performed in thermal power plants which utilized conventional steam turbines powered by the burning of coal. In more recent times coal has been replaced by new energy sources, but the steam turbines are still typically used today. Advancements in science, technology, and with new discoveries, natural gas and oil were utilized to produce the majority of the United States' electricity since the 1950s. Figure 2.1. United States Energy Consumption by Source in Quadrillion BTU's is a representation of the exponential growth of energy used by the United States.

Figure 2.1. United States Energy Consumption by Source in Quadrillion BTU's[1]



Since the oil embargo of 1973, energy auditing and improvements to the energy efficiency of new buildings have become increasingly popular. Interest in energy audits in recent

[1] http://www.eia.doe.gov/emeu/aer/eh/frame.html

times has increased as a result of a growing understanding of human impact upon global warming and climate change. This is reflected Figure 2.1. United States Energy Consumption by Source in Quadrillion BTU's where petroleum and natural gas consumption drop around 1975. Simple steps have been made by the populous to reduce energy usage in daily life such as turning off lights when not in use, replacing incandescent lights with fluorescent lighting, shutting down computers when not in use, and replacing old technologies with new.

In the electrical industry, i.e. U.S. power plants, steps have been made to develop and utilize technologies for "cleaner" burning coal, renewable energy sources such as wind, solar, geothermal, hydroelectric and tidal. This is illustrated in Table 2.1 which gives totals and a breakdown for energy consumption from 2002 to 2006.

Table 2.1. Detailed analysis of US energy consumption in more recent years.[2]

U.S. Energy Consumption by Energy Source, 2002-2006 (Quadrillion Btu)

Energy Source	2002	2003	2004	2005	2006
Total[a]	**97.684**	**97.971**	**100.051**	**100.161**	**99.398**
Fossil Fuels	83.994	84.386	86.191	86.451	85.307
Coal	21.904	22.321	22.466	22.795	22.452
Coal Coke Net Imports	0.061	0.051	0.138	0.044	0.061
Natural Gas[b]	23.558	22.897	22.931	22.583	22.190
Petroleum[c]	38.227	38.809	40.294	40.393	39.958
Electricity Net Imports	0.072	0.022	0.039	0.084	0.063
Nuclear	8.143	7.959	8.222	8.160	8.214
Renewable	5.893	6.150	6.261	6.444	6.922
Biomass[d]	2.706	2.817	3.023	3.154	3.374
Biofuels	0.309	0.414	0.513	0.595	0.795
Waste	0.402	0.401	0.389	0.403	0.407
Wood Derived Fuels	1.995	2.002	2.121	2.156	2.172
Geothermal	0.328	0.331	0.341	0.343	0.343
Hydroelectric Conventional	2.689	2.825	2.690	2.703	2.869
Solar/PV	0.064	0.064	0.065	0.066	0.072
Wind	0.105	0.115	0.142	0.178	0.264

[a] Ethanol blended into motor gasoline is included in both "Petroleum" and "Biomass," but is counted only once in total consumption.
[b] Includes supplemental gaseous fuels.
[c] Petroleum products supplied, including natural gas plant liquids and crude oil burned as fuel.
[d] Biomass includes: bio fuels, waste (landfill gas, MSW biogenic, and other biomass), wood and wood derived fuels.
MSW=Municipal Solid Waste.
Note: Data revisions are discussed in Highlights section. Totals may not equal sum of components due to independent rounding. Non-renewable energy: Energy Information Administration (EIA), Monthly Energy Review (MER) December 2007, DOE/EIA-0035 (2007/12) (Washington, DC, December 2007,) Tables 1.3, 1.4a and 1.4b. Renewable Energy: Table 2 of this report.

2 http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table1.html

There is a 2.4% increase in use from 2002 to 2005, a large increase over a very short period of time. Due to this increase, a large scale energy policy was formed and put into effect in 2005. A decrease of about 0.762% in usage can be seen in the numbers. This is a small victory, but demonstrates that even with a growing population, it is feasible to continue reducing our energy waste.

The United States Department of Energy was founded in 1942 during the development of the atomic bomb. Until the 1970s energy crisis, their focus was nuclear power and proliferation. At that time it was determined the U.S. needed unified energy organization and development. In 1977, the Department of Energy Organization Act was passed placing all U.S. government energy agencies and programs under one unified department. This department has been responsible for coordinating the U.S. energy efforts in high risk energy technology research and development, energy conservation, nuclear energy and weapons programs, as well as national energy data collection and analysis[3].

2.3 Creating Sustainable, Energy Efficient, Green Buildings

United States companies and industries are under increasing pressure to address their sustainability performance as bottom lines are being squeezed by energy prices and climate change which threatens the viability of energy. Many companies recognize the importance of energy efficiency as energy prices continue to rise. One could expect that profit-driven companies would be the first to move towards higher efficiency, but that is still not the case. It is surprising that very few companies have taken advantage of opportunities to incorporate energy efficiency into their building stock even though a general agreement exists that widespread savings are clearly available[4]. With the Energy Policy Act of 2005, companies are automatically eligible for tax deductions of as much as $1.80 per square foot if improvements to their energy systems were to be made. Those savings alone can help offset initial investment costs.

There are many barriers that slow or even prevent the incorporation of energy efficiency measures which include tenant and/or occupants, financial, building design, etc. According to studies, the primary obstacles institutions, industries, businesses, etc. face in increasing energy efficiency are listed below.

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[3] http://www.energy.gov/about/origins.htm

[4] Info gathered through conversations with National Grid Employees

Obstacles Face in Increasing Energy Efficiency[5]

- Investment Allocation
  - Companies may prefer to allocate their funds towards the core of their business rather than reducing utility expenditure
- Initial Investment Cost
  - Many companies believe that applying energy efficient measures to new buildings require higher initial expenses, higher than conventional methods.
- Life Cycle Analysis
  - Many companies only analyze initial costs when considering implementing energy efficiency measures and forget to calculate the reduction in costs possible for the life of the building. A life cycle analysis is required to look at expenditure of energy for the life of the building.
- Misaligned Incentives
  - During the development of a building, the allocation of funds my skew the construction to one area or another. For example, am efficient design budget can lead to larger mechanical systems in a building than what is required which leads to higher operational costs.
- Risk Factors
  - Benefactors and/or lenders may not incorporate value with the use of new technologies and may find it too risky. Any uncertainty with new technologies may result in a higher interest rate with loans or mortgages which may result in diminished returns for the company.

Today when a structure is being built it can achieve a ranking based on how green and sustainable it is. The United States Green Building Counsel has created LEED, the Leader in Energy and Environmental Design green building ranking system. These buildings receive a LEED certification of either Basic, Silver, Gold, or Platinum. Platinum is the highest rating and requires extensive planning in the design of a structure from beginning to end. The Oregon Center for Health and Healing located on the Oregon Health and Science University campus received this top ranking in 2007.

5 http://dukespace.lib.duke.edu:8080/dspace/bitstream/10161/417/1/MP_elm17_a_200712.pdf

Figure 2.2 Oregon Health Center[6]

Figure 2.2 is a photo of the Oregon Health Center. It is currently the largest United States health center to achieve such a high level of efficiency. The solar panels acting as shades can be seen above windows similar to awnings. These also collect electricity for the building. Other buildings have also achieved the Platinum ranking, around 30 or so in the whole country. The basic ranking is much more common.

2.4 WPI History and Background

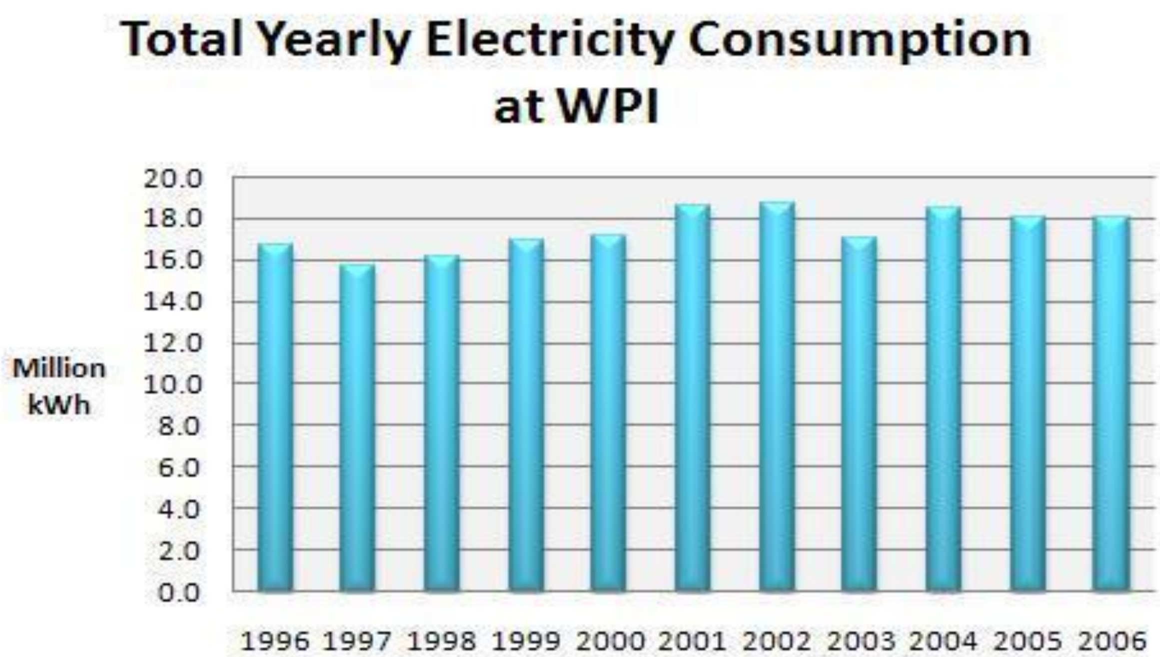
WPI is taking steps towards a "greener" campus, as evidenced in the construction of new buildings. One of its newest buildings, The Bartlett Center, is registered with the U. S. Green Building Council, and uses innovative architectural methods to reduce the load on its lighting and air-conditioning systems. Also, the newest residence hall that was recently constructed, East Hall, was aimed to achieve LEED silver certification, a step above basic LEED certification which certifies a certain level of environmental sustainability. There is, however, much more room to improve the environmental impact of the already present buildings. WPI is a leading technical institution, and as such, should serve as an example for integrating technology with environmental responsibility by tracking its electricity use.

[6] http://www.ohsu.edu/xd/research/centers-institutes/neurology/neuromuscular-disease-center/new-clinic.cfm 4/1/09

Sustainability Taskforce

WPI is a significant consumer of energy in Worcester County. Recently, the president of WPI had established a Sustainability Task Force whose purpose is "to provide leadership and coordination for WPI's campus-wide efforts in energy and resource conservation and reduction in the harmful environmental impacts of our operations, all directed toward enhancing the long-term sustainability of WPI's activities and the environment of which we are a part." Most recently, this taskforce implemented the use of solar powered lighting at WPI's Alumni Field. The taskforce also launched the availability of Zipcars for faculty, staff, and students, and continue their efforts to monitor and reduce energy usage and costs at WPI. Many of the buildings on campus do not have working energy meters. Currently there is no plan to install up to date energy monitoring systems in all of WPI's main facilities in order to track WPI's electricity consumption and identify unnecessary expenditure. Figure 2.3 shows campus yearly electricity use for a ten year period.

Figure 2.3 WPI's yearly electricity consumption over 10 years[7]



The Alumni Field has been equipped with three large solar powered LED path lights (

[7] http://www.wpi.edu/About/Sustainability/climateprotection.html 4/1/09

Figure 2.4. Solar powered path lights Figure 2.5. Closer look at solar light. They were installed on September 19th 2008, and were cheaper than installing an electrical system for conventional lighting. According to Fred Dimauro, these lights have increases safety on the field and on the walk to Harrington Auditorium.

Figure 2.4. Solar powered path lights[8]

Figure 2.5. Closer look at solar light[9]

On March 5th 2009, WPI's East Hall was nominated and won the Green Building's of America Award. Over 2,500 projects other extensive projects were considered. Teams developing these projects worked hard to attain a high level of sustainability. East Hall has become a well known successful green building.

[8] http://www.wpi.edu/About/Sustainability/76786.htm
[9] http://www.wpi.edu/About/Sustainability/76787.htm 4/1/09

East Hall[10]

East Hall Sustainable Features

- East Hall contains the city of Worcester's first "**living green roof**" (Figure 2.6) with 12,985 square feet of white, EnergyStar roofing. The green roof's size is approximately 5,000 square feet of sedum.
- Features such as occupant sensor lighting and low-flush toilets.
- Large number of windows maximizing the amount of natural light that enters the building, thereby reducing the need for artificial light and electricity use during the daylight hours.
- Dedicates interior storage for bikes to encourage students to consider forms of transportation other than automobiles. The new parking lot also has 12 parking spaces for Hybrid or alternative fuel vehicles.
- WPI's second "green" building; the first being the Bartlett Center. East Hall has been registered with the United States Green Building Council and is awaiting final LEED certification, which is anticipated to be at the gold level. (In February 2007, WPI's Board of Trustees voted to adopt a policy calling for all future buildings on campus to be environmentally friendly and LEED-certified structures.)

Figure 2.6. The "green" roof on top of East Hall[11]

[10] http://www.wpi.edu/About/Sustainability/eastha764.html 4/1/09

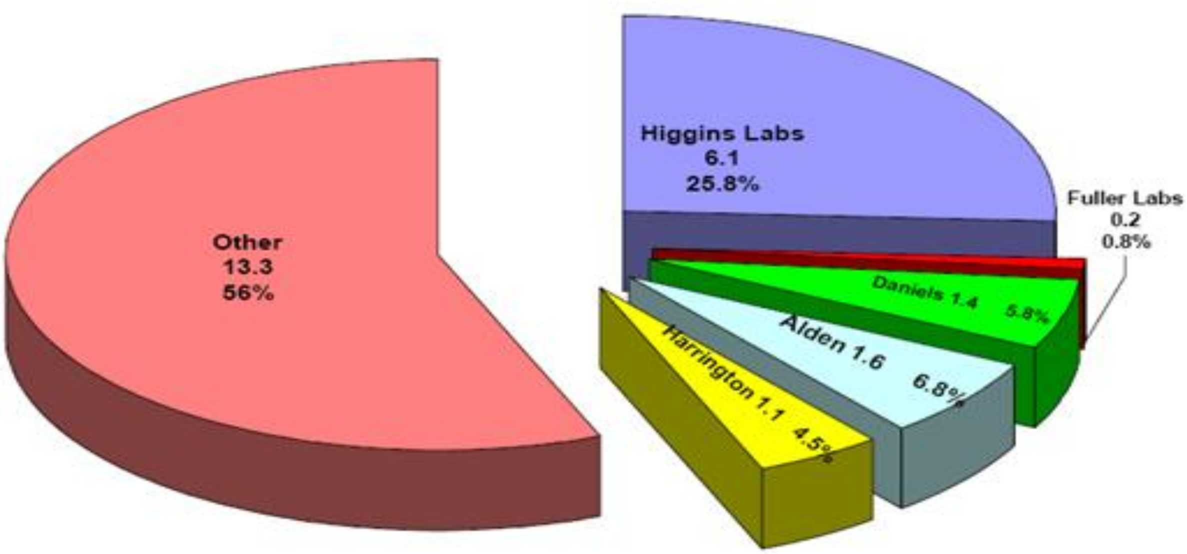
[11] http://www.wpi.edu/About/Sustainability/eastha764.html

2.5 Demographics

WPI consists of many kinds of buildings. There are academic buildings that each focus on different areas of study available to students. There are also administrative buildings and dormitories. Sports facilities also make up a small portion of campus structures. All together there are 23 different buildings not counting the car garages. Each building uses a different amount of energy.

A previous study showed that many of the meters are not functioning properly, and until they are repaired, a breakdown of percent usage by each building is not possible. A more generalized usage is shown in Figure 2.7, showing Higgins Labs to be a main consumer of electricity.

Figure 2.7 Average Usage/Day of WPI's Main campus (Mwh/day)[12]



It is important to understand how WPI’s energy use varies over the years, and see how campus energy demands change with class scheduling. During Christmas vacation the power used is very low because both graduate and undergraduate students have no classes. Between A and B term, and C and D term only the undergraduates have break, and only for one week. In the summer most people go home, but a good portion of WPI faculty and students stay to work and take classes in the summer E term.

12 Monitoring Electricity Consumption on the WPI Campus Christopher O’Hara, Maximillian Hobson-Dupont, Max Hurgin, Valerie Thierry

The campus has 10 undergraduate academic buildings. The names and seating capacities for each is listed below, along with the number of Computer Control Units (CCU's) they contain.

Table 2.2. Building Capacities

Building	Seat Capacity	# of CCU's
Atwater Kent	392	4
Fuller Labs	516	3
Gateway Park	90	1
Goddard Hall	80	1
Higgins Lab	**325**	**6**
Kaven Hall	176	3
Olin Hall	314	2
Stratton Hall	292	4
Salisbury Labs	617	9
Washburn Shops	159	3

2.6 Higgins Demographics and Background

Until the 1940s the Mechanical Engineering Department was located in Stratton Hall. In 1942 it was decided that a new mechanical engineering building would be erected. New laboratories in the building were made for heat transfer, lubricants, fuels, structure of metals, refrigeration, internal combustion, and others. Named for Milton P. Higgins, Higgins Laboratories was built in 1942.

Mechanical Engineering is one of the oldest departments at WPI. Keeping it updated with new facilities and equipment is important to WPI; renovations and a rededication of the labs occurred in 1996, including the construction of an addition with a dramatic glassed-in entrance facing the Quad. The labs contain laser systems, wind tunnels in the basement, and a large student project lab. It is also home to one of the nation's few fire protection engineering departments[13].

Part of the renovation consisted of replacing old constant drive motors in the HVAC system that ran any pumps or fans with Variable Frequency Drive (VFD) motors[14]. These VFD motors are naturally more efficient than the other motors in a sense that they adjust their running speeds with respect to their loads. This allows for precise electrical use. Since the case usually is that the system is not constantly operating under full loads, there is no need to be running those motors at their full potential. With a building the size of Higgins, you need a number of motors to power the fans to circulate the air throughout the building. You can see that the summation of

[13] Tech Bible

[14] Norman F. Hutchins-Head of HVAC Systems at WPI

their individual contributions to the unnecessary power draw crisis can be quite substantial. The excess electricity used can intuitively be noted and the advantages of Variable Frequency Drive motors are evident.

The renovation also included retrofitting the whole campus with better, more energy efficient lighting. This retrofit required replacing all of the old ballasts in every building up on the hill with new ones to fit the new slimmer fluorescent tubes. The job was done by a company out in Longmeadow and took about 6 months to complete[15].

2.7 Previous Energy Project

In 2007, there was a group who carried out a project titled "Monitoring Electricity Consumption on WPI Campus." The report, which was prepared for the Plant Services Department at WPI, evaluated the present status of WPI's electricity monitoring system on a building-by-building basis. It included a comprehensive report of the electricity meter functionality for several dormitories and academic buildings and also presented a short and long-term plan to improve the school's ability to monitor its electricity consumption. Unfortunately for them (and us), there was no single point-source for information on WPI's present electricity metering system and there was ambiguity among the administration about which meters were working, what they were recording, and for what buildings they provided data for. On top of that, no analysis of electricity usage data to observe any emerging trends has been done so they had to start from scratch.

2.8 Energy Audit

Performing a detailed energy audit for a building as large as Higgins Laboratory is a time consuming and complex process. Given the short 6 week time span for this audit, it is very important to figure out early on what are the important elements that need to be studied and documented. A typical energy audit consists of several steps.

Step One

The first step in an energy audit is to do a building and utility data analysis. Typically 3 years of information is gathered. The bills show the standard charges, as well as higher charges for peak demand times. A previous IQP group gathered and compiled information about the

[15] Lawrence B. Riley-WPI's Facilities Custodial Staff

overall campus usage for several past years. This information will be useful in developing and understanding an energy profile for the campus over the years.

Once enough data is obtained, it can be analyzed to develop patterns of usage. It is important to also classify the building. CAD drawings should be acquired and will help to calculate overall dimensions and number of rooms. Weather effects should also be looked into thoroughly. A list of heating and cooling devices, along with the amount of square footage of window spaces will be necessary in this portion of the audit. The environment in which the building is located should be studied as well. Does the building require heat all year? Is it located in an area where it has high sun or wind exposure? Developing the overall general characteristics of the building will aid in understanding how it reacts to and effects the environment.

Step Two

The second step of the audit requires a detailed walkthrough of the building, in this case Higgins Laboratory, where general usage of rooms, equipment type, lighting, and controls are observed and recorded. In this phase it is necessary to decide what in the building is wasting the most power and what items are using a negligible amount. The main goal of the audit should be determined, and address the concerns of any customer's requesting the audit. Operating and maintenance procedures should be obtained from janitorial or on site personnel that can give primary first hand information. The various kinds of spaces in the building need to be classified, along with the major pieces of electrical equipment located in these zones. A determination should be made as to which electrical devices can be considered negligible based upon the scale of the specific energy audit, and its goals. An energy use density map will show where the heavy areas of energy drain are from a building, but are not always readily available. If this tool is not available it will suffice to estimate the general occupancy and equipment use of the areas studied. The amount and classification of lighting is also developed in this phase.

Step Three

The third step of the audit process is to develop a baseline of the building's energy use. This is where the architectural, mechanical, and electrical drawings that were found can be analyzed. By now there should be a basic understanding of the spaces consuming the most power, and what kinds of equipment are present. These items should be inspected and tested to see how much energy they are truly using. Information regarding the efficiency of these machines as well as their reliability should be found and documented. Once all the data has been collected a baseline of building energy usage should be created. This will allow comparison of A-typical energy demands, and allow predictions of future energy use.

Step Four

Step 4 involves the total evaluation of energy saving methods and solutions. The first thing to do is make a list of all methods that could be implemented. Each method should be researched and the amount of energy savings offered should be evaluated. The amount of money required for initial investment and upkeep should also be calculated. This will help in figuring out payback periods. Once each method has been looked at they can be put into an order based on cost effectiveness, which will make selecting the best option easier.

2.9 Heating, Ventilation, Air Conditioning

Heating Ventilation and Air Conditioning systems, more formerly known as HVAC, maintain and control temperature and humidity levels to provide an adequate indoor environment for human activity, experimental labs, and/or for processing goods. In the U.S. it is estimated that the energy used to operate the HVAC systems account for about 50% of the total electrical energy use in a typical commercial building. It is therefore important to understand some of the characteristics of HVAC systems and determine if any retrofits can be recommended to improve the overall energy efficiency of the building.

A typical HVAC system consists of dampers (Outside Air, Return Air, Exhaust Air and Supply Air) to control the amount of air to be distributed, preheat coils, cooling coils, filters, humidifiers, and a distribution system where the air is channeled to various locations and spaces. These components come in all sorts of configurations and the integration of these components constitutes a system for the sole purpose of conditioned air distribution. These Air Distribution systems fall into two main categories: Constant Air Volume and Variable Air Volume Systems.

Constant Air Volume systems provide a constant amount of supply air conditioned at proper temperature to meet the thermal loads in each space based on a thermostat setting. Typically, the supply air temperature is controlled by either mixing cooled air with heated or bypassed air or by directly reheating cooled air. As a result, these systems waste energy because of the mixing and/or reheating especially under partial thermal load conditions. Fortunately, WPI produces its own steam for heating, so there is no electrical loss in that area.

Variable Air Volume systems provide a variable amount of supply air conditioned at a constant temperature to meet thermal loads in all spaces based on thermostat settings. The supply air volume can be controlled and modulated using various techniques such as outlet dampers, inlet vanes, and variable speed drives. Typically, only cooled air is supplied at the central air handling unit. In each space, reheat is provided depending on the space thermal load. Variable Air Volume systems are more efficient since they minimize reheat energy waste.

In most cases, conversion of constant volume systems to variable air volume systems is cost effective and should be considered for existing commercial and institutional buildings. There are still energy savings opportunities in the design of the systems, the method of operation, and the maintenance of the systems. Some steps include the aforementioned reduction in reheat since it wastes energy, eliminating overcooling and overheating of the conditioned spaces to improve comfort levels and avoid energy waste, operating the systems only when needed not in unoccupied rooms, and even reducing the amount of air delivered by minimizing the supply air, make up, and exhaust air.

INDOOR TEMPERATURE CONTROLS

During both heating and cooling seasons, indoor temperature settings have a significant impact on the energy use of the HVAC systems as well as the thermal comfort within occupied spaces. Consumers usually address this area first along with lighting control for immediate savings without out any substantial initial investment. There are four options for adjustments that can save heating and cooling energy, as long as set points are adjusted correctly.

- Overcooling can be eliminated by raising the cooling set-point during the summer.
- Overheating can be eliminated by lowering the heating set-point during the winter.
- Separating heating and cooling set-points can prevent simultaneous heating and cooling operations by the HVAC system.
- Heating and/or cooling requirements can be reduced during unoccupied hours by setting back the set-point temperature (or letting the indoor temperature float) during heating and setting up the set-point temperature during cooling.

UPGRADE OF FAN SYSTEMS

Fans are used to distribute conditioned air from central air handling units to heat or cool various zones within a building. Fans represent about 25% of the total electrical energy use of a building, thus significant energy savings can be seen through improvements in these systems. The electrical energy input required can be significantly reduced by reducing the amount of air to be moved by the fan. For example, a 50% reduction in the volume of air results in 87.5% reduction in fan energy use[16]. This is another reason why Variable Air Volume systems are more efficient compared to Constant Air Volume systems. Some other measures that can be taken are selecting energy-efficient motors, energy-efficient belts, variable speed drives, and sizing. A note

[16] Energy Audit of Building Systems-An Engineering Approach by Moncef Krarti

on sizing: It was found through a recent EPA study that 60% of building fan systems were oversized by at least 10%. Average savings of 50% can be achieved in energy use of fan systems just by simply reducing the size to the required capacity. The benefits of using the proper fan size not only save you money, but also extend to better comfort and longer equipment life.

CENTRAL HEATING SYSTEMS

Four types of heating systems are used extensively in commercial buildings. They are boilers, furnaces, individual space heaters, and packaged heating units. Boiler systems use a combustion process of hydrocarbons to provide the heat. A typical boiler is compromised of an insulated jacket, a burner, a mechanical draft system, tubes and chambers for combustion gas, tubes and chambers for water or steam circulation, and controls.

The main area which can be improved upon is the overall thermal efficiency. This can be improved by tuning-up the existing boiler, replacing the existing boiler with a high efficiency boiler, or use modular boilers. One can also install turbulators in the fire-tubes to increase the heat transfer between the hot combustion gas and water, insulate the jacket of the boiler to reduce heat losses, install soot-blowers to remove boiler tube deposits that reduce heat transfer, or use economizers to transfer energy from a stack flue gases to incoming feed water. Of course with a good budget one can always just replace the existing boiler with a higher efficiency one as manufacturers continue to improve both the combustion and the overall efficiency of boilers.

Modular boilers can increase the overall seasonal efficiency of the heating system by 15-30%.The principle behind modular boilers is that almost all heating systems are most efficient when they operate at full capacity. Instead of operating the boiler in an on/off mode when the load is lower than its capacity, controls use step-firing rates or modulating firing rates ranging from 100-15%.[17]

COOLING SYSTEMS

There are several types of cooling systems that are used in commercial buildings including: packaged air conditioner units, central chillers, heat pumps, residential-type central air conditioners, district chilled water, individual air conditioners, and evaporative coolers. In general, the packaged air conditioner units are the main equipment used to condition buildings in the U.S. The average cooling system consists of a compressor, a condenser, an expansion device, an evaporator, and other auxiliary equipment where both the evaporator and condenser are heat

[17] Energy Audit of Building Systems-An Engineering Approach by Moncef Krarti

exchangers. The energy efficiency of a cooling system is characterized by its Coefficient of Performance (COP), which is defined as the ratio of the heat extracted divided by the energy input required. Currently, the most energy efficient centrifugal water chiller has a COP of about 70% of the ideal Carnot cycle. The capacity of cooling systems is expressed in kW and is defined in terms of the maximum amount of heat that can be extracted. In large buildings, central chillers are used to cool water for space air conditioning. Some of these chillers are powered by electric motors which have their own inefficiencies associated with them. Some chillers use hot water to steam to generate chilled water, which is what is currently being used at WPI.

The energy use of cooling systems can be reduced by improving the efficiency of the equipment under both full and partial load conditions. Like the heating systems, this can be achieved by either improving the existing operating controls of the cooling systems, using alternative cooling systems, or simply by replacing the existing cooling systems. Indeed it can be cost-effective to replace an existing chiller with a new and more energy efficient chiller. Some strategies that can be used to improve the efficiency of existing chillers are as follows: Increase the evaporator and the condenser surface area for more effective heat transfer, improve the compressor efficiency and control, enlarge internal refrigerant pipes for lower friction, and ozonate the condenser water to avoid scaling and biological contamination. Before replacing an existing chiller though, it is recommended to consider alternative cooling systems or simple operating and control strategies to improve its energy performance. Evaporative cooling and water-side economizers are some of the common and proven alternative cooling systems. Two basic control strategies that can be implemented are supplying chilled water at the highest temperature that meets the cooling load and decreasing the condenser water supply temperature when the outside air wet bulb temperature is reduced. In the future, it is expected that higher efficiency cooling equipment will be available as well as other innovative air conditioning alternatives such as desiccant cooling systems. [18]

2.10 Lighting

There are many lights in each building on the WPI campus. Higgins is certainly no exception. Lighting is a very important factor of campus life. How much lighting is necessary in a classroom that has no windows so that students will remain awake, take notes, and be able to see the front of the room? Is full lighting needed in a hallway that has many windows? How about a machine shop where being able to see very clearly is a primary factor for safety? There are many elements that tie directly into how much lighting is needed in the various environments that each building contains.

[18] Energy Audit of Building Systems-An Enginnering Approach by Moncef Krarti

There are several precautions that can be taken in order to reduce the amount of electricity that is used by the lighting system of a building. Incandescence is when a hot body gives off light because of its high temperature. In these kinds of bulbs an electron flow is present and is resisted by the filament. This causes it to heat up enough that it gives off some light radiation that is within our visible spectrum. However, the majority of the light given off is infrared and therefore invisible. This is the reason that these bulbs are very inefficient and can result in a lot of undesirable heat radiation.

Florescence is very different in the way it produces light. In these tube-like bulbs a small current is passed through mercury atoms and causes them to give off light. This light is actually in the ultraviolet range and can be very harmful to people and animals. A fluorescent material, called phosphor, is coated along the inside of the tube, which absorbs the harmful light and in turn radiates safe visible light. These bulbs tend to give off up to quarter of the heat the incandescent bulbs do. This clearly makes florescent bulbs the more efficient choice, unless the heat radiation is desired.

Light Emitting Diodes (LEDs) work on electroluminescence, which is an optical and electrical phenomenon where light is emitted when electricity passes through a material. LEDs use up to 90% less electricity than fluorescent bulbs, don't contain hazardous gasses, and last up to 3 times longer. However, LEDs are still rather expensive, but with the increase in demand for low energy light bulbs, and increase in LED production, the cost should drop.

From advancements in lighting technology and with various sources of lighting, comes a variety of control systems. Most traditional are simple switches, where the light is either on or off. Dimmer switches were also developed in order to increase or decrease light intensity while on. To facilitate energy conservation, lighting timers and motion sensors were also developed in order to shut off lights when they are not needed. Most recently, Panasonic has developed a lighting system that automatically dims based upon ambient light intensity whereas a room would not be lit above the required lumen standard.

2.11 Federal and State Laws

The United States Department of Labor, Occupational Safety and Health Administration (OSHA) have standards for the illumination of all public areas and buildings. With the implementation of new lighting sources, many old buildings can be over illuminated which can lead to increased electrical usage. OSHA states that, for any corridors or hallways the minimum illumination required is 5 foot-candles. Ten foot candles of illumination are necessary for mess halls, equipment rooms, store rooms, workrooms, and bathrooms. Thirty foot-candles are mandatory for infirmaries and offices[19].

U.S. Congress passed the bill, Energy Policy act of 2005, and it was put into law by George W. Bush. This energy act is rather extensive and covers most all possibilities for energy conservation and the future of a greener U.S. This bill looked to authorize loans towards new technologies that produce less greenhouse gasses such as renewable energy sources, nuclear power, and cleaner coal. The energy act also authorized subsidies, grants, and up to $14.5 billion in tax incentives for the application of alternative energy sources towards corporations and industries[20].

2.12 Computers

WPI has hundreds of computers on campus, with over 50 in some of the labs. Though the machine has come a long ways, the computer continues to draw a lot of power. They are also very expensive and contain a lot of heavy metal waste. Keeping a computer running well requires minimal but consistent effort on the user's end. It is very important to allow the computer time to cool down. They have a very long shelf life when not being used, but when continuously running the life of the system is greatly reduced. One of the most common things missed is cleaning out the ventilation and fan areas. Fans do commonly fail in computers. It is much more likely that it will break when no one is around if the device is left constantly running, pulling in harmful dust when not in use. With the newer technologies available, cyclic fatigue is not as much of a worry with computers anymore. There is a greater need to shut them down in extended periods of non use usually, over an hour. This is beneficial in extending the machines life and greatly reduces energy waste.

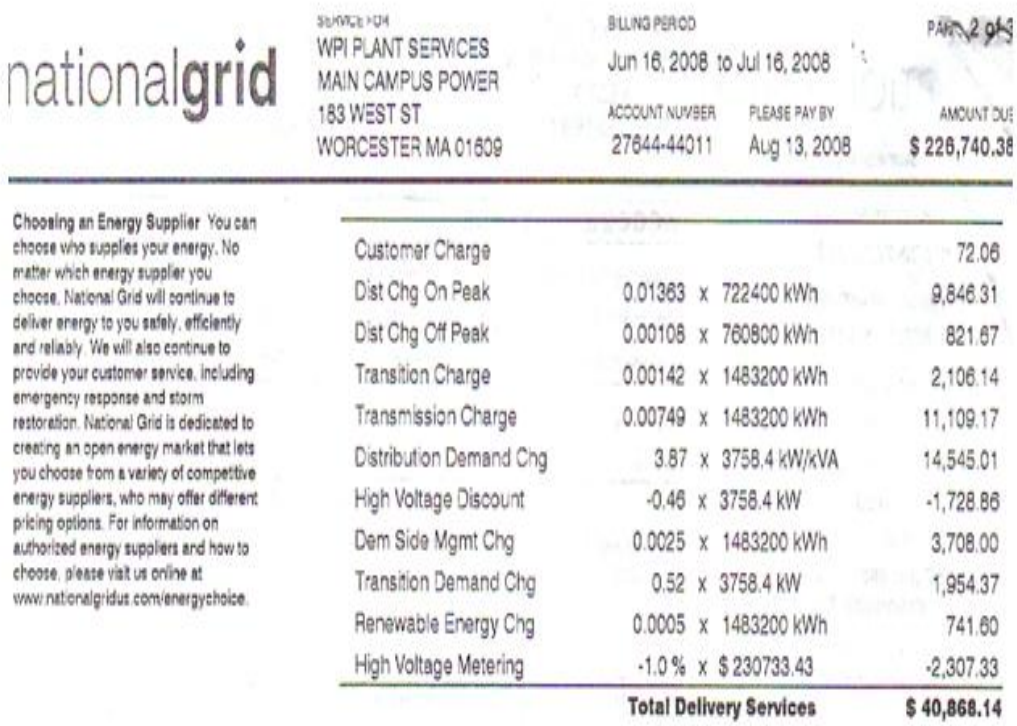
[19]Regulations (Standards - 29 CFR) Illumination. - 1926.56. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10630 **04/01/2009**

[20] http://www.epa.gov/oust/fedlaws/publ_109-058.pdf 4/1/09

2.13 Understanding the National Grid and Direct Energy Bills and Charges

WPI currently purchases electricity from National Grid (NG), who sends an employee to take a meter reading from 183 West Street once a month. The bills are comprised of a variety of different charges that fluctuate throughout the year. Understanding the individual charges that WPI incurs from NG will help in evaluating where the campus' money is going and what exactly is being paid for (Figure 2.1).

