Assessing and Reducing the Electricity Consumption of Residential Students At Worcester Polytechnic Institute

An Interactive Qualifying Project proposal to be submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science

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Abstract

This report explores electricity consumption of undergraduate students living in selected residence halls at Worcester Polytechnic Institute. The purpose of this study is to identify areas of energy waste and to promote viable options for resource conservation. This report will address pertinent background, assessment methods, results and analysis of two energy surveys and data collected from WPI's first Energy Savings Competition. The paper will also provide recommendations for future energy conservation initiatives on campus. We hope to establish a precedent for individual, energy audits and annual energy competitions aimed at reducing WPI's carbon footprint.

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Introduction

Throughout its long history, the Earth has gone through warming and cooling periods that were the direct result of natural forces. Volcanic eruptions, variability of the sun's intensity and changes in the Earth's orbit impacted concentrations of greenhouse gases (GHG's) found in the atmosphere. GHG's are gases that trap heat. Over the long history of Earth, naturally occurring GHG's helped produce temperatures that are ideal for sustaining life. (Nodvin, 2009) However, the introduction of a fossil fuel-based energy system, during the Industrial Revolution, altered the dynamics of climate by increasing atmospheric levels of GHG's to a point that caused global warming. (Steffen, et al, 2005)

The Environmental Protection Agency (EPA) reports that the burning of fossil fuels, (petroleum, coal, and natural gas) is responsible for most of the additional GHG's trapped in the atmosphere. (EPA, 2006) Climate change caused by anthropogenic or human activity is a phenomenon referred to as global warming. The Intergovernmental Panel on Climate Change (IPCC), a group of scientists sponsored by the United Nations (UN), has documented global warming trends from worldwide temperature records that have been maintained since the 1880s. (IPCC, 2001)

According to the IPCC, present levels of atmospheric CO_2 concentrations are higher than they have been in 650,000 years. The group attributes most of the rise in CO_2 to human activity. (IPCC, 2007) The combustion of petroleum, coal and natural gas represents 82% of U.S. greenhouse gas emissions. (Daily Galaxy, 2008) Humans produce GHG's primarily by generating electricity through the burning fossil fuels for transportation and industrial processes. Negative environmental impacts include permafrost thawing, shrinking glaciers, warming of rivers and lakes, and extinction of various animal species. (NWF, 2008)

In the past, trees were capable of processing most GHG's to maintain temperature stability. However, as humans developed complex societies, consumption of fossil fuels increased, leading to higher concentrations of CO_2 that were beyond levels natural forces could manage. The Fourth Annual Report of the IPCC notes, GHG emissions have grown by 70% between 1970 and 2004. Environmental consequences include: permafrost thawing, shrinking glaciers, warming of rivers and lakes, earlier bird migration and extinction of many animal species. (AR4, 2007) Clearly there is a need to reduce the amount of CO_2, and other greenhouse gases, humans release into the atmosphere. Cutting back on the amount of electricity usage is the first step toward reducing greenhouse gas emissions.

A majority of the world's scientists agree every country must begin to make the transition from a fossil fuel-based society to one built on clean, renewable energy. If any sector of society has the potential to lead the charge, it is higher education. Author David Orr of Oberlin College says it well: "No institutions in modern society are better equipped to catalyze the necessary transition to a sustainable world than colleges and universities." (NWF, 2009)

On college campuses 90% of energy consumption takes place within buildings. (Oberlin, 2009) Electrical lighting is responsible for a significant amount of residential halls electricity usage. Residence halls offer an excellent venue to promote energy conservation, because personal choices influence the amount of electricity used. Residential students have direct control over the use of lighting and other electrical appliances in their individual rooms. Therefore, residence halls are a logical place to start when looking for ways to reduce energy consumption on college campuses.

Many students unintentionally waste energy. Most are unaware of the environmental and economic impacts of their wasteful, energy choices. Leaving lights and computers on while out of their rooms, using incandescent light bulbs instead of more energy efficient LED lights, and keeping power strips on when the devices plugged into them are not in use, needlessly consumes energy. Many electrical devices continuously draw power from electrical outlets, even when not supplying any useful power. Eliminating these "power vampires" can decrease electrical consumption by 20%. According to The Carbon Buster's Home Energy Handbook, energy savings, from using sleep mode and turning off computers when not in use, amounts to enough savings to completely pay for another computer system. (Stoyke, 2007)

The lifestyle choices made by today's students "may decide the ultimate habitability of our planet." (Hamburger, 2008) Therefore it is vital that colleges promote environmental literacy and responsibility. In 2007 the Worcester Polytechnic Institute (WPI) Board of Trustees voted to endorse a policy of environmental responsibility, calling for future buildings on campus to be LEED-certified buildings (Leadership in Energy and Environmental Design). The Bartlett Center and East Hall are two LEED-certified buildings on campus. A LEED certified sports engaged complex is scheduled to be built in the near future. In a 2009 E-News interview, John Orr, Provost, Senior Vice President and Leader of the President's Task Force on Sustainability at WPI stated, "WPI is proudly in – and deeply committed to – sustainability," Increasing the efficiency of WPI resources — energy, water, and materials — while reducing building impacts on human health and the environment are administrative priorities according to Orr. (WPI, E-News, 2009)

In a meeting with Fred DiMauro, Assistant Vice President for WPI Facilities, DiMauro commented on energy saving actions that have been implemented on campus. To reduce electricity usage and GHG emissions, WPI has switched from oil to gas in WPI's main power plant. An energy management system was installed in Bartlett Center and East Hall and motion activated lights have been installed inside and outside specific buildings to lower WPI's electricity consumption. (DiMauro Interview, 2009) Due to these actions, WPI received an overall grade of B+ on the College Sustainability Report Card. That is an improvement from the C- grade WPI obtained on the 2009 report card. (2009, 2010 Green Card)

WPI's administration and staff have taken the first steps toward a greener, more energy efficient campus. However, there has been minimal, direct student involvement in sustainability efforts relating to energy conservation. When informally questioned about environmental issues, most students expressed an awareness of and concerns about global warming. They also admitted they had "no idea" what WPI was doing to address energy related climate issues or what they could do to make a significant difference in lowering WPI's CO_2 emissions.

A study of energy awareness and conservation programs at U.S. universities revealed "students are generally unaware of concrete steps they can take to reduce their own energy consumption beyond the most basic actions… and that dorm rooms are typically cluttered with energy consuming devices." A University of Indiana, Bloomington study concluded that with information and feedback on energy conservation efforts, student's electricity usage decreased significantly. Similar observations were reported at Amherst College, Wellesley College, Oberlin College, and Massachusetts Institute of Technology.

A primary goal of this project is to increase student awareness of the amount of electricity they use and to encourage energy conservation behaviors in a fun, competitive, atmosphere. An underlying premise is that with education, awareness, and feedback on energy usage, students will be motivated to implement energy saving strategies into their daily routines.

To increase awareness and promote conservation, an individual energy audit/survey will be conducted. This will be followed by the first energy savings competition at WPI. Two residence halls will be chosen to compete in a week-long energy saving event called, "Do it in the Dark." The building with the lowest electricity usage, during the competition period, will be declared the winner and awarded a prize.

A final report will document the process and provide an analysis of collected data. Recommendations will be made for further study, possibly by another IQP group.

Background

Natural Drivers of Climate Change

Before humans emerged as Earth's dominant species, climate change was generated by the great forces of nature. Volcanic eruptions, differences in the shape of the Earth's orbit (eccentricity), and variability of the intensity of sunlight reaching the surface, impacted the amount of greenhouse gases (GHG's) found in the Earth's atmosphere. In turn, GHG concentrations affected warming and cooling of the planet, serving as drivers of climate change. (Steffen, et al, 2005)

Greenhouse Gases and the "Greenhouse Effect"

Greenhouse gases (GHG's) are chemical compounds that allow sunlight to enter the Earth's atmosphere freely. As infrared radiation bounces back toward space, GHG's trap the heat in the atmosphere, resulting in warming trends on Earth. Without this "greenhouse effect" the average temperature of Earth would be about -2°F rather than the 57°F we currently experience. (EPA, 2008) Figure 1 illustrates the greenhouse effect.

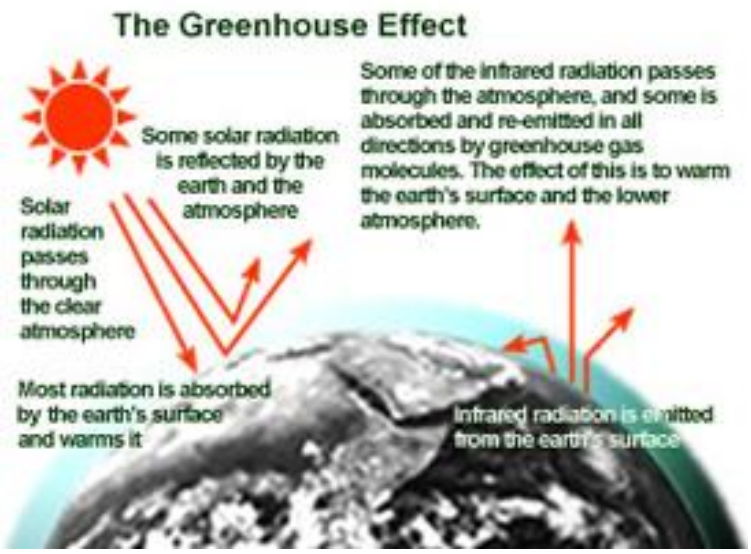


Figure 1 Environmental Protection Agency (Public Domain)

Some greenhouse gases, such as carbon dioxide (CO_2), occur naturally and are emitted into the atmosphere through natural processes and human activities. Other GHG's (e.g. fluorinated gases) are created and emitted solely through human activities.

Human Impacts on Global Climate Change

The onset of the Industrial Revolution caused a profound shift in climate dynamics. For the first time in Earth's history, levels of CO_2 and other greenhouse gas emissions were connected to human activities. Change caused by human activities is referred to as anthropogenic change. (Steffen et al. 2005)

The Intergovernmental Panel on Climate Change (IPCC) is an international group of 2,500 scientists from 130 countries. The United Nations (UN) brought this group together to address global climate change. According to the IPCC, the net average of human activities since 1750 has resulted in global warming. (IPCC, 2007) Most scientists agree this trend is anthropogenic and primarily due to the burning of fossil fuels.

Trends in Greenhouse Gas Emissions

Steady increases in CO_2 levels over the last thirty years are responsible for a new global perspective on environmental change. Measurements at the Mauna Loa Observatory in Hawaii first demonstrate beyond doubt that human activities have direct, global scale consequences for the environment. (Figure 2)

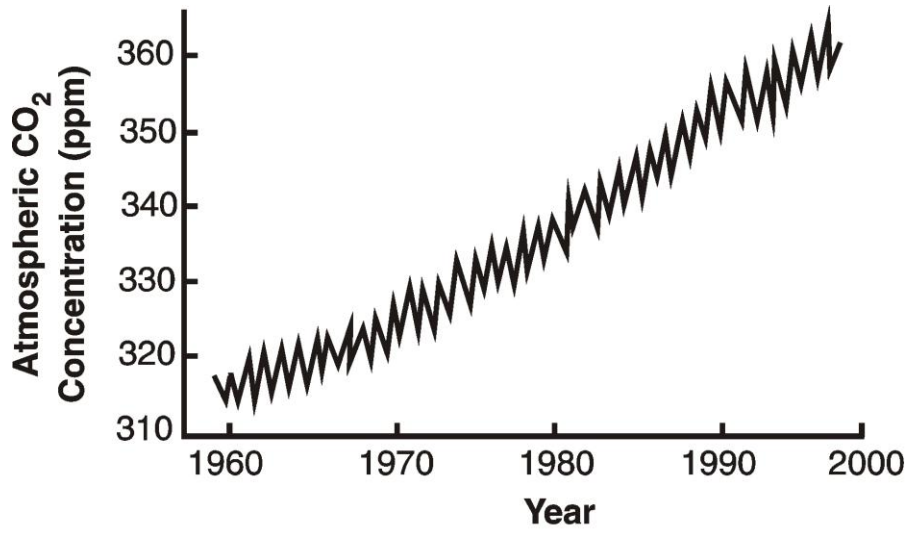


Figure 2 - Increases in atmospheric CO_2 – data from Mauna Loa Observatory, Hawaii

(Adapted from Keeling and Whorf, 2000 in Steffen et al, 2005)

Analysis of data from the Mauna Loa Observatory in Hawaii support observations based on data taken from the 420,000-year ice core record in Vostok, Antarctica. The Vostok studies showed consistent increases in CO_2 and other GHG's through four glacial cycles. (Petit et al, 1999)

Turning to the most recent past, evidence is mounting that the Earth's climate is changing at an accelerated rate due to human-induced GHG's. (Figure 3)

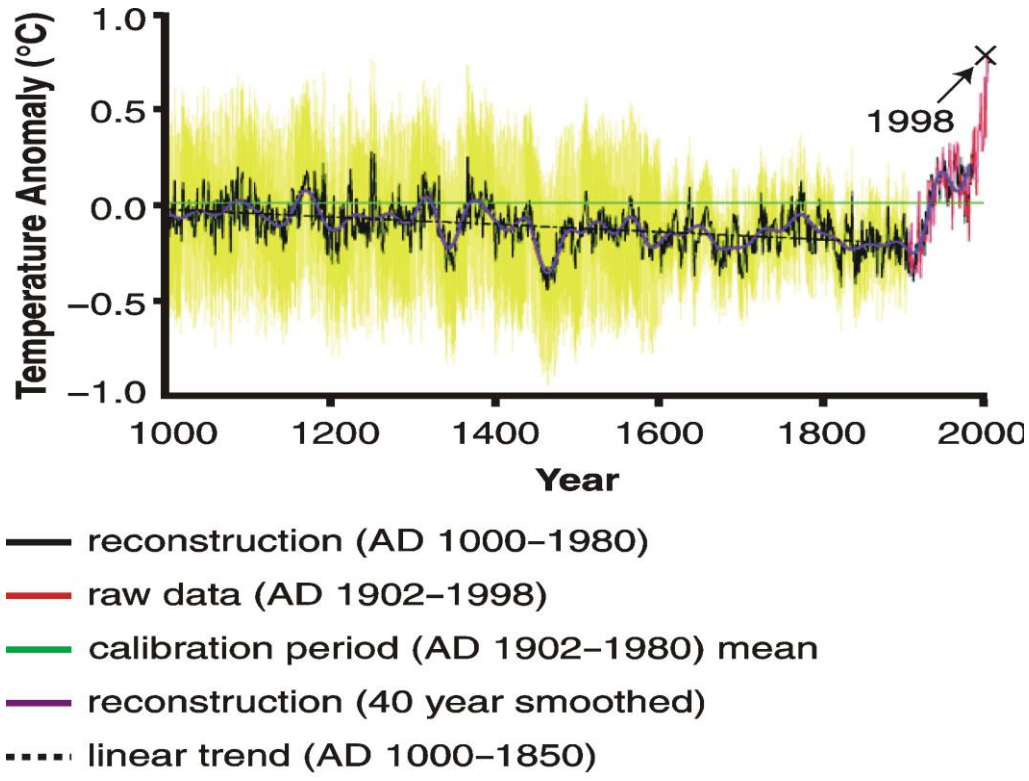


Figure 3

Increases in mean average surface temperatures on Earth for the last thousand years (Mann et al. 1999 in Steffen et al, 2005)

Definition of Global Warming

Global warming refers to average increases over a sustained period of time, in the temperature of the Earth's surface, water and atmosphere, due to GHG emissions in the atmosphere. (Clean Air Cool Planet, 2006) The Fourth Assessment Report of the IPCC (AR4) asserts with a "90% certainty" that emissions of heat-trapping gases from human activities are responsible for most of the increase in globally averaged temperatures since the mid-20th century.

Human Impacts on Climate

Considering the Earth has experienced warming and cooling periods long before humans evolved, how do scientists know human activity is responsible for present day global warming? The Union of Concerned Scientists (UCS) is an environmental advocacy group, founded in 1969 by students and faculty of the Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts. According to UCS scientists, a carbon molecule that is released from burning fossil fuels is lighter then those from other sources. As scientists "measure" the "weight" of carbon in the atmosphere, over time they have seen an increase in the lighter molecules from the combustion of fossil fuels by humans. (UCS, 2009)

Global warming is a serious environmental problem that needs to be addressed immediately. James Hansen, director of NASA's Goddard Institute for Space Studies, published a study showing that greenhouse gases emitted by human activities have brought the Earth's climate close to crucial tipping points, with potentially irreversible consequences for the planet. The Hansen study found that global warming of 0.6o C in the past 30 years has been forced mainly by human emissions of GHG's and very little by emissions of GHG's from natural forces.(ENS, 2007)

The Fourth IPCC report documented accelerated GHG increases of 70% between 1970 and 2004 and noted CO2, production, which the IPCC called the most important anthropogenic greenhouse gas, increased by 80% between 1970 and 2004. When IPCC scientists compared natural and human-induced climate drivers, they reported a "dramatic accumulation" of carbon from human sources and noted human-induced emissions were by far the largest driver of global warming over the past half century. (IPCC, 2007)

An exhaustive study by the National Wildlife Federation (NWF) provides additional proof of human impacts on global warming. The 2008 NWF ecology report stated, GHG levels produced by human activity far exceed levels emitted by natural forces... (NWF, 2008)

Mitigating Global Warming: Step One

The logical first step in mitigating the crisis of global climate warming is to reduce CO_2 emissions by cutting down on electricity consumption. To prevent irreversible impacts, energy conservation must be a priority for everyone.

Electricity Conservation on a University Campus

Turning the tide on global warming is a monumental challenge. It is also an opportunity for universities to lead the charge to a more sustainable world. An Oberlin College study of energy

usage on university campuses reported 90% of energy use takes place within academic and residential buildings. Students who live on campus spend a substantial amount of time in their rooms. Residential buildings offer a practical setting in which to introduce energy conservation measures and to get students involved in reducing electricity consumption.

In their rooms and suites, personal choices influence the amount of electricity students consume. College dormitories provide an excellent venue to introduce energy conservation initiatives and to analyze student's electricity usage in a controlled setting. Residence halls also provide a site to introduce energy conservation strategies and to evaluate their effectiveness.

Benefits of Electricity Conservation Initiatives on Campus

With increasing electricity costs, colleges and universities need to find ways to save energy. While facilities managers can help determine areas to consider for energy saving measures, students have played a role in such efforts on many college campuses, by conducting energy audits and greenhouse gas inventories.

Colleges and universities collectively spend $18 billion on energy each year (an average of $4.4 million per campus). Most energy is generated from burning coal, oil and natural gas (fossil fuels). Using less fossil fuel means less GHG's. Reducing electricity usage will significantly reduce fuel bills and reduce a campuses carbon footprint and help slow the global warming trend. (EPA, 2008)

Student Leadership in Campus Energy Conservation Initiatives

Students have long been the heart and brains behind campus greening efforts. Their involvement goes back to the recycling programs of the 1970's, when many of the parents of present day students were in college. The campus ecology report of the National Wildlife Federation (NWF) is a compendium of conservation efforts spearheaded by today's students.

Worcester Polytechnic Institute (WPI): Student Responses to Global Warming

In 2007, a team of WPI students initiated the development of a campus greenhouse gas (GHG) emissions inventory as a first step toward understanding and targeting programs to reduce emissions. This research, Tracing and Reducing Greenhouse Gas emissions at WPI (project 031107-200452) established a precedent for annual GHG inventories aimed at reducing WPI's carbon footprint.

A second IQP group project, Electricity Monitoring at WPI, (project 060107-130245) evaluated the status of WPI's electricity monitoring system on a building by building basis. A comprehensive report on the functionality of meters was made. Both projects provided opportunities for students to partner with WPI's administration and staff in addressing issues relating to anthropogenic, climate change.

WPI students created PREcyclemania on campus in December 2008 in preparation for Recyclemania, a nationwide competition, in January 2009. Measurements of recyclables were taken for five weeks from competing residence halls and Greek houses. Also, a competition called "Envisioning Sustainable Futures Poster Competition" was held to create awareness and share ideas about sustainability. WPI outranked both Harvard and MIT in Massachusetts. A student "Green Team" was created to work in partnership with WPI's administration and staff, and two student Green team members appointed as senators on the President's Task Force on Sustainability. In February 2009, for National-Teach-In on global warming, WPI students created a video letter and sent it to legislators in Washington. Students also partnered with staff and faculty to combine Quad Fest (student government festival) with Earth Day. (Okumura/Tomaszewski, 2009)

WPI's College Sustainability Report Card 2010

Documentation of WPI's many sustainability initiatives are detailed in a survey, submitted by WPI Facilities Systems Manager/Sustainability Coordinator, Liz Tomaszewski, for the College Sustainability Report Card survey. The Report Card is designed to identify colleges and universities that are "leading by example in their commitment to sustainability," and is the only independent sustainability evaluation of campus operations and endowments. Only initiatives related to energy conservation are included in this paper.

Since August 2008 WPI has opened a new residence hall. East Hall is an example of a living laboratory of sustainable design, construction, and living. This building was awarded Gold LEED (Leadership in Energy and Environmental Design) certification. This "green" building was named the project of the year by the Construction Management Association of America, New England Chapter, for building construction under $50 million.

Clearly WPI students are committed to conserving resources. When given opportunities to make our campus more sustainable, students have shown creativity and enthusiasm in partnering with other campus groups to work toward a greener campus. Many successful energy awareness and conservation programs, at other colleges and universities, include an energy competition. In reviewing WPI's energy initiatives, there was no record of any campus energy promotion of this kind. Our group felt that we could make a contribution to WPI's sustainability efforts by adding this component to the list of student-directed resource conservation programs. Considering the

number of successful energy competitions that have taken place at other colleges, we conducted a review of programs with competitions between residence halls.

Case Studies of Other Campus Energy Initiatives

Many schools have conducted residential hall versus residential hall energy savings competitions. A review of many competitions showed enthusiasm and willingness by students to modify energy wasting behaviors when given information, opportunity and a little incentive to reduce their electricity consumption. We have included summaries of programs that netted significant electricity reduction and had elements that were either feasible for our present project or had components that we would recommend for future energy initiatives at WPI.

Harvey Mudd College

Residential students of Atwood Dorm, at Harvey Mudd College, Claremont, California reduced energy consumption by 33% during an Energy Competition. Students embarked on an energy saving mission to reduce electricity usage in residence halls. They took small steps such as turning off lights when out of the room, switching out incandescent light bulbs and utilizing power strips to facilitate turning off all electrical devices at night. The initiative reaped significant energy savings with only minor changes in student behavior. The second place dorm reduced energy consumption by a credible 22%. Analysis of overall reduction in electricity amounted to a savings of several thousand dollars and thousands of kilowatt hours. The contest will become a yearly event due to the positive results of the initial competition. Part of the success of this program is attributable to sponsorship by Southern California Edison. This group provided florescent bulbs free of charge to students. The idea for this energy competition grew out of an energy audit conducted by students the summer before the competition. Once the audit was completed, areas of greatest energy use were identified and strategies to reduce usage in those areas were developed.