Figure 2.8 National Grid Bill Image


nationalgrid

SERVICE FOR
WPI PLANT SERVICES
MAIN CAMPUS POWER
183 WEST ST
WORCESTER MA 01609

BILLING PERIOD
Jun 16, 2008 to Jul 16, 2008

PAGE 2 of 3

ACCOUNT NUMBER	PLEASE PAY BY	AMOUNT DUE
27644-44011	Aug 13, 2008	$ 226,740.38

Choosing an Energy Supplier You can choose who supplies your energy. No matter which energy supplier you choose, National Grid will continue to deliver energy to you safely, efficiently and reliably. We will also continue to provide your customer service, including emergency response and storm restoration. National Grid is dedicated to creating an open energy market that lets you choose from a variety of competitive energy suppliers, who may offer different pricing options. For information on authorized energy suppliers and how to choose, please visit us online at www.nationalgridus.com/energychoice.

Customer Charge		72.06
Dist Chg On Peak	0.01363 x 722400 kWh	9,846.31
Dist Chg Off Peak	0.00108 x 760800 kWh	821.67
Transition Charge	0.00142 x 1483200 kWh	2,106.14
Transmission Charge	0.00749 x 1483200 kWh	11,109.17
Distribution Demand Chg	3.87 x 3758.4 kW/kVA	14,545.01
High Voltage Discount	-0.46 x 3758.4 kW	-1,728.86
Dem Side Mgmt Chg	0.0025 x 1483200 kWh	3,708.00
Transition Demand Chg	0.52 x 3758.4 kW	1,954.37
Renewable Energy Chg	0.0005 x 1483200 kWh	741.60
High Voltage Metering	-1.0 % x $ 230733.43	-2,307.33
	Total Delivery Services	**$ 40,868.14**

WPI is rated by NG as a G-3 category client. This means that the campus uses more than 10,000 kWh per month and has a demand higher than 200 kW. Residential homes will typically fall under a G-1 category, while small businesses tend to be in the G-2 group. As shown in Table 2.3, it is much more costly to use electricity during the peak hours rather than off peak. The cost is roughly 27 times more expensive per kWh during peak times (Table 2.3). The generation charge is separate from the distribution charge and is not typically reflected in the NG bill, but is a separate bill all together (See Appendix C and Appendix D).

Table 2.3 National Grid Charging System[21]

Time-of-Use (G-3) This service is primarily available for large commercial and industrial customers with demand greater than 200 kW.

Peak Hours:
January 1—March 7: 8:00 a.m. to 9:00 p.m.
March 8—April 4: 9:00 a.m. to 10:00 p.m.*
April 5—October 24: 8:00 a.m. to 9:00 p.m.
October 25—October 31: 7:00 a.m. to 8:00 p.m.*
November 1—December 31: 8:00 a.m. to 9:00 p.m.

*These Peak Hours are applicable during 2009 and reflect the difference between when the customer's meter records on-peak kWh consistent with the pre-2007 Daylight Saving Time schedule and the revised Daylight Savings Time schedule mandated by the Federal Energy Policy Act of 2005.

Off-Peak Hours: All hours not specified as peak hours.

Rates for Delivery Service

Customer Charge	$73.16/month
Distribution Demand Charge	$3.92/kW
Distribution Energy Charge	
Peak Hours	1.229¢/kWh
Off-Peak Hours	(0.045)¢/kWh
Transmission Charge	1.192¢/kWh
Transition Demand Charge	$0.19/kW
Transition Energy Charge	0.061¢/kWh
Demand Side Management Charge	0.250¢/kWh
Renewables Charge	0.050¢/kWh

Billing Terms

Off-Peak: This is when the National Grid Company has an overall low demand for electricity from its cumulative clientele. This is typically holidays, weekends and evenings.

Peak: This is when the National Grid Company has an overall high demand for electricity from its cumulative clientele. These periods are usually during the days of Monday through Friday.

Demand Charge: This is the cost of providing electrical transmission and distribution equipment to accommodate the largest electrical load WPI uses.

Explanation of Charges

Customer Charge: This is the cost of providing customer related services. These include metering, meter reading, and billing. This cost is fixed and does not change with increased or decreased electricity usage.

Distribution Charge On-Peak: This is the cost of delivering electricity from the beginning of the National Grid distribution center to WPI during the peak hours as defined above.

Distribution Charge Off -Peak: This is the cost of delivering electricity from the beginning of the National Grid distribution center to WPI during the off-peak hours as defined above.

Transition Charge: These charges are actually part of a debt owed to certain energy companies from National Grid due to early termination of a National Grid contract with the power generation company. Due to deregulation of certain policies in 1998, National Grid is now strictly a distribution center and is not allowed to generate electricity. They used to

[21] https://www.nationalgridus.com/masselectric/business/rates/4_tou.asp 4/13/09

make some of their own electricity, but there was a higher demand for power than the company had capacity for. It outsourced to small power generation companies to cover the remaining demand. Once National Grid stopped making energy, they had to outsource for their total electricity demand. The small companies they were using did not have the capacity to provide all of this power, so N.G. had to cancel all the contracts they had with the smaller companies and create new ones with much larger generation companies. This debt that N.G. owes is spread among all of its clients, and should be paid off in roughly 10-15 years[22].. After that, this charge will no longer appear on the monthly bills

Transmission Charge: This is the cost of delivering electricity from the electrical generation company to the beginning of National Grid's distribution center. This is a fixed rate, and is not a function of the distance between N.G. and its power generation source.

Distribution Demand Charge: This is the cost of delivering the largest instantaneous electricity demand throughout the month from the beginning of the National Grid distribution center to WPI.

High Voltage Discount: This is a discount offered to WPI because the electricity that we get from National Grid comes to the campus at 13,800 volts, where as a normal residential home or small business usually receives it at 120, 240 or 480 volts.

Demand Side Management Charge: This is the cost of demand side management programs offered by National Grid. Residential homes and small businesses can ask for a free energy audit from N.G., and can also be reimbursed for implementing energy saving methods such as more efficient lights and motion sensors.

Transition Demand Charge: This charge is essentially the same as the Transition Charge, except that it is a function of the largest instantaneous electrical demand throughout the month rather than the total month's usage.

Renewable Energy Charge: This is a charge to fund initiatives for communicating the benefits of renewable energy and fostering formation, growth, expansion, and retention of renewable energy and related enterprises. There is no way to track where this money goes, or to see what programs donations are being made to.

High Voltage Metering: This is a discount given to WPI because we use our own transformers to reduce the 13,800 volt electricity delivered by National Grid down to a more manageable voltage.

[22] A Conversation with a National Grid Representative

2.14 Summary

The background explains reasons as to why businesses have a difficult time operating with a high level of electrical efficiency and sustainability, and WPI is no exception. Although several steps towards a greener, more efficient campus have been taken, more needs to be done. The right motivated people, equipped with the proper tools and information could make a permanent positive change to the campus electrical waste. An energy audit is an extensive process when applied to a campus the size of WPI, but would provide much of this foundational information.

Chapter 3 Methodology

3.1 Introduction

This section details the process and procedures performed for an energy audit of Higgins Labs and sets up a general procedure for an energy audit of all other buildings on the WPI campus. It was chosen to perform an energy audit in order to create a baseline of data regarding excess electricity use. Organizing a set of data containing information on what electrical components in various spaces are wasting electricity will help in coming up with fixes to save money. Saving money and reducing electrical wasted are the main audit goals. The primary tools utilized to complete the audit, were a LUX light meter and a Kill-A-Watt meter.

3.2 Step One: Utility and Building Data Analysis

CAD drawings of Higgins Labs were obtained. These CAD drawings detail floor plans for each room and numbered section of the building, room size, location, etc.

The electricity bills from January 2006 to present for WPI's main campus were obtained. The information from the bills was put into an excel spreadsheet to develop patterns of electricity usage and cost at WPI for the past three years. Bills from National Grid, Hess Energy Corporation, and Direct Energy were all integrated to create an accurate energy profile.

A schematic of the HVAC system of Higgins Labs was obtained (Refer to Appendix H). This schematic shows all of the HVAC equipment specifications currently in use in the building. The schematic aided in the determination of a rough estimate of the electrical power draw of the HVAC system compromised of over 80 individual motors.

A schedule of the typical weekly classroom and office usage of Higgins Labs was obtained. This schedule allowed for the development of a pattern of use chart to further hone in on and identify key areas of inefficiency.

3.3 The Walkthrough

Utilizing the CAD drawings of Higgins Labs, each room number was classified as an auditorium, standard classroom, office, computer lab, laboratory, machine shop, conference room, bathroom, hallway, stairway or closet. For each room, all switches, lights, and any electronics or pieces of equipment were catalogued by number and by electricity consumption. The intensity of lighting was determined for each room using a Lux Meter. The intensity of light was measured with all lights on and all shades closed then open, and if possible, lights dimmed or at different levels, depending on the capability of the controls in the room, with shades open then closed. Lighting levels were measured at various times of the day and during cloudy and sunny days in this manor in order to show lighting intensity with varying ambient light.

3.4 Higgins Baseline Energy Use

For a period of 9 days, the electricity use for Higgins Labs was monitored through the use of Higgins Labs' main electricity meter in order to develop a baseline for Higgins Labs' electrical use. For one day, the electricity meter was monitored every hour on the hour to develop a "Day in the Life of Higgins Labs." For any building, an electricity metering system can be used by a licensed electrician to develop a more detailed, zone by zone or room by room, electricity profile. For this study of Higgins Labs, the budget did not allow for this detailed profile.

Case studies of a typical office, classroom, lecture hall, and computer lab were performed in order to develop profiles of energy uses in each of these types of rooms. A Kill-A-Watt meter was used in order to determine the electrical consumption, in kilowatts, by each and every device plugged into a 120 volt outlet. Each piece of equipment was classified based upon its electrical consumption.

3.5 Determining Results and Conclusions

The data collected in each step of the energy audit was utilized to develop energy saving methods for Higgins Labs, as well as develop potential energy saving methods for all WPI buildings.

Chapter 4 Results

4.1 Results Introduction

This chapter includes all raw data collected for the energy audit of Higgins Labs at WPI. This includes building schematics and room classifications, case studies of electrical components with electric consumption found in specific rooms, campus wide electric consumption data from National Grid, Direct Energy, and Hess Energy, and the HVAC system currently utilized.

4.2 Layout of Higgins Labs

Higgins Labs consists of 205 rooms from the basement level to the third floor. Each room is classified as follows:

Table 4.1 Room Classifications

Room Classification	Room Numbers
Auditorium	**116, 218**
Classroom	**114, 154, 202**
Laboratory	**004, 005, 006, 008, 016**, 025, **026,** 031, 042, **045, 124, 127, 129, 216, 230,** 232, **235, 248, 311, 312,** 313
Office	**003, 008A, 009, 010, 011, 012**, 027, 028, 032, 033, 034, 037, 038, 039, 041, 044, **103, 104-112,** 125, 126, 128, 131, 133, 134, 135-140, 143-145, 148, **150-153, 203, 204, 206-214, 231,** 234A, 236, 239, **240, 242-247, 249, 250, 301,** 306, 307
Hallway	**036, 048-051, 103, 156-159, 203A, 251, 253-255, 315, 316, 318**
Bathroom	**019, 020, 117, 118, 223, 224, 303, 304**
Closet or Storage Room	006, 015, **017, 018,** 021-024B, 038A, 103A, 103B, 119-122, 146, 217, 218A, 222, 225-228, 231, 241, 305, 322, 323
Conference Room	**102, 123, 115, 201, 229**
Stairwell	**001, 002, 007, 035, 101, 113, 130, 142, 215, 238, 302, 319, 321**

Note: The highest electrical consuming devices were documented for rooms in **BOLD**. Rooms in RED had limited or restricted access and the equipment in those rooms was not documented.

The CAD drawings of each of the floors in Higgins Labs with room numbers can be found in APPENDIX I**.**

4.3 Case Study Introduction

The following studies were performed in order to develop a detailed electricity profile for a typical office, auditorium, computer lab, and machine shop in Higgins Labs. Every piece of equipment in each room was documented with the equipments electricity usage in watts and run time in a typical day. Light intensity readings of each room were taken with a Digital LUX

Meter,[23] and Kill-A-Watt meter. (See footnote for link to information on this meter, detailed information on this meter can be found in **Appendix**).

4.4 Office Room 250

This room has no windows. There is only one light switch and with all lights on, the room is illuminated to 464 LUX (43.2 ft-candles). The electricity usage in watts was determined for each device in this room either while on or in standby. Shown in Table 4.2 below are all the components with their electrical consumption and typical usage.

Table 4.2 Room 250 Case Study

Component	On Watts	Standby Watts	Daily Usage (hrs) (Not on Standby hrs)	Daily Electric Consumption (kW-hrs)(Includes Standby hrs)
Fluorescent Lights	160	0	10.00	1.62
Laser Printer	150	35	4.50	0.54
Computer	65	3	9.00	0.58
Computer Monitor	45	3	9.00	0.40
Desk Light	34	1	9.00	0.32
Desk Fan	12	1	4.50	0.07
Paper Shredder	227	1	0.20	0.07
Computer Speakers	4	2	1.00	0.03
Pencil Sharpener	13	1	0.02	0.02
Label Printer	10	1	0.08	0.02

Shown below in Figure 4.1 is a graphical representation of the instantaneous electricity consumption by component, and in Figure 4.2 is daily electricity usage for each component.

[23] LX1010B. http://www.multimeterwarehouse.com/FX101f.htm

Figure 4.1

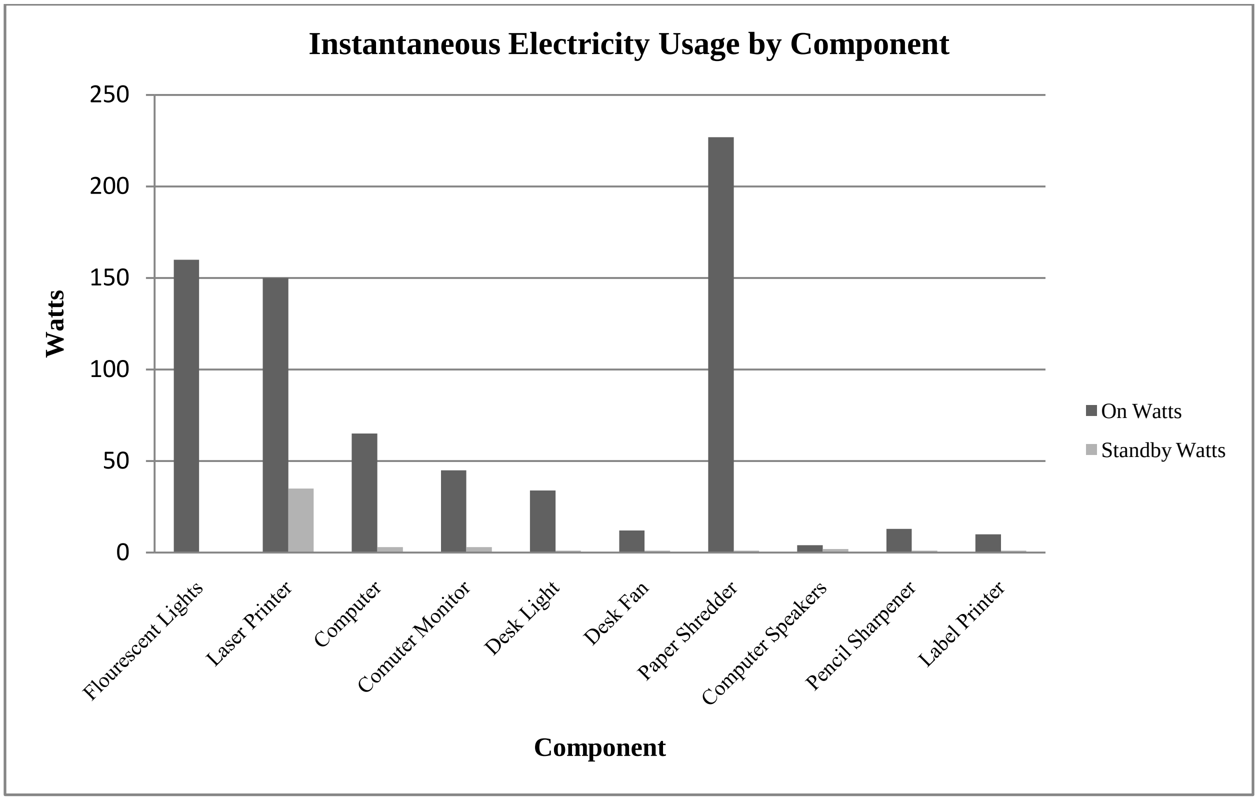
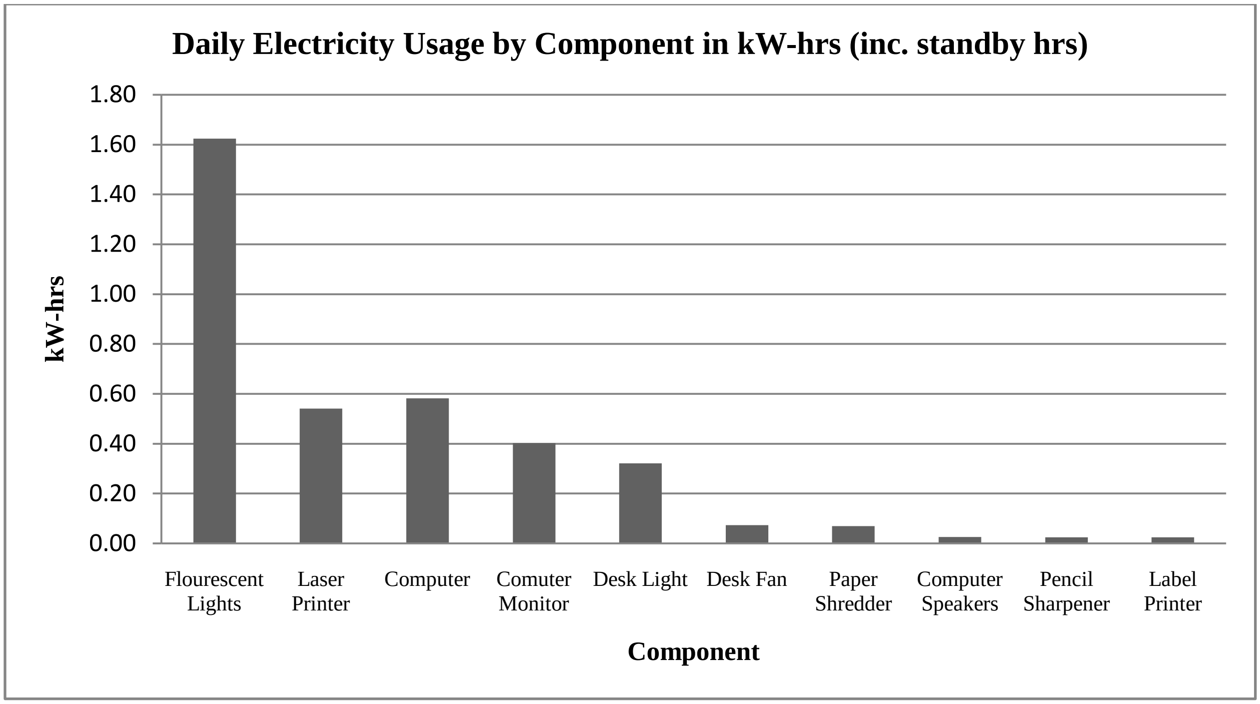


Figure 4.2



Offices in Higgins Labs vary slightly with components and size. Some offices contain windows and allow for ambient lighting. Even with additional components, such as personal laptops, office room 250 sets a typical standard for office rooms 104-112, 203, 204, 206-214, and 239-249.

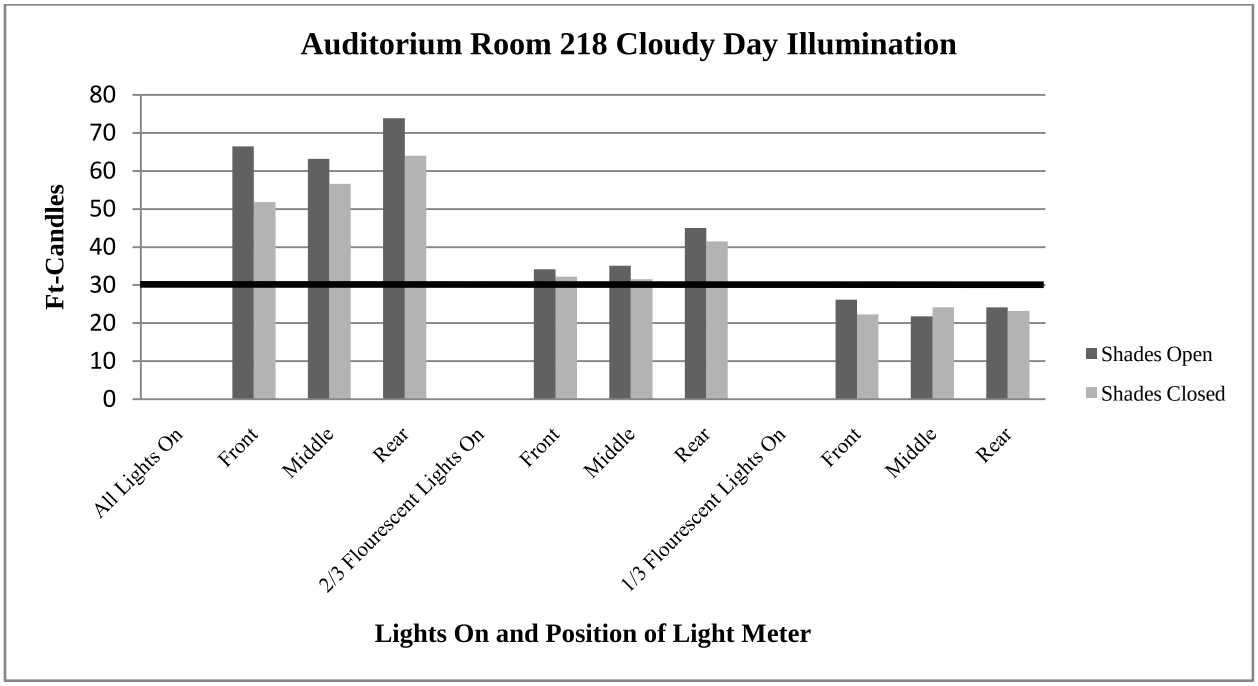
4.5 Auditorium Room 218

This room is classified as an auditorium and is almost identical to Auditorium room 116, the only other auditorium in the building. There are two light switches that allow control of the fluorescent lights illuminating the front/podium area of the room, either on or off. Five switches are used to control the rows of fluorescent lights over the auditorium seating, either on or off. One dimmer switch is used to control the stairway incandescent lighting in the room. One dimmer switch is used to control incandescent lighting over the auditorium seating. Lastly, one dimmer switch is used to control the flood lighting used to illuminate the white board. The lights over the seating area can either be all fluorescent bulbs on, two thirds bulbs on, or one third bulbs on. Dimmer switches can be utilized to change the level of lighting of the incandescent bulbs in the room.

The light intensity was measured at three points in the room, front, middle, and back, with either the shades on the windows open or closed. The light intensity was also measured during a sunny day and a cloudy day to show the difference in ambient light in the auditorium. The recorded light intensities are shown in the

Figure 4.3 below. The reduced lighting columns refer to when the fluorescent lights are on and incandescent bulbs are off. The bold horizontal trend line is set at the required lighting level for the room.

Figure 4.3



Each piece of equipment and all light bulbs were catalogued with their instantaneous electrical consumption in watts. (Table 4.3)

Table 4.3 Room 218 Case Study

Component	Number of Components	On Watts per Component	Standby Watts per Component	Total On Watts per Component	Typical Weekly Usage (hrs) (Not Standby)	Weekly Electric Consumption (kW-hrs) (inc. Standby hrs)
Florescent Light	90	32	0	2880	90	259.37
Incandescent Bulb	21	75	0	1575	90	141.92
Projector	2	367	367	734	168	61.82
Marker Board Lights	3	75	0	225	90	20.42
Exit Sign	3	40	0	120	168	20.33
CCU	1	150	60	150	90	8.27
Clock	1	0.4	0	0.4	168	0.24
Air conditioners	3	N/A				
Security Camera	1	N/A				
Projector Screen	1	N/A				
Heater	0	N/A				
Light Switch	10	N/A				
Windows	3	N/A				

Figure 4.4 is a graphical representation of the total instantaneous electricity usage by component and Figure 4.5 is a graphical representation of the weekly electricity usage by component for Auditorium Room 218.

Figure 4.4

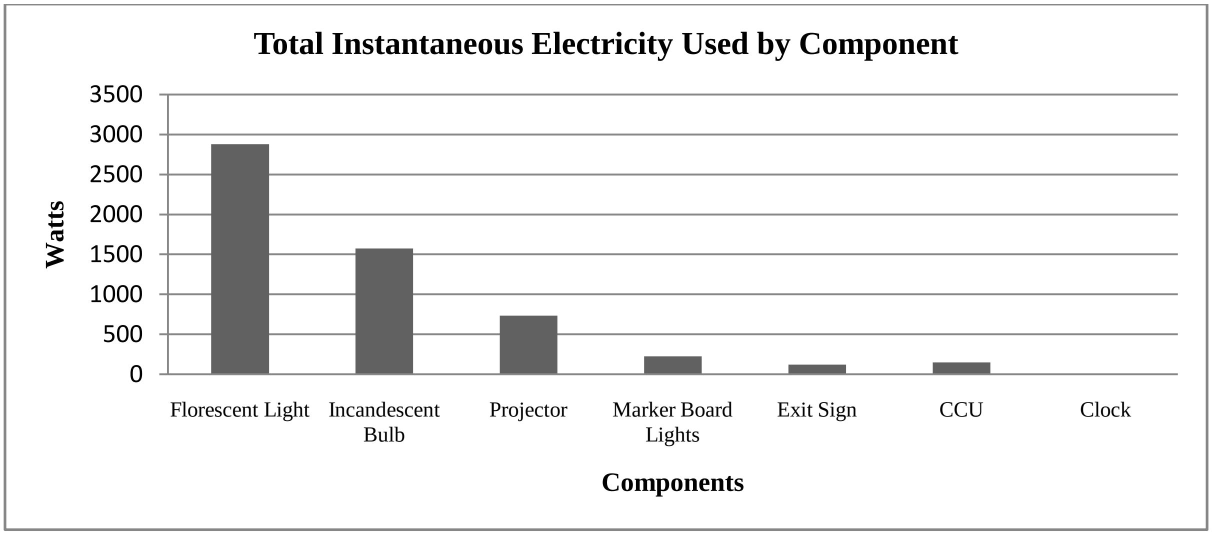
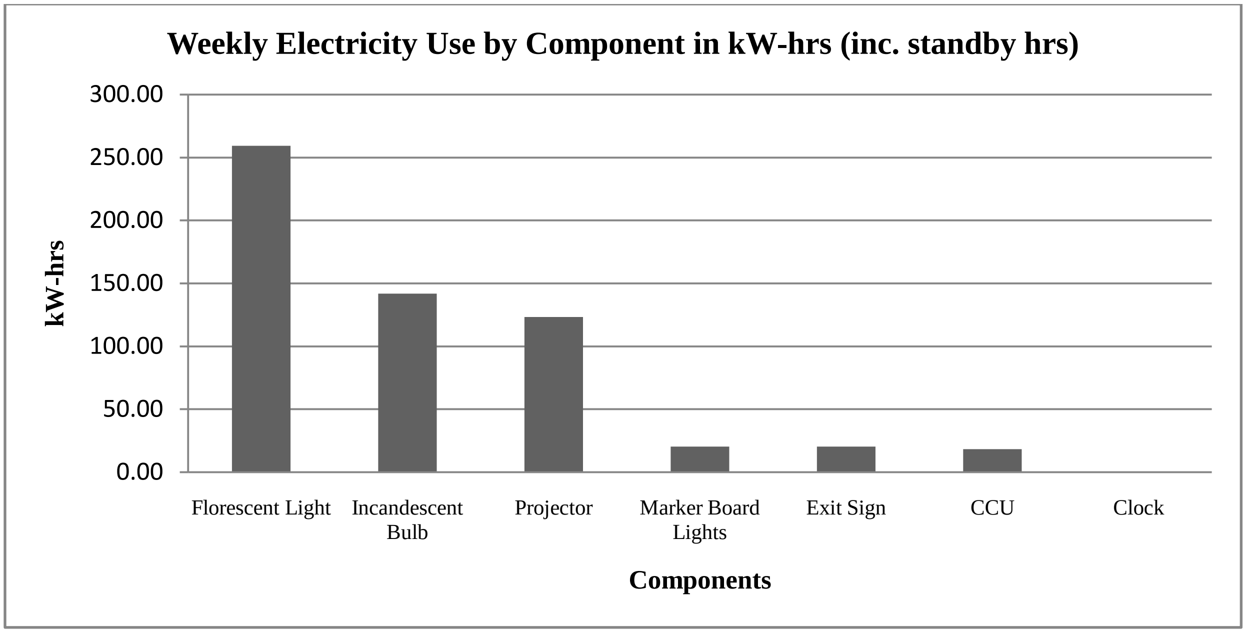


Figure 4.5

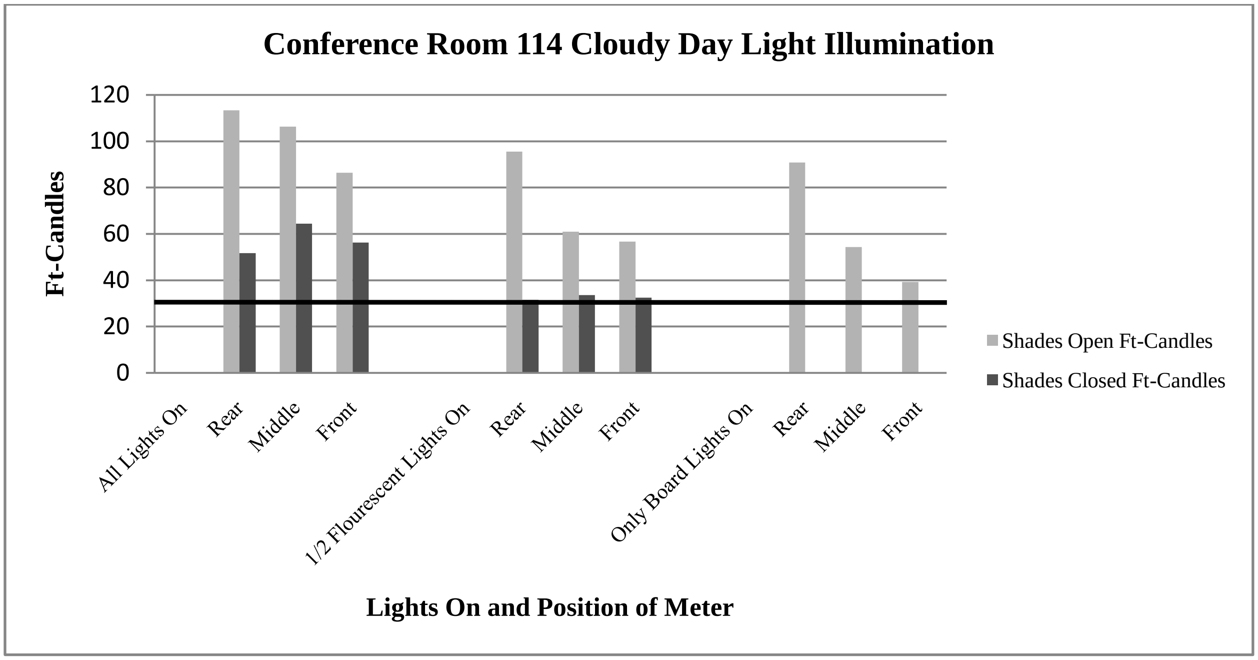


Weekly Electricity Use by Component in kW-hrs (inc. standby hrs)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
kW-hrs
Florescent Light
Incandescent Bulb
Projector
Marker Board Lights
Exit Sign
CCU
Clock
Components

4.6 Classroom Room 114

Room 114 is classified as a classroom. feet. In room 114 there are three is one light switch to control the lighting over the podium/front area and two switches to control the rest of the lighting in the room, half or full lighting. The light intensity was also measured during a cloudy day to show low ambient lighting with the shades open in the room. The recorded light intensities are shown in the Figure 4.6 below. The bold horizontal trend line is set at the required lighting level for the room.

Figure 4.6



Each piece of equipment along with each light bulb was catalogued with its instantaneous power consumption in watts. In the Table 4.4 Room 114 Case Study below, utilizing scheduling data for the room, the electricity profile is shown.

Table 4.4 Room 114 Case Study

Component	Number of Components	On Watts per Component	Standby Watts per Component	Total Watts per Component	Typical Weekly Usage (hrs) (Not Standby)	Weekly Electricity Consumption (kW-hrs) (inc. Standby hrs)
Florescent Light	36	32	0	1152	65	74.88
Projector	1	367	367	367	65	61.66
CCU	1	150	60	150	65	15.93
Marker Board Lights	4	32	0	128	65	8.32
Clock	1	0.4	0	0.4	168	0.07
Incandescent Bulb	0	N/A				
Projector Screen	1	N/A				
Heater	3	N/A				
Light Switch	3	N/A				
Windows	5	N/A				
Air conditioners	1	N/A				

Figure 4.7 is a graphical representation of the instantaneous electricity usage by component in watts and Figure 4.8 is a graphical representation of the yearly electricity usage by component in kW-hrs for room 114.