Williams College

Williams College, Williamston, Maine increased environmental literacy and reduced energy consumption through an energy conservation project called the “Do It in the Dark Energy Saving Competition,” The contest name has been used by other colleges and universities with similar programs. William’s project was designed to reap short-term reductions in energy consumption and to creating general environmental awareness that could promote further reductions. Like the Harvey Mudd Competition, the Williams program involved an energy competition between individual residential houses and spanned a one month period. The winning house was a freshman residence hall. Energy consumption was reduced by 40% in the first place building. The second place house was an upper-class residence. Energy consumption was reduced by 12%. Analysis of all competing buildings showed at least a 3% decrease during the promotion.

Dartmouth College

Dartmouth College, Hanover, New Hampshire educates students about their energy usage via display kiosks in dormitory common spaces. The displays broadcast energy usage levels on low-energy monitors that show an animated polar bear whose comfort or distress, depends on students' energy usage. The underlying premise of Dartmouth's "Green Light" program is that students will modify their behavior toward less energy use if they can see how their energy consumption fluctuates with each light switched on or off, or each laptop or other appliance plugged in. Six buildings have kiosks and four others are being electronically metered in preparation for an expansion of the system. Participating residence halls engage in a year long energy savings competition. In dorms displaying the animated polar bear, students' have shown an attachment to the safety of the bear, and by extension, energy conservation. The bear was happy and played on the ice when energy readings were low. High readings resulted in the bear falling through the ice. Participating dorms achieved up to a 22% reduction in energy consumption during the initial program.

Oberlin College and Conservatory

Oberlin College students developed a campus resource monitoring system to display electricity usage in dormitories. The objective was to provide real-time feedback on electricity usage to encourage and empower students to conserve energy resources. In 2004 Oberlin's per-student consumption of electricity was 8,000kWh of electricity. After an energy awareness campaign and the installation of a real-time feedback system of usage, an energy savings were 32% was realized. In 2007 Oberlin's "Turn It Off" dorm energy competition netted a remarkable 56% reduction in electricity consumption in seventeen residence halls. Students saved the college $5,120. Funds supporting this conservation promotion are provided by the U.S. EPA's "People, Prosperity and the Planet (P3) program and from the Ohio Department of Development.

Elon University

Elon University, Elon, North Carolina held its first energy competition, POWERless, in the spring of 2008. As a kick-off event, free CFLs were provided to students and the online real-time monitoring was displayed. Elon's radio station broadcast energy announcements and conservation between songs throughout the event. The greatest residential area electricity reduction was 15.1% the first year and 20.3% the second year. Additional, non-residential buildings participated in this energy conservation program with overall energy savings of 23.8% the first year and 22.5% the second year. Overall the electricity reduction or kilowatt hours not used during the two competitions equated to a savings of 99 tons of coal being burned and 153 tons of carbon dioxide emissions.

According to the event's final report, the greatest challenge was keeping students motivated during the seven week competition. Attention and enthusiasm were high the first few weeks then but dropped in the final weeks. However, an infusion of media and internet messages to participants helped rekindle interest.

Alleghany, College

Alleghany College, Alleghany, Pennsylvania employed a marketing technique, the pledge, to make energy waste and commit to switching off lights as often as possible. As a result of signing the "Lights Out Pledge," several student organizers began shutting off lights on their way through buildings if they noticed empty rooms. Eventually students signed cards to "adopt a room" in addition to their own rooms. By the time a campus wide competition was held to determine which residence hall netted the most energy savings, residential students were already in the mindset to turn off lights and electronic devices in their rooms and the winning building reduced consumption by 36%.

Survey Design

Surveys have remained a popular and useful tool for learning about people's opinions and behaviors for more than 75 years. During this time, surveys have evolved from face-to-face conversation, to telephone interviews, to mailed surveys and finally, e-mail and internet surveys. One of the significant impacts of the electronic age is that the lines between writing a question, constructing a questionnaire, and implementing a survey are blurred. Conducting surveys that produce accurate information that reflects the views and behaviors of a given population requires careful preparation. According to Dillman et al, there are basic guidelines that should be considered for any survey, regardless of mode. Below is a summary of the main points of question and survey design, from the third edition of, Internet, Mail, and Mixed Mode Surveys- The Tailored Design Method, (Dillman et al, 2009)

General Guidelines for all modes of Survey Design:

Choose first questions carefully

Group related questions that cover similar topics

Ask questions about events in the order they occur

Establish consistency in visual presentation across pages or screen

Use color and contrast to help respondents organize questions and navigate through the questionnaire

Avoid visual clutter

Specific Guidelines for Web Questionnaires:

Choose how the survey will be programmed and hosted; base on project goals and skills of respondents

Take steps to ensure questions will display similarly across different platforms, browsers and user settings

Decide how many questions will be presented on each page and how questions will be arranged

Use a consistent page layout

Allow respondents to stop survey and finish at another time

Design survey-specific and item-specific error messages to help respondents troubleshoot any issues they may encounter

Take screenshots of the final page of each survey for documentation

Formulating questions may seem like a simple task, but research has shown crafting effective survey questions involves not only choosing words to form clear questions but also deciding how the components of the questions are presented.

Guidelines for Choosing Words and Formatting Questions:

Ask one question at a time

Use simple, familiar and concrete words

Use as few words as possible

Use complete sentences

Use darker print for questions and lighter for answers

Standardize answer spaces

For open-ended questions the following:

Ask for the specific unit desired in the question stem

Provide unit labels with answer spaces

Specify the number and type of responses desired

For Close-ended questions:

Ask respondents to rank only a few items at once rather than a long list

Avoid bias from unequal comparisons

Use forced-choice rather than all-that-apply questions

Types of Questions: Open-ended and Close-ended

When people think of open-ended questions, the descriptive question comes to mind, in which respondents are asked to provide in-depth information. (e.g. What sustainability issues are you most interested in addressing on campus?) There is another type of open-ended, the number box question. (e.g. In an average week, how often do you turn off your lights when leaving your room?)

Closed-ended questions are the most commonly used survey questions because they measure gradations of a variety of opinions, behaviors, and attributes. These questions need to be presented in a way that supports the inherent order of the question.

Figure

When you leave the room, how often do you generally turn off the lights?

Always

More than half the time, but not always

Half the time

Less than half the time, but sometimes

Never

WEB Survey Implementation

On the surface, many features of web survey implementation seen very similar to those used for mail implementation, but web implementation has to be handled differently due to different technologies. By mail, surveys are delivered to the respondents. By web, respondents are essentially asked to go and get the survey using particular technologies. Sometimes the respondents are not skilled or comfortable using technology, therefore it's important to make the task as easy as possible. According to Dillman et al, a personalized (Dear [First] [Last name] increases the number of student responses, particularly when the survey invitations come from a "powerful" individual (e.g. a professor, the provost or vice chancellor) Sending multiple contacts or reminders also increases the response rate.

Timing of the survey is also an important factor.

Methodology

The short term goal of our project was to increase environmental literacy on campus. There were three main components to our IQP. The first phase was to conduct an online survey of residential students' electricity consumption. The second element was educating students about the consequences of energy consumption. The underlying premise was students would choose to reduce consumption if they were aware of the consequences of their choices. The third component of our project, the main event, was to host an energy competition with daily feedback on usage. Our primary objective was to encourage residential students to reduce electricity consumption in their rooms. By doing so, students would be making a contribution toward lowering WPI's carbon footprint.

For our Interactive Qualifying Project (IQP) we worked through terms A and B, covering a period of time from August 28, 2009 through December 24, 2009. Normally an IQP is done in three terms, but we chose to condense the timeframe into two terms. The basic outline for our project is presented below:

Phase I: Research

Compiled scientific research on climate change/global warming

Reviewed WPI's sustainability policies, programs, and resources

Researched design of internet surveys – Dillman, 3rd Edition

Conducted interviews: person-to-person, via email and telephone

Met with Facilities and Residential Life staff

Phase II: Design and Development

Designed energy survey

Met with Facilities and Residential Life staff

Negotiated with Chartwells to cater post competition party

Arrange meter access to Institute, Stoddard and Riley Halls

Selected Survey Monkey as web service provider

Created competition posters and individual energy tips brochure

Compiled a list of energy reminders to be emailed to students during the competition

Phase III: Implementation

Sent out online energy survey, through Survey Monkey, to Institute, Stoddard and Riley Hall residents

Took daily, manual electricity readings and recorded data

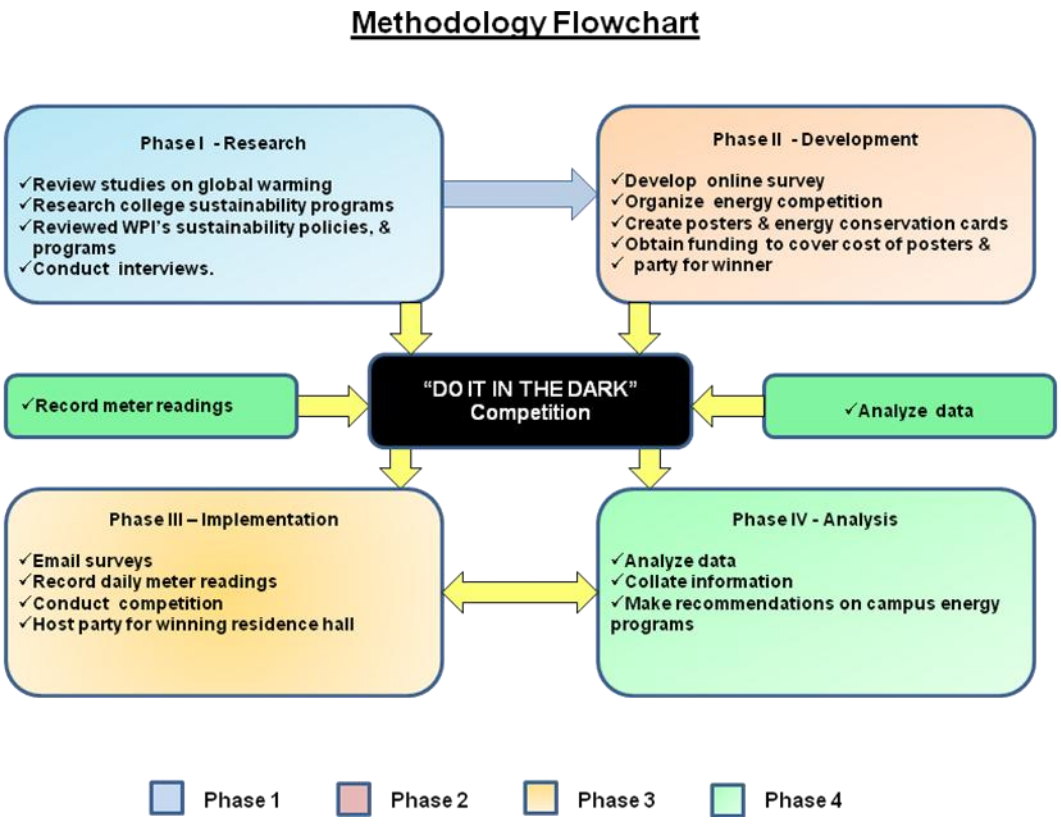
Analyzed data

Compiled information from individual project team members

Synthesized information

Phase IV: Analysis and Recommendations

The final part of the project was analysis of data, generation of charts and graphs to visually represent the data and combining information compiled by three different team members from multiple sources, into one, coherent report. Below is a methodology flow chart that represents the process: **Figure 4** (below)



Summary of Methodology

In Phase I – the Research phase, a thorough review of literature on global warming and higher education's response to this environmental challenge, was conducted. The study provided a foundation and rationale for our IQP. The study took considerably more time than we initially anticipated. We spent additional time doing research because we lacked relevant background on the dynamics of climate change. Once we had the necessary background information, our research turned toward colleges and universities. We examined campus promotions that encouraged student involvement in energy conservation programs. In particular, we looked for campus initiatives that specifically addressed students' electricity consumption in campus housing.