Figure 4.7

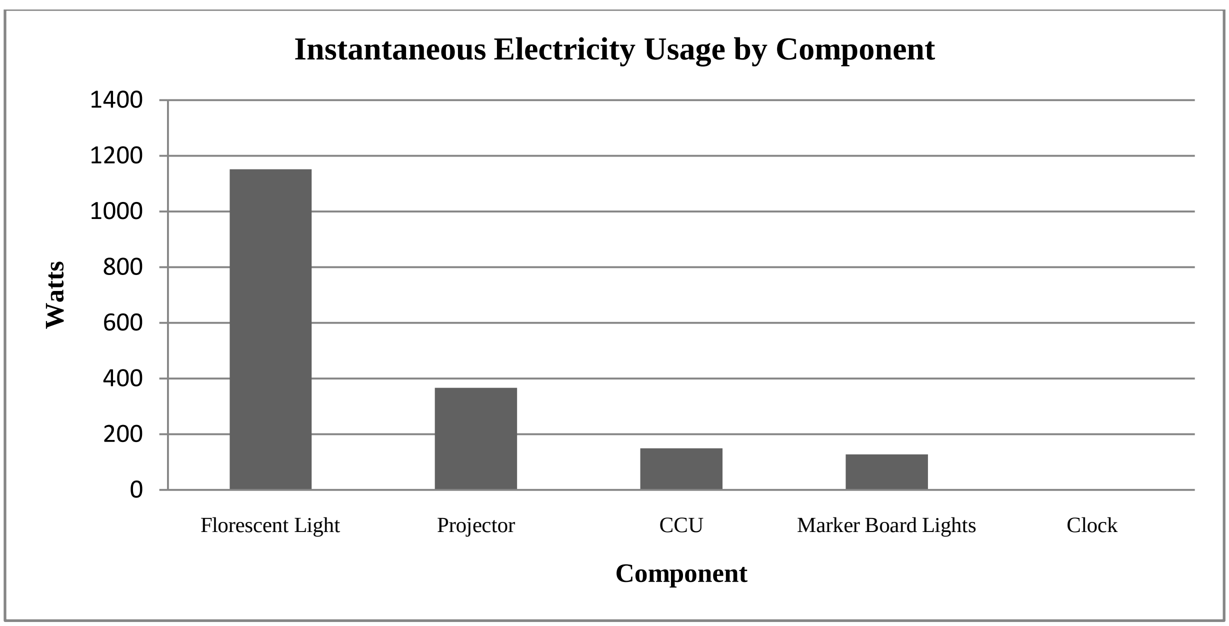
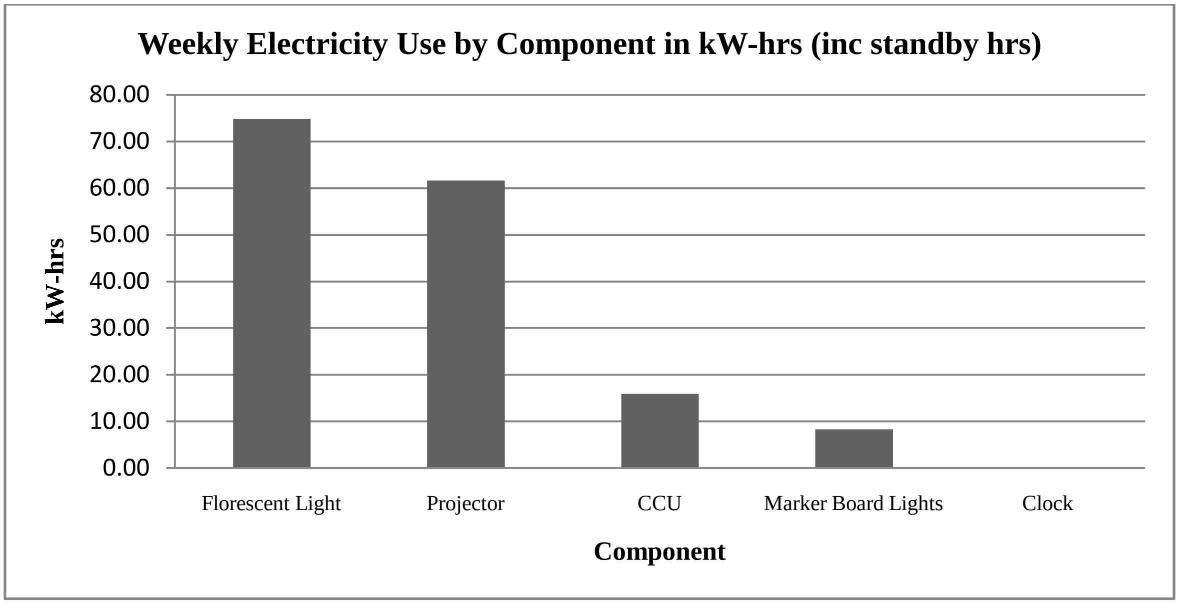


Figure 4.8


Weekly Electricity Use by Component in kW-hrs (inc standby hrs)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
kW-hrs
Florescent Light
Projector
CCU
Marker Board Lights
Clock
Component

4.7 Conference Room 201

This conference room 201 has two dimmer switches to control the lighting. There are no fluorescent bulbs, only incandescent. The light intensity was measured with all lights on and off, with shades open and closed, as well as on both a cloudy and sunny day. The light intensity data is shown in Figure 4.9 and Figure 4.10 below. The bold horizontal trend line is set at the required lighting level for the room.

Figure 4.9

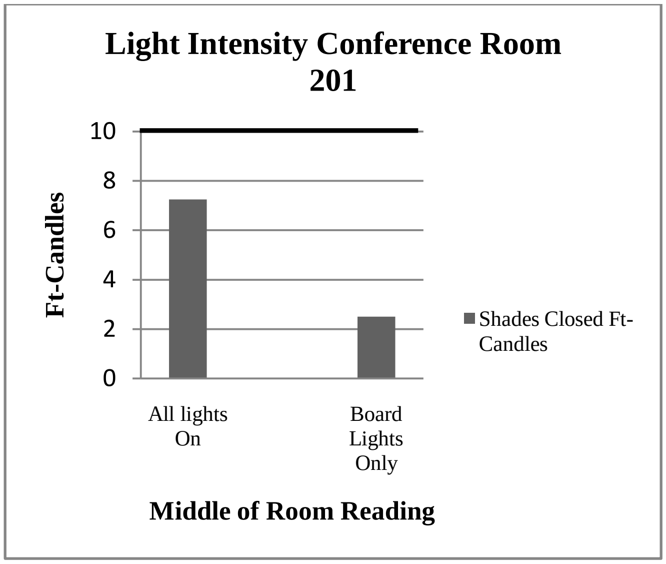
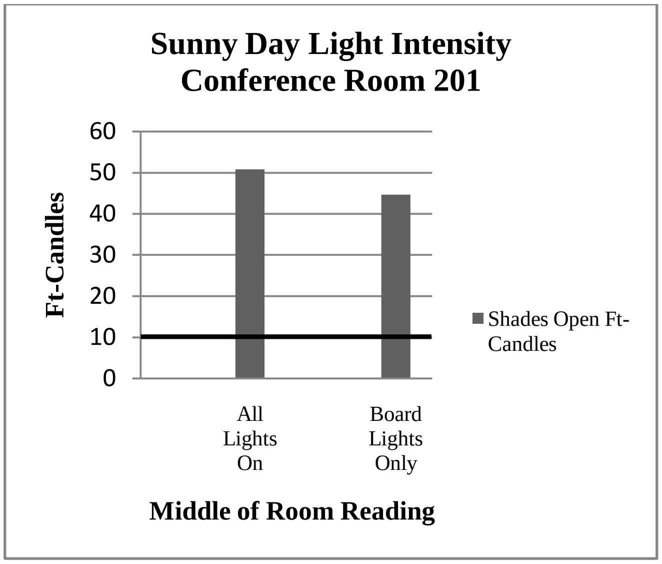


Figure 4.10



All equipment and each light bulb in room 201 were catalogued, shown in Table 4.5. The only non-HVAC components of the room that required electricity were the lights and the clock.

Table 4.5 Room 201 Case Study

Component	Number of Components	Watts per Component	Total Watts per Component	Typical Weekly Usage (hrs)	Weekly Electric Consumption (kW-hrs)
Incandescent Bulb	6	75	450.0	14	6.30
Clock	1	0.4	0.4	168	0.07
Florescent Light	0	0	0		
Air conditioners	0	0	0		
Heater	0	0	0		
Windows	1	N/A			
Light Dimmer	2	N/A			

4.8 Conference Room 102

Room 102 is classified as a conference room. There are two on/off switches to control the overhead lighting and two on/off light switches to control board lighting in the front and rear of room 102. The light intensity was measured with all lights on and off, with shades open, as well as on both a cloudy and sunny day. The light intensity data is shown in **Error! Reference source not found.** and **Error! Reference source not found.** below. The bold horizontal trend line is set at the required lighting level for the room.

Figure 4.11

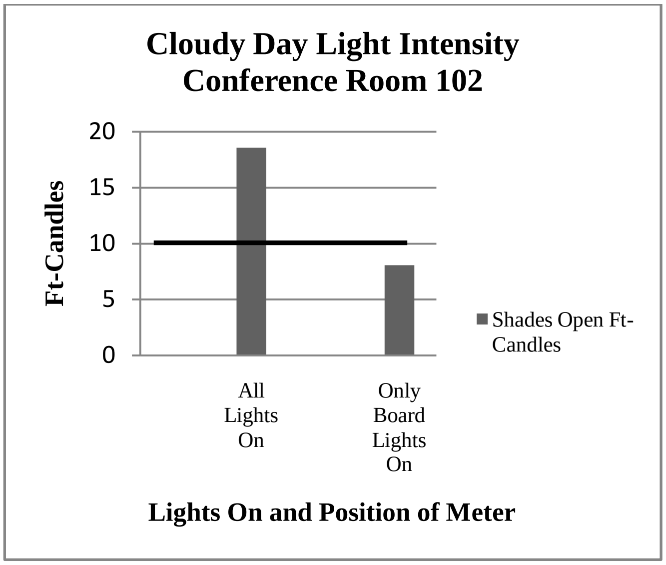
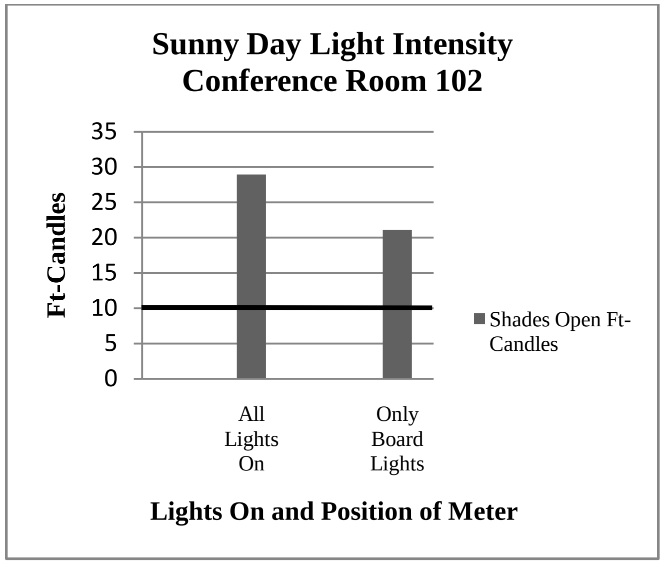


Figure 4.12



As can be seen in Figure 4.11 and Figure 4.12, room 102 is actually never illuminated to 30 ft-candles.

All equipment and each light bulb in room 103 were catalogued, shown in Figure 4.6. The only non-HVAC components of the room that required electricity were the lights. Figure 4.6 below shows the instantaneous electricity consumption by the lighting as well as the yearly electricity usage.

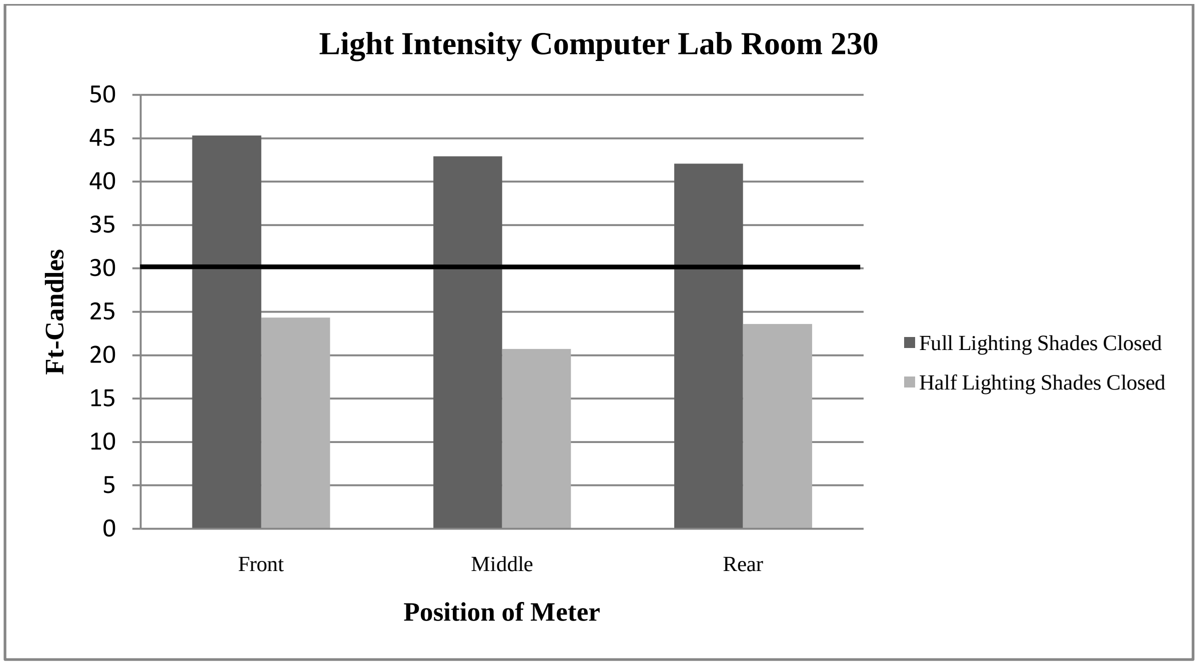
Table 4.6 Room 102 Case Study

Component	Number of Components	Watts per Component	Total Watts per Component	Typical Weekly Usage (hrs)	Weekly Electric Consumption (kW-hrs)
3 Prong Florescent	18	40	720	24	17.28
Ls212k1 Bulb	4	75	300	24	7.20
Air conditioners	2	N/A			
Heater	0	N/A			
Projector Screen	1	N/A			
Windows	3	N/A			
Light Switch	4	N/A			

4.9 Computer Lab Room 230

Room 230 is classified s a Computer Lab. There are four on/off light switches in this computer lab. These are redundant switches whereas two switches control on bank of lights, and two control another. The lighting in the room can either be all on, half on, or all off. There is no board lighting, only lighting over the seating. Figure 4.13 shows the light intensity in room 230 measured with all lights on and half lighting with no ambient light. The bold horizontal trend line is set at the required lighting level for the room.

Figure 4.13



Each piece of equipment and every light bulb were catalogued with its instantaneous electrical consumption. Utilizing the schedules found in **Appendix** and the fact that this lab is open 24 hours a day, yearly usage was determined for each component. This data is shown in Table 4.7 below.

Table 4.7 Computer Lab Case Study

Component	Number of Components	On Watts per Component	Standby Watts per Component	Total Watts per Component	Typical Weekly Usage (hrs) (Not Standby)	Weekly Electricity Consumption (kW-hrs)(inc. Standby hrs)
Computers	41	70	2	2870.0	168	482.16
Monitors	41	45	1	1845.0	168	309.96
Florescent Light	51	32	0	1632.0	168	274.18
Projector	1	367	367	367.0	30	61.66
CCU	1	150	60	150.0	30	12.78
Exit Sign	2	40	0	80.0	168	13.44
Printer	1	21	21	21.0	72	3.53
Clock	1	0.4	0	0.4	168	0.07
Projector Screen	1	N/A	N/A			
Handicap Switch	1	N/A	N/A			
Heater	0	N/A	N/A			
Light Switch	4	N/A	N/A			
Windows	2	N/A	N/A			
Air conditioners	1	N/A	N/A			

The computers electrical usage was determined in stand-by mode. When the computers in lab 230 were on, they used negligible more electricity. These computers are never shut off unless maintenance is being performed on them.

Figure 4.14 is a graphical representation of the instantaneous electricity usage by component in watts and Figure 4.15 is a graphical representation of the yearly electricity usage by component in kW-hrs for room lab 230.

Figure 4.14

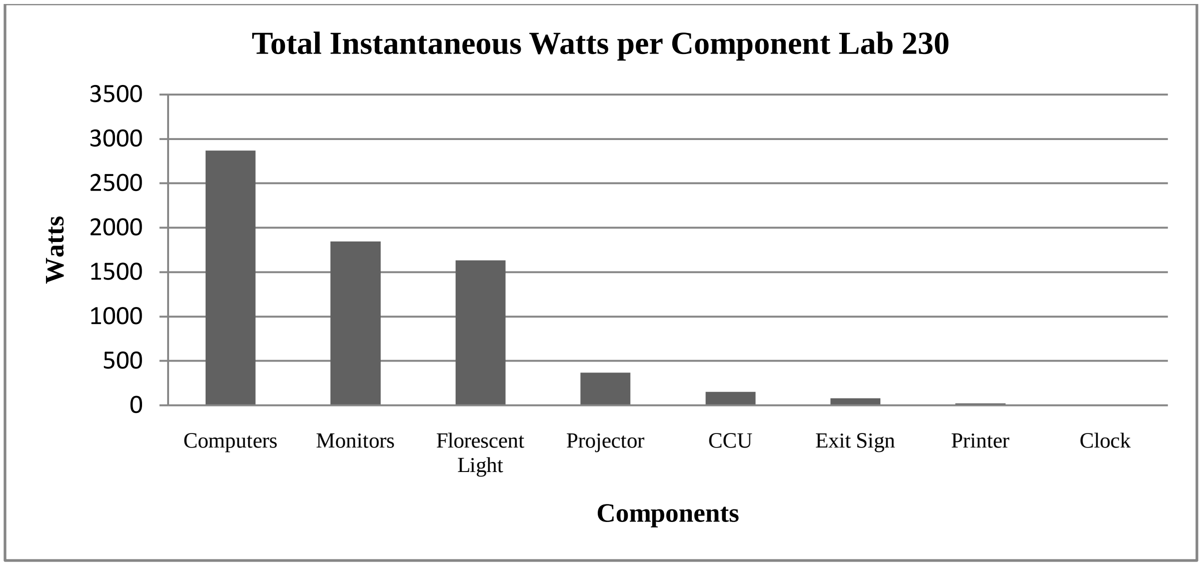
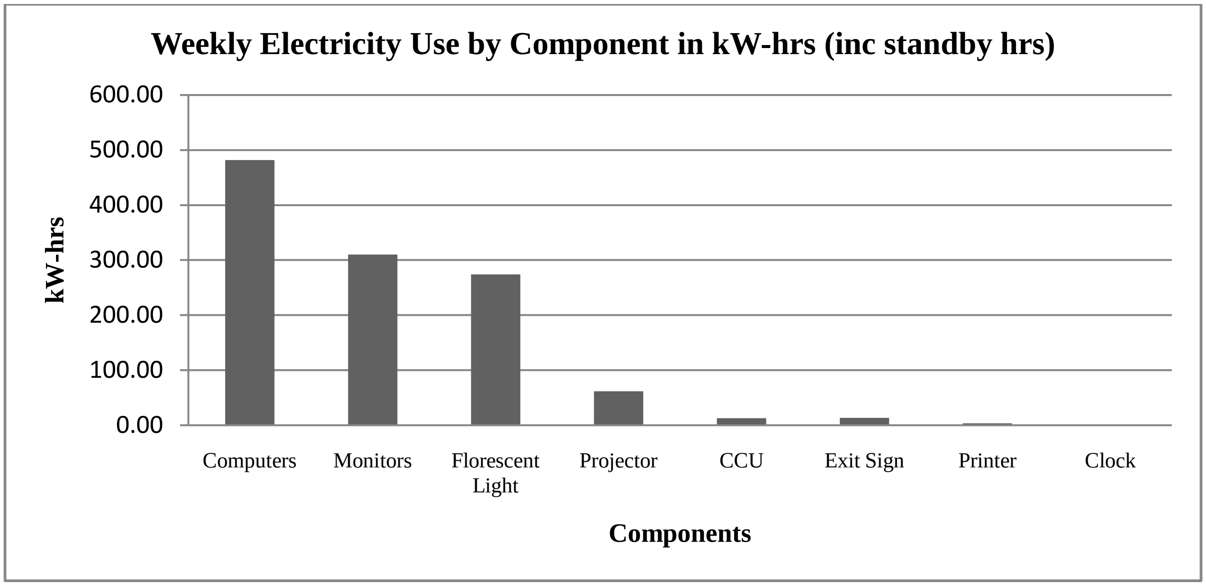


Figure 4.15

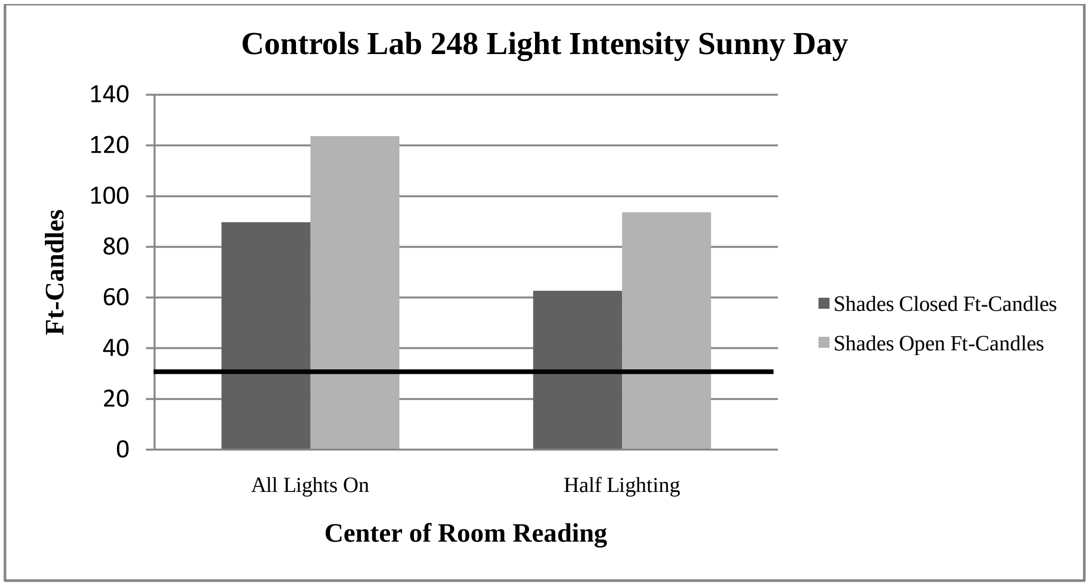


As shown in both Figure 4.14 and Figure 4.15the computers and monitors use about 67% of the total electricity, and the lighting system uses about 23%.

4.10 Controls Lab Room 248

Controls lab room 248 has two on/off light switches to control all illumination in the room either fully on, half on or off. Figure 4.16 shows the light intensity in room 248 measured with all lights on and half lighting with the shades open or closed. The bold horizontal trend line is set at the required lighting level for the room.

Figure 4.16



Each piece of equipment and every light bulb were catalogued with its instantaneous electrical consumption. This lab is used sparingly for projects. The usage data is shown in Table 4.8 Controls Lab Case Study, which is a conservative estimate.

Table 4.8 Controls Lab Case Study

Component	Number of Components	Watts per Component	Total Watts per Component	Typical Weekly Usage (hrs)	Weekly Electric Consumption (kW-hrs)
Florescent Light	64	32	2048	63	129.02
Work Station W/Comp	5	180	900	28	25.20
Air conditioners	1	N/A			
Heater	2	N/A			
Light Switch	2	N/A			
Windows	4	N/A			

4.11 Bathroom Room 118

Room 118 is classified as a bathroom and is almost identical to bathroom rooms 019, 020, 117, 223, 224, 303, and 304. The lighting is controlled by a motion sensor which has either all lights on when motion is present, or has 1/3 of the lights on the rest of the time. With all lights on, room 118 is illuminated to 561 LUX (52.1 ft-candles), and with the lights at 1/3 on, the room is illuminated to 122 LUX (11.3 ft-candles). The only electrical components of room 118 were the lights shown in Table 4.9 below.

Table 4.9 Bathroom Case Study

Component	Number of Components	Watts per Component	Total Standby Watts per Component	Total Watts Per Component	Typical Weekly Usage (hrs)	Weekly Electric Consumption (kW-hrs) (inc Standby hrs)
Florescent Bulbs	9	32	96	288	84	32.26
Emergency Lights	1	N/A				

The average yearly usage was determined with the lighting being all on half the year and 1/3 on half the year due to waiting period for the motion sensor to turn off the lights.

4.12 Hallways Rooms 156-158

Rooms 158, 157, and 156 are classified as hallways. These hallways are identical to the basement hallways rooms 048-050, and the second floor hallways 253-255. There are four lights on/off light switches to have either all lights on or half lights on. These lights are never reduced to half and are left on all year. The lighting intensity varies slightly in the halls and stay typically at about 380 LUX (35 ft-candles). The component data for hallway rooms 156-158 is shown in Table 4.10 below.

Table 4.10 Hallway Case Study

Component	Number of Components	Watts per Component	Total Watts per Component	Typical Weekly Usage (hrs)	Weekly Electric Consumption (kW-hrs)
Florescent Bulbs	106	32	3392	168	569.86
Exit Signs	7	40	280	168	47.04
Emergency Lights	0	N/A			
Light Switches	4	N/A			

4.13 Meter Readings

The main electrical meter in the sub-basement of Higgins Lab was accessed in order to develop a day by day electricity usage profile. This meter can read current, amperage, voltage, wattage, watt hours, and demand power in watts and volts. The instantaneous wattage and the watt hours were measured every day at 1:30pm for 9 days. This is shown in Table 4.11 below.

Table 4.11 Higgin's Electrical Meter Readings

Date	Instantaneous Watts	Watt Hour Meter Mega-Watts	Watt Hour Meter Mega-Watts per Day
4/21/2009	316	3771.64	
4/22/2009	352	3778.18	6.54
4/23/2009	329	3784.42	6.24
4/24/2009	288	3790.44	6.02
4/25/2009	314	3796.56	6.12
4/26/2009	323	3802.34	5.78
4/27/2009	360	3808.48	6.14
4/28/2009	382	3816.08	7.60
4/29/2009	294	3822.36	6.28
		Average	**6.34**

4.14 WPI Electricity Use/Cost Profile

Figure 4.17 and Figure 4.18 give a full compilation of WPI's electric bills and charges for the last 3 years. In 2006 the campus energy supplier was Select Energy, who was being bought out by Hess Energy Corporation at the time. Hess bought Select on June 1st 2006. The energy supplier is the company actually making the electricity, not distributing it. Hess was still using Select's information management system up through around January 1st 2007. At the same time in January WPI switched their energy supplier to National Grid's basic energy provider, and began paying for electricity supply through their NG bill, Only one or two people in the current Hess Corporation were familiar with the old information system, and were able to email copies of the bills. The campus switched suppliers again in August of 2008 to Direct Energy and has been with them ever since. National Grid has been WPI's electricity distributor for the entire 3 years.

Figure 4.17 gives a breakdown of average kilowatt hours used daily. The meter reading periods often vary as can be referenced in the table in Appendix A. This graph was obtained by dividing the kWh billed for each month by the number of days the corresponding meter reading covered. This information was acquired through the National Grid Bills. Figure 4.17 shows a rise in energy consumption in the later summer months. This makes sense because the campus provides its own heating during the winter, but uses a lot of electricity to power its water coolers and air conditioners. There is also a drop in January which is when all students are on a month break. The usage pattern is steady, with a slight decrease overall in 2008 and 2009.

Figure 4.17 Average Kilowatt Hours Used Daily

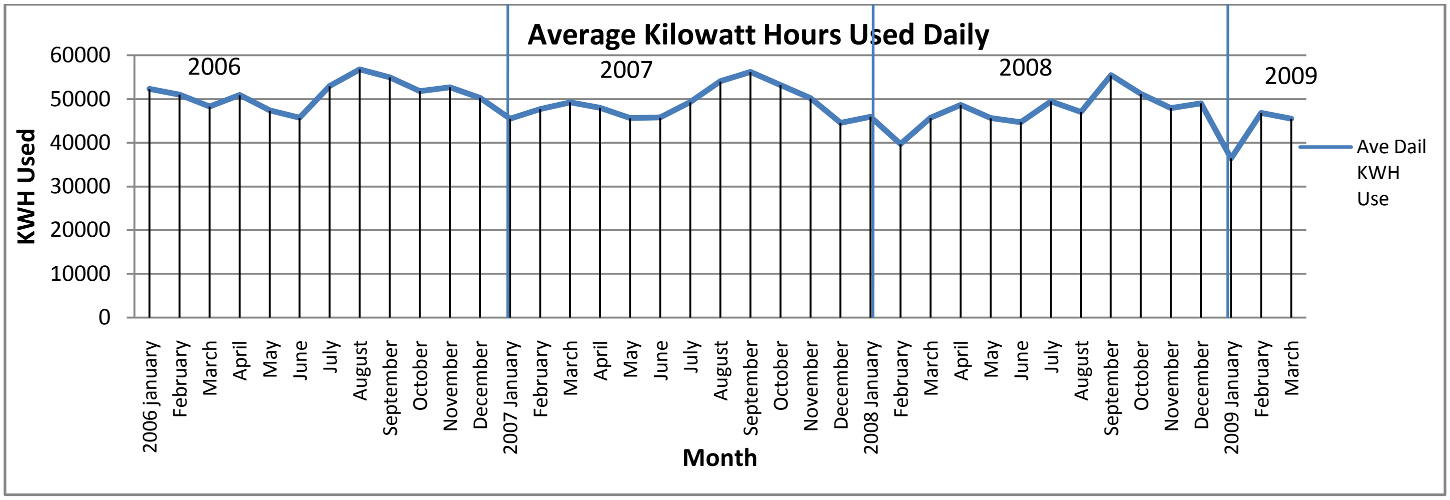
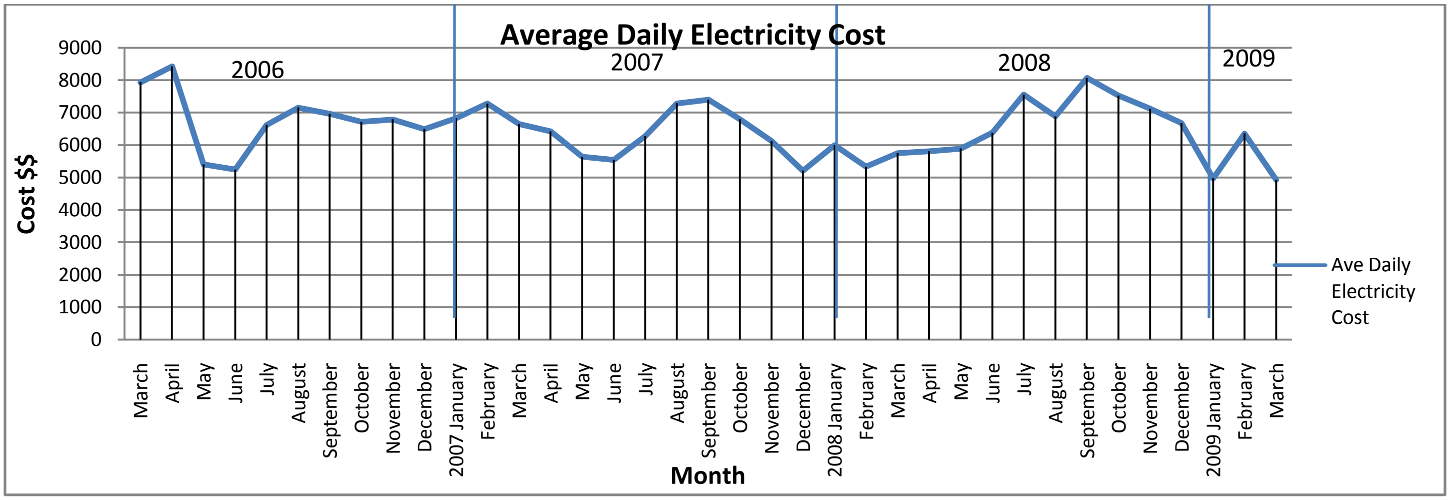


Figure 4.18 is a compendium of data acquired from National Grid Bills, Hess Energy Bills, and Direct Energy bills that can be referenced in Appendices B, C, and D respectively. This figure reflects cost fluctuations and trends in electrical spending through the last three years.

Figure 4.18 Average Daily Electricity Cost



4.15 Higgins Laboratory HVAC

The entire HVAC system is turned on at 6 a.m. and is shut off at 9 p.m. during weekdays, turned on at 7 a.m. and shut off at 3:30 p.m. during weekends, and completely shut off during vacations and holidays. For the majority of the time, only one chiller is operating with two pumps on the rooftop. The other chiller is left on standby for extreme cases that would occur only in the summer. The system continuously runs throughout the day and is controlled by a program on a computer in the office of Norman Hutchins. The system is basically set at a certain value during heating season and cooling season and is left to run on its own. The system is fairly efficient as is, with the installed VFD motors and the use of Variable Air Volume distribution systems.[24]

Since WPI provides its own heating through steam, that further adds to the efficiency of the Higgins HVAC system leaving only the cooling and ventilation systems in charge of the electrical consumption. Higgins Labs is kept cool by two Air-Cooled Series R Rotary Liquid Chillers manufactured by Trane located on the rooftop. The cooled water is moved down into the building by 3 pumps (two of which are on VFD motors) each operating at 1/3 HP at 120 Volts corresponding to a power draw of 11.7 kWh per pump motor daily. While running, these systems alone consume roughly 23.4 kWh per day which corresponds to 8424 kWh/yr and a total of $1,179 per year. In Higgins Labs, there are a total of 85 electric motors which run the fans and pumps on the circulation systems. The different types of motors and their power draws are listed in **Error! Reference source not found.**.

Table 12-HVAC System Motors & Their Associated Power Draws.

Quantity	HP	Voltage Req. (V)	Instantaneous Power Draw (kW)	Weekday Run Time (hr)	Weekend Run Time (hr)	Weekday Daily Power Draw (kWh)	Weekend Daily Power Draw (kWh)
8	1/3	120	1.99	15	8.5	29.83	16.90
13	3/4	120	7.27	15	8.5	109.06	61.80
6	1	120	4.47	15	8.5	67.11	38.03
6	1 1/2	120	6.71	15	8.5	100.67	57.05
20	1/4	120	3.73	15	8.5	55.93	31.69
4	2	120	5.97	15	8.5	89.48	50.71
1	2 1/2	120	1.86	15	8.5	27.96	15.85
2	3	120	4.47	15	8.5	67.11	38.03
1	20	120	14.91	15	8.5	223.71	126.77
1	5	120	3.73	15	8.5	55.93	31.69
9	1/6	120	1.12	15	8.5	16.78	9.51
6	1	208	4.47	15	8.5	67.11	38.03
3	7 1/2	208	16.78	15	8.5	251.67	142.62
2	5	208	7.46	15	8.5	111.85	63.38
3	20	208	44.74	15	8.5	671.13	380.31
Total Power Draw:			**129.69 kW**			**1945.34 kWh**	**1102.36 kWh**

[24] Interview with Norman F. Hutchins-Head of HVAC Systems here at WPI

Motion Occupancy Sensors

Motion sensors coupled with replacing standard light bulbs with energy-efficient ones is way to add a bit of more on energy-savings in Higgins Labs. Alone they won't save as much money or energy as replacing standard light bulbs with energy-efficient ones but together can boost up efficiency. Currently in Salisbury 305 the sensor illustrated below is in use.

Figure 4.19 Occupancy Sensor currently in use in Salisbury Labs 305

PRODUCT DESCRIPTION Price: $264.

67 The **CI-24** is a ceiling-mount passive infrared occupancy sensor specifically designed to interface with Building Automation Systems through an internal isolated relay. A user-adjustable time delay (30 seconds to 30 minutes) on deactivation may be programmed through DIP switches to prevent unnecessary cycling. The **CI-24** includes a built-in override switch. Two levels of sensitivity are also selectable through DIP switches. The four-level patented Fresnel lens allows the **CI-24** to cover up to 1200 ft2 (111.48 m2).

Table 4.13 Sensor Information

Power supply	24 VAC/DC
Power consumption	37 mA
Time-delay adjust	Digital (DIP switch setting) for 30 sec, 10 min., 20 min. or 30 min.
Coverage	360° up to 1200 ft2 (111.48m2)
Color	White
Isolated contact rating	1A 24 VAC/VDC, 1/2A 120VAC
Agency approvals	UL and ULC listed
Operating temp	32° to 98°F (0°to 36°C)

CO2 Occupancy Sensors

When a building is designed, the maximum expected occupancy is determined to develop settings for outdoor fresh air ventilation required for the building. The use of outside air, needed for fresh air ventilation, can be expensive due to the heating or cooling requirements of the fresh air on particularly warm or cool days.

When occupancy is at only a fraction of the possible maximum occupancy or the room is just vacant, the amount of outside air, which is typically at a fixed level, may be 10 times what is needed for the actual occupancy of the building at any given time. The cost of heating or cooling this excessive amount can be significant. CO2 sensors lower the demand on the chillers, the supply fan loads, and heaters.

Figure 4.20 Example of a typical CO2 Sensor.

Price: $264.67

Vendor: HONEYWELL COMMERCIAL

A CO2 (carbon dioxide) sensing system uses real time CO2 measurements throughout the building to determine actual occupancy continuously during the day. The CO2 system adjusts outside air delivery to provide only the amount of ventilation needed for actual real-time occupancy in the space, thus virtually eliminating 100% of the excessive amount of outside air used in a building. The result is the elimination of the cost of excessive outside air ventilation.

4.16 Higgins Laboratories

The major electric components such as incandescent and fluorescent light bulbs, computers, projectors, and the CCUs of the rooms in **bold** in Figure 4.1 were documented. Table 4.14 Building Electric Consumption by Component contains the data collected.

Table 4.14 Building Electric Consumption by Component

Component	Quantity	Average Watts per Component	Total kWatts
HVAC	85	1526	129.69
Number of Fluorescent Light Bulbs	1933	32	61.86
Number of Computers	120	115	13.80
Number of Incandescent Bulbs	67	75	5.03
Projectors	6	367	2.20
CCUs	6	150	0.90
TOTAL			**213.47**

4.17 A day in the Life of Higgins Laboratories

The electricity consumption of Higgins Labs was monitored every hour for a period of 24 hours in order to develop a baseline daily electric consumption. A walkthrough was performed periodically in order to see what computers, lights and equipment were in use. The monitoring started at 11:00 PM and went to 11:00 PM the following day. It was found that all classroom lights were on when not in use, and all hall lighting was set to its highest setting. The only rooms with equipment and lighting turn to its lowest level were all laboratories that were not occupied and the offices. Therefore, at 3:00 AM, all lighting in the entire building was turned to its lowest level. The data collected from the electric meter is shown in Table 4.15.

Table 4.15 A day in the Life of HL Meter Readings

Time	Instantaneous kWatts	Demand kWatts	Watt Hour Meter MWatt Hours	Watt Hour Meter MWatt Hours per Hour
11:00 PM	219	236	3819.06	
12:00 AM	241	210	3819.28	0.22
1:00 AM	168	177	3819.47	0.19
2:00 AM	178	198	3819.67	0.20
3:00 AM	211	201	3819.85	0.18
4:00 AM	146	142	3820.01	0.16
5:00 AM	162	153	3820.18	0.17
6:00 AM	201	200	3820.36	0.18
7:00 AM	227	222	3820.58	0.22
8:00 AM	240	246	3820.80	0.22
9:00 AM	275	265	3821.06	0.26
10:00 AM	278	289	3821.34	0.28
11:00 AM	315	292	3821.62	0.28
12:00 PM	315	281	3821.91	0.29
1:00 PM	304	295	3822.21	0.30
2:00 PM	289	297	3822.50	0.29
3:00 PM	329	308	3822.81	0.31
4:00 PM	327	308	3823.12	0.31
5:00 PM	287	287	3823.41	0.29
6:00 PM	286	280	3823.69	0.28
7:00 PM	230	246	3823.95	0.26
8:00 PM	248	267	3824.21	0.26
9:00 PM	194	226	3824.45	0.24
10:00 PM	212	240	3824.67	0.22
11:00 PM	235	239	3824.87	0.20

Chapter 5 Analysis

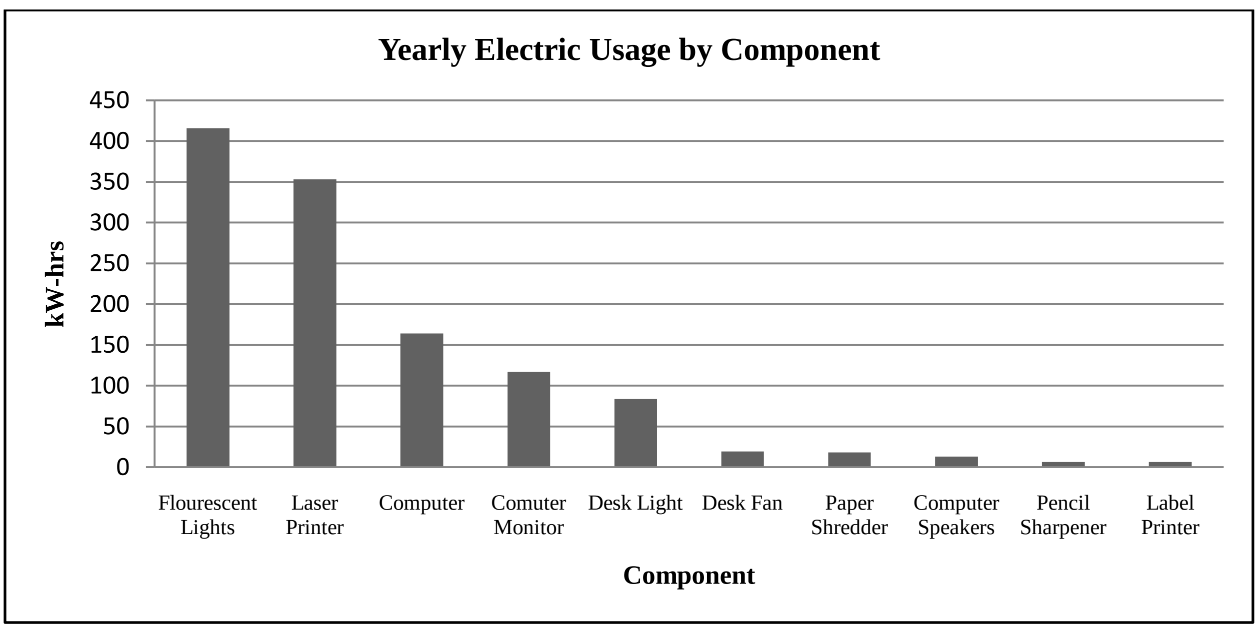
5.1 Introduction

This chapter contains analysis of the data collected in Chapter 4 Results. This includes Higgins Labs illumination, projections of yearly electrical consumption and costs for case studies, electric use in ‘A Day in the Life of Higgins Labs’, overall building electric consumption and projected costs by core systems, National Grid incentives, and campus wide electricity costs.

5.2 Office Room 250

In this office, take note that the paper shredder takes the most electricity to run, however, it is not used frequently, as can be seen in the comparison between Figure 4.1and Figure 4.2. The laser printer is never shut off and the printer remains in standby until something is being printed. For this office, the OSHA standards require illumination of 30 ft-candles. From the results in Office Room 2504.4, this office is over-illuminated by 44%. The yearly electric usage, Figure 5.1, was extrapolated using Table 4.1 and determined on a five day work week whereas all equipment is typically shut off for the weekend. As can be seen in Figure 5.1, the fluorescent lights in this room use the most electricity on a year by year basis, about 35%. The second most consumer of electricity is the laser printer which expends about 30% of the yearly electric consumption.

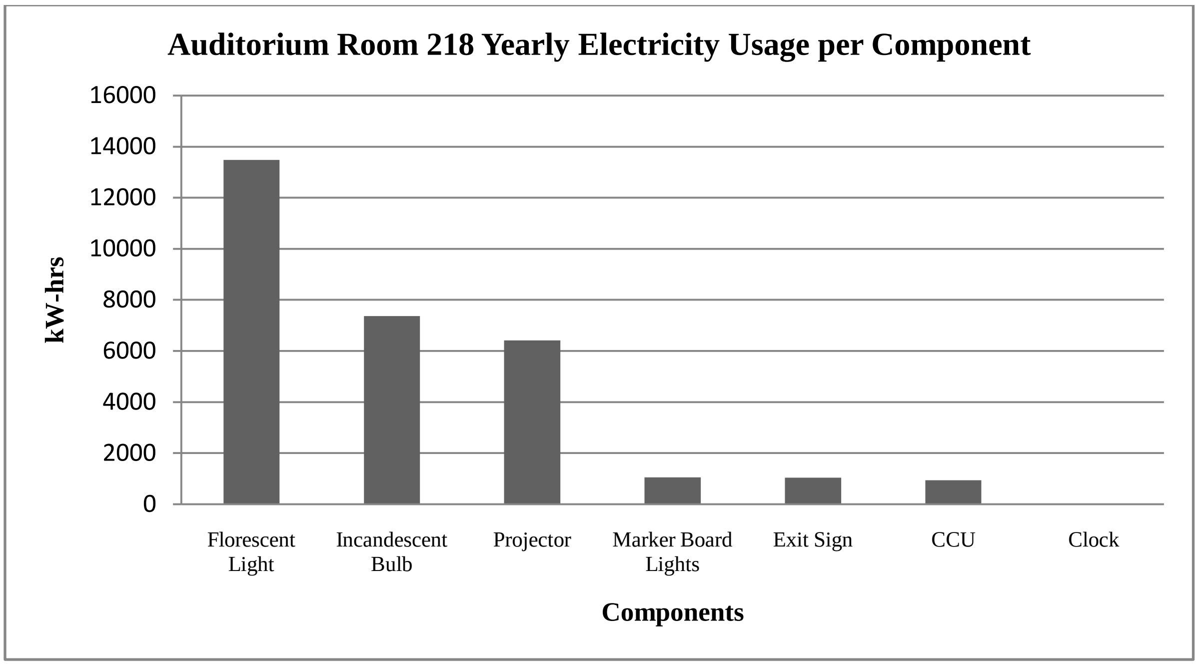
Figure 5.1



5.3 Auditorium room 218

OSHA standards state for this room to be illuminated a minimum 30 ft-candles. Figure 4.3 shows that the room is over-illuminated by about 190% with all lights on. Room 218 can be properly illuminated at night or on a cloudy day by just the fluorescent bulbs in the room two thirds on. On a sunny day, with no direct sunlight, the room can be illuminated with just one third of only the fluorescent lights. Figure 5.2 shows the yearly electric consumption of Auditorium Room 218, extrapolated from Table 4.3, where it can be seen that the fluorescent lighting of the room uses about 45% of the electricity, and the incandescent lighting uses about 24% of the electricity.

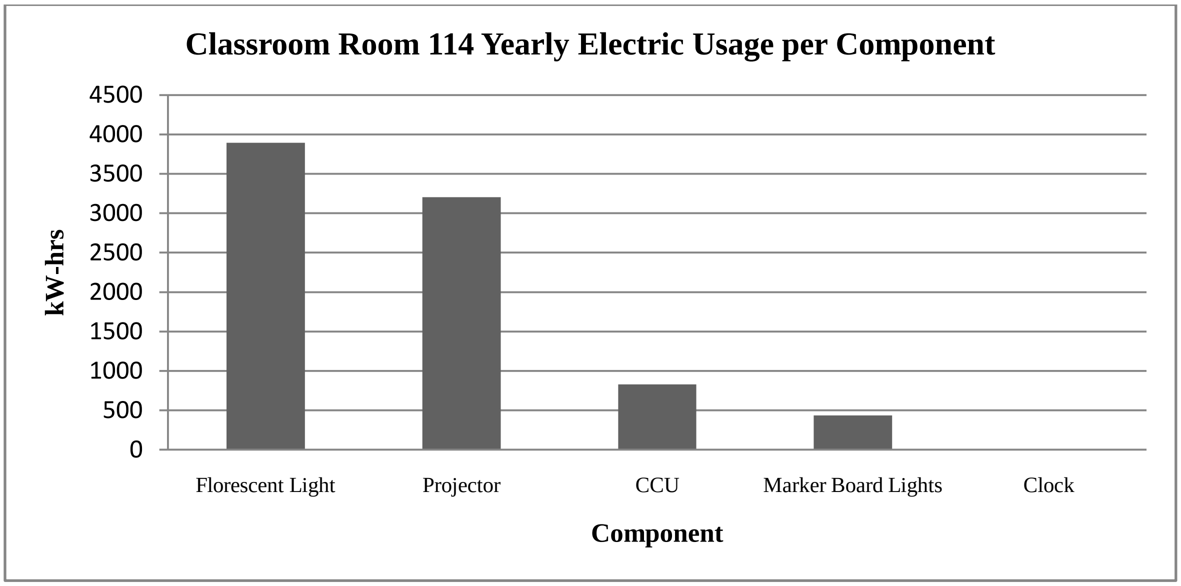
Figure 5.2



5.4 Classroom 114

OSHA standards state for this room to be illuminated a minimum 30 ft-candles. Therefore, this room is always over-illuminated. Figure 4.6 shows that room 114 is over-illuminated by about 190% with all lights on. Room 114 can be properly illuminated on a cloudy day with the shades open and only the board lights on, as well for a sunny day. As can be seen in Figure 4.7, the lighting in room 114 utilizes about 71% of the instantaneous electricity but, from Figure 5.3, extrapolated from Table 4.4, only uses about 54% of the yearly electricity consumption. The projector uses about 38% of the yearly electric consumption.

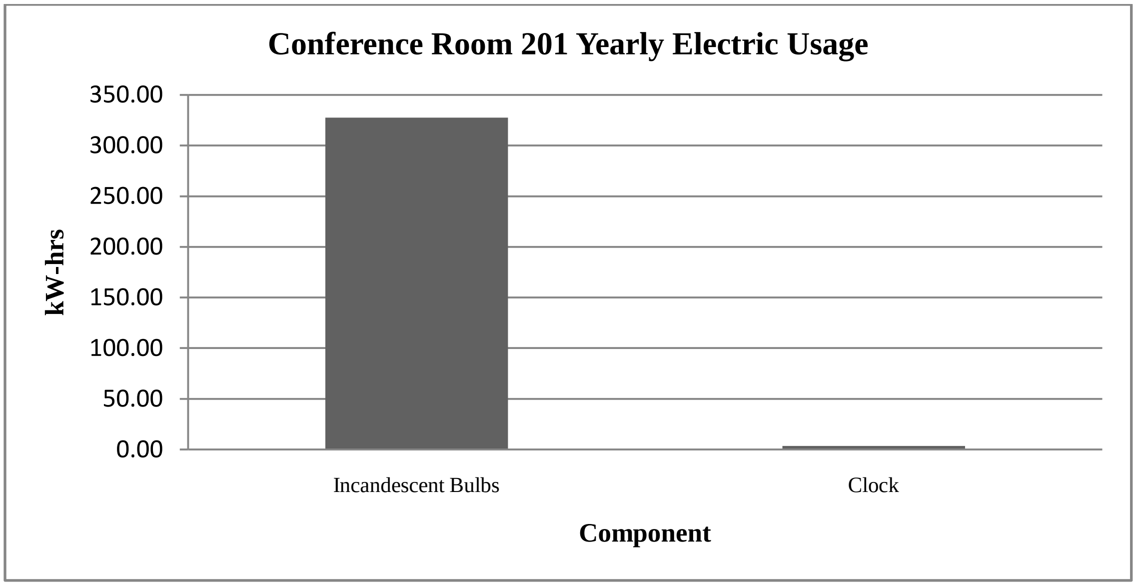
Figure 5.3



5.5 Conference Room 201

OSHA standards state for this room to be illuminated a minimum 10 ft-candles. Room 201 is actually under-illuminated (Figure 4.9) if the shades are closed, but is over-illuminated by as much as 470% (Figure 4.10) with the shades open. Table 4.5 shows the instantaneous electricity consumption by the lighting is 99% of the total, and, from Figure 5.4, extrapolated from Table 4.5, 99% of the yearly electricity consumption for room 201.

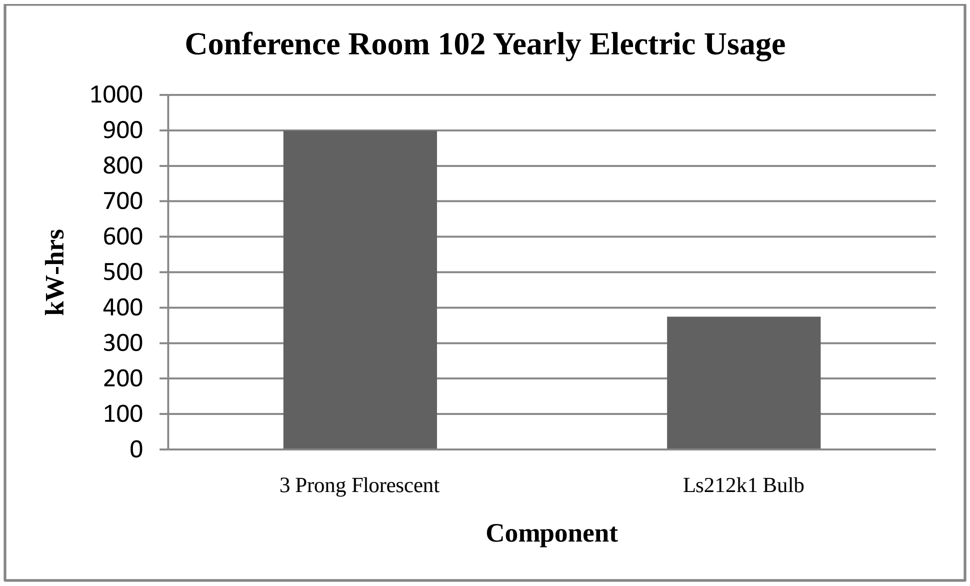
Figure 5.4



5.6 Conference Room 102

OSHA standards state for this room to be illuminated a minimum 10 ft-candles. From **Error! Reference source not found.** and **Error! Reference source not found.**, conference room 102 is always over-illuminated with all lights on as long as the shades are open. Figure 5.5, extrapolated from Table 4.6, shows the fluorescent lighting consumes about 71% of the room electricity, and the incandescent lighting, Ls212k1 bulbs, use the remaining 29%.

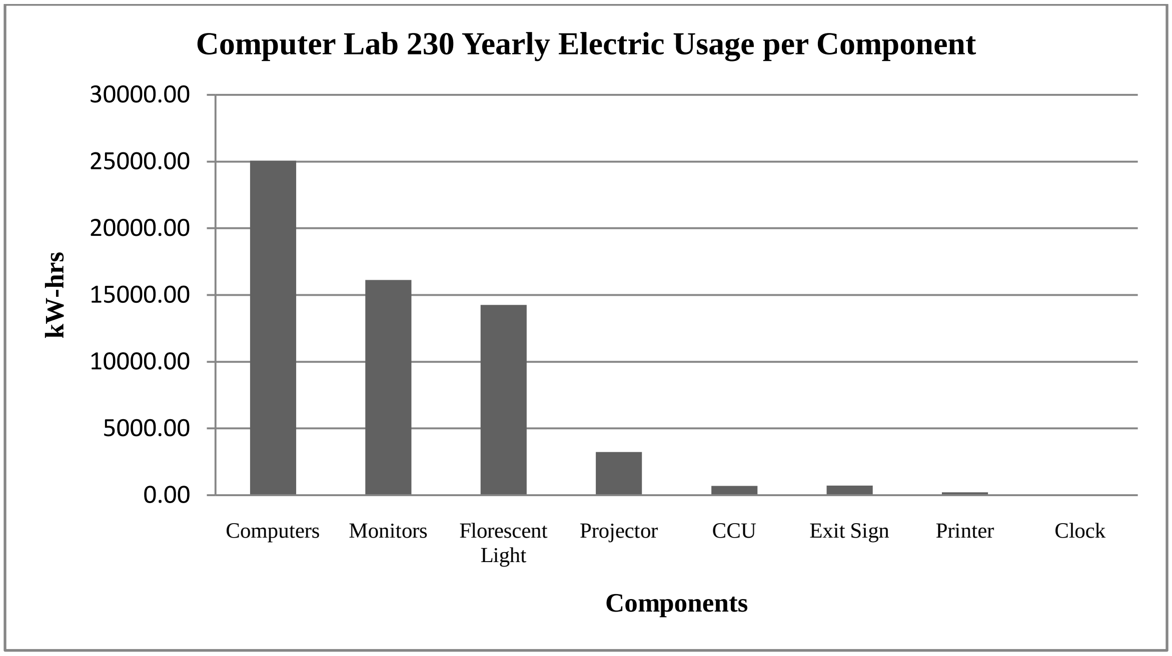
Figure 5.5



5.7 Computer Lab Room 230

OSHA standards state for this room to be illuminated a minimum 30 ft-candles. Figure 4.13 shows that room 230 is over-illuminated by about 145% with all lights on. Figure 5.6 is extrapolated from Table 4.7. Figure 5.6 shows that the computers and monitors use about 69% of the yearly electric consumption for room 230. The lighting uses about 24% of the yearly electric consumption.

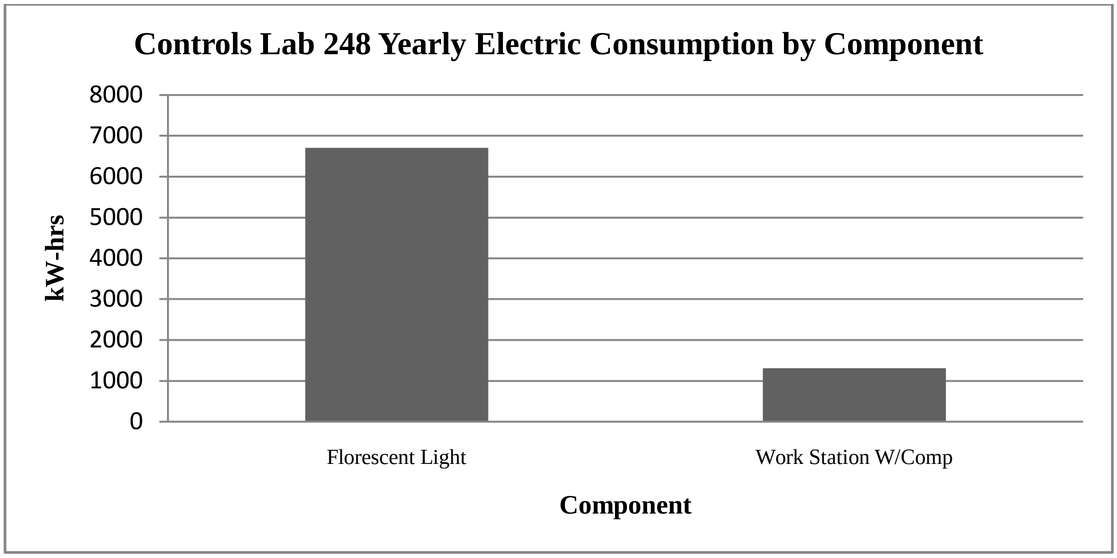
Figure 5.6



5.8 Controls Lab Room 248

OSHA standards state for this room to be illuminated a minimum 30 ft-candles. From Figure 4.16, at half lighting and the shades closed, room 248 is over-illuminated by 210%. With the shades closed and at full illumination, room 248 is over-illuminated by 300%. Therefore, this room is always over-illuminated. Figure 5.7, extrapolated from Table 4.8, shows the yearly electric consumption of the lighting is about 84% of the total and the remainder by the work stations.

Figure 5.7



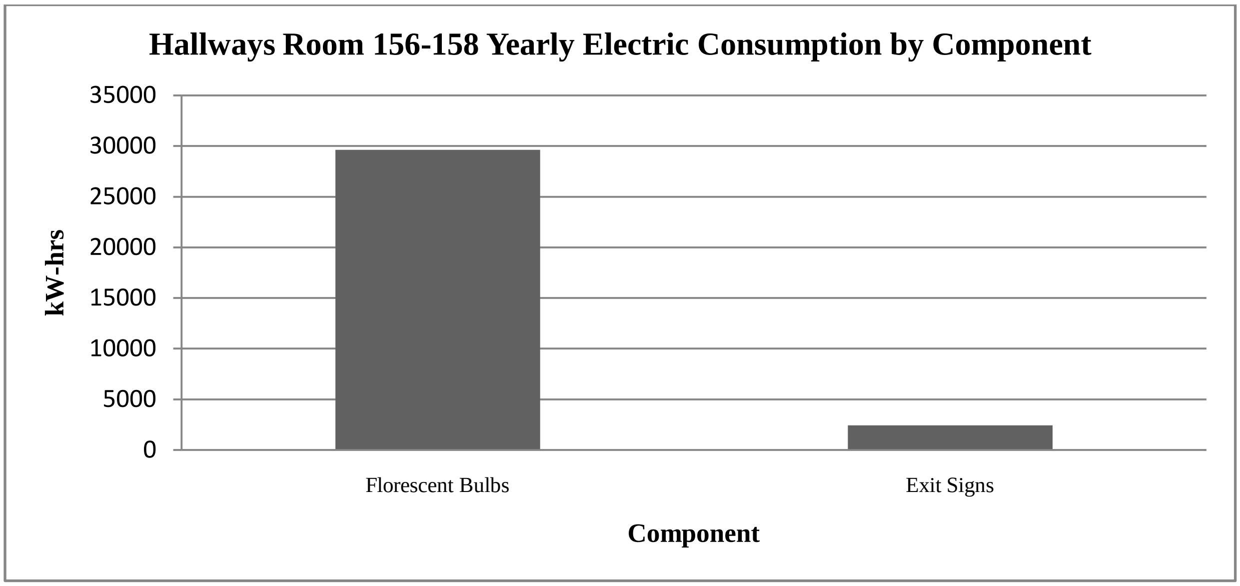
5.9 Bathroom Room 118

OSHA standards state for this room to be illuminated a minimum 10 ft-candles. From the light intensity readings in section 4.11 Bathroom Room 118, this room is always over-illuminated by 13% with 1/3 lighting, and by 421% when fully illuminated. The yearly electrical consumption of Bathroom 118 was extrapolated from Table 4.9 whereas all the electrical consumption is due to lighting. This is about 1600 kW-hrs.

5.10 Hallways Rooms 156-158

According to OSHA, as stated earlier, the minimum illumination requirement is 5 ft-candles. Therefore, from the illumination readings in section 4.12 Hallways Rooms 156-158, this hallway is over-illuminated by about 600%. Figure 5.8 shows the yearly electric consumption of hallways 156-158 by component which was extrapolated from Table 4.9, for which the fluorescent illumination was determined to use about 92% of the yearly consumption and the exit signs used the remainder.

Figure 5.8



5.11 Higgins Labs Meter Readings

Extrapolated from Table 4.11, for the week of April 21 to April 28, 2009, Higgins Labs used an average of 329kW instantaneous electricity and 6.34 MW-hrs of electricity per day. From the documented electrical consuming equipment in Table 4.14, the calculated instantaneous electric consumption only accounts for about 65% of the metered reading. This was to be expected due to the varying factors of the building. Components of the building such as mills and lathes in the machine shop laboratory room 004 draw large amounts of electricity however are not used on a scheduled basis. These mills and lathes are not incorporated in Table 4.14. Other equipment such as personal laptop computers, refrigerators and microwaves were not accounted for either. The electric consumption of the computer servers located in Higgins Labs could not be determined.

During a day in the Life of Higgins Laboratories, the average instantaneous electric consumption, from Table 4.15, was 244kW, the average peak demand was 244.2kW, and the average watt hours used was 242.2kWh per hour. This is lower than the average taken from Table 4.11 by about 24%. This is due to the time the meter readings from Table 4.11 were taken. From Table 4.14, the documented equipment accounts for 87% of the electric consumption.

5.12 CCU and Computer Analysis

There are several small scale, low cost changes that can be made to existing systems in order to reduce campus wide electricity consumption. There is a computer control unit inside every classroom and auditorium. This is typically a podium that locks so that none of the interior equipment can be removed with a monitor on top. Inside there is a video cassette player, a digital video disc player and the computer for the monitor. There is also a set of controls that power on the ceiling mounted projector as well as lower the projector screen above the whiteboards. These podiums can be found inside of every academic building. Some classrooms have the equipment inside a cabinet with a counter on top for the monitor. The ceiling projectors and CCU are two components that draw a large amount of electricity, even when in their lowest standby phase. The CCU draws 50-60 watts in its lowest power stages, and as much as 160 watts when in full use. The nominal use is considered to be when the VCR and DVD player are off, but the computer and monitor are on and in standby mode, and uses about 140 watts. This is the most common situation to encounter when entering a classroom and inspecting the CCU. The projectors use 360-370 watts when in standby mode. Almost every area with a CCU also has a projection unit, and between the main academic buildings alone there are about 36 CCUs.

The main dilemma here is that the computer control units are not capable of a true shutdown. This can be easily overcome by installing small outlet switches between the component's plug and the wall outlet, containing a switch on the side that allows for true shutoff of anything plugged into it. This would allow the CCU to be truly shutdown. The projector on the ceiling is always in a standby mode, and the controls on the podium simply turn the bulb in the projector on. This is a little trickier to handle because it is out of reach so a simple fix like an outlet switch is not feasible. If the projector was rewired so that all power to it came directly from the CCU, then it could also be truly shutdown with the switch.

5.13 National Grid Incentive Programs

National Grid has many services available to their clients to aid in creating a more energy efficient world. Mike Thompson is a National Grid employee who directly handles WPI's energy account. He explained that when East Hall was built NG paid approximately $200,000 dollars for having energy efficient lights, chillers, and ventilation motors installed. He pointed out that there are also many programs that can help in renovating current lighting and HVAC systems in existing buildings. These programs are called incentive programs. The incentive means that depending on how efficient the new upgraded system is, as long as the minimum requirements are met for energy savings, NG will pay WPI back a specific amount of money for each change made. The eligibility requirements are outlined below.

II. Incentive Program Selection[25]: Energy Initiative vs Design 2000*plus*

The Energy Initiative incentive program is applicable to projects where there are existing lighting systems that are being upgraded to improve efficiency.

Exceptions: The Design 2000*plus* incentive program would apply if there is an existing lighting system under any of the following conditions:

- The space is undergoing a major renovation
- The use of the space is changing so that the required lighting levels are dropping by 20% or more
- **Whenever the proposed lighting project reduces light levels by 20% or more**

Based on the studies done during this project with LUX meter, reducing light levels in the majority of rooms by 20% is realistic and will still keep the levels within OSHA standards. This makes WPI eligible to receive incentive payments or upgrading the lighting system.

Figure 5.9 shows an example of a lighting incentive. Each one has an associated code number. The incentive explains what criteria must be met, and what situations need to be avoided to remain eligible for payback. The Incentive box gives the dollar amount per fixture

[25] https://www.nationalgridus.com/non_html/shared_energyeff_lighting_existing.pdf 4/19/09

that the campus could receive from NG if this specific fixture is installed. Many other examples are shown in the National Grid Incentive Document in Appendix D. Some of the incentives require that a minimum number of watts must be saved with the new installation.

Figure 5.9 National Grid Incentive Example

nationalgrid

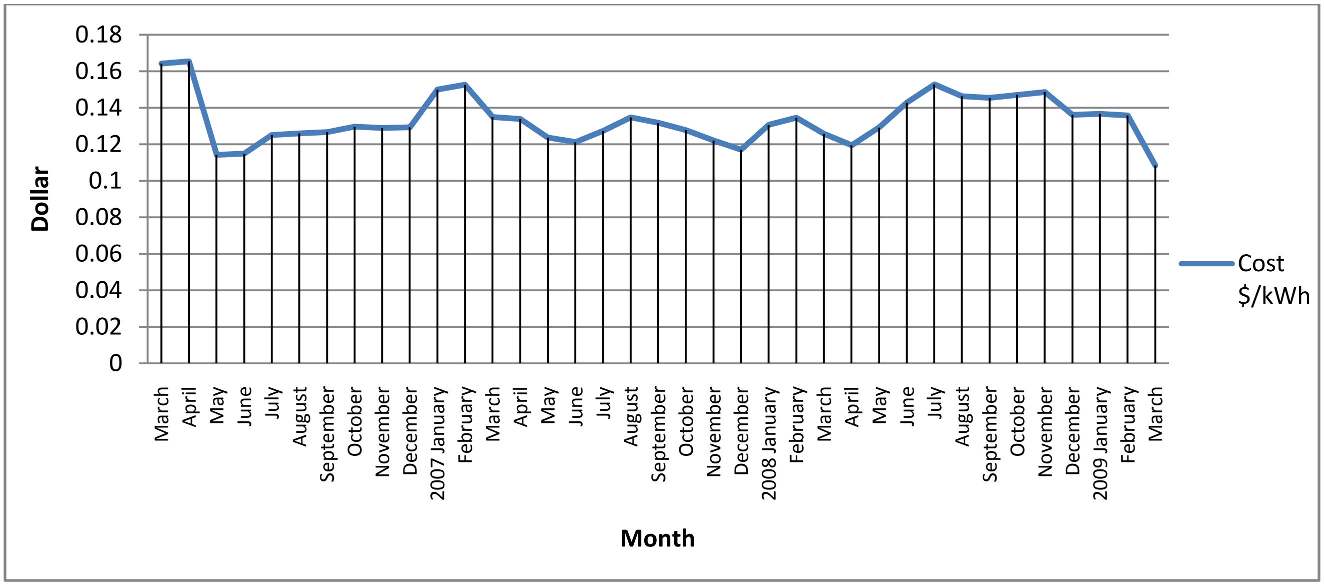
IV. Energy Initiative Eligibility Requirements for Lighting Product Incentives

Program: Energy Initiative	
Measure Code: 10	
Device Description: Re-lamp and re-ballast of existing fixtures or any new fluorescent fixture with new T8/T5 lamps and electronic ballasts.	
Incentive: $10/fixture	**Min. Watts Saved**: 5
High Performance T-8 Upgrade Eligible: yes	**Min. Watts Controlled**:
Style: Recessed or surface mounted fixture with parabolic louver or prismatic lens	
Eligibility Criteria: Each fixture is composed of a ballast and 1,2,3 or 4 lamps. Only one incentive may be counted per fixture. All customers are eligible for eight foot T8 electronic ballast incentives. *All installations utilizing 32W 4ft T-8 straight tube lamps and ballasts must meet the Consortium for Energy Efficiency High Performance T-8 specification. For a list of eligible equipment, see www.cee1.org.* Existing fixtures equipped with T8 lamps are not eligible.	
Special Requirements:	
Example of Qualify Product:	
Alternatives and Enhancements	
Control Options: See Measure Codes 61, 62, 63 and 64	
Fixture Alternatives: • Higher efficiency: Measure Code 30 • Higher efficiency: High Performance T-8 Upgrade	• Lower energy/lower glare: Measure Code 32 • Higher efficiency (for industrial): Measure Code 41

5.14 Actual Cost of Electricity

Computing how much WPI actually pays for each kilowatt-hour they use required compiling a lot of information from many sources.