Through research, we discovered environmental stewardship is a priority on most university and college campuses, including WPI. With over 4,000 accredited colleges and universities in the U.S., many of which had exemplary sustainability programs, it was impossible to analyze all the campaigns that related to our project topic. Therefore, we narrowed our research to colleges and universities that received top sustainability ratings, by the National Wildlife Federation (NWF) and by the Association for the Advancement of Sustainability in Higher Education (AASHE). We singled out those organizations because of their credibility and proven commitment to promoting environmental literacy and conservation of natural resources.

WPI was one of 300 institutions of higher education chosen to participate in the pilot sustainability survey conducted by the AASHE. WPI was also referenced in the Higher Education in a Warming World: the Business Case for Climate Leadership study, conducted by the NWF. WPI's overall score on the STARS (Sustainability Tracking Assessment and Rating system) was 58.01. This was significantly above the average score of 40.3.

During the research phase of our project, the team reviewed WPI's energy policies and practices. It became clear that WPI is deeply committed to becoming a "greener," more sustainable campus. In terms of energy conservation, WPI's switch from coal to natural gas has improved the school's energy efficiency. From 2002 to 2006 overall CO2 emissions were reduced from 20 Million kg CO_2 to 18 Million kg of CO_2.

A review of WPI's green efforts revealed the administration supported "green" initiatives and student participation in sustainability efforts. However, our team found a disconnect between intentions and practice, particularly in the area of energy conservation. The most visible sustainability partnership between students and WPI's administration is the annual Precyclemania and Recyclemania competitions to reduce energy, water and waste on campus. Those annual recycling events are very popular and produce positive results.

Considering students spend a great deal of time in their rooms, and their individual choices influence the total amount of electricity consumed in residential buildings, our team decided to work on improving and expanding WPI's energy conservation efforts in that area. Considering the amount of time residential students spend in their rooms, and the amount of electricity consumed in those buildings, we decided to utilize residence halls as a venue for controlled study of student response to feedback on electricity usage. We hoped to assess the impact, if any, that feedback would have on students' energy conservation efforts.

In Phase II – Development, initial efforts centered on designing an online survey. The purpose of the survey was to assess students' energy habits and attitudes. Time was divided between survey development, meeting with staff to arrange meter readings and to set up an account with the online survey provider, Survey Monkey. During this development phase, the pre and post competition surveys were drafted, using the second edition of Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method, by Don A. Dillman.

In addition to the Dillman book, we incorporated questions from an energy conservation survey conducted by the University of South Australia (UniSA), for the Australian Greenhouse Office.

The main outcome of our project was the "Do It in the Dark" Energy Competition. We worked on promoting and organizing the contest during phase II with some overlap in phase III. Interviews were conducted with WPI's president, Dr. Dennis Berkey, who recommended that we look at the Oberlin College energy competition. Dr. Berkey also generously agreed to fund the cost of a catered party for the winning residence hall. Institute Hall was the building that reduced electricity consumption by the highest percentage during the competition and was determined the winner.

After deciding to hold the competition between Institute and Stoddard Halls, we needed to gain permission to obtain meter data. We met with Fred DiMauro, Facilities Vice President. After pitching our idea for the competition, he seemed very enthusiastic about the potential outcome. Mr. DiMauro gave us permission to take meter readings as often as we wanted, if we had a staff member walk around to the meters with us. He referred us to Chris Salter, Bill Grudzinski, and Maureen Burke, for specific information and access to various buildings on campus.

After emailing Chris Salter, we learned that the school is planning to install individual meters for Morgan, Daniels, and Riley Halls to obtain specific electrical readings for each residence. The school is planning on installing the meters over the course of the 2009-2010 winter break. Mr. DiMauro also recommended talking with Maureen Burke, manager of Salisbury Estates, an off-campus residential property. Although most of the apartments are not presently managed by WPI, recently control has been expanded. WPI's Office of Residential Services has recently

taken control of several more units for additional, off-campus student housing. Our team emailed Ms. Burke and pitched the idea of conducting an energy survey and energy reduction competition for WPI students living in Salisbury. She replied that it would be a very difficult project because each apartment has its own meter located in the basement. Access would be a problem due to lack of maintenance staff.

Finally, Bill Grudzinski, Head Engineer at the WPI power house, helped us locate each residential building's meter. From Mr. Grudzinski we learned that the electrical meter in East Hall is located in the parking lot between East and the Armenian Church. Founder's meter is in the campus police office and Institute's meter is in the Crow parking lot. Fuller and Ellsworth each have meters in their designated parking lots, and Stoddard meter can be found in the bushes between Stoddard B and C. Over the course of the project, Mr. Grudzinski was extremely helpful in providing meter and bill information that was required for the competition and analysis and results documentation.

Promotion for the competition was very basic and minimal due to time and budget constraints. Contest posters and energy conservation cards were printed and distributed in residence halls with help from RA's. Naomi Carton, Director of Residential Services, covered printing costs for the posters. Ms Carton also served as an advisor for the project with David DiBiasio, Associate Professor and Department Head for chemical engineering.

In Phase III – or the Implementation stage of the project, two online surveys were distributed through Survey Monkey. See Appendix A, Figures 1.2, 1.2 and Appendix B, figures 1.1-1.3. The first survey was distributed a week before the competition and the second one a week after the competition. During this phase, manual electricity readings were taken, recorded. Daily updates on usage were posted on a chart located in each residence hall. Readings were t starting one week prior to the competition (to establish a baseline for electricity consumption) and were planned to continue for one week after the event. Due to the Thanksgiving holiday, there was a four day break before reading could be taken after the competition ended.

To generate interest in building versus building energy competition, we designed posters and individual, note cards with environmental information and conservation tips. See Appendix C for poster. We also met with residence hall staff, discussed contest incentives (the winning building would be treated to a catered party). Background information was compiled for the Resident Advisors (RA's) to share with students during floor meetings. The RA's helped put up posters, held floor meetings to share energy saving strategies, passed out the individual energy reminder cards and helped generated a friendly spirit of competition. We are very grateful for their support.

The “Do It In the Dark” Energy competition was held the week before Thanksgiving. Email reminders of energy saving tips were sent out, and progress was recorded on charts in each participating building. After the third day, updates on energy consumption were also emailed to participants to generate friendly competition.

After one week energy savings were calculated. Institute Hall was declared the winning building and a catered party was hosted for residents. During the competition week Institute residents reduced their electricity usage by 10.4%.

The final component of the project was to write a comprehensive report that included a summary of background research, explanation of the process (methodology), analysis and synthesis of data, a summary of achievements and challenges and recommendations for improvement.

Results and Discussion

Analysis of Surveys

To gather statistical data we distributed a pre and post competition survey. The initial survey was sent out a week before the competition. The second survey was distributed one week after the competition ended. Stoddard and Institute were participants in the energy competition, but we included Riley in the survey to give us an unaffected constant to use as a baseline.

The first survey showed fairly similar results for all buildings. The second survey did show a variance between halls. Energy usage dropped in Stoddard and Institute whereas the usage in Riley generally remained constant.

By looking at Figure 5 and Figure 6, it is clear the overall percentage of appliances that were left on all night, dropped in numerous categories after the first survey.

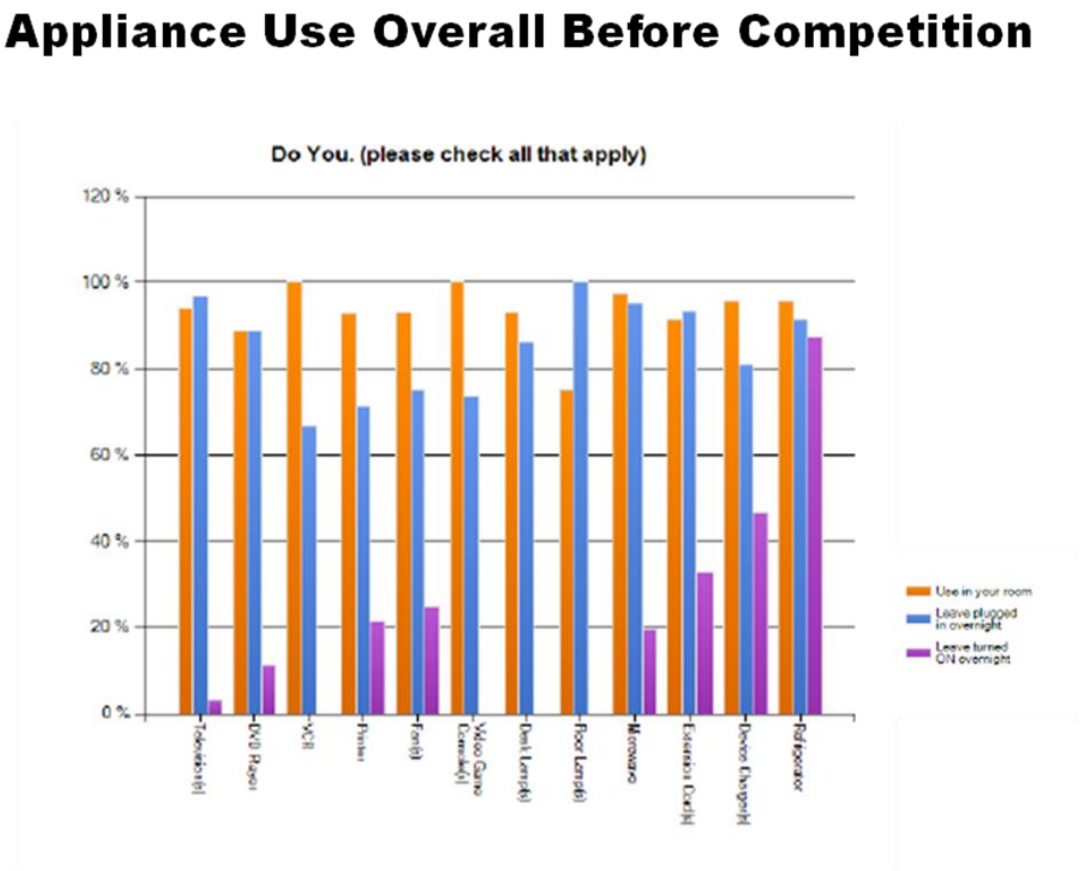


Figure 5

Appliances from left to right: Televisions, DVD player, VCR, Printer, Fan, Video Game Console, Desk Lamp, Microwave, Extension Cord, Device Charger, Refrigerator.