Figure 5.10 Cost in USD Per kWh



As Figure 5.10 shows, WPI has paid almost as much as $0.168/kWh and as little as $0.105/kWh. The lower cost actually occurs most recently in March of this year. Some of the peak charges are due to a month where there was a large instantaneous demand. When all the students return from breaks, they tend to turn everything on, and plug in many thing in a short amount of time. This can result in an abnormally high instant demand for electricity, which National Grid applies to the entire monthly billing period.

5.15 HVAC Analysis

After speaking with Norman Hutchins from the Facilities Department, who is in charge of the HVAC systems here at WPI, it can be concluded that there isn't much that can be done to improve the current system without replacing it with a newer system. Certainly there is a more efficient system out there on the market as technology continues to improve over the years, especially since the current system was issued for construction in July of 1994. The payback period and inconvenience to install a new system is costly and unreasonable and there really is no reason to do so.

Norman has been monitoring the success of this device. He developed an Excel spreadsheet showing fan run time hours saved as a result of the installation of this device. The data obtained spans from 3/19/09 – 4/23/09. It shows that initially on 3/19 in this room alone, the ventilation fans were running for 337.59 hours. Now as of 4/23, the fans were running for 152.02 hours. The fan hours saved were 185.57 which correspond to a 54.9% decrease (see Table 18 below). One can only imagine the amount of savings incurred if these sensors were to be installed throughout the campus.

Table 16-Fan Run time hours Saved in Salisbury Labs 305

	Name	Value	Units	State
1	CoolingSP	73.0	Deg F	Enabled
2	CoolLockout	54.0	Deg F	Enabled
3	DirtyFilterAlarm	Off	On/Off	Enabled
4	DischSP	63.4	Deg F	Enabled
5	EconomizerSP	58.0	Deg F	Enabled
6	FanHoursSaved	185.57	Hrs	Enabled
7	FanRunHours	152.02	Hrs.	Enabled
8	FreezeStatAlarm	Off	On/Off	Enabled
9	FreezeStatReset	Off	On/Off	Enabled
10	HeatingSP	71.0	Deg F	Enabled
11	HeatLockout	60.0	Deg F	Enabled
12	HWAvailable	On	On/Off	Enabled
13	MinDamperSP	12.0	% OA	Enabled
14	Oat	53.3	Deg F	Enabled
15	OatOffset	66.2	Deg F	Enabled
16	ZoneCo2SP	300.0	ppm	Enabled
17	ZoneOccHours	337.59	Hrs	Enabled
18	ZoneOccupied	On	On/Off	Enabled
19	ZoneOptStart	Off		Enabled
20	ZoneTempSp	72.0	Deg F	Enabled

The system works well with constant or variable airflow systems and installation is quite simple, with the availability of wireless systems that work equally well with pneumatic or digital building control systems. A typical installation would involve installing CO2 sensors in each major distinct occupied zone (i.e. a suite, meeting room, or lecture hall). Generally one sensor should serve about 5000 square feet of floor area. Based on the CO2 reading in the space, ventilation can be regulated in the zone, for the floor or entire building. If a number of areas are served by one ventilation control device, ventilation levels are usually based on the highest level measured in all served zones. Return air sensing is not advised as it may not represent ventilation levels in a particular space. The combined use of economizers and CO2 control are the one-two punch for getting control of ventilation related energy costs. When outside conditions are right, the outside air will be used for free cooling. During the bulk of time when outside air is too warm, too humid or too cold, CO2 control will regulate outside air to minimize energy cost and optimize indoor air quality. Unusual levels of CO2 can also give an indication of a malfunction somewhere in the air delivery system. In selecting a CO2 sensor, it is important to consider how the sensor deals with calibration. While first cost may in some cases be lower, the maintenance requirements for a poorly performing sensor can far exceed any energy savings generated

Chapter 6 Conclusions and Suggestions

6.1 Introduction

There are several actions that can be taken to address issues discovered throughout the course of the energy audit. This chapter includes suggestions based on the results and analysis chapters in order to develop higher energy awareness for Higgins Labs and WPI such as energy monitoring and potential electric saving measures.

6.2 Lighting Suggestions

Many of Higgins Labs classrooms, auditoriums, offices, hallways, bathrooms, and laboratories are over-illuminated at all times. Lights are left on when room are not in use. Incandescent lighting can still be found throughout Higgins Labs. This excess lighting leads to excess wasted electricity.

The first suggestion is to replace any incandescent lighting with alternative electricity saving bulbs. Compact fluorescent bulbs can produce as much light as incandescent bulbs while using a fraction of the electricity. The standard 75watt incandescent bulb can be replaced with a dimmable 15watt compact fluorescent bulb[26]. Documented in Higgins Labs, this would reduce electric consumption by about 4kW minimum. Based on an average electric cost of $0.14 per kW-hr, the retail payback period for one bulb would be about one month. Projected savings would be about $3800 per year **(appendix)**. Even more efficient lighting, LED bulbs, can be implemented to replace any incandescent bulbs. Replacing the incandescent bulbs in Higgins Labs, a 1W LED bulb can be utilized[27]. Even though the LED bulbs are at a higher cost, the payback period would only be about two months. The projected annual savings would be about $4500. These projections do not include life expectancy of the bulbs. However, the life expectancy of the compact fluorescent bulbs is greater than the incandescent bulbs, and the life expectancy of the LED bulbs is even greater.

The most utilized form of lighting in Higgins Labs consists of the 32W fluorescent bulbs. These bulbs can be replaced by 15W LED T8 bulbs[28]. The LED T8 bulbs come at a high retail cost of about $65 per bulb, however they are dimmable using from 0-15W. The payback period for these bulbs would be about three years. The annual savings thereafter would be about $40,000.

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[26] SDS15-2P (Dimmable). Bulbs.com. http://www.bulbs.com/eSpec.aspx?ID=15427&Ref=Category&RefId=13&Ref2=Light+Bulbs

[27] LED/G16W (LED, White). Bulbs.com. http://www.bulbs.com/eSpec.aspx?ID=13973&Ref=Category&RefId=13

[28] LED T8. Creativelightings.com. http://www.creativelightings.com/ProductDetails.asp?ProductCode=200007

In order to eliminate human error of forgetting to turn off lights, motion sensors can be installed in hallways, storage rooms, classrooms, and laboratories. Motions sensors[29], akin to the one in Figure 6.1, can already be found in all the bathrooms in Higgins Labs. This will ensure lights are not on when not in use.

Figure 6.1 Motion Sensor Light Switch

A more sophisticated lighting system was developed by Panasonic called the "Auto-eco Light-control Twin Pa[30]." This lighting system measures the light intensity in the room the system is in and automatically dims the lighting to required levels. This allows for rooms to not be over-illuminated and decreases the lighting electrical consumption. This is a new product that hasn't hit the market yet. However, this eco lamp shows a potential to be utilized at WPI in order to help decrease the lighting issues.

6.3 Computer Suggestions

The majority of computers in Higgins Labs are on 24 hours a day. Most of these computers are manually programmed to go into a sleep or hibernation mode after some period of non use. Unfortunately, many computers go into a standby mode after a period of non use. This standby mode puts the monitor at a lower level of electric consumption, but the computer itself still draws about 60W. All computers in Higgins Labs have the ability of completely shutting off after a period of non use. This feature should be implemented in order to decrease this excess electric consumption.

In addition to programming computers to shut off after non-use, the implementation of smart power strips[31] can decrease electrical consumption of the computers in Higgins Labs. Even when the computer is set to automatically shut off, the computer and monitor still draws about 6W. A smart power strip can detect when a device is in the lowest power setting and cut the

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[29] White Motion Switch. DoItBest.com. http://doitbest.com/Main.aspx?PageID=64&SKU=512273&utm_source=Froogle&utm_medium=FREECSE&utm_term=512273&utm_content=6790&utm_campaign=DATAFEED
[30] Panasonic Launches Eco Lamp. http://gadgets.softpedia.com/news/Panasonic-Launches-Eco-Lamp-1003-01.html
[31] Smart Surge Strip. http://www.topmic.com/112-0189.html

power completely therefore eliminating electric leakage. If one of these smart power strips were attached to each computer, the payoff period would be about 5 years. The annual savings would be about $440. This is a conservative estimate since more than just the computer and monitor can be attached to this strip, eliminating even more electric leakage. This payback period is based on leakage alone. If the true shutoff is implemented instead of standby, the payback period for these strips would be about nine months and the annual savings would be about $4400.

6.4 CCU and Projector Suggestion

Below is information taken offline about the switch that is being proposed as a solution. The payback period is estimated for one CCU by purchasing one switch. If the switches were bought in bulk the price would drop as well as the time for payback. In order to keep the estimate conservative, it is assumed the CCU is in its lowest power state of 50 watts when not being used. In actuality, the CCU's have a program that puts them into a sleep/standby mode after about fifteen minutes. People utilizing the rooms have been advised by Network Operations not to shut the computers down during the week, since they have this standby program. Due to this fact, the computers are almost always found in their nominal 140 watt-drawing stage.

Figure 6.2 Outlet Switch

The "BH9936 Remote Controlled Switch Socket"[32] is ideal for the remote operation of many electrical devices, including lamps, appliances, tools and more. It offers a working range of up to 100-feet, and even works outside! The remote control and power socket are fashioned in a sleek pearl design. With one 9-volt (**not included**) battery for the remote you are ready to go! Get your BH9936 Remote Controlled Switch Socket today!

[32] http://closeoutcomputerwarehouse.com/index.php?main_page=product_info&products_id=7799 4/20/09

This is one kind of outlet switch (Figure 6.2 that would address the computer control unit issue. The first option explored was very similar but did not have a ground. A second option was very similar, but did not come with a remote and was a little more expensive. The switch shown above is available at low cost, comes with a one year warranty, and has the added convenience of being remote controlled. This means that a professor leaving the room does not have to bend down to flip the outlet switch. The remote functions off of a nine-volt battery. The wall unit itself also has an on-off button in case the remote is lost or dies.

Payback

In a worst case scenario, the CCU will be in use from 7am until 10pm. This would mean that it is not in use eleven hours a day. This assumes that every professor and group using the room will need the CCU for their entire hour, and that none are teaching from the whiteboards. This was done to make sure the payback calculation is conservative. Shutting the CCU off for eleven hours a day, assuming it is pulling 50 watts and WPI is paying 14 cents a kWh, equates to a payback period of just less than 5 months. This warranty covers a full year, which is almost triple the conservative payback period estimate.

Features/Specifications:

- **General Features:**
- Remote controlled outlet
- Turn lights on from anywhere (even outside)
- 433.92 MHz frequency
- 100-foot range
- Works through walls, floors and doors
- Great for use anywhere in your home
- Single 3-prong outlets
- 120 v 60 Hz voltage
- 10 A current
- Operates on a 9-volt battery (not included)

- **Socket Dimensions:**
- 2.75 x 5 x 1.75-inches (W x L x D, approximate)

- **Regulatory Approvals:**
- cULus
- FCC

- Remote controlled switch socket included
- Remote control included

- **Notes:**
- Model: BH9936
- No.: 1408
- **9-volt battery not included**

- **Product Requirements:**
- Available power outlets
- 9-volt battery (for remote)

- **The Warranty Period Is: 1 Year**
- **Product Number: CON-BH9936**

6.5 National Grid Relationship

Mike Thompson has a daughter that goes to WPI, and is familiar with the campus. He said he would be very happy to help, and that he hopes to hear from WPI on a more regular basis, in order to start an ongoing evolution of developing a more energy efficient campus. National Grid offers to pay a minimum of 45%, and up to 100% of an energy audit if WPI has one performed. If the campus puts into place any of the suggestions that the audit company has, NG will cover even more of the cost of electrical renovations. This brings to light the importance of having an extensive campus wide energy audit done. This will benefit the campus when upgrading existing systems as well as when installing new ones.

There is also an Energy Profiler Online program that WPI pays for. It was signed up for by John Miller and hasn't been utilized since he left the campus. This system will allow the campus to track its energy use and peak demand times. This makes it possible to identify what times extra precautions towards electrical consumption should be taken. The profiler takes an instantaneous reading from the campus core meter every fifteen minutes. In order to utilize this tool to its full potential, fully working electrical meters should be replace any broken ones on campus.

6.6 HVAC Conclusions

Savings with the current HVAC system are going to come from the installation of occupancy sensors and CO_2 sensors. So far, there are about a half dozen installed on campus. It shows that efforts have been made towards the efficiency matter, but still shy of the ultimate goal. The current HVAC system is as efficient as it is going to get without replacing it with newer technology. Yes, there are over 82 motors that operate on constant drives but because the majority of these motors are a fraction of a Horsepower there is nothing valuable gained if you were to put these all on Variable Frequency Drives. "You actually get more savings by just shutting them off," said Norman. With all of the funding for these energy savings projects coming from the Building Management Systems (BMS) budget of only $30,000 it can be seen why a significant effort hasn't been made to implement these sensors all over campus. The first step to making efficiency possible would be to increase the available budget allocated for these matters.

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4/20/09 No longer Exists

Monitoring Electricity Consumption on the WPI Campus Christopher O'Hara, Maximillian Hobson-Dupont, Max Hurgin, Valerie Thierry
Norman F. Hutchins-Head of HVAC Systems at WPI
Lawrence B. Riley-WPI's Facilities Custodial Staff

Appendices

Appendix A

This chart is a full compilation of WPI's electric bills and charges for the last 3 years. The information in light red reflects billing periods where the campus energy supplier was Select Energy, who was being bought out by Hess Energy Corporation at the time. The energy supplier is the company actually making the electricity, not distributing it. The information in blue reflects the more recent time where Direct Energy has been the electrical supplier. National Grid has been the electricity distributor for the whole 3 years.

Read Date & Days	Read Type	Total kWh	Utility Charges	Supplier Charges	Late Payment Charges	Total Charges	TOU On-Peak kWh	TOU Off-Peak kWh
12/15/2006 31 days	Actual	1,557,600	$49,854.20	$151,538.90	$0.00	$201,393.10	741,600	816,000
11/14/2006 19 days	Actual	1,000,800	$31,677.47	$97,367.83	$0.00	$129,045.30	463,200	537,600
10/26/2006 41 days	Actual	2,124,000	$68,853.74	$206,643.96	$0.00	$275,497.70	984,000	1,140,000
9/15/2006 30 days	Actual	1,648,800	$48,522.00	$160,411.75	$516.40	$208,933.75	780,000	868,800
8/16/2006 29 days	Actual	1,646,400	$47,376.19	$160,178.26	$0.00	$207,554.45	813,600	832,800
7/18/2006 32 days	Actual	1,694,400	$47,140.87	$164,848.18	$0.00	$211,989.05	777,600	916,800
6/16/2006 29 days	Actual	1,324,800	$38,902.96	$113,270.40	$0.00	$152,173.36	621,600	703,200
5/18/2006 30 days	Actual	1,420,800	$40,301.93	$121,478.40	$447.89	$162,228.22	691,200	729,600
4/18/2006 29 days	Actual	1,476,000	$41,090.46	$203,289.48	$0.00	$244,379.94	710,400	765,600
3/20/2006 33 days	Actual	1,593,600	$42,398.85	$219,486.53	$0.01	$261,885.39	698,400	895,200
2/15/2006 28 days	Actual	1,428,000	$40,075.34	$0.00	$0.76	$40,076.10	667,200	760,800

Read Date & Days	Read Type	Total kWh	Utility Charges	Metered Peak kW	Metered On-Peak kW	TOU On-Peak kWh	TOU Off-Peak kWh
7/16/2008 30 days	Actual	1,483,200	$226,697.24	3,528.00	3,528.00	722,400	760,800
6/16/2008 32 days	Actual	1,430,400	$204,274.10	3,576.00	3,576.00	636,000	794,400
5/15/2008 28 days	Estimated	1,276,800	$165,554.72	2,952.00	2,952.00	612,000	664,800
4/17/2008 30 days	Actual	1,459,200	$174,324.98	2,952.00	2,952.00	705,600	753,600
3/18/2008 28 days	Actual	1,279,200	$161,038.17	2,664.00	2,664.00	597,600	681,600
2/19/2008 34 days	Actual	1,348,800	$181,479.53	2,472.00	2,472.00	583,200	765,600
1/16/2008 30 days	Estimated	1,377,600	$179,983.01	2,928.00	2,928.00	607,200	770,400
12/17/2007 33 days	Actual	1,514,400	$177,225.19	0	0	667,200	847,200
11/14/2007 30 days	Actual	1,504,800	$183,732.11	0	0	696,000	808,800
10/15/2007 31 days	Actual	1,648,800	$210,728.74	0	0	734,400	914,400
9/14/2007 30 days	Actual	1,684,800	$221,914.22	0	0	796,800	888,000
8/15/2007 29 days	Actual	1,567,200	$211,305.18	0	0	772,800	794,400
7/17/2007 32 days	Actual	1,576,800	$200,750.75	0	0	715,200	861,600
6/15/2007 30 days	Actual	1,372,800	$166,372.70	0	0	638,400	734,400
5/16/2007 29 days	Actual	1,322,400	$163,631.15	0	0	633,600	688,800
4/17/2007 29 days	Actual	1,391,712	$186,307.60	0	0	634,398	757,314
3/19/2007 32 days	Actual	1,575,932	$212,769.21	0	0	718,373	857,559
2/15/2007 30 days	Actual	1,431,288	$218,505.92	0	0	652,438	778,850

Read Date & Days	Read Type	Total kWh	Utility Charges	Supplier Charges	Total Charges	Metered Peak kW	TOU On-Peak kWh	TOU Off-Peak kWh
3/19/2009 29 days	Actual	1,320,000	$38,621.80	$104,451.00	$143,072.80	2,640.00	616,800	703,200
2/18/2009 29 days	Actual	1,358,400	$41,961.09	$142,455.40	$184,416.49	2,616.00	612,000	746,400
1/20/2009 36 days	Actual	1,310,400	$41,667.31	$137,421.00	$179,088.31	2,736.00	612,000	698,400
12/15/2008 28 days	Estimated	1,372,800	$43,070.89	$143,965.50	$187,036.39	3,000.00	559,200	813,600
11/17/2008 32 days	Actual	1,533,600	$47,565.05	$180,382.00	$227,947.05	3,048.00	664,800	868,800
10/16/2008 29 days	Actual	1,483,200	$43,849.04	$174,453.00	$218,302.04	3,048.00	681,600	801,600
9/17/2008 30 days	Actual	1,663,200	$46,429.98	$195,625.00	$242,054.98	3,720.00	789,600	873,600
8/18/2008 10 days	Actual	470,400	$13,530.60	$55,328.00	$68,858.60	3,720.00	194,400	276,000

The table on the following page was put together using the information from the charts above. The graphs in the paper were created from this table.

National Grid/Select Energy/Hess Energy/Direct Energy Bill Information

Year	Month	KWH	# of days meter reading covered	Average KWH/Day	Monthly Cost $$	Average Daily cost
2006	**2006 january**	**732000**	**14**	**52285.7143**		
	February	1428000	28	51000	40076.1	1431.2893
	March	1593600	33	48290.9091	261885.39	7935.9209
	April	1476000	29	50896.5517	244379.94	8426.8945
	May	1420800	30	47360	162228.22	5407.6073
	June	1324800	29	45682.7586	152173.36	5247.3572
	July	1694400	32	52950	$211,989.05	6624.6578
	August	1646400	29	56772.4138	$207,554.45	7157.05
	September	1648800	30	54960	$208,933.75	6964.4583
	October	2124000	41	51804.878	$275,497.70	6719.4561
	November	1000800	19	52673.6842	$129,045.30	6791.8579
	December	1557600	31	50245.1613	$201,393.10	6496.5516
2007	**2007 January**	**1365600**	**30**	**45520**	**204840**	**6828**
	February	1431288	30	47709.6	218505.92	7283.5307
	March	1575932	32	49247.875	212769.21	6649.0378
	April	1391712	29	47990.069	186307.6	6424.4
	May	1322400	29	45600	163631.15	5642.4534
	June	1372800	30	45760	166372.7	5545.7567
	July	1576800	32	49275	200750.75	6273.4609
	August	1567200	29	54041.3793	211305.18	7286.3855
	September	1684800	30	56160	221914.22	7397.1407
	October	1648800	31	53187.0968	210728.74	6797.7013
	November	1504800	30	50160	183732.11	6124.4037
	December	1514400	34	44541.1765	177225.19	5212.5056
2008	**2008 January**	**1377600**	**30**	**45920**	**179983.01**	**5999.4337**
	February	1348800	34	39670.5882	181479.53	5337.6332
	March	1279200	28	45685.7143	161038.17	5751.3632
	April	1459200	30	48640	174324.98	5810.8327
	May	1276800	28	45600	165038.17	5894.2204
	June	1430400	32	44700	204274.1	6383.5656
	July	1483200	30	49440	226697.24	7556.5747
	August	470400	10	47040	$68,858.60	6885.86
	September	1663200	30	55440	$242,054.98	8068.4993
	October	1483200	29	51144.8276	$218,302.04	7527.6566
	November	1533600	32	47925	$227,947.05	7123.3453
	December	1372800	28	49028.5714	$187,036.39	6679.8711
2009	**2009 January**	**1310400**	**36**	**36400**	**$179,088.31**	**4974.6753**
	February	1358400	29	46841.3793	$184,416.49	6359.1893
	March	1320000	29	45517.2414	$143,072.80	4933.5448

*BWNFKKP **C097
191111525005
WPI PLANT SERVICES
MAIN CAMPUS POWER
100 INSTITUTE RD
WORCESTER MA 01609-2247

905191111525005 0006885374

14
1 US ATTN: JOHN MILLER

nationalgrid

o Reach Us
:ustomer Service: 1-800-322-3223
:redit Department: 1-866-395-0316
:-mail: CustomerService@us.ngrid.com
Vebsite: www.nationalgrid.com

Pay This Amount
\$68853.74

Account Number
19111 15250 05

Bill Date
OCT 30 2006

NEXT METER READING DATE
NOVEMBER 14

MONTH	TOTAL KWH
N 06	2124000
D	
S	1648800
A	3340800
J	
J	1324800
M	1420800
A	1476000
M	3021600
F	
J 06	732000

BILLED DEMAND LAST 12 MTHS

MIN	
MAX	7408.8
AVG	3629.6

SERVICE ADDRESS LOAD ZONE WCMASS 905191111525005
183 WEST ST WORCESTER MA WPI , CY, 14

SERVICE PERIOD
SEP 15 TO OCT 26 2006 41 DAYS

TYPE OF METER READING
ACTUAL

METER NUMBER	RATE	METER PRESENT	READING PREVIOUS	METER CONST	KWH USAGE	ACTUAL DEMAND
A04848559	PEAK	6271	5861	2400	984000	
	OFF PK	7328	6853		1140000	
Q04848559	G-3			2400		4032.0 KVA
M04848559	G-3			2400		3600.0 KW
					2124000	

NATIONAL GRID
RATE: TIME OF USE G-3

PREVIOUS BALANCE			\$ .00
BALANCE FORWARD			.00
DELIVERY SERVICES:			
CUSTOMER CHG			95.15
DISTRIBUTION CHG			
DEMAND	5.12505 X 3628.8 KVA=	18597.79	
ENERGY PEAK	.01171 X 984000 KWH=	11522.64	
ENERGY OFF-PEAK	- .00035 X 1140000 KWH=	-399.00	
			29721.43
TRANSITION CHG			
DEMAND	1.23001 X 3628.8 KVA=	4463.47	
ENERGY	.00324 X 2124000 KWH=	6881.76	
			11345.23
TRANSMISSION CHG	.01145 X 2124000 KWH=		24319.80
ENERGY CONSERVATION	.00250 X 2124000 KWH=		5310.00
RENEWABLE ENERGY CHG	.00050 X 2124000 KWH=		1062.00
HIGH VOLTAGE MTR DISC	71853.61 X 1.00%=		-718.54
HIGH VOLTAGE DEL DISC	.6286 X 3628.8 KVA=		-2281.33
TOTAL DELIVERY SERVICES			\$ 68853.74
ACCOUNT BALANCE			\$ 68853.74

Make check payable to: *National Grid*
Mail to: Processing Center, Woburn MA 01807-0005 • See reverse side.

#BWNFKKP **C097
#1911115250054#
WPI PLANT SERVICES
MAIN CAMPUS POWER
100 INSTITUATE RD
WORCESTER MA 01609-2247

905191111525005 0008153167

14
\# 1 B2 ATTN: JOHN MILLER

nationalgrid

Reach Us
Customer Service: 1-800-322-3223
Credit Department: 1-866-395-0315
Email: CustomerService@us.ngrid.com
Website: www.nationalgrid.com

Pay This Amount
$81531.67

Account Number
19111 15250 05

Bill Date
DEC 19 2006

NEXT METER READING DATE
JANUARY 18

MONTH	TOTAL KWH
D 06	1557600
N	3124800
O	
S	1648800
A	3340800
J	
J	1324800
M	1420800
A	1476000
M	3021600
F	

BILLED DEMAND LAST 12 MTHS

MIN
MAX 7408.8
AVG 4064.0

SERVICE ADDRESS — LOAD ZONE WCMASS — 905191111525005
183 WEST ST WORCESTER MA — WPI , CY. 14

* * * * SUPPLIER SWITCH NOTIFICATION * * * *

OUR RECORDS INDICATE THAT YOU HAVE SWITCHED YOUR SUPPLIER OPTION TO NATIONAL GRID BASIC SERVICE

IF YOU HAVE BEEN SWITCHED WITHOUT YOUR AUTHORIZATION, YOU CAN FILE A FORMAL COMPLAINT WITH THE DEPARTMENT OF TELECOMMUNICATIONS AND ENERGY. IF YOU NEED ASSISTANCE OR WISH TO DISCUSS YOUR OPTIONS PLEASE CALL US AT 1-800-322-3223.

SERVICE PERIOD
NOV 14 TO DEC 15 2006 31 DAYS

TYPE OF METER READING
FINAL DUE TO SUPPLIER SWITCH

METER NUMBER	RATE	METER READING PRESENT	METER READING PREVIOUS	METER CONST	KWH USAGE	ACTUAL DEMAND
A04848559	PEAK	6773	6464	2400	741600	
	OFF PK	7892	7552		816000	
Q04848559	G-3			2400		3792.0 KVA
M04848559	G-3			2400		3360.0 KW
					1557600	

Make check payable to: *National Grid*
Mail to: Processing Center, Woburn MA 01807-0005 • See reverse side.

nationalgrid

To Reach Us
Customer Service: 1-800-322-3223
Credit Department: 1-866-395-0315
E-mail: CustomerService@us.ngrid.com
Website: www.nationalgrid.com

Pay This Amount
$280806.48

Account Number
19111 15250 06

Bill Date
AUG 16 2007

NEXT METER READ DATE:
AVOID INTEREST PAY BY:
SEPTEMBER 14

MONTH	TOTAL KWH
A 07	1567200
J	1576800
J	1372800
M	5721332
A	
M	
F	
J 07	1365600

BILLED DEMAND LAST 12 MTHS
MIN
MAX 11869.8
AVG 3117.2

SERVICE ADDRESS LOAD ZONE WCMASS 705191111525006
183 WEST ST WORCESTER MA WPI , CY. 14

NATIONAL GRID
RATE: TIME-OF-USE G-3

PREVIOUS BALANCE			$ 238941.63
PAYMENT-THANK YOU 08/06/07			-170554.62
BALANCE FORWARD			68387.01
DELIVERY SERVICES:			
CUSTOMER CHG			70.72
DISTRIBUTION CHG			
DEMAND	3.80000 X 3823.2 KVA=	14528.16	
ENERGY PEAK	.01249 X 772800 KWH=	9652.27	
ENERGY OFF-PEAK	.00017 X 794400 KWH=	135.05	
			24315.48
TRANSITION CHG			
DEMAND	.75000 X 3823.2 KVA=	2867.40	
ENERGY	.00140 X 1567200 KWH=	2194.08	
			5061.48
TRANSMISSION CHG	.01032 X 1567200 KWH=		16173.51
ENERGY CONSERVATION	.00250 X 1567200 KWH=		3918.00
RENEWABLE ENERGY CHG	.00050 X 1567200 KWH=		783.60
HIGH VOLTAGE MTR DISC	215216.01 X 1.00%=		-2152.16
HIGH VOLTAGE DEL DISC	- .4600 X 3823.2 KVA=		-1758.67
DELIVERY SERVICE			46411.96
INTEREST CHARGE	68387.01 X 1.16%=		793.29
ENERGY PROFILER ONLINE	QTY 1 08/07 - 08/08		321.00
TOTAL DELIVERY SERVICES			$ 47526.25
SUPPLIER SERVICES:			
GENERATION CHARGE			
BASIC SERVICE-VARIABLE	.10522 X 1567200 KWH=		164893.22
TOTAL COST OF ELECTRICITY			$ 164893.22
TOTAL CURRENT BALANCE			$ 212419.47
ACCOUNT BALANCE			$ 280806.48

Make check payable to: *National Grid*
Mail to: Processing Center, Woburn MA 01807-0005 • See reverse side.

nationalgrid

www.nationalgrid.com

SERVICE FOR
WPI PLANT SERVICES
MAIN CAMPUS POWER
153 WEST ST
WORCESTER MA 01609

BILLING PERIOD
Jun 16, 2008 to Jul 16, 2008

ACCOUNT NUMBER 27644-44011
PLEASE PAY BY Aug 13, 2008

PAGE 1 OF
JUL 25 20
AMOUNT D
$ 226,740.

CUSTOMER SERVICE
1-800-322-3223

CREDIT DEPARTMENT
1-888-211-1313

POWER OUTAGE OR DOWNED LINE
1-800-465-1212

EMAIL BILLING INQUIRES
customerservice@us.ngrid.com

ADDRESS
PO Box 960
Northborough, MA 01532-0960

DATE BILL ISSUED
Jul 18, 2008

ACCOUNT BALANCE

Previous Balance		372,146.0
Payment Received on JUL 10 (Check)	THANK YOU	- 204,551.9
Payment Received on JUN 30 (Check)	THANK YOU	- 167,871.9
Balance Forward		-277.8
Current Charges		+ 227,018.2
	Amount Due Now ▶	$ 226,740.3

To avoid late payment charges of 1.12%, your "Amount Due Now" must be received by Aug 13 2008.

DETAIL OF CURRENT CHARGES

Delivery Services

Type of Service	Current Reading	- Previous Reading	= Difference	x Meter Multiplier	= Total Usag
Energy	25516 *Actual*	24898 *Actual*	618	2400	1483200 kWI
Peak	11760 *Actual*	11459 *Actual*	301	2400	722400 kWI
Off Peak	13756 *Actual*	13439 *Actual*	317	2400	760800 kWI
				Total Energy	1483200 kWI
Demand-kW					
Peak				2400	3528.0 kV
Off Peak				2400	2808.0 kV
Demand-kVA					
Peak				2400	4176.0 kV/
Off Peak				2400	3432.0 kV/

METER NUMBER 04848559 NEXT SCHEDULED READ DATE Aug 18

SERVICE PERIOD Jun 16 - Jul 16 NUMBER OF DAYS IN PERIOD 30

RATE Time-of-Use G-3 VOLTAGE DELIVERY LEVEL 2.2 - 15 kv

Enrollment Information

To enroll with a supplier or change to another supplier, you will need the following information about your account:

Loadzone WCMA

Acct No: 27644-44011 Cycle: 14, WPI

Electric Usage History

Month	kWh	Month	kWh
Jul 07	1576800	Feb 08	1348800
Aug 07	1567200	Mar 08	1279200
Sep 07	1684800	Apr 08	1459200
Oct 07	1648800	May 08	1276800
Nov 07	1504800	Jun 08	1430400
Dec 07	1514400	Jul 08	1483200
Jan 08	1377600		

Billed Demand Last 12 months

Minimum	2472
Maximum	3823.2
Average	3256

KEEP THIS PORTION FOR YOUR RECORDS.

RETURN THIS PORTION WITH YOUR PAYMENT.

nationalgrid

ACCOUNT NUMBER	PLEASE PAY BY	AMOUNT DUE
27644-44011	Aug 13, 2008	$ 226,740.38

PO Box 960
Northborough MA 01532-0960

ENTER AMOUNT ENCLOSED
$

Write account number on check and make payable to National Grid

*****AUTO**5-DIGIT 01609
WPI PLANT SERVICES
MAIN CAMPUS POWER
100 INSTITUATE RD
WORCESTER MA 01609-2247

03897

NATIONAL GRID
PO BOX 1005
WOBURN MA 01807-1005

022701824 2764444011302267403822б

nationalgrid

SERVICE FOR
WPI PLANT SERVICES
MAIN CAMPUS POWER
183 WEST ST
WORCESTER MA 01609

BILLING PERIOD
Jun 16, 2008 to Jul 16, 2008

ACCOUNT NUMBER	PLEASE PAY BY	AMOUNT DUE
27644-44011	Aug 13, 2008	$ 226,740.38

Choosing an Energy Supplier You can choose who supplies your energy. No matter which energy supplier you choose, National Grid will continue to deliver energy to you safely, efficiently and reliably. We will also continue to provide your customer service, including emergency response and storm restoration. National Grid is dedicated to creating an open energy market that lets you choose from a variety of competitive energy suppliers, who may offer different pricing options. For information on authorized energy suppliers and how to choose, please visit us online at www.nationalgridus.com/energychoice.

Customer Charge		72.06
Dist Chg On Peak	0.01363 x 722400 kWh	9,846.31
Dist Chg Off Peak	0.00108 x 760800 kWh	821.67
Transition Charge	0.00142 x 1483200 kWh	2,106.14
Transmission Charge	0.00749 x 1483200 kWh	11,109.17
Distribution Demand Chg	3.87 x 3758.4 kW/kVA	14,545.01
High Voltage Discount	-0.46 x 3758.4 kW	-1,728.86
Dem Side Mgmt Chg	0.0025 x 1483200 kWh	3,708.00
Transition Demand Chg	0.52 x 3758.4 kW	1,954.37
Renewable Energy Chg	0.0005 x 1483200 kWh	741.60
High Voltage Metering	-1.0 % x $ 230733.43	-2,307.33
	Total Delivery Services	**$ 40,868.14**

Explanation of General Billing Terms

KWH: Kilowatt-hour, a basic unit of electricity used.
Off-Peak: Period of time when the need or demand for electricity on the Company's system is low, such as late evenings, weekends and holidays.
Peak: Period of time when the need or demand for electricity on the Company's system is high, normally during the day, Monday through Friday, excluding holidays.
Estimated Bill: A bill which is calculated based on your typical monthly usage rather than on an actual meter reading. It is usually rendered when we are unable to read your meter.
Meter Multiplier: A number by which the usage on certain meters must be multiplied by to obtain the total usage.
Demand Charge: The cost of providing electrical transmission and distribution equipment to accommodate your largest electrical load.

Supplier Service Charges are comprised of:

Generation Charge: The charge(s) to provide electricity and other services to the customer by a supplier.

Delivery Service Charges are comprised of:

Customer Charge: The cost of providing customer related service such as metering, meter reading and billing. These fixed costs are unaffected by the actual amount of electricity you use.
Distribution Charge: The cost of delivering electricity from the beginning of the Company's distribution system to your home or business.
Transition Charge: Company payments to its wholesale supplier for terminating its wholesale arrangements.
Transmission Charge: The cost of delivering electricity from the generation company to the beginning of the Company's distribution system.