Orange – Use in your room Blue – Leave Plugged in Overnight

Purple – Leave Turned On Overnight

Appliance Use Overall After Competition

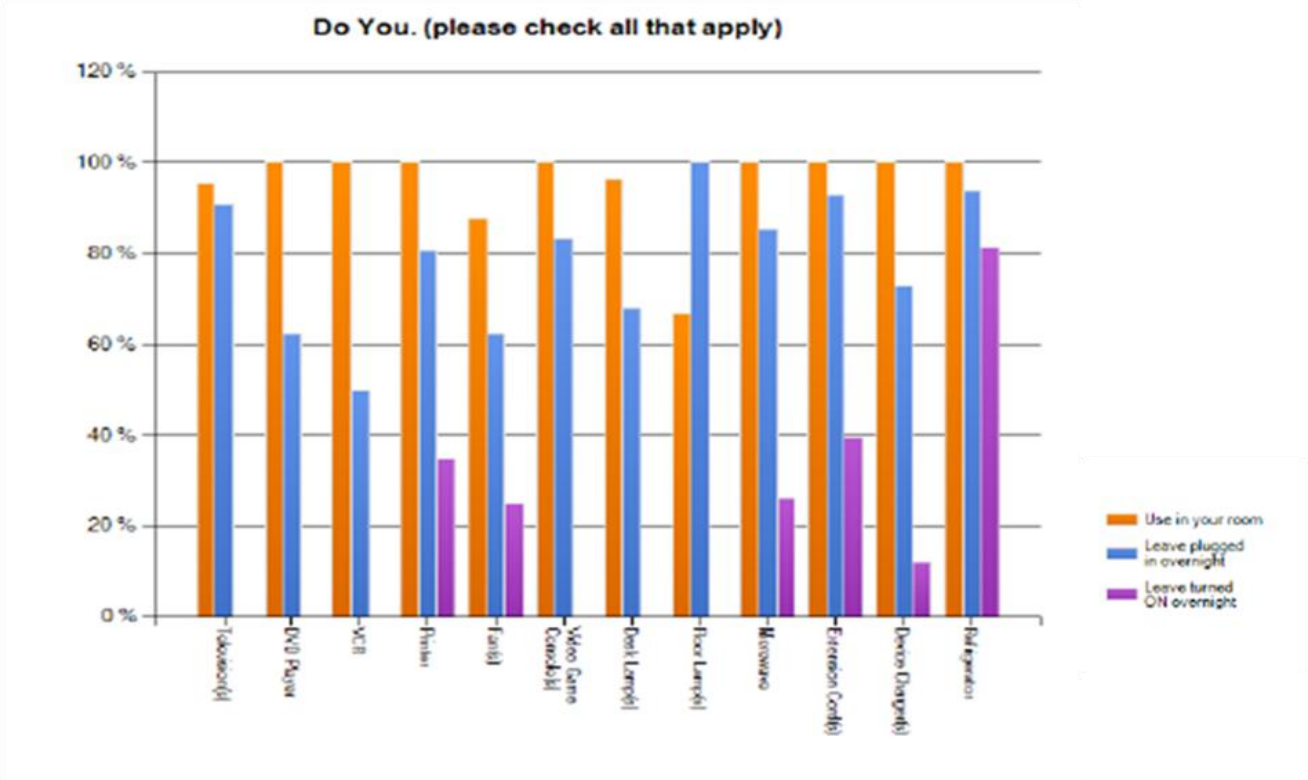


Figure 6

Figure 5 represents the rise in number of laptops turned off at night after the competition had occurred.

Appliances from left to right: Televisions, DVD player, VCR, Printer, Fan, Video Game Console, Desk Lamp, Microwave, Extension Cord, Device Charger, Refrigerator.

Orange – Use in your room

Blue – Leave Plugged in Overnight

Purple – Leave Turned On Overnight

Which of the following is true about your laptop behavior?

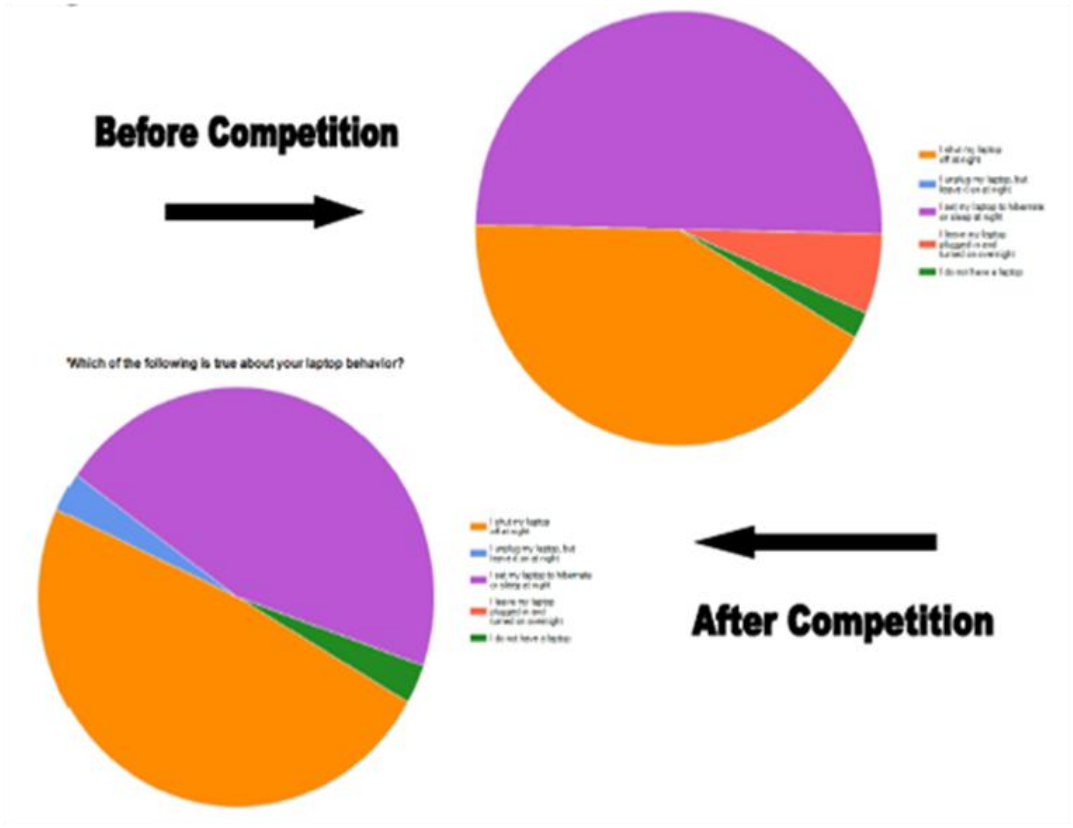


Figure 7 Laptop Behavior Before Competition

Figure 8 Laptop Behavior After Comparison

Orange – Shut off at night

Blue – Unplug but leave on at night

Purple – Set to hibernate or sleep at night

Red- Leave plugged in and turned on

Green- Do not have a laptop

Figure 8 also shows that more lights were turned off after the competition.

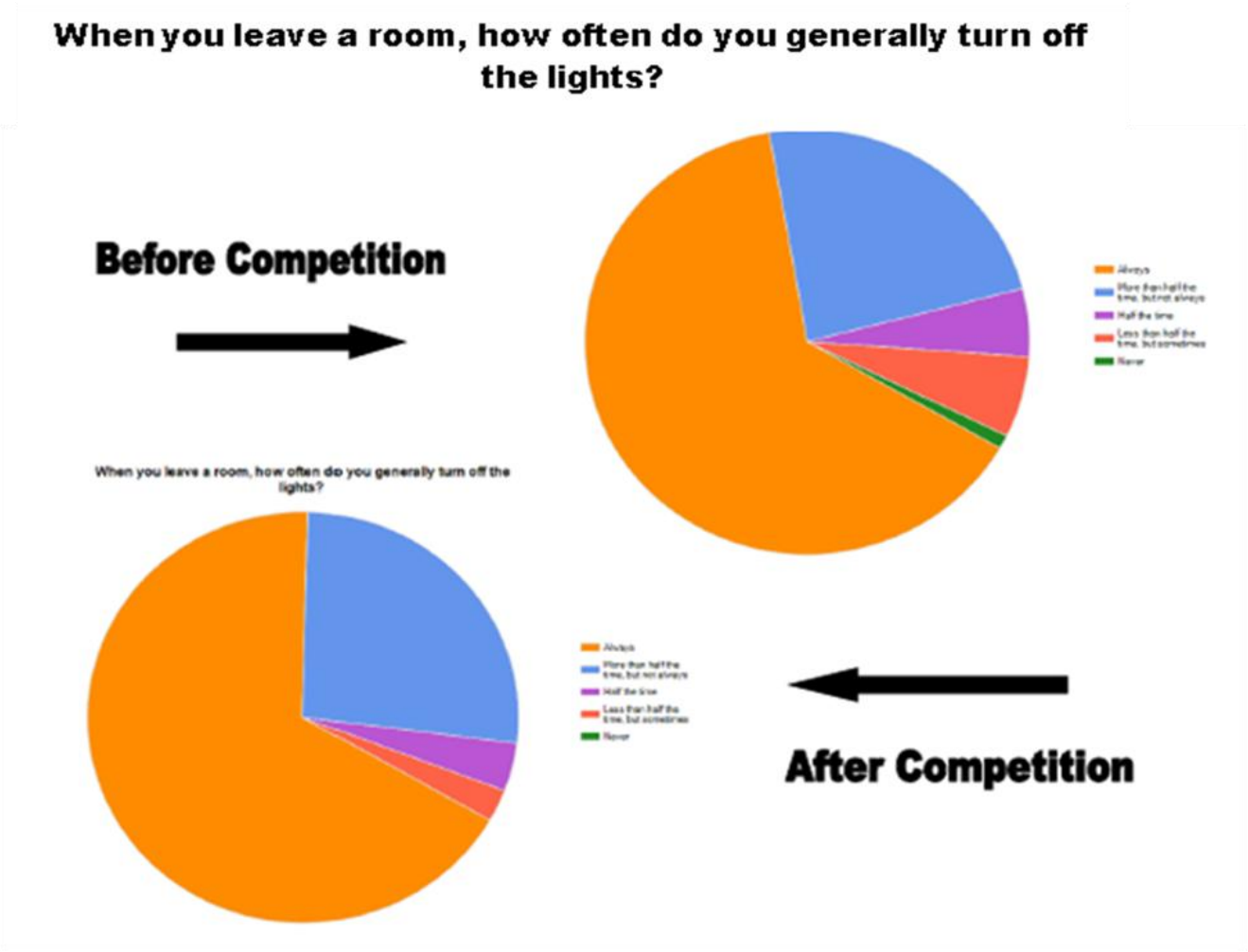


Figure 9 Before Competition **Figure 10** After competition

Orange – Always

Blue – More than half the time, but not always

Purple – Half the time

Red- Less than half the time, but sometimes

Green- Never

Results: Survey I

The first of two online surveys were distributed through Survey Monkey, one week prior to the energy competition. Email reminders were sent to Stoddard, Institute, and Riley. Stoddard's response was 22%. Institute had the lowest response with a 13% return, and the control group Riley response with a high of 32%.

Of 154 Stoddard residents, 34 responded to the initial survey, which accounts for 22% of the total population. Twenty-five students checked they have televisions in their rooms and 96% leave them plugged in overnight. On question two, 32 students checked they use device chargers and 87.5% leave them plugged in overnight. Thirty students use power strips and 16.7% keep them turned on overnight. Fifteen students, or 44.0% of respondents, marked the response they turn off their laptops at night. An additional 41.2% switched their laptops to hibernation mode overnight.

Of the 66 students living in Institute, nine or 13% completed the initial survey. Six respondents have televisions in their rooms and 100% leave them plugged in overnight. For question two, nine students checked they use device chargers and 100% keep them plugged in overnight. Eight of the nine respondents use power strips and none responded that they turn them off overnight. Six of nine students, representing 66.7% of the students who competed the survey said they turn-off their laptops at night.

The results from Riley's survey are based on a return of 50 out of 154 student surveys. That amounts to 32% of hall residents. Thirty-three respondents checked they have televisions in their rooms; 97.0% said they leave them plugged in overnight. Forty-seven students checked they leave device chargers plugged in overnight. Of 50 respondents, 48 use power strips but only 10% turn them off at night. For laptop usage, 42% of Riley respondents turn them off at night and 50% leave them in hibernation mode. Refer to Appendix A, 2.1 to 5.3, for visuals representing the results of survey one.