Demand Side Management: The cost of demand side management programs offered by the Company.
Renewable Energy Charge: A charge to fund initiatives for communicating the benefits of renewable energy and fostering formation, growth, expansion and retention of renewable energy and related enterprises.

Questions:
If you have questions or complaints regarding this bill or National Grid's service quality, please contact Customer Service at 1-800-322-3223. You may also contact the Massachusetts Department of Public Utilities, Consumer Division at 617-305-3531 or toll free at 1-800-392-6066 or web site www.mass.gov/dpu.

nationalgrid

www.nationalgrid.com

SERVICE FOR	BILLING PERIOD		PAGE 3
WPI PLANT SERVICES MAIN CAMPUS POWER 183 WEST ST WORCESTER MA 01609	Jun 16, 2008 to Jul 16, 2008		
	ACCOUNT NUMBER	PLEASE PAY BY	AMOUN
	27644-44011	Aug 13, 2008	$ 226,74

Supply Services

SUPPLIER National Grid

Basic Service Variable	0.12528931 x 1483200 kWh	185,829
	Total Supply Services	**$ 185,829**

Other Charges/Adjustments

Energy Profiler Online	321
Total Other Charges/Adjustments	**$ 321**

nationalgrid

www.nationalgrid.com

SERVICE FOR
WPI PLANT SERVICES
MAIN CAMPUS POWER
183 WEST ST
WORCESTER MA 01609

BILLING PERIOD
Feb 18, 2009 to Mar 19, 2009

PAGE 1 c

ACCOUNT NUMBER	PLEASE PAY BY	AMOUNT
27644-44020	Apr 15, 2009	$ 38,621.

CUSTOMER SERVICE
1-800-322-3223

CREDIT DEPARTMENT
1-888-211-1313

POWER OUTAGE OR DOWNED LINE
1-800-465-1212

EMAIL BILLING INQUIRES
customerservice@us.ngrid.com

ADDRESS
PO Box 960
Northborough, MA 01532-0960

DATE BILL ISSUED
Mar 20, 2009

ACCOUNT BALANCE

Previous Balance		41,489.
Payment Received on MAR 6 *(Check)*	*THANK YOU*	- 41,489.
Current Charges		+ 38,621.
	Amount Due Now ▶	$ 38,621.

To avoid late payment charges of 0.95%, your "Amount Due Now" must be received by Apr 15 2009.

➤ **GO WITH THE FLOE -- TAKE ACTION TO COMBAT CLIMATE CHANGE:** Join the Floe community and pledge today at www.nationalgrid.com/floe to reduce your energy use and help the environment.

DETAIL OF CURRENT CHARGES

Delivery Services

Type of Service	Current Reading	- Previous Reading	= Difference	x Meter Multiplier	= Total Usag
Energy	30407 *Actual*	29857 *Actual*	550	2400	1320000 kWh
Peak	13984 *Actual*	13727 *Actual*	257	2400	616800 kWh
Off Peak	16423 *Actual*	16130 *Actual*	293	2400	703200 kWh
				Total Energy	**1320000 kWh**
Demand-kW					
Peak				2400	2640.0 kW
Off Peak				2400	2304.0 kW
Demand-kVA					
Peak				2400	2952.0 kVA
Off Peak				2400	2568.0 kVA

METER NUMBER 04848559 NEXT SCHEDULED READ DATE Apr 21
SERVICE PERIOD Feb 18 - Mar 19 NUMBER OF DAYS IN PERIOD 29
RATE Time-of-Use G-3 VOLTAGE DELIVERY LEVEL 2.2 - 15 kv

Enrollment Information

To enroll with a supplier or change to another supplier, you will need the following information about your account:
Loadzone WCMA
Acct No: 27644-44020 Cycle: 14, WPI

Electric Usage History

Month	kWh	Month	kWh
Aug 08	470400	Mar 09	1320000
Sep 08	1663200		
Oct 08	1483200		
Nov 08	1533600		
Dec 08	1372800		
Jan 09	1310400		
Feb 09	1358400		

Billed Demand Last 12 months

Minimum	2635.2
Maximum	3844.8
Average	2080.2

KEEP THIS PORTION FOR YOUR RECORDS.

RETURN THIS PORTION WITH YOUR PAYMENT.

nationalgrid

ACCOUNT NUMBER	PLEASE PAY BY	AMOUNT DUE
27644-44020	Apr 15, 2009	$ 38,621.80

PO Box 960
Northborough MA 01532-0960

ENTER AMOUNT ENCLOSED
$

Write account number on check and make payable to National Grid

*****AUTO**5-DIGIT 01609
WPI PLANT SERVICES
MAIN CAMPUS POWER
183 WEST ST
WORCESTER MA 01609-2253

03525

NATIONAL GRID
PO BOX 1005
WOBURN MA 01807-1005

003862180 27644440200003862180105

SERVICE FOR	BILLING PERIOD		PAGE 2 OF
WPI PLANT SERVICES MAIN CAMPUS POWER 183 WEST ST WORCESTER MA 01609	Feb 18, 2009 to Mar 19, 2009		
	ACCOUNT NUMBER	PLEASE PAY BY	AMOUNT DU
	27644-44020	Apr 15, 2009	$ 38,621.8

Customer Charge				72.78
Dist Chg On Peak	0.01275205	x	616800 kWh	7,865.46
Dist Chg Off Peak	0.00007758	x	703200 kWh	54.56
Transition Charge	0.00088928	x	1320000 kWh	1,173.85
Transmission Charge	0.01207861	x	1320000 kWh	15,943.77
Distribution Demand Chg	3.90275822	x	2656.8 kW/kVA	10,368.85
High Voltage Discount	-0.46	x	2656.8 kW	-1,222.13
Dem Side Mgmt Chg	0.0025	x	1320000 kWh	3,300.00
Transition Demand Chg	0.30379305	x	2656.8 kW	807.12
Renewable Energy Chg	0.0005	x	1320000 kWh	660.00
High Voltage Metering	-1.0 %	x	$ 40246.39	-402.46
			Total Delivery Services	**$ 38,621.80**

Explanation of General Billing Terms

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Transmission Charge: The cost of delivering electricity from the generation company to the beginning of the Company's distribution system.

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Questions:
If you have questions or complaints regarding this bill or National Grid's service quality, please contact Customer Service at 1-800-322-3223. You may also contact the Massachusetts Department of Public Utilities, Consumer Division at 617-305-3531 or toll free at 1-800-392-6066 or web site www.mass.gov/dpu.

Appendix C Hess Energy Corporation Bills[33]

Sold To	Utility Account No.	Invoice Date	Invoice No.	Amount	Due Date	From	To	Volume	
479301	5191111525006	8/7/06	SE0022564	$164,848.18	9/6/06	6/16/06	7/18/06	1,694,400	KWH
479301	5191111525006	8/22/06	SE0032514	$160,178.26	9/21/06	7/18/06	8/16/06	1,646,400	KWH
479301	5191111525006	9/20/06	SE0046506	$160,411.75	10/20/06	8/16/06	9/15/06	1,648,800	KWH
479301	5191111525006	11/1/06	SE0066838	$206,643.96	12/1/06	9/15/06	10/26/06	2,124,000	KWH
479301	5191111525006	11/21/06	SE0076758	$97,367.83	12/21/06	10/26/06	11/14/06	1,000,800	KWH
479301	5191111525006	12/21/06	SE0087966	$151,538.90	1/20/07	11/14/06	12/15/06	1,557,600	KWH

[33] These Document were emailed

043309 000026422 0 0000508124 0104451

MAR 27

Direct Energy Business

Account Number:	Invoice Number:	Invoice Date:	Due Date:
26422	508124	03/23/2009	04/13/2009

Amount Now Due: $104,451

Amount Enclosed: $

WORCESTER POLYTECHNIC INSTITUTE
OFFICE OF FACILITIES
100 INSTITUTE RD
WORCESTER, MA 01609

Send Payment To:
Direct Energy Services, LLC
P.O. Box 1564
New York, NY, 10008-1564

☐ Change of Address

*Include Your Account & Invoice Number On The Ch

Please detach and return this stub with your check payable to "Direct Energy Services, LLC". Thank You.

Customer Service Information

Questions about your bill?

Call: 1-800-925-9115
Email: CustomerRelations@directenergy.com
Internet: www.DirectEnergy.com

Write to:
Customer Relations Manager
Two Gateway Center
Pittsburgh, PA, 15222

1001-4660-7434

Account Number:	26
Invoice Number:	508
Invoice Date:	03/23/2
Amount Due:	$104,451

Summary of Charges/Credits

Prior Balance	$142,455
Payment Received on 03/16/2009	($142,455.
Current Charges	$104,451
Amount Due:	$104,451.

Service Information

Mailing Address:
WORCESTER POLYTECHNIC INSTITUTE
OFFICE OF FACILITIES
100 INSTITUTE RD
WORCESTER, MA 01609

Service Address:
WORCESTER POLYTECHNIC INSTITUTE
183 West St
Worcester, MA 01609

Account Information:

Commodity:	Electricity
Utility Account:	2764444020
Utility Name:	Massachusetts Electric
Emergency Phone #:	800-867-5222

Detail Information

Product: Fixed Price

Congestion Zone: MECO WCMASS

Billing Period: 02/18/2009 - 03/19/2009 Total Usage: 1,320,000 KWh

Charges	Unit	Volume	Unit Price	Percentage	Amou
Fixed Price	KWh	1,320,000.00	$0.07913		$104,451
Total Charges					$104,451

Current Charge Total: $104,451.

031609 000026422 0 0000488049 014245541

Direct Energy Business

Account Number:	Invoice Number:	Invoice Date:	Due Date:
26422	488049	02/23/2009	03/18/2009
	Amount Now Due:		$142,455

Amount Enclosed: $

WORCESTER POLYTECHNIC INSTITUTE
OFFICE OF FACILITIES
100 INSTITUTE RD
WORCESTER, MA 01609

Send Payment To:
Direct Energy Services, LLC
P.O. Box 1564
New York, NY, 10008-1564

☐ Change of Address

*Include Your Account & Invoice Number On The Che

Please detach and return this stub with your check payable to "Direct Energy Services, LLC". Thank You.

Customer Service Information

Questions about your bill?

Call: 1-888-925-9115
Email: CustomerRelations@directenergy.com
Internet: www.DirectEnergy.com

Write to:
Customer Relations Manager
Two Gateway Center
Pittsburgh, PA, 15222

Account Number:	264
Invoice Number:	488(
Invoice Date:	02/23/20
Amount Due:	$142,455.

Summary of Charges/Credits

Prior Balance	$281,387
Payment Received on 02/02/2009	($143,965.
Payment Received on 02/13/2009	($137,421.
Current Charges	$142,455
Amount Due:	**$142,455.**

Service Information

Mailing Address:	Service Address:	Account Information:	
WORCESTER POLYTECHNIC INSTITUTE OFFICE OF FACILITIES 100 INSTITUTE RD WORCESTER, MA 01609	WORCESTER POLYTECHNIC INSTITUTE 183 West St Worcester, MA 01609	Commodity: Utility Account: Utility Name: Emergency Phone #:	Electricity 2784444020 Massachusetts Electric 800-867-5222

Detail Information

Product: Fixed Price

Congestion Zone: MECO WCMASS

Billing Period: 01/20/2009 - 02/18/2009 Total Usage: 1,358,400 KWh

Charges	Unit	Volume	Unit Price	Percentage	Amou
Fixed Price	KWh	1,358,400.00	$0.10487		$142,455
Total Charges					$142,455

Current Charge Total: $142,455.4

021209 000026422 0 0000467911 028138719

JAN 2 9 20[

Direct Energy
Business

Account Number:	Invoice Number:	Invoice Date:	Due Date:
26422	467911	01/23/2009	02/12/2009
	Amount Now Due:		$281,387.

Amount Enclosed: $

WORCESTER POLYTECHNIC INSTITUTE
OFFICE OF FACILITIES
100 INSTITUTE RD
WORCESTER, MA 01609

Send Payment To:
Direct Energy Services, LLC
P.O. Box 1564
New York, NY, 10008-1564

☐ Change of Address

*Include Your Account & Invoice Number On The Che

Please detach and return this stub with your check payable to "Direct Energy Services, LLC". Thank You.

Customer Service Information

Questions about your bill?

Call: 1-888-925-9115
Email: CustomerRelations@directenergy.com
Internet: www.DirectEnergy.com

Write to:
Customer Relations Manager
Two Gateway Center
Pittsburgh, PA, 15222

Account Number:	264
Invoice Number:	4679
Invoice Date:	01/23/20
Amount Due:	$281,387.

Summary of Charges/Credits

Prior Balance	$143,965
Current Charges	$137,421
Amount Due:	**$281,387.**

Service Information

Mailing Address:
WORCESTER POLYTECHNIC INSTITUTE
OFFICE OF FACILITIES
100 INSTITUTE RD
WORCESTER, MA 01609

Service Address:
WORCESTER POLYTECHNIC INSTITUTE
183 West St
Worcester, MA 01609

11001-4660-7434

Account Information:

Commodity:	Electricity
Utility Account:	2764444020
Utility Name:	Massachusetts Electric
Emergency Phone #:	800-867-5222

Detail Information

Product: Fixed Price

Congestion Zone: MECO WCMASS

Billing Period: 12/15/2008 - 01/20/2009 Total Usage: 1,310,400 KWh

Charges	Unit	Volume	Unit Price	Percentage	Amo
Fixed Price	KWh	1,310,400.00	$0.10487		$137,421
Total Charges					$137,421

JAN 2 1 2009

020409 000026422 0 0000461635 014396554

Direct Energy
Business

Account Number:	Invoice Number:	Invoice Date:	Due Date:
26422	461635	01/15/2009	02/04/2009

Amount Now Due: $143,965

Amount Enclosed: $

WORCESTER POLYTECHNIC INSTITUTE
OFFICE OF FACILITIES
100 INSTITUTE RD
WORCESTER, MA 01609

Send Payment To:
Direct Energy Services, LLC
P.O. Box 1564
New York, NY, 10008-1564

☐ Change of Address

*Include Your Account & Invoice Number On The Che

Please detach and return this stub with your check payable to "Direct Energy Services, LLC". Thank You.

Customer Service Information

Questions about your bill?

Call: 1-888-925-9115
Email: CustomerRelations@directenergy.com
Internet: www.DirectEnergy.com

Write to:
Customer Relations Manager
Two Gateway Center
Pittsburgh, PA, 15222

11001-4660-7434

Account Number:	264
Invoice Number:	4616
Invoice Date:	01/15/20
Amount Due:	$143,965.

Summary of Charges/Credits

Prior Balance	$180,382
Payment Received on 12/17/2008	($180,382.
Current Charges	$143,965
Amount Due:	**$143,965.**

Service Information

Mailing Address:	Service Address:	Account Information:	
WORCESTER POLYTECHNIC INSTITUTE OFFICE OF FACILITIES 100 INSTITUTE RD WORCESTER, MA 01609	WORCESTER POLYTECHNIC INSTITUTE 183 West St Worcester, MA 01609	Commodity: Utility Account: Utility Name: Emergency Phone #:	Electricity 2784444020 Massachusetts Electric 800-867-5222

Detail Information

Product: Fixed Price

Congestion Zone: MECO WCMASS

Billing Period: 11/17/2008 - 12/15/2008 Total Usage: 1,372,800 KWh

Charges	Unit	Volume	Unit Price	Percentage	Amou

121008 000026422 0 0000426165 DEC 08 2008 3

Direct Energy Business

Account Number:	Invoice Number:	Invoice Date:	Due Date:
26422	426165	11/20/2008	12/10/2008

Amount Now Due: $180,382.(

Amount Enclosed: $

WORCESTER POLYTECHNIC INSTITUTE
100 INSTITUTE RD
WORCESTER, MA 01609

Send Payment To:
Direct Energy Services, LLC
P.O. Box 1564
New York, NY 10008-1564

☐ Change of Address

*Include Your Account & Invoice Number On The Che

Please detach and return this stub with your check payable to "Direct Energy Services, LLC". Thank You.

Customer Service Information

Questions about your bill?

Call: 1-866-809-9143
Email: CustomerCareUS@directenergy.com
Internet: www.directenergy.com

Write to:
One Hamden Center
2319 Whitney Ave, 4th Fl
Hamden, CT 06518

1001-4660-7434
APPROVED - Michael C...
12/8/08 $180,382.03

Account Number:	264
Invoice Number:	4261
Invoice Date:	11/20/20
Amount Due:	$180,382.(

Summary of Charges/Credits

Prior Balance	$425,408.
Payment Received on 11/14/2008	($425,408.(
Current Charges	$180,382.
Amount Due:	**$180,382.(**

Service Information

Mailing Address:
WORCESTER POLYTECHNIC INSTITUTE
100 INSTITUTE RD
WORCESTER, MA 01609

Service Address:
WORCESTER POLYTECHNIC INSTITUTE
183 West St
Worcester, MA 01609

Account Information:

Commodity:	Electricity
Utility Account:	2764444020
Utility Name:	Massachusetts Electric
Emergency Phone #:	800-867-5222

Detail Information

Product: Fixed Price

Congestion Zone: MECO WCMASS

Billing Period: 10/16/2008 - 11/17/2008 **Total Usage:** 1,533,600 KWh

Charges	Unit	Volume	Unit Price	Percentage	Amou
Fixed Price	KWh	1,533,600.00	$0.11762		$180,382
Total Charges					$180,382

Current Charge Total: $180,382.(

Page: 1 of 1

Direct Energ

Direct Energy
Business

Account Number:	Invoice Number:	Invoice Date:	Due Date:
26422	406499	10/23/2008	11/12/2008

Detail Information

Product: Fixed Price

Congestion Zone: MECO WCMASS

Billing Period: 06/09/2008 - 06/18/2008 Total Usage: 470,400 KWh

Charges	Unit	Volume	Unit Price	Percentage	Amou
Fixed Price	KWh	470,400.00	$0.11762		$55,328.
Total Charges					$55,328.

Product: Fixed Price

Congestion Zone: MECO WCMASS

Billing Period: 09/17/2008 - 10/16/2008 Total Usage: 1,483,200 KWh

Charges	Unit	Volume	Unit Price	Percentage	Amou
Fixed Price	KWh	1,483,200.00	$0.11762		$174,453.
Total Charges					$174,453.

Product: Fixed Price

Congestion Zone: MECO WCMASS

Billing Period: 08/18/2008 - 09/17/2008 Total Usage: 1,663,200 KWh

Charges	Unit	Volume	Unit Price	Percentage	Amou
Fixed Price	KWh	1,663,200.00	$0.11762		$195,625.
Total Charges					$195,625.

Current Charge Total: $425,408.0

111208 000026422 0 0000406499 042540801

Direct Energy
Business

Account Number:	Invoice Number:	Invoice Date:	Due Date:
26422	406499	10/23/2008	11/12/2008

Amount Now Due: $425,408.0

Amount Enclosed: $

WORCESTER POLYTECHNIC INSTITUTE
100 INSTITUTE RD
WORCESTER, MA 01609

Send Payment To:
Direct Energy Services, LLC
P.O. Box 1564
New York, NY 10008-1564

☐ Change of Address

*Include Your Account & Invoice Number On The Chec

Please detach and return this stub with your check payable to "Direct Energy Services, LLC". Thank You.

Customer Service Information

Questions about your bill?

Call: 1-866-809-9143
Email: CustomerCareUS@directenergy.com
Internet: www.directenergy.com

Write to:
One Hamden Center
2319 Whitney Ave, 4th Fl
Hamden, CT 06518

Account Number:	2642
Invoice Number:	40649
Invoice Date:	10/23/200
Amount Due:	$425,408.0

Summary of Charges/Credits

Current Charges	$425,408.0
Amount Due:	**$425,408.0**

Service Information

Mailing Address:
WORCESTER POLYTECHNIC INSTITUTE
100 INSTITUTE RD
WORCESTER, MA 01609

Service Address:
WORCESTER POLYTECHNIC INSTITUTE
183 West St
Worcester, MA 01609

Account Information:

Commodity:	Electricity
Utility Account:	2764444020
Utility Name:	Massachusetts Electric
Emergency Phone #:	800-867-5222

Page: 1 of 2

Direct Energ

Appendix E

OSHA Standards Illumination Chart

Foot-Candles	Area of Operation
5	General construction area lighting.
3	General construction areas, concrete placement, excavation and waste areas, access ways, active storage areas, loading platforms, refueling, and field maintenance areas.
5	Indoors: warehouses, corridors, hallways, and exitways.
5	Tunnels, shafts, and general underground work areas: (Exception: minimum of 10 foot-candles is required at tunnel and shaft heading during drilling, mucking, and scaling. Bureau of Mines approved cap lights shall be acceptable for use in the tunnel heading)
10	General construction plant and shops (e.g., batch plants, screening plants, mechanical and electrical equipment rooms, carpenter shops, rigging lofts and active store rooms, mess halls, and indoor toilets and workrooms.)
30	First aid stations, infirmaries, and offices.

Appendix F

LUX Meter Information

Click here see large view

Download Specifications

Application Software

Buy extra test leads

LX1010B	Economic Lux Meter ever made with great accuracy
US $39.95	Special Offer
~~$59.00~~	Suggest Retail Price
Super Save	Save up: ------- 46% , Now !
Accessories Included	Battery and manual included

Please check on the right side to compare other models

Brief Specifications:

To check the level of bright
Range:0- 2,000/20,000/ 50,000 Lux (+-5% +2D)
Accuracy: 5.0%
Resolution: 1 Lux
Sampling time:0.4 second
Dimensions:
Body: 4.6 X 2.7 X 1.10"
Sensor: 3.26 X 2 X0.8"
Weight: 160 g.

Click here to see the package

The protective cover has to be removed before use. If you do not see the number change, the sensor cover is not taken off.

Advantage:

Measure 0 -- 50,000 lux for a wide range of use.
Auto zero adjustment
Data hold
High accuracy
Low battery alert
Ideal for use by architectures, light designers, and photographers..

Size(Inches):4.3x2.9x0.90

Weight (lbs) 0.56

Appendix G

Scheduling Documents

News and Information

February 22, 2007

Contact: Harry Lenhart
503-494-8231
Email Harry Lenhart

OHSU Center First Medical Facility in Nation to Win LEED Platinum Award

The Center for Health & Healing blazes a trail with coveted green building certification

PORTLAND, Ore. - The U.S. Green Building Council has awarded Oregon Health & Science University's Center for Health & Healing LEED platinum certification for energy efficiency and environmental sustainability, the first medical and research facility anywhere to have achieved this distinction.

The Center, located in the South Waterfront district, is one of only 30 buildings of all kinds in the country to have been awarded platinum certification and the largest and most complex medical building in the country to have achieved it. The building garnered 55 points out of a possible 69 on the USBGC's Leadership in Energy and Environmental Design (LEED) scorecard, three more points than required for platinum.

"We set out to meet the highest standards of sustainability and energy efficiency when this project was started. This award recognizes the melding of the OHSU Medical Group's vision and the innovative team that designed and built this remarkable building," said Joseph Robertson, M.D., MBA, president of OHSU. "The Center for Health & Healing is the first step in our development of the South Waterfront and demonstrates in bricks and mortar OHSUÍs belief that a healthy built environment is integral to healthy living."

"The OHSU Center for Health & Healing is a real testament to how we can advance green building practices," said Dennis Wilde, principal and senior project manager at Gerding Edlen Development. "It's one of the largest buildings in the country to augment forced air-conditioning with a vastly more efficient chilled beam and displacement ventilation system. All told, the energy that will be saved as a result of the buildingÍs many innovations will be nearly 5.1 million pounds of carbon dioxide a year, the equivalent of removing 443 cars from our highways."

"This is a remarkable achievement given the complex array of uses and systems that were needed in the building," added David Crawford, chief financial officer of the OHSU Medical Group, who oversaw construction. "We had to capture every opportunity to integrate together function, architecture and engineering. This is really the result of a great collaborative team effort. We have set a new standard for OHSU and for other projects in Portland."

The 16-story, 400,000 square foot building - the first OHSU building to be completed in the South Waterfront and now OHSUÍs gateway to health care - houses clinical offices, ambulatory surgery suites, a rehabilitation center, research laboratories, educational facilities, a conference center, and the march wellness and fitness center with its saline-treated swimming and therapy pools, basketball court and locker rooms. A Casey Eye Optical Shop, an OHSU retail pharmacy and the Daily Café restaurant occupy space on the ground floor near the three-story atrium.

The building is 61 percent more energy-efficient than required by Oregon code. It uses nearly 60 percent less potable water than a similar conventional building does. One-hundred percent of the sewage generated in the building is treated in a membrane bioreactor on site. Building systems also included an integrated day-lighting system, naturally ventilated stair towers, radiant heating and cooling, and eco-roofs. Rainwater and wastewater are harvested for landscaping, keeping 15,000 gallons a day from reaching the cityÍs overburdened sewer system. No potable water is used for waste conveyance or irrigation in the building, and the swimming pools are integrated with the heating and cooling system as a thermal storage unit.

The south-side façade of the building on the 15th and 16th floors was transformed into a giant solar air heater by creating a 6,000 square foot trombe wall consisting of two glass skins. The warm air produced inside the trombe wall by the greenhouse effect is recirculated through the building in winter reducing the buildingÍs energy use.

The building also features:

- Sunshades on the south side that double as solar electricity generators;
- Lighting in stairwells and offices controlled by occupancy sensors as well as reduced lighting in lobbies and other pass-through areas;
- A gas-fueled cogeneration system powered by five 60-kilowatt microturbines, the first of its scale in Oregon;
- Chilled beams that combine convective cooling systems with displacement ventilation, which cut energy use by 20 percent to 30 percent under conventional air conditioning systems and reduce the need for ductwork and other mechanical systems;
- Use of sustainable and lower toxicity materials in interior finishes and furnishings, including low volatile organic compound paints and sealants, sustainably manufactured carpeting systems, and the used of Forest Stewardship Council (FSC) certified wood products.
- More than 950 OHSU employees work in the building either full time or part time. It is the centerpiece of a nearly $2.3 billion array of new investment in the South Waterfront and is ringed by public transportation links. The lower terminal of the Portland Aerial Tram is located next door and the Portland Streetcar stops across the street.

The LEED green building rating system is a voluntary, consensus-based national standard for developing high-performance sustainable buildings. It targets areas such as sustainable site development, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. The U.S. Green Building Council, which administers the rating system, is a coalition of leaders from every sector of the building industry working to promote environmentally responsible, profitable and healthy places to live and work.

The building represents the state-of-the-art in integrative design, a process in which all project team members provided an exceptional level of collaboration. Key team members, in addition to OHSU and the OHSU Medical Group included Gerding Edlen Development, the development managers; GBD Architects and Interface Engineering, Inc., who were responsible for the design of the building and its mechanical, electrical and plumbing systems; Walker Macy, the landscape designers; Hoffman Construction Co., who built it; and Brightworks, the sustainability advisors who coordinated the green building strategies. Also involved in the project were KPFF Consulting Engineers and Peterson Kohlberg Associates.

For more information about the Center for Health & Healing, go to http://www.ohsu.edu/ohsuedu/about/transformation/commons/index.cfm

Appendix H

LIGHTING CONTROLS

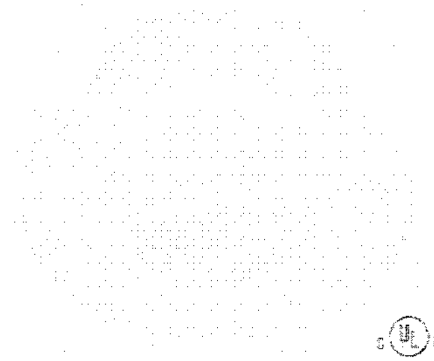
OCCUPANCY SENSOR

MODEL CI-24

WattStopper legrand

DESCRIPTION

The **Model CI-24** is a ceiling-mount passive infrared (PIR) occupancy sensor specifically designed to interface with building automation systems through an internal isolated relay. A user-adjustable time delay (30 seconds to 30 minutes) on deactivation may be programmed through DIP switches to prevent unnecessary cycling. The **Model CI-24** includes a built-in override switch, and two levels of sensitivity are selectable through DIP switches. The four-level patented Fresnel lens allows the **Model CI-24** to cover up to 1200 ft² (111.48m²).



c UL us

FEATURES

- *Advanced PIR technology*
- *Adjustable time delay*
- *Adjustable sensitivity*
- *Isolated relay for use with BAS and other control systems*
- *Patented Fresnel lens*
- *360-degree coverage up to 1200 ft² (111.48m²)*
- *Red LED to indicate occupancy detection*
- *Five-year warranty*
- *Manual override switch*

SPECIFICATIONS

Power supply	24 VAC/VDC
Power consumption	37 mA
Time-delay adjust	Digital (DIP switch setting) for 30 sec, 10 min., 20 min., or 30 min.
Coverage	360 degrees up to 1200 ft² (111.48m²)
Color	White
Isolated contact rating	1A @ 24 VDC, 24 VAC; 1/2A @ 120 VAC
Agency approvals	UL and ULC listed
Operating temp	32° to 98°F (0° to 36°C)
Mounting	2.75" to 3" hole in ceiling
Dimensions	3.3" dia x 2.2" deep (8.5 x 5.6 cm), extends approx. 0.36" (0.91 cm) from ceiling
Weight	1.0 lb (0.46 kg)
Warranty	5 years

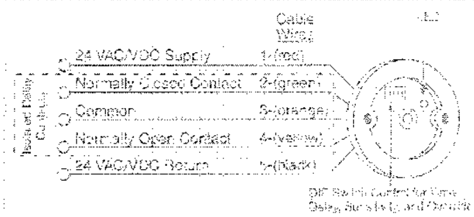
ORDERING INFORMATION

MODEL	DESCRIPTION
CI-24	24 VAC/VDC ceiling-mount occupancy sensor with SPDT isolated contact

OPERATION

Powered by 24 VAC/VDC, the Model CI-24 uses advanced PIR technology to detect occupancy. Detection occurs when the unit senses the difference between infrared emissions from a human body and the background space. When occupancy is detected, the **Model CI-24** transfers an SPDT contact set. The contacts return to their normal state after a user-selectable time delay once the space is unoccupied.