Results: Survey 2

There was a 22% response rate by Stoddard residents on the final survey. This was the same percentage as the first survey. However, the percent reduction for students' leaving TV's plugged in overnight dropped from 96.0% to 88.0%. Question 2 asked how much effort participants put into conserving energy. Only 17% of the thirty-five respondents said they put a lot of effort into the competition, although 51.4% said they put a fair amount of effort into the competition.

Feedback was an issue for 62.9% of Stoddard respondents. On the final survey they indicated efforts would have increased if they had known how much money they were saving. We were pleased that 62.9% of the responding students also said they are willing to participate in future energy competitions (question 6) and 38.2% of the participants responded they were more aware of energy conservation since the competition.

A post competition analysis of appliance use showed a drop in the number of appliances left on overnight. Figure 8 shows that more lights were turned off after the competition.

There was no change in the percent of Institute residents' response on survey two. It remained at 13%. Seven checked they have a TV in their room, and 85% leave the TV plugged in overnight. That was a reduction from the pre-competition survey that showed 100% of respondents left their TV's plugged in. There was a significant reduction in the number of students who turned off power strips at night after the competition. In the second survey, 85.7% left power strips turned on overnight. This is a 12.5 reduction from the first survey that was taken a week before the energy competition.

Question 6 on the final survey demonstrates 66.7% of students who responded are willing to participate in competitions that involve energy conservation. Also, 55.6% of students responded they are more aware of energy and related issues since the energy initiative. Based on this observation it is likely that a larger energy savings competition would be of interest to more than the halls used in this project. However, for this to occur, each building would need an individual meter or a sub meter that would allow for individual readings for each residence.

While the data from survey results was informative, it is not absolute. Student apathy contributed to a varied and low percentage response to the survey. We were pleased that the results of the final survey conveyed the message that students are willing to participate in future energy conservation programs. A larger sample and return is necessary for a more accurate of residential students' energy consumption.

The final survey did not apply to Riley residents because they did not participate in the competition. The questions on the second survey focused on behavior changes resulting from the competition.

While the data from survey results was informative, it is not absolute. Student apathy contributed to a varied and low percentage response to the survey. We were pleased that the results of the final survey conveyed the message that students are willing to participate in future energy

conservation programs. A larger sample and return is necessary for a more accurate of residential students' energy consumption.

Upon review of both surveys, it is obvious that there is room for improvement in terms of educating students on the environmental impacts of energy usage and for implementing future energy conservation competitions. Recommendations are included in the recommendations section of this report.

Overall Project Analysis

Over the course of our project we had no idea what to expect in terms of the percent in energy reduction to expect in Stoddard and institute. Although we were optimistic, hoping for a 20% reduction, we knew that our feedback system was basic compared to Oberlin, one of the first colleges to implement an energy competition to encourage residential students to reduce their electricity usage. Because of their automated, real-time, monitoring and feedback system, it was unrealistic that our halls would achieve the 50% reduction achieved at Oberlin. Appendix D contains the completed data for the base readings and competition readings, as well as a graphical representation for the competition data.

The first three days of the competition did not go as well as expected. Institute and Stoddard posted a savings of only 6% and 4% respectively. During that initial period, feedback on electricity consumption for both halls was posted on hand-written charts in participating residential buildings. After three days of six and four percent reductions, we decided to email results along with energy saving tips to reduce usage. The introduction of the first email update changed readings dramatically, showing a peak reduction of 12.4% by Stoddard and 10.4% by Institute. The email updates increased hall spirit and heightened students' competitive spirit. Compared to the individual postings on each floor, the emailed updates were considerably more effective in motivating students to reduce resource use. We discovered some RA's had not put up the conservation posters or handed out individual, conservation-saving cards on day three. And immediately put up posters and distributed as many cards as we could. However, the online reminders and postings were definitely the most effective feedback tool at our disposal.

There are many unpredictable variables that can impact electricity consumption and weather was a factor that we could not anticipate. On November 20th it rained the entire day. Now this was no gentle rain but a deluge that kept most students in their dorms as opposed to going outside as usual. There was a noticeable energy spike in both buildings that day for the highest daily usage totals of the competition. The weather was relatively constant, with temperatures dropping toward the middle of the week and rising again at the end. During the competition, the daily mean temperature was almost always higher than the yearly average. If the weather had turned colder during the competition, residential students may have turned up the heat, causing a spike in electricity usage. Thankfully, the warm temperature and low precipitation levels resulted in

moderate electricity consumption. All temperature and weather data was obtained online. (Wunderground, 2009)

One of the most important conclusions, that we aimed to determine from an analysis of competition results, was the amount of money WPI saved from students' conservation efforts. To calculate savings we needed information electrical rates. The information was not easy to get because WPI purchases power from Direct Energy but still needs to pay National Grid for transportation from the power plant to the university. Because National Grid, and not Direct Energy, transports power to the WPI campus, charges come from both sources. The National Grid bills are considerably more complex than the Direct Energy bills. To obtain the rate for power usage used in making calculations for the project, we divided the National Grid bill for December by the amount of kW hrs used in that month. In order to find the totals, we needed to determine Institute and Stoddard's totals independently, because the two buildings have different transportation rates. After calculating the two rates separately, the flat rate charge for power generation by Direct Energy was added to calculate the total cost of power. After determining the rate, we found WPI had saved $216.43 over the nine days of the competition. Originally this value seemed too low for the competition. However, considering there were only 250 participants, or 10% of the residential student population, that was actually a reasonable amount of savings. If the program was expanded to include freshman housing, the addition Morgan, Daniels, and Riley, three large population buildings, predicted savings are approximately $850.00 total.

Overall the data that was received appeared to be consistent enough compared to the previous year and to data taken from bills for the month before and after the competition. While $216.00 is not a substantial savings, with better feedback technology and metering, as well as more time for planning, and education, future energy initiatives could generate higher savings. The following calculations were used to determine money saved and kWh saved:

kWhrs Saved = kWhrs used during competition * Average % reduction at end of competition = ((11/25) * measurement – (11//16) * measurement) * Meter Multiplier * average % reduction

kWhrs Saved for Institute = (23842 – 23799) * 80 *0.10416667 = 358.333 kWhrs

kWhrs Saved for Stoddard = (07903 – 07860) * 400 * 0.085106383 = 1464.817 kWhrs

Total kWhrs Saved = kWhrs Saved for Institute + kWhrs Saved for Stoddard =358.333 + 1464.8178 = 1823.15 kWhrs

Money Saved Institute = (0.08746 + 0.03964) * 358.333 = $45.54

Money Saved Stoddard = (0.08746 + 0.02920) * 1464.8178 = $170.88

Total Money Saved = $45.45 + $170.88 = $216.43

Recommendations

The ability to communicate clearly, and to work effectively as part of a team, is best learned through real life experiences. WPI's Interactive Qualifying Project (IQP) has given us an opportunity to apply critical and creative thinking skills to address real problems in society. As part of the process, we also had a chance to develop important communication skills, essential for making the transition from classroom to boardroom.

Upon reviewing the project, Assessing and Reducing the Electricity Consumption of Residential Students, it became clear that this is not a one team project. Although we achieved some of our objectives, we discovered that the scope of the project requires a far greater timeframe than two terms. The work that we did barely scratches the surface of addressing the issue of energy conservation on campus. However, our IQP can serve as a cornerstone for related projects.

As a team we did accomplish our primary objectives. However, several factors created challenges for us that affected quality in some areas. Clearly, team dynamics impacted final outcomes. Communication issues created challenges. To move forward as a team, we needed to establish unity of purpose and develop a protocol for sharing information and responsibilities. In retrospect, social issues should have been worked out before starting the project. Ultimately we managed to resolve many issues and move forward as a team. It was not easy to replace an "I" mindset for a "we" approach to problem solving.

In looking back over the past 14 weeks, we can take pride in having organized and hosted the first energy savings competition on campus. Although it is hard to quantify an attitude change, from conversations with participants at the winner's dinner party, we know the energy competition, conservation posters and emails from our group raised awareness of the need to rethink our energy usage behaviors. In our post competition, energy survey, 55.6% of the Institute respondents said they became aware of energy conservation and other related topics during the three weeks surrounding the energy competition. At the post competition dinner, many students told us they will continue to implement energy saving actions introduced through our project. An analysis of the energy competition results showed a 10.41% reduction in electricity usage by Institute residents, and an 8.5% reduction in consumption by Stoddard residents. With additional time and a better feedback system, we are confident those numbers would be higher. However, considering the actual amount of contact time we had with students was limited to three weeks that was a credible result.

Given the varied personalities of group members, as well as different schedules and work ethics, we found it challenging to come together as a team. Through dialogue and support from advisors, we ultimately worked through many stressful and frustrating situations and completed the project. Based on our experiences, we recommend the addition of a team building component, similar to the pre qualifying project (PQP) component of the Global Perspectives

Program. Adding a PQP component would help individuals develop a team mindset and establish mutually shared goals. On the other hand, if students got together and discovered they were not really suited to working together, they would still have time to join another group.

Time management was an issue that presented an opportunity to develop additional life skills. As a group, we decided to complete our IQP in two rather than three terms. Given the fact two team members scheduled class overloads, expectations were different for the team member on a reduced schedule. The combination of a shortened timetable and unequal division of labor resulted in conflict. However, with support from advisors and increased dialogue among group members, we solved many of our issues.

During the research and planning stages of our IQP, it was necessary to contact a number of individuals for background information. Access to electrical meters and utility records also had to be worked out. Making contact with the right personnel and getting them to respond, took a lot of effort. Although we realize each contact had their own priorities, it was frustrating when responses were delayed. Patience and persistence was necessary to gain information from WPI staff and off campus resources. In looking back, we have to accept some responsibility for setbacks. On occasion, our organization could have been better. That would have eliminated the need to ask for information that we probably should have requested sooner, to give contacts a reasonable amount of time to respond. On a more positive note, we did follow-through and make multiple, courteous, requests when necessary.

Delayed responses did put us behind schedule even more. We were forced to make adjustments and proceed. The results were not always of the quality we wanted, but sometimes you just have to accept the situation and keep moving forward. A greater frustration was missed deadlines by team members. Again, communication was a key. Alterations were made, other teammates picked up the slack and we move forward.

By the midpoint of Term B, we realized that we could not meet our final project deadline and complete the project analysis and write a final report by the end of the term, if the competition was held after Thanksgiving. We rushed to send out the pre-competition survey and moved up the timetable for the energy competition. A third term would have eliminated the rush.

The more students know about the consequences of their energy consumption, the more likely they are to put forth serious effort to conserve energy, during and after the competition. We would have done more to educate students on human impacts on global warming if there had been more time. This is something future IQP teams may want to consider. Also, we could have done a more thorough job of soliciting support from RA's and other students to generate interest and motivate greater participation in the energy savings contest. In retrospect, we did not plan

enough time to get the word out or do the best job we could to educate residential students on strategies they could use to reduce electricity consumption in residence halls..

Feedback was an issue. We did send out emails about the energy contest and put up posters. With hindsight, we would have included more information on emails about the rationale for our project and included specifics on the benefits of saving energy, as incentives for greater participation. An analysis of the competition data showed residents of Institute Hall reduced their electricity usage by 10.41% over a nine day period. There was an 8.5% reduction in electricity consumption by Stoddard residents during that time. If the competition was extended to include more residence halls and time, we predict energy savings would increase.

We hope the first energy competition sets a precedent for future energy awareness initiatives. When the energy contest is held again (and we hope that it will be), other marketing strategies could include coverage in the student newspaper, more posters distributed throughout the campus, including the campus center and academic buildings. Timing the event to coincide with other campus initiatives such as Earth Day, National Teach-In Day or a Green Team program could generate increased participation. Another suggestion is to organize a campus, energy conservation poster contest. All entries would be displayed in the campus center and students could vote for their favorites. The two posters with the most votes would be printed and used for the energy competition.