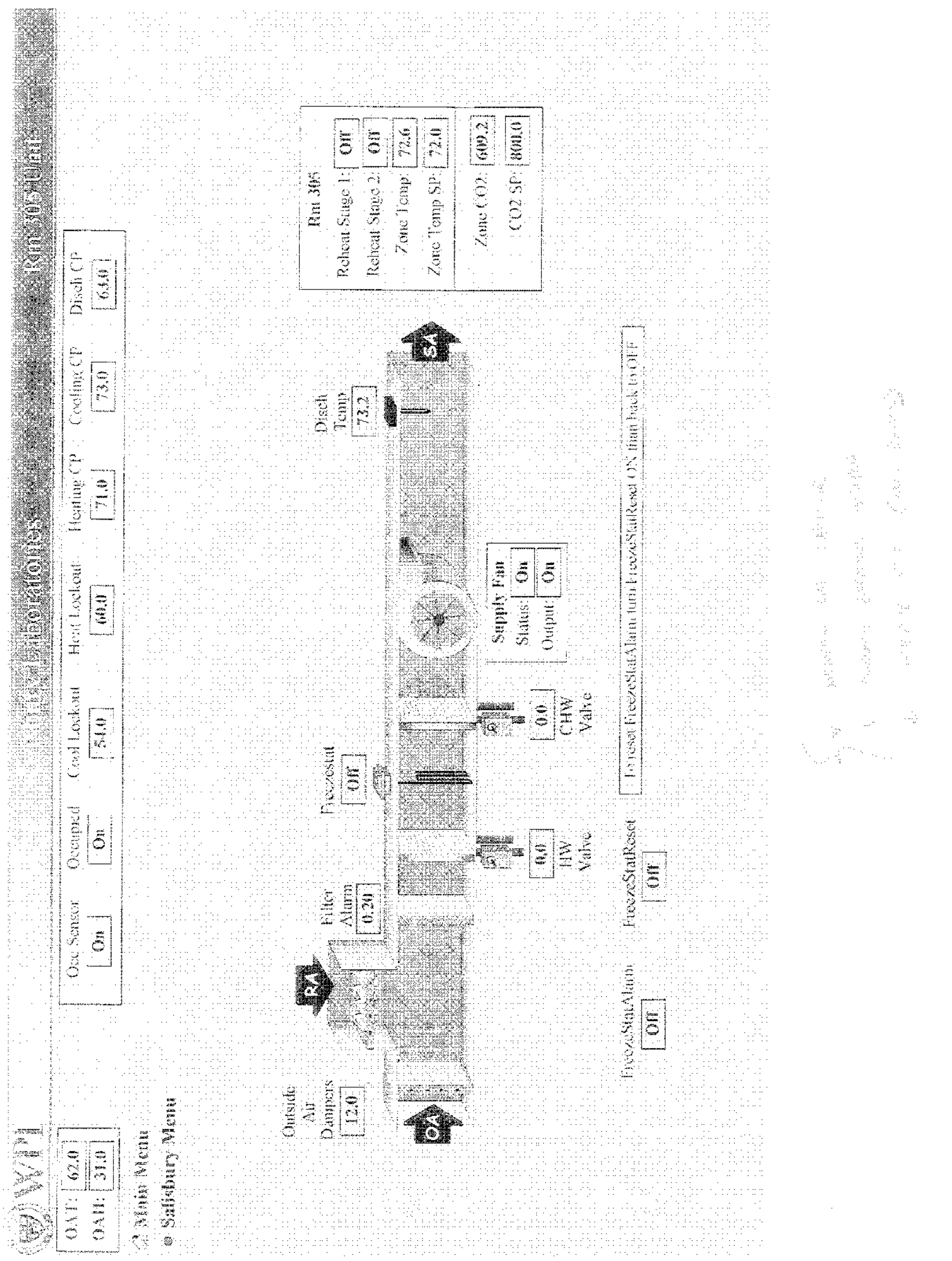
WIRING



DIP Switch Control for Time Delay, Sensitivity and Override

DIP SWITCH	1	2	3	4
TIME DELAYS				
30 sec.	X	X		
10 min.	X	O		
20 min.	O	X		
30 min.	O	O		
SENSITIVITY				
Minimum			O	
Maximum			X	
OVERRIDE				
Normal				O
Override				X

X=on O=off


WPI
Rm 305 Unit
OAT: 62.0
OAH: 31.0
Main Menu
Salisbury Menu
Occ Sensor On
Occupied On
Cool Lockout 54.0
Heat Lockout 60.0
Heating CP 71.0
Cooling CP 73.0
Disch CP 64.0
Rm 305
Reheat Stage 1: Off
Reheat Stage 2: Off
Zone Temp: 72.6
Zone Temp SP: 72.0
Zone CO2: 609.2
CO2 SP: 800.0
Outside Air Dampers 12.0
OA
RA
SA
Filter Alarm 0.20
Freezestat Off
HW Valve 0.0
CHW Valve 0.0
Supply Fan
Status: On
Output: On
Disch Temp 73.2
FreezeStatAlarm Off
FreezeStatReset Off
To reset FreezeStatAlarm turn FreezeStatReset ON then back to OFF

	Name	Value	Units	State
1	CoolingCP	73.0	Deg F	Enabled
2	CoolLockout	54.0	Deg F	Enabled
3	DirtyFilterAlarm	Off	On/Off	Enabled
4	DischCP	63.4	Deg F	Enabled
5	EconomizerSP	58.0	Deg F	Enabled
6	FanHoursSaved	185.57	Hrs	Enabled
7	FanRunHours	152.02	Hrs.	Enabled
8	FreezeStatAlarm	Off	On/Off	Enabled
9	FreezeStatReset	Off	On/Off	Enabled
10	HeatingCP	71.0	Deg F	Enabled
11	HeatLockout	60.0	Deg F	Enabled
12	HWAvailable	On	On/Off	Enabled
13	MinDamperSP	12.0	% OA	Enabled
14	Oat	53.3	Deg F	Enabled
15	OatOffset	66.2	Deg F	Enabled
16	ZoneCo2SP	800.0	ppm	Enabled
17	ZoneOccHours	337.59	Hrs	Enabled
18	ZoneOccupied	On	On/Off	Enabled
19	ZoneOptStart	Off		Enabled
20	ZoneTempSp	72.0	Deg F	Enabled

Date/Time	FanStatus	ZoneTemp	OccSensor	ZoneOccupied
4/23/2009 4:13:00 PM	Off	72.8	Off	On
4/23/2009 3:43:00 PM	On	72.7	Off	On
4/23/2009 3:13:00 PM	On	72.7	On	On
4/23/2009 2:43:00 PM	On	72.7	On	On
4/23/2009 2:13:00 PM	On	72.8	On	On
4/23/2009 1:43:00 PM	Off	72.9	Off	On
4/23/2009 1:13:00 PM	Off	72.8	Off	On
4/23/2009 12:43:00 PM	Off	72.7	Off	On
4/23/2009 12:13:00 PM	On	72.2	Off	On
4/23/2009 11:43:00 AM	On	72.6	On	On
4/23/2009 11:13:00 AM	On	73.1	On	On
4/23/2009 10:43:00 AM	Off	73.0	Off	On
4/23/2009 10:13:00 AM	Off	72.8	Off	On
4/23/2009 9:43:00 AM	Off	72.6	Off	On
4/23/2009 9:13:00 AM	Off	72.5	Off	On
4/23/2009 8:43:00 AM	Off	72.2	Off	On
4/23/2009 8:13:00 AM	Off	72.0	Off	On
4/23/2009 7:43:00 AM	Off	72.1	Off	On
4/23/2009 7:13:00 AM	Off	72.3	Off	On
4/23/2009 6:43:00 AM	Off	72.7	Off	Off
4/23/2009 6:13:00 AM	Off	73.0	Off	Off
4/23/2009 5:43:00 AM	Off	73.1	Off	Off
4/23/2009 5:13:00 AM	Off	73.2	Off	Off
4/23/2009 4:43:00 AM	Off	73.3	Off	Off
4/23/2009 4:13:00 AM	Off	73.3	Off	Off
4/23/2009 3:43:00 AM	Off	73.3	Off	Off
4/23/2009 3:13:00 AM	Off	73.3	Off	Off
4/23/2009 2:43:00 AM	Off	73.3	Off	Off
4/23/2009 2:13:00 AM	Off	73.2	Off	Off
4/23/2009 1:43:00 AM	Off	73.2	Off	Off
4/23/2009 1:13:00 AM	Off	73.1	Off	Off
4/23/2009 12:43:00 AM	Off	73.0	Off	Off
4/23/2009 12:13:00 AM	Off	72.8	Off	Off
4/22/2009 11:43:00 PM	Off	72.6	On	Off
4/22/2009 11:13:00 PM	Off	72.5	On	Off
4/22/2009 10:43:00 PM	Off	72.6	Off	Off
4/22/2009 10:13:00 PM	On	72.8	On	Off
4/22/2009 9:43:00 PM	On	72.7	On	On
4/22/2009 9:13:00 PM	On	72.4	On	On
4/22/2009 8:43:00 PM	On	72.0	Off	On
4/22/2009 8:13:00 PM	On	71.7	On	On
4/22/2009 7:43:00 PM	On	71.7	On	On
4/22/2009 7:13:00 PM	On	71.8	On	On
4/22/2009 6:43:00 PM	On	72.3	On	On
4/22/2009 6:13:00 PM	On	72.8	On	On
4/22/2009 5:43:00 PM	Off	72.9	Off	On
4/22/2009 5:13:00 PM	-	-	Off	-
4/22/2009 4:43:00 PM	-	-	Off	-
4/22/2009 4:13:00 PM	-	-	Off	-
4/22/2009 3:43:00 PM	-	-	Off	-
4/22/2009 3:13:00 PM	-	-	On	-

AVERAGE ELECTRIC MOTOR SPECS

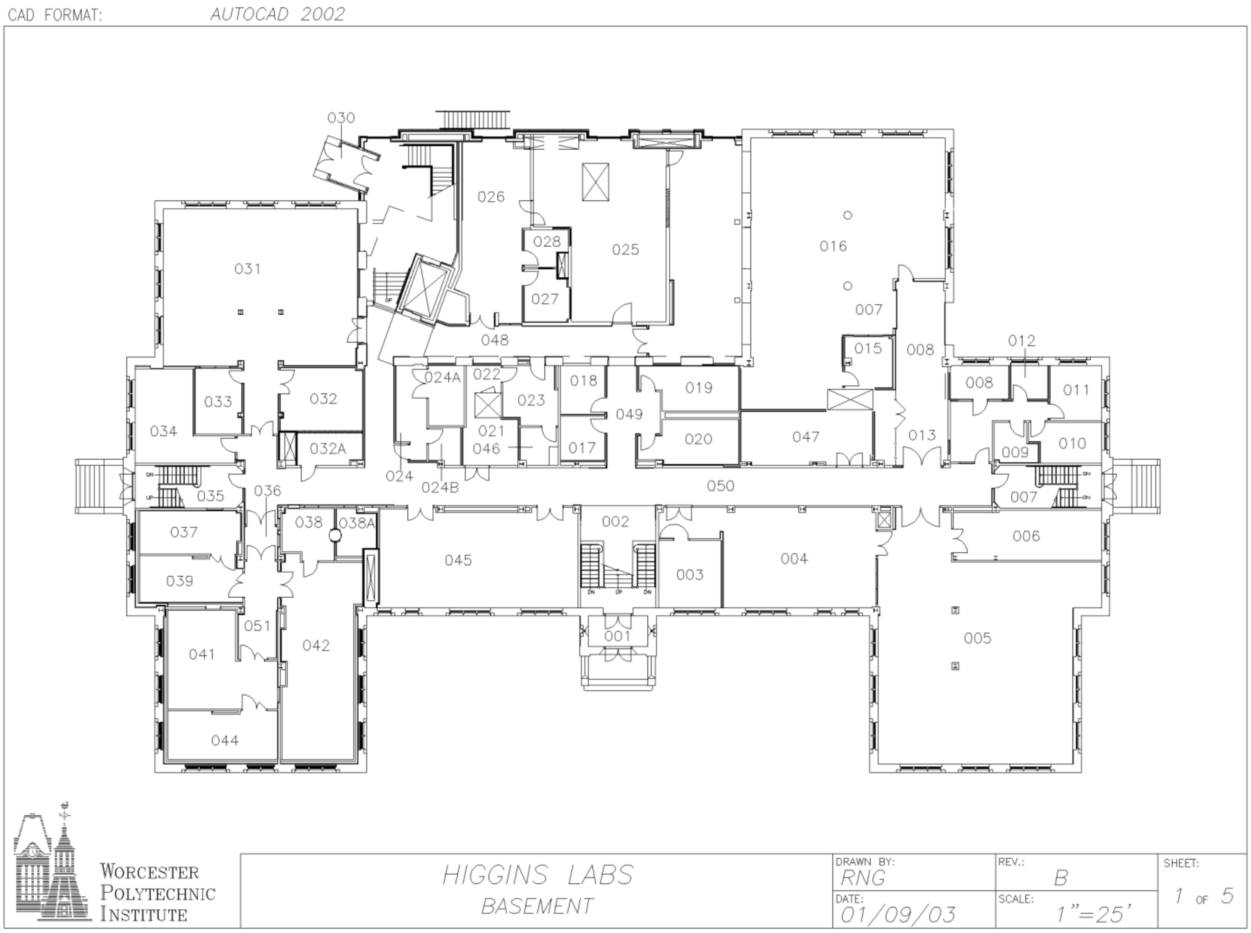
NOTE: Use the following table as a general guide only. These numbers are for normal fan, furnace, appliance, pump, and normal duty applications. The exact specifications for any given motor can vary greatly from those listed below. For 230V motors simply divide the indicated amps by 2.

Specs for 115 volt, 60 Hz, 1 Phase, AC Electric Motors

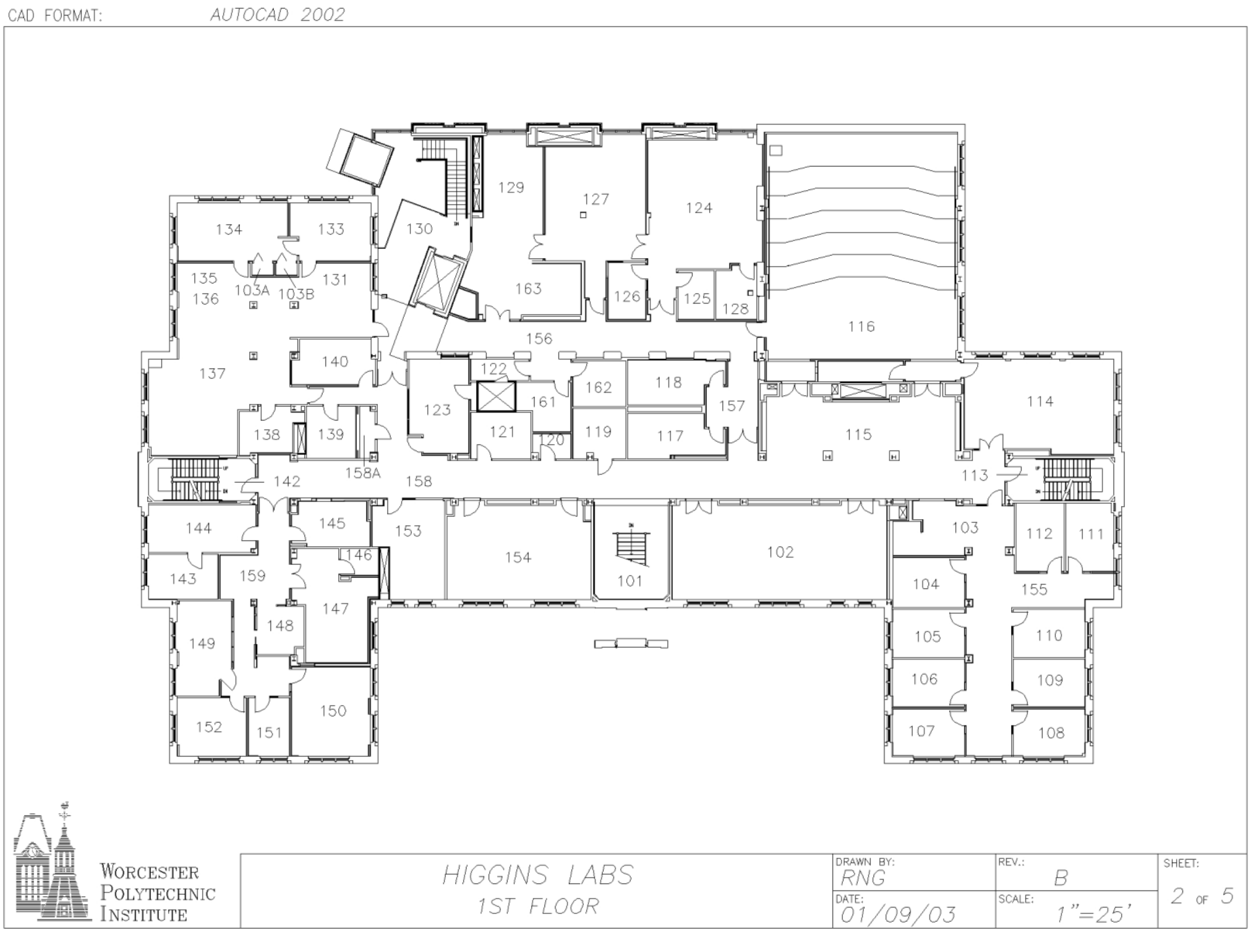
Motor Horsepower	RPM	Full Load Amps
1/20	1550	2.5
1/15	1550	2.6
1/12	1725	2.2–2.8
	1550	4.1
	850	3.2
1/10	1550	3.3
	1050	3.4–4.2
1/8	1725	1.5–2.7
	1140	3.6
	1075	1.8–3.0
1/6	1725	3.3–4.7
	1550	4.0–4.8
	1140	4.0–4.9
	1075	2.4–5.0
1/4	1725	4.4–6.3
	1625	3.1–3.6
	1140	5.6–6.2
	1075	3.4–6.6
	850	6.9
1/3	3450	5.6–6.5
	1725	5.3–6.8
	1140	5.0–7.2
	1075	5.1
1/2	3450	9.8
	1725	7.0–9.2
	1075	7.3
3/4	3450	11.8
	1725	11.6
	1075	9.5
1	3450	13.0–15.0
	1725	13.6–16.0
1–1/2	3450	16.4–19.8
	1725	19.6
2	3450	19–23

The above general specifications are based on motor data from the *1988 Graingers Catalog, Chicago, Illinois.*

Appendix I CAD Drawings



*not to scale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127
124
134
133
130
135
136
103A
103B
131
163
126
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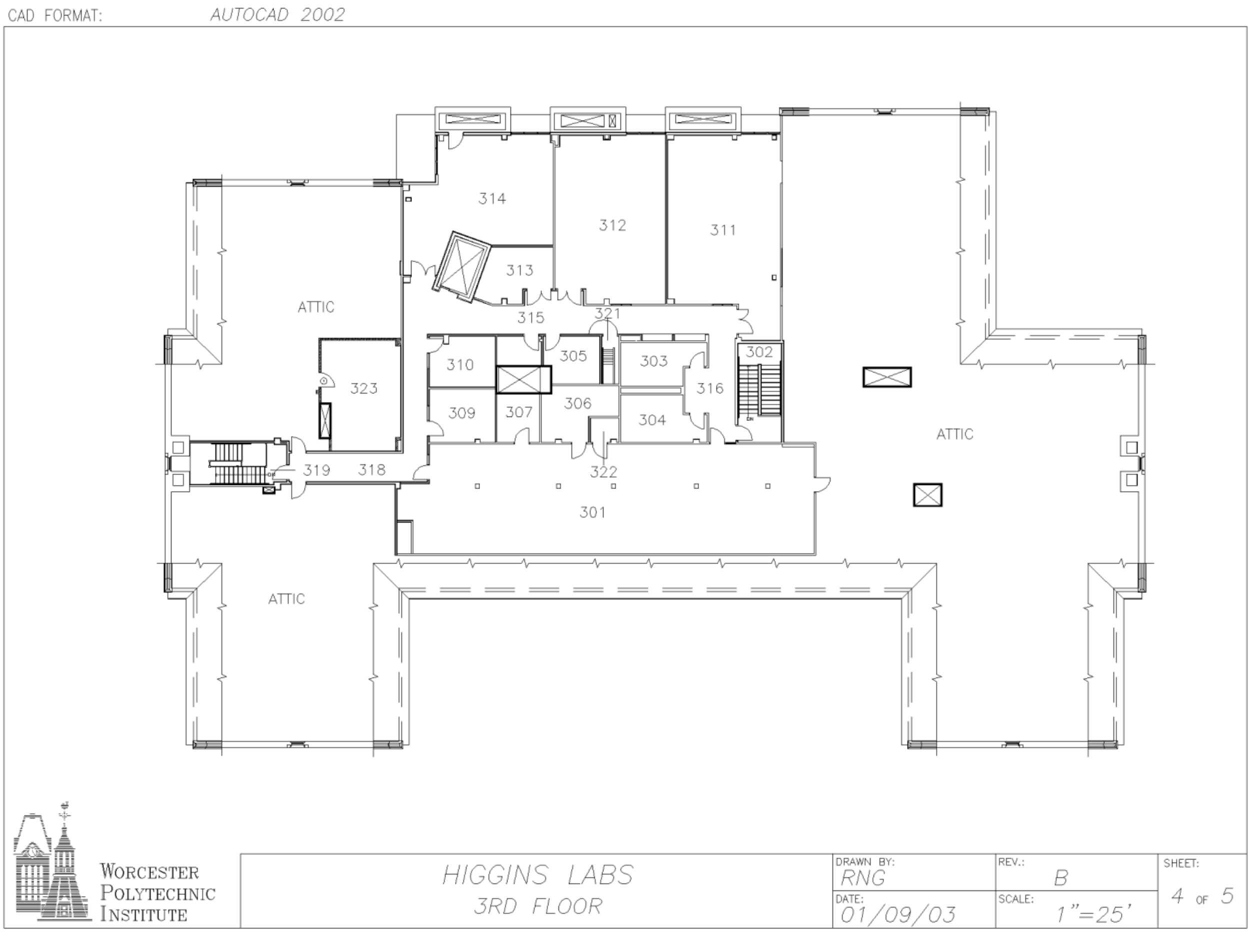
118
114
161
157
123
121
119
117
115
138
139
120
158A
142
158
113
144
145
153
154
102
103
112
111
146
159
143
101
104
155
147
148
149
105
110
106
109
150
152
151
107
108
WORCESTER
POLYTECHNIC
INSTITUTE
HIGGINS LABS
1ST FLOOR
DRAWN BY:
RNG
DATE:
01/09/03
REV.:
B
SCALE:
1"=25'
SHEET:
2 OF 5

*not to scale


CAD FORMAT: AUTOCAD 2002
232
230
235
231
254
221
218
218A
228
224
236
234A
229
225
255
216
226
227
223
222
219
217
238
253
215
249
203
214
213
212
239
251
248
201
202
240
250
204
241
242
247
206
211
243
246
207
210
244
245
208
209
WORCESTER POLYTECHNIC INSTITUTE
HIGGINS LABS
2ND FLOOR
DRAWN BY: RNG
DATE: 01/09/03
REV.: B
SCALE: 1"=25'
SHEET: 3 OF 5

*not to scale


CAD FORMAT:
AUTOCAD 2002
314
312
311
313
315
321
ATTIC
310
305
303
302
323
316
309
307
306
304
ATTIC
319
318
322
301
ATTIC
WORCESTER
POLYTECHNIC
INSTITUTE
HIGGINS LABS
3RD FLOOR
DRAWN BY:
RNG
DATE:
01/09/03
REV.:
B
SCALE:
1"=25'
SHEET:
4 OF 5

*not to scale

Appendix J Schedules

WPI CLASSROOMS

Building	Room #	Seats	Style	AKA	Dept.	MULTI-MEDIA	WHITEBOARDS	AIR-CONDITIONED	CABLE
Atwater Kent					ECE; SSPS				
	AK116	206	T	Newell Hall		w/ DVD			
	AK219	86	FT - MC - TL			w/ DVD			
	AK232	30	TA			w/ DVD			
	AK233	70	FT - MC - TL			w/ DVD			
Fuller Labs					CS				
	FL222	27	FT - MC	IMGD Computer Lab					
	FL311	38	FT - MC						
	FL320	65	TA						
	FLAUD	386	T	Perreault Hall		w/DVD			
Gateway Park									
	GP1002	90	T		BB; BME only	w/ DVD			
Goddard Hall					CHE; CH				
	GH227	80	FT - MC - TL			w/ DVD			
Higgins labs					ME; FPE				
	HL114	35	TA						
	HL116	90	FT - MC - TL			w/ DVD			
	HL154	35	TA			w/DVD			
	HL202	35	TA			w/DVD			
	HL218	90	FT - MC - TL	Discovery Classroom		w/ DVD			
	HL230(Lab)	40	FT - MC	Geometric Modeling Lab		w/DVD			
Kaven Hall					CEE				
	KH115	26	FT - MC						
	KH116	70	FT - MC - TL			Key-card			
	KH202(Lab)	25	FT - MC	"CAR Lab"		Key-card			
	KH204	25	MT - MC						
	KH207(Lab)	30	FT - MC	"STAT Lab"		Key-card			
Olin Hall					PH				
	OH107	202	T			w/DVD			
	OH126	35	TA						
	OH218	35	TA						
	OH223	42	TA			w/DVD			
Stratton Hall					MA				
	SH106	40	TA			w/ DVD			
	SH202	45	TA						
	SH203	30	FT - MC			Key-card			
	SH304	35	TA						
	SH306(Lab)	40	FT - MC	MA-only Computer Lab					
	SH308	54	TA						
	SH309	48	TA						
Salisbury Labs					BB; BME; HUA				
	SL011	25	MT - MC						
	SL104	76	FT - MC - TL			w/ DVD			
	SL105	54	FT - MC - TL			w/ DVD			
	SL115	220	T	Kinnicutt Hall		w/ DVD			
	SL123(Lab)	27	FT - MC	CS / Open Computer Lab		w/DVD			
	SL305	60	FT; MC			w/ DVD			
	SL405	60	FT; MC			w/ DVD			
	SL406	48	FT - MC			w/ DVD			
	SL407	35	TA						
	SL412 (Lab)	12	FT - MC	BME Computer lab					
Washburn Shops					MFE; MTE; MG				
	WB226 (Lab)	14	FT - MC	"Flower Lab"					
	WB228 (Lab)	24	FT - MC	MG-only Computer Lab		need laptop			
	WB229	85	FT - MC - TL			Key-card			
	WB323	36	TA						

Seating Style code = TA : Tablet Armchairs; MC : Movable Chairs; FT : Fixed Tables; MT : Movable Tables; TL : Tiered Levels; T : Theater

36 Classrooms; 8 computer labs (Lab)

WPI Building/Room Utilization Report
200902 Fall Of Term E (Mar 16 2009 to May 25 2009)

Room: SL 114 Capacity: 35 Desc: HL114 - Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun\TBA	Attributes and Comments
08:00	08:50	A5442 EVNT A5784 CONF A5886 SEM A6834 PRES				.<>		.<> .<> .<>	.<>	10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 23-APR-09 : Proj. Pres. Day (ME) - 2009
09:00	09:50	A5442 EVNT A5784 CONF A5886 SEM A6834 PRES SP 3522 L	.9	.9		.<> .9	.9	.<> .<> .<>	.<>	10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 23-APR-09 : Proj. Pres. Day (ME) - 2009
10:00	10:50	A5442 EVNT A5784 CONF A5886 SEM A6825 OPEN A6834 PRES SP 1528 L	.25	.25	.<>	.<> .25	.25	.<> .<> .<>	.<>	10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 15-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009
11:00	11:50	A5442 EVNT A5784 CONF A5886 SEM A6825 OPEN A6834 PRES IS 3322 L	.36		.<>	.<> .36		.<> .<> .<>	.<>	10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 15-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009
12:00	12:50	A5442 EVNT A5784 CONF A5886 SEM A6825 OPEN A6834 PRES PT 3331 L	.9		.<>	.<> .9		.<> .<> .<>	.<>	10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 15-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009
1:00	1:50	A5442 EVNT A5784 CONF A5886 SEM A6834 PRES PT 3331 L SE 1906 L	.9		.24	.<> .9	.24	.<> .<> .<>	.<>	10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 23-APR-09 : Proj. Pres. Day (ME) - 2009
2:00	2:50	A5442 EVNT A5784 CONF A5886 SEM A6834 PRES MS 4840 L	.12	.12		.<> .12	.12	.<> .<> .<>	.<>	10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 23-APR-09 : Proj. Pres. Day (ME) - 2009
3:00	3:50	A5442 EVNT A5784 CONF A6814 MEET A6834 PRES A6864 MEET	.<> .<>			.<>		.<> .<>	.<>	10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 27-APR-09 : Dissertation Defense 23-APR-09 : Proj. Pres. Day (ME) - 2009 08-APR-09 : CS2102 Help Session
4:00	4:50	A5442 EVNT A5784 CONF A6814 MEET A6834 PRES ME 623 L	.<>	.17		.<> .17		.<> .<>	.<>	10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 27-APR-09 : Dissertation Defense 23-APR-09 : Proj. Pres. Day (ME) 2009
5:00	5:50	A5442 EVNT A6413 MEET A6890 MEET A6977 MEET ME 623 L	.<> .<>	.<> .17	.<>	.17	.<>	.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009 30-JAN-09 : 05-MAY-09 : MEPS Lab Group 23-APR-09 : 27-APR-09 : US Missile Defense Agency Info 13-APR-09 : 15-APR-09 : CDC
6:00	6:50	A5442 EVNT A6413 MEET A6826 MEET A6977 MEET	.<> .<>	.<>			.<>	.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009 30-JAN-09 : 05-MAY-09 : MEPS Lab Group 06-APR-09 : Cape Town Orientation 23-APR-09 : 27-APR-09 : US Missile Defense Agency Info
7:00										

03-Apr-09 15:28:58 (C 32) Pa 2

WPT Building/Room Utilization Report *
200902 Part Of Term D (Mar 15 2009 to May 25 2009)

Room: HL 114 Capacity: 35 Desc: HL114 - Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun\TBA	Attributes and Comments
7:00	7:50	A5442 EVNT					<>	<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A6731 MEET				<>				19-MAR-09 : 30-APR-09 : Exchange Students Mtg
		A6802 MEET	<>							06-APR-09 : Cape Town Orientation
		A6890 MEET	<>							23-APR-09 : 27-APR-09 : US Missile Defense Agency Info
8:00	8:50	A5442 EVNT					<>	<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A6731 MEET				<>				19-MAR-09 : 30-APR-09 : Exchange Students Mtg
		A6802 MEET	<>							06-APR-09 : Cape Town Orientation
9:00	9:50	A5442 EVNT					<>			10-APR-09 : 11-APR-09 : Destination Imagination 2009
10:00	10:50	A5442 EVNT					<>			10-APR-09 : 11-APR-09 : Destination Imagination 2009
11:00	11:50	A5442 EVNT					<>			10-APR-09 : 11-APR-09 : Destination Imagination 2009 Open Laboratory Include in IR data feed

WPI Building/Room Utilization Report *
200902 Part Of Term D (Mar 16 2009 To May 25 2009)

Room: HL 116 Capacity: 95 Desc: HL116 - Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun\TBA	Attributes and Comments
08:00	08:50	A5389 EVNT				.<>	.<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5442 EVNT						.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A5784 CONF						.<>	.<>	25-APR-09 : 26-APR-09 : AMS Sectional Meeting
		A5864 EXAM	.<>	.<>	.<>	.<>	.<>			06-MAY-09 : 14-MAY-09 : North HS AP Testing
		A5886 SEM						.<>		04-APR-09 : Women In Science
		A6834 PRES				.<>				23-APR-09 : Proj. Pres. Day (ME) - 2009
09:00	09:50	A5389 EVNT				.<>	.<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5409 PRES						.<>		06-SEP-08 : 09-MAY-09 : Admissions Saturdays 2008-09
		A5442 EVNT						.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A5784 CONF						.<>	.<>	25-APR-09 : 26-APR-09 : AMS Sectional Meeting
		A5864 EXAM	.<>	.<>	.<>	.<>	.<>			06-MAY-09 : 14-MAY-09 : North HS AP Testing
		A5886 SEM						.<>		04-APR-09 : Women In Science
		A6834 PRES				.<>				23-APR-09 : Proj. Pres. Day (ME) - 2009
		ES 2502 C			.68					
		ES 3001 L	.92	.92		.92	.92			
10:00	10:50	A5389 EVNT				.<>	.<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5409 PRES						.<>		06-SEP-08 : 09-MAY-09 : Admissions Saturdays 2008-09
		A5442 EVNT						.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A5784 CONF						.<>	.<>	25-APR-09 : 26-APR-09 : AMS Sectional Meeting
		A5864 EXAM	.<>	.<>	.<>	.<>	.<>			06-MAY-09 : 14-MAY-09 : North HS AP Testing
		A5886 SEM						.<>		04-APR-09 : Women In Science
		A6834 PRES				.<>				23-APR-09 : Proj. Pres. Day (ME) - 2009
		ES 2502 C			.68					
		ES 2502 L	.68	.68		.68	.68			
11:00	11:50	A5389 EVNT				.<>	.<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5409 PRES						.<>		06-SEP-08 : 09-MAY-09 : Admissions Saturdays 2008-09
		A5442 EVNT						.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A5784 CONF						.<>	.<>	25-APR-09 : 26-APR-09 : AMS Sectional Meeting
		A5864 EXAM	.<>	.<>	.<>	.<>	.<>			06-MAY-09 : 14-MAY-09 : North HS AP Testing
		A5886 SEM						.<>		04-APR-09 : Women In Science
		A6834 PRES				.<>				23-APR-09 : Proj. Pres. Day (ME) - 2009
		BME 4606 L	.35	.35		.35	.35			
		ES 3003 C			.43					
		ME 4606 L	.16	.16		.16	.16			
12:00	12:50	A5389 EVNT				.<>	.<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5409 PRES						.<>		06-SEP-08 : 09-MAY-09 : Admissions Saturdays 2008-09
		A5442 EVNT						.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A5784 CONF						.<>	.<>	25-APR-09 : 26-APR-09 : AMS Sectional Meeting
		A5864 EXAM	.<>	.<>	.<>	.<>	.<>			06-MAY-09 : 14-MAY-09 : North HS AP Testing
		A5886 SEM						.<>		04-APR-09 : Women In Science
		A6686 PRES					.<>			17-MAR-09 : 24-APR-09 : ChE Faculty Candidate
		A6825 OPEN			.<>					15-APR-09 : 22-APR-09 : Closer Look 2009
		A6834 PRES				.<>				23-APR-09 : Proj. Pres. Day (ME) - 2009
1:00	1:50	A5389 EVNT				.<>	.<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5409 PRES						.<>		06-SEP-08 : 09-MAY-09 : Admissions Saturdays 2008-09
		A5442 EVNT						.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A5784 CONF						.<>	.<>	25-APR-09 : 26-APR-09 : AMS Sectional Meeting
		A5864 EXAM	.<>			.<>				06-MAY-09 : 14-MAY-09 : North HS AP Testing
		A5886 SEM						.<>		04-APR-09 : Women In Science
		A6721 CLAS			.<>					18-MAR-09 : 29-APR-09 : ES 3001 Review
		A6834 PRES				.<>				23-APR-09 : Proj. Pres. Day (ME) - 2009
		MA 2612 L	.57	.57		.57	.57			
2:00	2:50	A5389 EVNT				.<>	.<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5409 PRES						.<>		06-SEP-08 : 09-MAY-09 : Admissions Saturdays 2008-09
		A5442 EVNT						.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A5784 CONF						.<>	.<>	25-APR-09 : 26-APR-09 : AMS Sectional Meeting
		A5864 EXAM	.<>			.<>				06-MAY-09 : 14-MAY-09 : North HS AP Testing
		A5886 SEM						.<>		04-APR-09 : Women In Science
		A6826 MEET	.<>							10-APR-09 : 01-MAY-09 : Admissions Overflow
		A6834 PRES				.<>				23-APR-09 : Proj. Pres. Day (ME) - 2009
		AS 1004 L			.12					
		ECON 1120 L		.86			.86			
3:00	3:50	A5389 EVNT				.<>	.<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5442 EVNT						.<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A5784 CONF						.<>	.<>	25-APR-09 : 26-APR-09 : AMS Sectional Meeting

WPI Building/Room Utilization Report *
200902 Part Of Term D (Mar 16 2009 to May 25 2009)

Room: HL 116 Capacity: 95 Desc: HL116 - Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun\TBA	Attributes and Comments
3:00	3:50	A5864 EXAM A6834 PRES AS 1004 X AS 2004 X AS 3004 X AS 4104 X ECON 1120 L	.<>	.86	.12 .11 .3 .4	.<> .<>	.86			06-MAY-09 : 14-MAY-09 : North HS AP Testing 23-APR-09 : Proj. Pres. Day (ME) - 2009
4:00	4:50	A5389 EVNT A5442 EVNT A5784 CONF A5864 EXAM A6798 MEET A6805 PRES A6834 PRES AS 1004 X AS 2004 X AS 3004 X AS 4104 X	.<>		.12 .11 .3 .4	.<> .<> .<> .<>	.<> .<>	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 06-MAY-09 : 14-MAY-09 : North HS AP Testing 17-APR-09 : Alpha Xi Delta 09-APR-09 : Shane Chalke Talk 23-APR-09 : Proj. Pres. Day (ME) - 2009
5:00	5:50	A5389 EVNT A5442 EVNT A6319 MEET A6703 MEET A6798 MEET A6805 PRES A6900 MEET AS 1004 X AS 2004 X AS 3004 X AS 4104 X	.<>	.<> .<>	.12 .11 .3 .4	.<> .<>	.<> .<> .<>	.<> .<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 19-JAN-09 : 04-MAY-09 : FIRST Team Meeting 21-APR-09 : Class of 2011 Board 17-APR-09 : Alpha Xi Delta 09-APR-09 : Shane Chalke Talk 07-APR-09 : ES2502 Help Session
6:00	6:50	A5389 EVNT A5412 MEET A5442 EVNT BUS 515 L ME 612 L MFE 540 L	.23	.21	.23	.<> .17	.<> .<>	.<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 31-AUG-08 : 03-MAY-09 : Alpha Gamma Delta 10-APR-09 : 11-APR-09 : Destination Imagination 2009
7:00	7:50	A5389 EVNT A5412 MEET A5442 EVNT BUS 515 L ME 612 L MFE 540 L	.23	.21	.23	.<> .17	.<> .<>	.<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 31-AUG-08 : 03-MAY-09 : Alpha Gamma Delta 10-APR-09 : 11-APR-09 : Destination Imagination 2009
8:00	8:50	A5389 EVNT A5412 MEET A5442 EVNT A6120 MEET MFE 540 L		.<>		.<> .17	.<> .<>	.<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 31-AUG-08 : 03-MAY-09 : Alpha Gamma Delta 10-APR-09 : 11-APR-09 : Destination Imagination 2009 18-NOV-08 : 28-APR-09 : Relay For Life
9:00	9:50	A5389 EVNT A5412 MEET A5442 EVNT MFE 540 L				.<> .17	.<> .<>	.<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 31-AUG-08 : 03-MAY-09 : Alpha Gamma Delta 10-APR-09 : 11-APR-09 : Destination Imagination 2009
10:00	10:50	A5389 EVNT A5442 EVNT				.<>	.<> .<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009
11:00	11:50	A5389 EVNT A5442 EVNT				.<>	.<> .<>	.<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 Incline - Slight Projection Booth Screen include in IMC data feed

Building/Room Utilization Report *
200903 Part Of Term D (Mar 16 2009 to May 25 2009)

Room: HL 154 Capacity: 35 Desc: HL154 - Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun\TBA	Activities and Comments
08:00	08:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6834 PRES				<> <>	<>	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 23-APR-09 : Proj. Pres. Day (ME) - 2009
09:00	09:50	A5389 EVNT A5442 EVNT A5794 CONF A5886 SEM A6834 PRES SF 1524 L	.27	.27		<> <> .27	<> .27	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 23-APR-09 : Proj. Pres. Day (ME) - 2009
10:00	10:50	A5389 EVNT A5442 EVNT A5794 CONF A5886 SEM A6834 PRES ME 3506 L	.21	.21	.21	<> <> .21	<> .21	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 23-APR-09 : Proj. Pres. Day (ME) - 2009
11:00	11:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6825 OPEN A6834 PRES SP 3522 L	.10	.10	<>	<> <> .10	<> .10	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 15-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009
12:00	12:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6825 OPEN A6834 PRES A6887 MEET			<>	<> <>	<>	<> <> <> <>	<> <>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 15-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009 19-APR-09 : 26-APR-09 : Panhellenic Council
1:00	1:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6745 MEET A6825 OPEN A6834 PRES A6887 MEET HI 3314 L	.25		<>	<> <> .20	<> <>	<> <> <> <>	<> <>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 20-MAR-09 : 31-MAY-09 : China MOP Meetings 15-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009 19-APR-09 : 26-APR-09 : Panhellenic Council
2:00	2:50	A5389 EVNT A5423 EVNT A5781 CONF A5886 SEM A6745 MEET A6834 PRES HI 3314 L	.20			<> <> .20	<> <>	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 20-MAR-09 : 31-MAY-09 : China MOP Meetings 23-APR-09 : Proj. Pres. Day (ME) - 2009
3:00	3:50	A5389 EVNT A5442 EVNT A5784 CONF A6834 PRES IDED 1002 L	.25	.25		<> <> .25	<> .25	<> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 23-APR-09 : Proj. Pres. Day (ME) - 2009
4:00	4:50	A5389 EVNT A5442 EVNT A5784 CONF A6834 PRES IDED 1002 L	.25	.25		<> <> .25	<> .25	<> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 23-APR-09 : Proj. Pres. Day (ME) - 2009
5:00	5:50	A5389 EVNT A5442 EVNT A6890 MEET AS 2004 L		.11		<> <>	<> <>	<> <>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 23-APR-09 : 27-APR-09 : US Missile Defense Agency Info

03-Apr 09 15:31:55 (U_3?) Pg 2

RPI Building/Room Utilization Report *
200902 Part Of Term D (Mar 16 2009 to May 25 2009)

Room: HL 154 Capacity: 35 Desc: HL154 Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun/TBA	Attributes and Comments
5:00	5:50	ME 554 L	13		13					
6:00	6:50	A5399 EVNT A5442 EVNT A6890 MEET ME 554 L	13		13	<> <>	<> <>	<> <>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 23-APR-09 : 27-APR-09 : US Missile Defense Agency Info
7:00	7:50	A5389 EVNT A5442 EVNT A6573 MEET A6890 MEET			<>	<> <>	<> <>	<> <>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 15-APR-09 : Masque meeting 23-APR-09 : 27-APR-09 : US Missile Defense Agency Info
8:00	8:50	A5389 EVNT A5442 EVNT A6573 MEET A6870 MEET A6887 MEET			<>	<> <>	<> <>	<> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 15-APR-09 : Masque meeting 02-APR-09 : Phi Sigma Sigma 19-APR-09 : 26-APR-09 : Panhellenic Council
9:00	9:50	A5310 MEET A5389 EVNT A5442 EVNT A6573 MEET A6870 MEET A6887 MEET			<>	<> <> <>	<> <>	<>	<>	24-APR-08 : 23-APR-09 : SWE<> 14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 15-APR-09 : Masque meeting 09-APR-09 : Phi Sigma Sigma 19-APR-09 : 26-APR-09 : Panhellenic Council
10:00	10:50	A5389 EVNT A5442 EVNT				<>	<> <>	<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009
11:00	11:50	A5389 EVNT A5442 EVNT				<>	<> <>	<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 include in EMS data feed

OPT Building/Room Utilization Report *
200902 Part Of Term D (Mar 16 2009 to May 24 2009)

Room: FL 202 Capacity: 35 Descr: FL202 - Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun/TBA	Attributes and Comments
08:00	08:50	A5389 EVNT A5442 EVNT A5784 CONF A6834 PRES				.<> .<>	.<>	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 23-APR-09 : Proj. Pres. Day (ME) - 2009
09:00	09:50	A5389 EVNT A5442 EVNT A5784 CONF A6834 PRES MA 1034 L	.40	.40		.<> .46	.<> .40	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 23-APR-09 : Proj. Pres. Day (ME) - 2009
10:00	10:50	A5389 EVNT A5442 EVNT A5784 CONF A6834 PRES MTE 575 C MTE 575 L SP 3522 L	.16 .13	.16 .13	.16	.<> .<> .16 .13	.<> .16 .13	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 23-APR-09 : Proj. Pres. Day (ME) - 2009
11:00	11:50	A5389 EVNT A5442 EVNT A5784 CONF A6825 OPEN A6834 PRES			.<>	.<> .<>	.<>	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 15-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009
12:00	12:50	A5389 EVNT A5442 EVNT A5784 CONF A6748 MEET A6825 OPEN A6834 PRES	.<>	.<>	.<>	.<> .<> .<>	.<>	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 19-MAR-09 : 05-MAY-09 : CH4170 Conferences 15-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009
1:00	1:50	A5389 EVNT A5442 EVNT A5784 CONF A6748 MEET A6825 OPEN A6834 PRES	.<>	.<>	.<>	.<> .<> .<>	.<>	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 19-MAR-09 : 05-MAY-09 : CH4170 Conferences 15-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009
2:00	2:50	A5389 EVNT A5442 EVNT A5605 SEM. A5784 CONF A6834 PRES				.<> .<>	.<> .<>	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 05-SEP-08 : 01-MAY-09 : AE Meeting 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 23-APR-09 : Proj. Pres. Day (MA) - 2009
3:00	3:50	A5389 EVNT A5442 EVNT A5784 CONF A6804 MEET A6834 PRES	.<>			.<> .<>	.<>	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 23-MAR-09 : 04-MAY-09 : Demetriou's Research Group 23-APR-09 : Proj. Pres. Day (ME) - 2009
4:00	4:50	A5389 EVNT A5442 EVNT A5784 CONF A6729 MEET A6834 PRES	.<>	.<>		.<> .<>	.<>	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 10-MAR-09 : 05-MAY-09 : Gamma Conversation 23-APR-09 : Proj. Pres. Day (ME) - 2009
5:00	5:50	A5389 EVNT A5442 EVNT A6894 MEET A6897 MEET FP 3070 L	.22	.<>	.<>	.<> .22	.<> .<>	.<> .<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 22-APR-09 : SGA 13-APR-09 : 15-APR-09 : CDI
6:00	6:50	A5389 EVNT A5442 EVNT A6894 MEET FP 3070 L	.22		.<>	.<> .22	.<> .<>	.<> .<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 22-APR-09 : SGA
7:00										

[illegible] Building/Room Utilization Report

200902 Part Of Term D (Mar 16 2009 to May 25 2009)

03-Apr-09 15:32:07 (PL_3F) Pg 2

Room: [illegible] 202 Capacity: 25 Desc: [illegible] - Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun\TBA	Attributes and Comments
7:00	7:50	A5389 EVNT				<>	<>	<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5442 EVNT					<>	<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
8:00	8:50	A5389 EVNT				<>	<>	<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5442 EVNT					<>	<>		10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A6834 MESP	<>			<>				30-MAR-09 : 30-APR-09 : CS Project Group (Police)
9:00	9:50	A5389 EVNT				<>	<>	<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5442 EVNT					<>			10-APR-09 : 11-APR-09 : Destination Imagination 2009
		A6854 MESP	<>			<>				30-MAR-09 : 30-APR-09 : CS Project Group (Police)
10:00	10:50	A5389 EVNT				<>	<>	<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5442 EVNT					<>			10-APR-09 : 11-APR-09 : Destination Imagination 2009
11:00	11:50	A5389 EVNT				<>	<>	<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009
		A5442 EVNT					<>			10-APR-09 : 11-APR-09 : Destination Imagination 2009
										Office
										include in TMC data feed

03-Apr-09 15:32:16 (U_3F) Uy

SET Building/Room Utilization Report *
200902 Part Of Term B (Mar 16 2009 to May 25 2009)

Room: HL 218 Capacity: 90 Feat: H218 - Discovery Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun/TBA	Attributes and Comments
08:00	08:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6600 CONF A6834 PRES ES 3004 C ES 3004 L	.85	<> .85	.85	<> <> .85	<> .85	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 12-MAY-09 : NEMA Conference 23-APR-09 : Proj. Pres. Day (ME) - 2009
09:00	09:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6600 CONF A6737 MEET A6834 PRES CS 4[illegible] MA 2201 C	.22 .66	<> .22 .66	<>	<> <> .22 .66	<> .22 .66	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 12-MAY-09 : NEMA Conference 18-MAR-09 : 01-MAY-09 : ES3001 Help Session 23-APR-09 : Proj. Pres. Day (ME) - 2009
10:00	10:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6600 CONF A6834 PRES ES 2001 C	.90	<> .90	.90	<> <> .90	<> .90	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 12-MAY-09 : NEMA Conference 23-APR-09 : Proj. Pres. Day (ME) - 2009
11:00	11:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6600 CONF A6834 PRES A6886 MEET ES 3003 C ME 4718 L	.43	<> .43	.95	<> <> .43	<> .43	<> <> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 12-MAY-09 : NEMA Conference 23-APR-09 : Proj. Pres. Day (ME) - 2009 18-APR-09 : AIAA Presentation
12:00	12:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6600 CONF A6834 PRES A6886 MEET ES 1310 L ME 591 L		<> .61	.56	<> <>	<> .61	<> <> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 12-MAY-09 : NEMA Conference 23-APR-09 : Proj. Pres. Day (ME) - 2009 18-APR-09 : AIAA Presentation
1:00	1:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6600 CONF A6325 OPEN A6834 PRES CS 4732 L		<> .22	<>	<> <>	<> .22	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 12-MAY-09 : NEMA Conference 19-APR-09 : 22-APR-09 : Closer Look 2009 23-APR-09 : Proj. Pres. Day (ME) - 2009
2:00	2:50	A5389 EVNT A5442 EVNT A5784 CONF A5886 SEM A6600 CONF A6834 PRES CS 4732 L		<> .22		<> <>	<> .22	<> <> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 04-APR-09 : Women In Science 12-MAY-09 : NEMA Conference 23-APR-09 : Proj. Pres. Day (ME) - 2009
3:00	3:50	A5389 EVNT A5442 EVNT A5784 CONF A5600 CONF A6834 PRES ECON 1120 L MA 3501 L	.58	<> .86	.58	<> <>	<> .86	<> <> <>	<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 26-APR-09 : AMS Sectional Meeting 12-MAY-09 : NEMA Conference 23-APR-09 : Proj. Pres. Day (ME) - 2009

WPI Building/Room Utilization Report *
200902 Part 02 Term D (Mar 16 2009 to May 25 2009)

Room: HL 213 Capacity: 90 Desc: HL213 - Discovery Classroom

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun/IBA	Attributes and Comments
[illegible]	4:50	A5389 EVNT A5442 EVNT A5784 CONF A6600 CONF A6854 PRES A6948 MEET ECUR 1120 L		.<> .86	.<>	.<> .<>	.<> .86	.<> .<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 25-APR-09 : 25-APR-09 : AMS Sectional Meeting 22-MAY-09 : NRMA Conference 23-APR-09 : Proj. Pres. Day (ME) - 2009 15-APR-09 : Panel Discussion/Vassello
5:00	5:50	A5389 EVNT A5442 EVNT A6648 MEET BME 595 L	.14		.<>	.<>	.<> .<>	.<> .<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 15-APR-09 : Panel Discussion/Vassello
6:00	6:50	A5389 EVNT A5442 EVNT A5456 MEET BME 595 L ME 542 L MFE 510 L	.14	.19 .5		.<> .<>	.<> .<>	.<> .<>		14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 10-APR-09 : 11-APR-09 : Destination Imagination 2009 04-SEP-08 : 30-APR-09 : Alpha Phi Omega
7:00	7:50	A5389 EVNT A5399 MEET A5442 EVNT A5456 MEET A6313 MEET BME 595 L ME 542 L MFE 510 L	.14	.19 .5	.<>	.<> .<>	.<> .<>	.<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 31-AUG-08 : 03-MAY-09 : Alpha Xi Delta 10-APR-09 : 11-APR-09 : Destination Imagination 2009 04-SEP-08 : 30-APR-09 : Alpha Phi Omega 21-JAN-09 : 29-APR-09 : Science Fiction Society
8:00	8:50	A5389 EVNT A5399 MEET A5421 SEM A5442 EVNT A6313 MEET A6447 MEET BME 595 L ME 542 L MFE 510 L	.<> .14	.19 .5	.<>	.<> .<>	.<> .<>	.<> .<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 31-AUG-08 : 03-MAY-09 : Alpha Xi Delta 11-SEP-08 : 09-APR-09 : Student-Athlete Ldership Progr 10-APR-09 : 11-APR-09 : Destination Imagination 2009 21-JAN-09 : 29-APR-09 : Science Fiction Society 30-JAN-09 : 04-MAY-09 : Science Fiction Society
9:00	9:50	A5389 EVNT A5399 MEET A5421 SEM A5442 EVNT A6313 MEET A6447 MEET ME 542 L MFE 510 L	.<>	.19 .5	.<>	.<> .<>	.<> .<> .<>	.<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 31-AUG-08 : 03-MAY-09 : Alpha Xi Delta 11-SEP-08 : 09-APR-09 : Student-Athlete Ldership Progr 10-APR-09 : 11-APR-09 : Destination Imagination 2009 21-JAN-09 : 29-APR-09 : Science Fiction Society 30-JAN-09 : 04-MAY-09 : Science Fiction Society
10:00	10:50	A5389 EVNT A5399 MEET A5421 SEM A5442 EVNT A6447 MEET	.<>			.<> .<>	.<> .<> .<>	.<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 31-AUG-08 : 03-MAY-09 : Alpha Xi Delta 11-SEP-08 : 09-APR-09 : Student Athlete Ldership Progr 10-APR-09 : 11-APR-09 : Destination Imagination 2009 30-JAN-09 : 04-MAY-09 : Science Fiction Society
11:00	11:50	A5389 EVNT A5399 MEET A5442 EVNT A6447 MEET	.<>			.<>	.<> .<> .<>	.<>	.<>	14-MAY-09 : 16-MAY-09 : Graduation Viewing - 2009 31-AUG-08 : 03-MAY-09 : Alpha Xi Delta 10-APR-09 : 11-APR-09 : Destination Imagination 2009 30-JAN-09 : 04-MAY-09 : Science Fiction Society

Include in IPC data feed

WPI Building/Room Utilization Report *
200902 Part Of Term D (Mar 16 2009 to May 05 2009)

03-Apr-09 15:32:30 (Q 3F) Pg

Room: HL 230 Capacity: 60 Desc: HL230 - Geo Modelling Computer Lab

Start	End	Course/Event	Mon	Tue	Wed	Thu	Fri	Sat	Sun/TBA	Attributes and Contents
08:00	08:50	A6808 MEET						.<>		04-APR-09 : Women in Science Conf
09:00	09:50	A5336 SEM A6808 MEET ME 4430 L	.16	.16		.16	.16	.<> .<>		17-JAN-09 : 13-JUN-09 : National Grid 3 04-APR-09 : Women in Science Conf
10:00	10:50	A5336 SEM A6808 MEET ES 1310 X	.28		.28			.<> .<>		17-JAN-09 : 13-JUN-09 : National Grid 3 04-APR-09 : Women in Science Conf
11:00	11:50	A5336 SEM A6808 MEET ES 1310 X	.28		.28			.<> .<>		17-JAN-09 : 13-JUN-09 : National Grid 3 04-APR-09 : Women in Science Conf
12:00	12:50	A5336 SEM ES 1310 X	.33		.33			.<>		17-JAN-09 : 13-JUN-09 : National Grid 3
1:00	1:50	A5336 SEM ES 1313 X	.33		.33			.<>		17-JAN-09 : 13-JUN-09 : National Grid 3
2:00	2:50	A5336 SEM A6360 CLAS		.<>		.<>		.<>		17-JAN-09 : 13-JUN-09 : National Grid 3 26-MAR-09 : 30-APR-09 : CHE 3501 Lab
3:00	3:50	A5336 SEM A6360 CLAS		.<>		.<>		.<>		17-JAN-09 : 13-JUN-09 : National Grid 3 26-MAR-09 : 30-APR-09 : CHE 3501 Lab
4:00										
5:00										
6:00	6:50	A6851 MEET					.<>			03-APR-09 : RA Course Selection
7:00	7:50	A6851 MEET					.<>			03-APR-09 : RA Course Selection
8:00	8:50	A6851 MEET					.<>			03-APR-09 : RA Course Selection
9:00	9:50	A6851 MEET					.<>			03-APR-09 : RA Course Selection
10:00	10:50	A6851 MEET					.<>			03-APR-09 : RA Course Selection
11:00	11:50	A6851 MEET					.<>			03-APR-09 : RA Course Selection

Computer Room
LAB - ME
Include in EMS data feed

April 26, 2009 - May 02, 2009

April 2009

S	M	T	W	T	F	S
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May 2009

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31						

26 Sunday

8:00am 5:30pm Math Dept. AMS Sectional Meeting - Vernescu

27 Monday

10:00am 12:00pm PHD Defense - MPI - Maureen Plunket

3:00pm 5:00pm Prof Tryggvason ERT11XX

28 Tuesday

11:00am 12:00pm ME FACULTY MEETING; HL 102

12:00pm 3:00pm Thesis defensus -Siju Thomas

3:00pm 5:00pm Thesis defense - Maureen

29 Wednesday

9:00am 10:00am Subcommittee on Advancement & Opportunities -C

10:00am 4:00pm Prof Tryggvason - KEEN regional meeting

30 Thursday

3:00pm 5:00pm Prof Tryggvason ERT11XX

5:00pm 7:00pm FPE

1 Friday

10:00am 12:00pm MS Thesis Defense (Dawei Zhang)

12:30pm 1:30pm Glazer Luncheon Higgins House Sunroom

2 Saturday

April 26, 2009 - May 02, 2009

April 2009						
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May 2009						
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24	25	26	27	28	29	30
31						

26 Sunday
- From Apr 25 **Maths Society Meeting (Bill Martin)** 6:00pm

27 Monday

28 Tuesday
- 2:30pm 3:30pm Office Hours (Siju Thomas)
- 4:00pm 5:00pm Prof. Ault

29 Wednesday
- 12:00pm 1:00pm FPE
- 4:30pm 6:00pm Robotics Meetings - Stanford

30 Thursday
- 2:30pm 3:30pm Office Hours (Siju Thomas)

1 Friday
- 11:00am 12:00pm MQP Furlong - Czarnecki canczar@wpi.edu

2 Saturday

Calendar - HL 201 1 4/24/2009 10:30 AM

April 26, 2009 - May 02, 2009

April 2009						
S	M	T	W	T	F	S
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26	27	28	29	30		

May 2009						
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24	25	26	27	28	29	30
31						

26 Sunday	27 Monday

28 Tuesday	29 Wednesday
12:30pm 1:00pm MQP (Prof. Olinger)	

30 Thursday	1 Friday

2 Saturday	

April 2009

April 2009

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May 2009

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31						

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Mar 29 - Apr 4	**Mar 29**	**30**	**31**	**Apr 1** 9:00am Subcommitte	**2** 9:00am Professor Ric 10:30am HUA Dept Se 3:00pm Prof Tryggva	**3** 4:00pm Meet and Gre	**4** 8:00am Woman in Sc
Apr 5 - 11	**5**	**6** 3:00pm Prof Tryggva	**7** 9:00am Thesis Defen 5:00pm ES2502	**8** 9:00am Subcommitte 12:00pm SFPE Meeting 2:00pm NSF Program 4:00pm James Kema	**9** 3:00pm Prof Tryggva 5:00pm Poster Sessio	**10** 11:00am On-line mast	**11**
Apr 12 - 18	**12**	**13** 12:00pm PhD Defense 3:00pm Prof Tryggva	**14** 11:00am ME FACULTY 3:00pm Gretar - Onli 4:00pm Campus Hea	**15** 9:00am Subcommitte 10:00am FPE - Faculty	**16** 3:00pm Prof Tryggva	**17** 10:00am ES3001 Prof.	**18**
Apr 19 - 25	**19**	**20** 3:00pm Prof Tryggva	**21** 11:00am ME FACULTY 7:00pm Meet and Gre	**22** 9:00am Subcommitte 10:00am FPE-Faculty c	**23** 8:00am MQP DAY 3:00pm Prof Tryggva	**24** 8:30am Math Depart	**25** 8:00am Math Dept -
Apr 26 - May 2	**26** 8:00am Math Dept. A	**27** 10:00am PHD Defense 3:00pm Prof Tryggva	**28** 11:00am ME FACULTY 12:00pm Thesis defen 3:00pm Thesis defen	**29** 9:00am Subcommitte 10:00am Prof Tryggva	**30** 3:00pm Prof Tryggva 5:00pm FPE	**May 1**	**2**

Calendar - HL 102 1 4/24/2009 10:33 AM

April 2009

April 2009

S	M	T	W	T	F	S
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May 2009

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24	25	26	27	28	29	30
31						

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Mar 29 - Apr 4	**Mar 29**	**30**	**31**	**Apr 1** 5:30pm Robotics Mee	**2** 2:30pm Office Hours	**3** 11:00am MQP Furlong	**4** 8:00am Woman in Sc
Apr 5 - 11	**5**	**6**	**7** 2:30pm Office Hours 4:00pm Prof. Ault	**8** 4:30pm Robotics Mee	**9** 2:30pm Office Hours	**10** 11:00am MQP Furlong	**11**
Apr 12 - 18	**12**	**13** 2:00pm Prof. Gatsoni	**14** 2:30pm Office Hours 4:00pm Prof. Ault	**15** 4:30pm Robotics Mee	**16** 2:30pm Office Hours	**17** 8:00am ES3001 Prof. 11:00am MQP Furlong	**18**
Apr 19 - 25	**19**	**20**	**21** 10:00am ES3003 Prof. 2:30pm Office Hours 4:00pm Prof. Ault	**22** 11:00am ME4429 mak 4:30pm Robotics Mee	**23** 11:00am AE MQP judg 2:30pm Office Hours	**24** 11:00am MQP Furlong	**25** **Maths Society Meetin**
Apr 26 - May 2	**26** **Maths Society Meetin**	**27**	**28** 2:30pm Office Hours 4:00pm Prof. Ault	**29** 12:00pm FPE 4:30pm Robotics Mee	**30** 2:30pm Office Hours	**May 1**	**2**

Calendar - HL 201 1 4/24/2009 10:37 AM

April 2009

April 2009						
S	M	T	W	T	F	S
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26	27	28	29	30		

May 2009						
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17	18	19	20	21	22	23
24	25	26	27	28	29	30
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	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Mar 29 - Apr 4	**Mar 29**	**30**	**31**	**Apr 1** 10:00am Prof. Demetr 12:00pm IQP team me	**2** 10:00am ES3001 Prof.	**3** 8:00am ES3001 Prof. 3:00pm AIAA meeting	**4** 8:00am Woman in Sc
Apr 5 - 11	**5**	**6** 10:00am ES3003 Prof.	**7** 12:30pm MQP (Prof. C	**8** 10:00am FPF Interview	**9**	**10** 10:00am ES3003 exan	**11**
Apr 12 - 18	**12**	**13**	**14** 12:30pm MQP (Prof. C	**15**	**16**	**17** 10:00am Prof. Demetr 1:00pm ES3001 Exan	**18**
Apr 19 - 25	**19**	**20**	**21** 12:30pm MQP (Prof. C	**22**	**23**	**24**	**25**
Apr 26 - May 2	**26**	**27**	**28** 12:30pm MQP (Prof. C	**29**	**30**	**May 1**	**2**

Calendar HL 229 1 4/24/2009 10:33 AM

Appendix K

Room 250 spreadsheets

Room 250 Case Study Component	On Watts	Standby Watts	Daily Usage (hrs) (Not on Standby hrs)	Daily Electricity Consumption (kW-hrs)(Includes Standby hrs)	Yearly Usage (kW-hrs) (Combined Usage)	Average Yearly Cost ($) (Based on an average of $0.14 per kW-hr)
Fluorescent Lights	160	0	10.00	1.62	416	$ 58.24
Laser Printer	150	35	4.50	0.54	353	$ 49.41
Computer	65	3	9.00	0.58	164	$ 22.93
Computer Monitor	45	3	9.00	0.40	117	$ 16.38
Desk Light	34	1	9.00	0.32	83	$ 11.68
Desk Fan	12	1	4.50	0.07	19	$ 2.68
Paper Shredder	227	1	0.20	0.07	18	$ 2.52
Computer Speakers	4	2	1.00	0.03	13	$ 1.82
Pencil Sharpener	13	1	0.02	0.02	6	$ 0.88
Label Printer	10	1	0.08	0.02	6	$ 0.90

Room 218

Room 218 Case Study Component	Number of Components	On Watts per Component	Standby Watts per Component	Total On Watts per Component	Typical Weekly Usage (hrs) (Not on Standby)	Weekly Electricity Consumption (kW-hrs)(Includes Standby hrs)	Yearly Usage (kW-hrs)	Average Yearly Cost (based on an average cost of $0.14 per kW-hr)
Florescent Light	90	32	0	2880	90	259.20	13478	$ 1,886.98
Incandescent Bulb	21	75	0	1575	90	141.75	7371	$ 1,031.94
Projector	2	367	367	734	168	123.31	6412	$ 897.71
Marker Board Lights	3	75	0	225	90	20.25	1053	$ 147.42
Exit Sign	3	40	0	120	168	20.16	1048	$ 146.76
CCU	1	150	60	150	90	18.18	945	$ 132.35
Clock	1	0.4	0	0.4	168	0.07	3	$ 0.49
Air conditioners	3	N/A						
Security Camera	1	N/A						
Projector Screen	1	N/A						
Heater	0	N/A						
Light Switch	10	N/A						
Windows	3	N/A						

Cloudy Day	Shades Open	Shades Open	Shades Closed	Shades Closed
Room 218 Case Study	**LUX**	**Ft-Candles**	**LUX**	**Ft-Candles**
All Lights On				
Front	715	66	558	52
Middle	680	63	609	57
Rear	795	74	689	64
2/3 Fluorescent Lights On				
Front	368	34	347	32
Middle	378	35	340	32
Rear	484	45	446	41
1/3 Fluorescent Lights On				
Front	290	26	240	22
Middle	241	22	260	24
Rear	267	24	250	23

Room 114

Classroom 114 Component	Number of Components	On Watts per Component	Standby Watts per Component	Total Watts per Component	Typical Weekly Usage (hrs) (Not On Standby)	Weekly Electricity Consumption (kW-hrs)(Includes Standby hrs)	Yearly Usage (kW-hrs)	Average Yearly Cost (based on an average cost of $0.14 per kW-hr)
Florescent Light	36	32	0	1152	65	74.88	3894	$ 545.13
Projector	1	367	367	367	65	61.66	3206	$ 448.86
CCU	1	150	60	150	65	15.93	828	$ 115.97
Marker Board Lights	4	32	0	128	65	8.32	433	$ 60.57
Clock	1	0.4	0	0.4	168	0.07	3	$ 0.49
Incandescent Bulb	0	N/A						
Projector Screen	1	N/A						
Heater	3	N/A						
Light Switch	3	N/A						
Windows	5	N/A						
Air conditioners	1	N/A						

Cloudy Day	Shades Open	Shades Open	Shades Closed	Shades Closed
Room 114 Case Study	**LUX**	**Ft-Candles**	**LUX**	**Ft-Candles**
All Lights On				
Rear	1220	113	557	52
Middle	1145	106	693	64
Front	930	86	605	56
1/2 Fluorescent Lights On				
Rear	1028	96	339	31
Middle	657	61	361	34
Front	610	57	350	33
Only Board Lights On				
Rear	977	91		0
Middle	585	54		0
Front	422	39		0

Room 201

Room 201	Number of	Watts per	Total Watts	Typical Weekly	Weekly Electricity Consumption	Yearly Usage	Average Yearly Cost
Component	**Components**	**Component**	**per Component**	**Usage (hrs)**	**(kW-hrs)**	**(kW-hrs)**	**(based on an average cost of $0.14 per kW-hr)**
Incandescent Bulbs	6	75	450	14	6.30	327.60	$ 45.86
Clock	1	0.4	0.4	168	0.07	3.49	$ 0.49
Florescent Light	0	0	0				
Air conditioners	0	0	0				
Heater	0	0	0				
Windows	1	N/A					
Light Dimmer	2	N/A					

Sunny Day	Shades Open	Shades Open
Room 201 Case Study	**LUX**	**Ft-Candles**
All Lights On	547	51
Board Lights Only	481	45
	Shades Closed	**Shades Closed**
	LUX	**Ft-Candles**
All lights On	78	7.2462
Board Lights Only	27	2.5083

Room 102

Room 102	Number of	Watts per	Total Watts	Typical Weekly	Weekly Electricity Consumption	Yearly Usage	Average Yearly Cost
Component	**Components**	**Component**	**per Component**	**Usage (hrs)**	**(kW-hrs)**	**(kW-hrs)**	**(based on an average cost of $0.14 per kW-hr)**
3 Prong Florescent	18	40	720	24	17.28	899	$ 125.80
Ls212k1 Bulb	4	75	300	24	7.20	374	$ 52.42
Air conditioners	2	N/A					
Heater	0	N/A					
Projector Screen	1	N/A					
Windows	3	N/A					
Light Switch	4	N/A					

Cloudy Day	Shades Open	Shades Open
Room 102 Case Study	**LUX**	**Ft-Candles**
All Lights On	200	19
Only Board Lights	87	8
Sunny Day	**Shades Open**	**Shades Open**
Room 102 Case Study	**LUX**	**Ft-Candles**
All Lights On	312	29
Only Board Lights On	227	21

Room 230

Lab Room 230	Number of	On Watts per	Standby Watts per	Total Watts	Typical Weekly	Weekly Electricity Consumption	Yearly Usage	Average Yearly Cost
Component	**Components**	**Component**	**Component**	**per Component**	**Usage (hrs) (Not On Standby)**	**(kW-hrs)(Includes Standby hrs)**	**(kW-hrs)**	**(based on an average cot of $0.14 per kW-hr)**
Computers	41	70	2	2870.0	168	482.16	25072.32	$ 3,510.12
Monitors	41	45	1	1845.0	168	309.96	16117.92	$ 2,256.51
Florescent Light	51	32	0	1632.0	168	274.18	14257.15	$ 1,996.00
Projector	1	367	367	367.0	30	61.66	3206.11	$ 448.86
CCU	1	150	60	150.0	30	12.78	664.56	$ 93.04
Exit Sign	2	40	0	80.0	168	13.44	698.88	$ 97.84
Printer	1	21	21	21.0	72	3.53	183.46	$ 25.68
Clock	1	0.4	0	0.4	168	0.07	3.49	$ 0.49
Projector Screen	1	N/A	N/A					
Handicap Switch	1	N/A	N/A					
Heater	0	N/A	N/A					
Light Switch	4	N/A	N/A					
Windows	2	N/A	N/A					

Room 230	Full Lighting Shades Closed	LUX	Ft-Candles	Half Lighting Shades Closed	LUX	Ft-Candles
	Front	488	45		262	24
	Middle	462	43		223	21
	Rear	453	42		254	24

Room 248

Room 248	Number of	Watts per	Total Watts	Typical Weekly	Weekly Electricity Consumption	Yearly Usage	Average Yearly Cost
Component	**Components**	**Component**	**per Component**	**Usage (hrs)**	**(kW-hrs)**	**(kW-hrs)**	**(based on an average cost of $0.14 per kW-hr)**
Florescent Light	64	32	2048	63	129.02	6709	$ 939.29
Work Station W/Comp	5	180	900	28	25.20	1310	$ 183.46
Air conditioners	1	N/A	N/A				
Heater	2	N/A	N/A				
Light Switch	2	N/A	N/A				
Windows	4	N/A	N/A				

Controls Lab 248 Illumination	Shades Closed LUX	Shades Closed Ft-Candles	Shades Open LUX	Shades Open Ft-Candles
Sunny Day				
All Lights On	965	90	1332	124
Half Lighting	674	63	1008	94

Bathroom

Bathroom Component	Number of Components	Watts per Component	Total Standby Watts per Component	Total Watts per Component	Typical Weekly Usage (hrs)	Weekly Electricity Consumption (kW-hrs)(Includes Standby hrs)	Yearly Usage (kW-hrs)	Average Yearly Cost (based on an average cost of $0.14 per kW-hr)
Florescent Bulbs	9	32	96	288	84	32.26	1677	$ 234.82
Emergency Lights	1	N/A						

Hallways

Hallways Rooms 156-158	Component	Number of Components	Watts per Component	Total Watts per Component	Typical Weekly Usage (hrs)	Weekly Electricity Consumption (kW-hrs)	Yearly Usage (kW-hrs)	Average Yearly Cost (based on an average cost of $0.14 per kW-hr)
	Florescent Bulbs	106	32	3392	168	569.86	29633	$ 4,148.55
	Exit Signs	7	40	280	168	47.04	2446	$ 342.45
	Emergency Lights	0	N/A					
	Light Switches	4	N/A					

Appendix L

National Grid Incentive Documents

National Grid's Lighting Incentive and Eligibility Requirements Manual

for Massachusetts, Rhode Island and Nantucket Customers

2009 Energy Initiative Program

January 1, 2009

nationalgrid

Appendix M

National Grid Incentive Application Form

nationalgrid

Energy Initiative

Lighting - *Systems & Controls*

2009 Project Information Form for Massachusetts, Rhode Island, and Nantucket

This *Project Information Form* provides a template to collect project systems and equipment information and specifications. In addition, this form serves as a guide to lighting system and controls terms and identifies energy efficiency improvement products and incentives. Prior to the start of any installation of equipment or systems, call your **Energy Solutions representative** to arrange a convenient time to perform an inspection of the existing equipment or systems. This inspection is required for all applications.

Customer Facility Information

Customer Facility Name: ______________________________

____

Contact Person: ______________________________

Street Address: ______________________________

City: ____________ State: ______ Zip: ______

E-mail Address: ______________________________

Facility Description: ______________________________

Date of Application: ______________________

Sq. Ft. Covered by Application: ______________

Federal ID Number: ______________________

Company Type:
❑ Incorporated ❑ Exempt ❑ Not Incorporated

Phone Number: ______________________

Fax Number: ______________________

Customer of Record Information: Billing Account Number: ______________________ *Internal Use only*

Installation Contractor Information

Installation Performed By:* ❑ Customer ❑ Installation Contractor ❑ Project Expediter ❑ Other (Vendor)

Complete this section if installation is not by the customer

Installation Company: ______________________________

Contact Person: ______________________________

E-mail Address: ______________________________

* *If contractor has not been selected, select Customer*

Street Address: ______________________

City: ______________________

State: ____________ Zip: ____________

Phone Number: ______________________

Application Information

Application Funding Type: ❑ AAP ❑ Other *Internal Use only*

Expected Completion Date: ______________________

Proposed Incentive Recipient: ❑ Customer (*Account Credit or Check*) ❑ Installation Contractor** ❑ Project Expediter

** ***Complete this section if Installation Contractor has been selected***

Federal ID Number: ______________________ Company Type: ❑ Incorporated ❑ Exempt ❑ Not Incorporated

This Form Was Completed By:

Name: ______________________________

Phone Number: ______________________ E-mail Address: ______________________

For More Information

Phone: 1-800-787-1706 Internet: www.nationalgridus.com