During the competition we attempted to keep participants motivated by providing feedback. We posted daily results on charts in participating halls. Our expectation was that daily feedback would increase competitive spirit and results. The postings showed the percentage of energy saved by each building. However, after analyzing the post competition survey, we suggest posting the amount of money saved by the percent reduction of electricity used.

On question 4 of the final energy survey, we asked: Would you be more likely to conserve energy if you knew how much money it saved? Of the 79 respondents, 56 said they would have worked harder to conserve energy if they could equate the percentage of savings to a monetary figure. Refer to Appendix B, Figure 1.1. Based on survey results, we recommend providing more concrete feedback that relates results monetary outcomes. Students can relate to saving money. It would be worthwhile to calculate the actual money saved. If Institute Hall students were told their 10.4% reduction in energy usage equated to an additional $4.56 we are confident the following week energy savings would increase the following week. Regardless of their motivation, any strategy that increases students' awareness and willingness to reduce resource consumption is worth considering. One of our project goals for students to reduce electricity usage energy savings habits are in residence halls. Although the net reduction in both Stoddard and Institute were less than we hoped for, 10.4% and 8.5% are better than increased consumption.

In the post-competition survey, 25 of 78 respondents said they would be more willing to participate in a similar competition if the reward was worth it. The prize for our energy competition was a catered dinner for the winning hall. The funding for this incentive was provided courtesy of WPI's president, Dr. Dennis Berkey. We appreciate his support of our energy initiative. Most students enjoyed and thanked us for the dinner party. Only a few people complained that they expected a bigger or better reward. With more time to secure additional funding, a larger incentive could have been offered and participation might have increased.

For the future energy competitions, we recommend a different incentive based on school spirit – an inscribed trophy. Students from winning halls for the Goat's Head Competition seem excited and proud to have their residence hall's and year engraved on a trophy that is passed on from winner to winner each year. In that way, they become part of WPI's recorded history.

Although WPI is a school noted for its high tech programs, the metering system on our campus is outdated. The current metering system does not monitor electricity consumption of buildings on an individual basis. Some buildings share meters with other facilities. That makes it impossible to target buildings with the highest electricity usage and compare them to more efficient facilities.

Our competition was possible because some buildings on campus have individual meters. After identifying the residence halls that have their own meters, chose Founders to compete against Institute in the energy competition. However, the location of the Founders meter, in the campus police office, made access excessively difficult. Security did not want to grant access and made it untenable for us to do so. When security could not guarantee access to collect data at Founders the same time each day, we adjusted our plan and switched to Stoddard Hall.

In anticipation of future energy projects that involve assessing electricity usage in residential buildings, we suggest the Founders meter be moved to a location that could be reached without compromising security operations. Installation of individual meters in all campus buildings is something the administration and Facilities Department should continue to look into. We were pleased to hear that individual meters are scheduled for installation at Riley, Daniels and Morgan Halls during the 2009-2010 school year, and eventually all buildings on campus will have individual or sub meters, making it possible to record individual consumption. Until all buildings have that capability, the free Google Power Meter, accessible online, is a viable alternative on campus. (Google, 2009)

In researching colleges and universities that have significantly reduced their electricity consumption in residential buildings, real-time monitoring, feedback systems were a key to their success. For our project, we did not have access to the technology use at the top schools, including Oberlin or Dartmouth. We had to physically walk to each building (Stoddard & Institute) and manually record meter readings. We posted the results on hand-written charts placed in participating halls. After the third day, of the energy competition, we decided to send out email updates with daily usage totals. We hoped to generate enthusiasm and better participation, as the numbers were disappointing. The emails did seem to generate a slight increase in participation.

Upon review of our project, we have identified weaknesses and discussed steps that can be taken by future groups to build and improve upon our processes to increase energy conservation on campus. Time is essential. We recommend taking three or even four terms, to allow adequate time for research, planning, and implementation. Build more time than you think you need into the research and planning states. If you rush through either of those phases, implementation will be less effective.

We highly recommend future teams secure support from administration, faculty, and staff, particularly residential and facilities staff. Student organizations (the Green Team etc.) and committees (President's Task Force on Sustainability) could also provide support through funding and expertise. Enlist volunteers to spread the word of the energy contest by putting up posters, distributing literature and talking to friends about energy conservation.

There are many schools in Worcester that are committed to conservation. Consider establishing a partnership with area schools, Clark University, Worcester State and Holy Cross. The too have sustainability programs and may be interested in forming a cooperative resource conservation program. With additional manpower, funding, publicity, and more prestigious reward, greater participation in the energy competition would be improved. If every building on campus lowered their energy consumption by even 10-15% per year, the savings to WPI would be significant. In addition to lower utilities costs, the school's carbon footprint would be substantially reduced. And that is a benefit to all of society.

A final area of improvement is out of the control of student project groups, but needs to be addressed, is WPI's metering system. Installation of individual meters or sub meters is essential to identifying buildings with the highest consumption. Improving the meter system to one with real-time feedback capabilities that would monitor buildings individually, and even by floor or room, would allow waste to be targeted and dealt with.

Our project was a first step in the right direction toward environmental awareness and energy conservation. We invite other student groups to continue where we left off and accept the challenge of mitigating human impacts on global warming.

Conclusion

Through the course of this project, a number of objectives were achieved. We collected meter data to evaluate electricity usage at two of WPI's twelve residence halls. Stoddard and Institute Halls were chosen for the project because they have individual electrical meters. Many campus residences have shared meter, making it impossible to determine energy usage on an individual basis.

A survey of electricity consumption, for students in Stoddard and Institute, was completed and electricity usage trends were established for those halls. Baseline data was also collected from Riley our control group. Although it is difficult to quantify attitude changes, the energy surveys demonstrated greater awareness of environmental issues related to electricity usage, due to our project. Conservation posters, individual, energy information cards, and emailed conservation tips, were sent out regularly to increase environmental literacy. Also WPI's first energy savings competition was organized and held in November of 2009. Stoddard and Institute participated in this pilot energy program. We hope that it will serve as a precedent for future energy conservation initiatives on campus.

Throughout the IQP we enhanced critical and creative thinking skills, and learned to communicate more effectively. As a team we take pride in meeting our primary objectives. We hope the energy conservation competition that we piloted will serve as a foundation for similar energy conservation initiatives in the future.

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Appendix A

1.1 Energy Survey I

Energy Survey

1. Default Section

1. Which residence hall do you currently live in?

- ◯ Institute
- ◯ Riley
- ◯ Stoddard

2. Do You. (please check all that apply)

	Use in your room	Leave plugged in overnight	Leave turned ON overnight
Television(s)	☐	☐	☐
DVD Player	☐	☐	☐
VCR	☐	☐	☐
Printer	☐	☐	☐
Fan(s)	☐	☐	☐
Video Game Console (s)	☐	☐	☐
Desk Lamp(s)	☐	☐	☐
Floor Lamp(s)	☐	☐	☐
Microwave	☐	☐	☐
Extension Cord(s)	☐	☐	☐
Device Charger(s)	☐	☐	☐
Refrigerator	☐	☐	☐

3. Power Strips

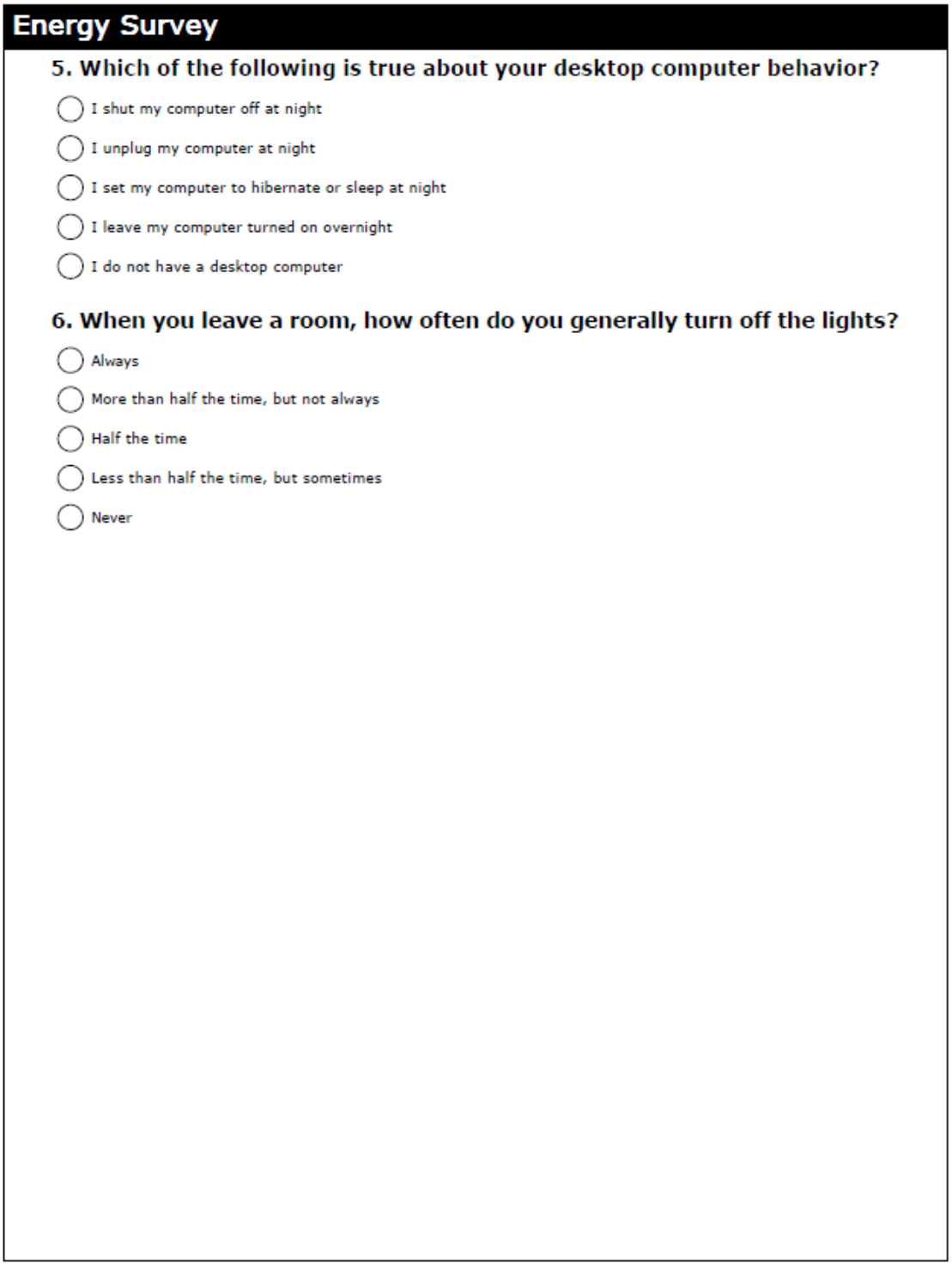
	Yes	No
Do you use powers strips?	◯	◯
Do you unplug or turn off your power strip at night? (if you do not use power strips please leave blank)	◯	◯

4. Which of the following is true about your laptop behavior?

- ◯ I shut my laptop off at night
- ◯ I unplug my laptop, but leave it on at night
- ◯ I set my laptop to hibernate or sleep at night
- ◯ I leave my laptop plugged in and turned on overnight
- ◯ I do not have a laptop

Appendix A

1.2



Energy Survey

5. Which of the following is true about your desktop computer behavior?

- ◯ I shut my computer off at night
- ◯ I unplug my computer at night
- ◯ I set my computer to hibernate or sleep at night
- ◯ I leave my computer turned on overnight
- ◯ I do not have a desktop computer

6. When you leave a room, how often do you generally turn off the lights?

- ◯ Always
- ◯ More than half the time, but not always
- ◯ Half the time
- ◯ Less than half the time, but sometimes
- ◯ Never

Appendix A

2.1 All Buildings Survey I Data

Energy Survey

1. Which residence hall do you currently live in?

	Response Percent	Response Count
Stoddard	36.6%	34
Institute	9.7%	9
Riley	**53.8%**	**50**
answered question		**93**
skipped question		**4**

2. Do You. (please check all that apply)

	Use in your room	Leave plugged in overnight	Leave turned ON overnight	Response Count
Television(s)	94.0% (63)	**97.0% (65)**	1.5% (1)	67
DVD Player	80.0% (12)	**86.7% (13)**	6.7% (1)	15
VCR	**83.3% (5)**	**83.3% (5)**	0.0% (0)	6
Printer	**92.1% (70)**	78.9% (60)	25.0% (19)	76
Fan(s)	**92.3% (72)**	73.1% (57)	24.4% (19)	78
Video Game Console(s)	**97.3% (36)**	83.8% (31)	0.0% (0)	37
Desk Lamp(s)	**94.8% (73)**	85.7% (66)	0.0% (0)	77
Floor Lamp(s)	75.0% (9)	**100.0% (12)**	0.0% (0)	12
Microwave	**97.5% (79)**	95.1% (77)	23.5% (19)	81
Extension Cord(s)	**92.9% (78)**	**92.9% (78)**	31.0% (26)	84
Device Charger(s)	**95.7% (88)**	84.8% (78)	34.8% (32)	92
Refrigerator	**96.7% (88)**	91.2% (83)	79.1% (72)	91
answered question				**97**
skipped question				**0**

Appendix A

2.2 All Buildings Survey Data

3. Power Strips

	Yes	No	Response Count
Do you use powers strips?	**91.8% (89)**	8.2% (8)	97
Do you unplug or turn off your power strip at night? (if you do not use power strips please leave blank)	12.6% (11)	**87.4% (76)**	87
		answered question	**97**
		skipped question	**0**

4. Which of the following is true about your laptop behavior?

	Response Percent	Response Count
I shut my laptop off at night	**44.3%**	**43**
I unplug my laptop, but leave it on at night	1.0%	1
I set my laptop to hibernate or sleep at night	43.3%	42
I leave my laptop plugged in and turned on overnight	6.2%	6
I do not have a laptop	5.2%	5
	answered question	**97**
	skipped question	**0**

Appendix A

2.3 All Buildings Survey I Data

5. Which of the following is true about your desktop computer behavior?

	Response Percent	Response Count
I shut my computer off at night	9.6%	9
I unplug my computer at night	0.0%	0
I set my computer to hibernate or sleep at night	5.3%	5
I leave my computer turned on overnight	1.1%	1
I do not have a desktop computer	**84.0%**	**79**
answered question		**94**
skipped question		**3**

6. When you leave a room, how often do you generally turn off the lights?

	Response Percent	Response Count
Always	**63.9%**	**62**
More than half the time, but not always	23.7%	23
Half the time	5.2%	5
Less than half the time, but sometimes	6.2%	6
Never	1.0%	1
answered question		**97**
skipped question		**0**

Appendix A

3.1 Institute Survey I Data

Energy Survey

1. Which residence hall do you currently live in?

	Response Percent	Response Count
Stoddard	0.0%	0
Institute	**100.0%**	**9**
Riley	0.0%	0
answered question		**9**
skipped question		**0**

2. Do You. (please check all that apply)

	Use in your room	Leave plugged in overnight	Leave turned ON overnight	Response Count
Television(s)	**100.0% (6)**	**100.0% (6)**	0.0% (0)	6
DVD Player	0.0% (0)	0.0% (0)	0.0% (0)	0
VCR	0.0% (0)	0.0% (0)	0.0% (0)	0
Printer	**100.0% (5)**	80.0% (4)	0.0% (0)	5
Fan(s)	**100.0% (7)**	85.7% (6)	42.9% (3)	7
Video Game Console(s)	**100.0% (5)**	**100.0% (5)**	0.0% (0)	5
Desk Lamp(s)	**100.0% (8)**	**100.0% (8)**	0.0% (0)	8
Floor Lamp(s)	66.7% (2)	**100.0% (3)**	0.0% (0)	3
Microwave	**100.0% (9)**	88.9% (8)	33.3% (3)	9
Extension Cord(s)	**100.0% (7)**	**100.0% (7)**	57.1% (4)	7
Device Charger(s)	**100.0% (9)**	**100.0% (9)**	33.3% (3)	9
Refrigerator	**100.0% (9)**	77.8% (7)	66.7% (6)	9
answered question				**9**
skipped question				**0**

Appendix A

3.2 Institute Survey I Data

3. Power Strips

	Yes	No	Response Count
Do you use powers strips?	**88.9% (8)**	11.1% (1)	9
Do you unplug or turn off your power strip at night? (if you do not use power strips please leave blank)	0.0% (0)	**100.0% (8)**	8
		answered question	**9**
		skipped question	**0**

4. Which of the following is true about your laptop behavior?

	Response Percent	Response Count
I shut my laptop off at night	**66.7%**	**6**
I unplug my laptop, but leave it on at night	11.1%	1
I set my laptop to hibernate or sleep at night	11.1%	1
I leave my laptop plugged in and turned on overnight	0.0%	0
I do not have a laptop	11.1%	1
	answered question	**9**
	skipped question	**0**

Appendix A

3.3 Institute Survey I Data

5. Which of the following is true about your desktop computer behavior?

	Response Percent	Response Count
I shut my computer off at night	33.3%	3
I unplug my computer at night	0.0%	0
I set my computer to hibernate or sleep at night	0.0%	0
I leave my computer turned on overnight	0.0%	0
I do not have a desktop computer	**66.7%**	**6**
answered question		**9**
skipped question		**0**

6. When you leave a room, how often do you generally turn off the lights?

	Response Percent	Response Count
Always	**77.8%**	**7**
More than half the time, but not always	22.2%	2
Half the time	0.0%	0
Less than half the time, but sometimes	0.0%	0
Never	0.0%	0
answered question		**9**
skipped question		**0**

Appendix A

4.1 Stoddard Survey 1 Data

Energy Survey

1. Which residence hall do you currently live in?

	Response Percent	Response Count
Stoddard	**100.0%**	**34**
Institute	0.0%	0
Riley	0.0%	0
answered question		**34**
skipped question		**0**

2. Do You. (please check all that apply)

	Use in your room	Leave plugged in overnight	Leave turned ON overnight	Response Count
Television(s)	92.0% (23)	**96.0% (24)**	0.0% (0)	25
DVD Player	66.7% (4)	**83.3% (5)**	0.0% (0)	6
VCR	66.7% (2)	**100.0% (3)**	0.0% (0)	3
Printer	**92.0% (23)**	88.0% (22)	36.0% (9)	25
Fan(s)	**88.0% (22)**	64.0% (16)	20.0% (5)	25
Video Game Console(s)	**90.0% (9)**	**90.0% (9)**	0.0% (0)	10
Desk Lamp(s)	**95.8% (23)**	79.2% (19)	0.0% (0)	24
Floor Lamp(s)	75.0% (3)	**100.0% (4)**	0.0% (0)	4
Microwave	**96.6% (28)**	**96.6% (28)**	27.6% (8)	29
Extension Cord(s)	**92.9% (26)**	89.3% (25)	25.0% (7)	28
Device Charger(s)	**93.8% (30)**	87.5% (28)	21.9% (7)	32
Refrigerator	**96.8% (30)**	93.5% (29)	74.2% (23)	31
answered question				**34**
skipped question				**0**

Appendix A

4.2 Stoddard Survey I Data

3. Power Strips

	Yes	No	Response Count
Do you use powers strips?	**88.2% (30)**	11.8% (4)	34
Do you unplug or turn off your power strip at night? (if you do not use power strips please leave blank)	16.7% (5)	**83.3% (25)**	30
		answered question	**34**
		skipped question	**0**

4. Which of the following is true about your laptop behavior?

	Response Percent	Response Count
I shut my laptop off at night	**44.1%**	**15**
I unplug my laptop, but leave it on at night	0.0%	0
I set my laptop to hibernate or sleep at night	41.2%	14
I leave my laptop plugged in and turned on overnight	5.9%	2
I do not have a laptop	8.8%	3
	answered question	**34**
	skipped question	**0**

Appendix A

4.3 Stoddard Survey I Data

5. Which of the following is true about your desktop computer behavior?

	Response Percent	Response Count
I shut my computer off at night	6.1%	2
I unplug my computer at night	0.0%	0
I set my computer to hibernate or sleep at night	9.1%	3
I leave my computer turned on overnight	3.0%	1
I do not have a desktop computer	**81.8%**	**27**
answered question		**33**
skipped question		**1**

6. When you leave a room, how often do you generally turn off the lights?

	Response Percent	Response Count
Always	**79.4%**	**27**
More than half the time, but not always	11.8%	4
Half the time	5.9%	2
Less than half the time, but sometimes	2.9%	1
Never	0.0%	0
answered question		**34**
skipped question		**0**

Appendix A

5.1 Riley Survey I Data

Energy Survey

1. Which residence hall do you currently live in?

	Response Percent	Response Count
Stoddard	0.0%	0
Institute	0.0%	0
Riley	**100.0%**	**50**
answered question		**50**
skipped question		**0**

2. Do You. (please check all that apply)

	Use in your room	Leave plugged in overnight	Leave turned ON overnight	Response Count
Television(s)	93.9% (31)	**97.0% (32)**	3.0% (1)	33
DVD Player	**88.9% (8)**	**88.9% (8)**	11.1% (1)	9
VCR	**100.0% (3)**	66.7% (2)	0.0% (0)	3
Printer	**92.9% (39)**	71.4% (30)	21.4% (9)	42
Fan(s)	**93.2% (41)**	75.0% (33)	25.0% (11)	44
Video Game Console(s)	**100.0% (19)**	73.7% (14)	0.0% (0)	19
Desk Lamp(s)	**93.0% (40)**	86.0% (37)	0.0% (0)	43
Floor Lamp(s)	75.0% (3)	**100.0% (4)**	0.0% (0)	4
Microwave	**97.6% (40)**	95.1% (39)	19.5% (8)	41
Extension Cord(s)	91.3% (42)	**93.5% (43)**	32.6% (15)	46
Device Charger(s)	**95.7% (45)**	80.9% (38)	46.8% (22)	47
Refrigerator	**95.7% (45)**	91.5% (43)	87.2% (41)	47
answered question				**50**
skipped question				**0**

Appendix A

5.2 Riley Survey I Data

3. Power Strips

	Yes	No	Response Count
Do you use powers strips?	**96.0% (48)**	4.0% (2)	50
Do you unplug or turn off your power strip at night? (if you do not use power strips please leave blank)	10.9% (5)	**89.1% (41)**	46
		answered question	**50**
		skipped question	**0**

4. Which of the following is true about your laptop behavior?

	Response Percent	Response Count
I shut my laptop off at night	42.0%	21
I unplug my laptop, but leave it on at night	0.0%	0
I set my laptop to hibernate or sleep at night	**50.0%**	**25**
I leave my laptop plugged in and turned on overnight	6.0%	3
I do not have a laptop	2.0%	1
	answered question	**50**
	skipped question	**0**

Appendix A

5.3 Riley Survey I Data

5. Which of the following is true about your desktop computer behavior?

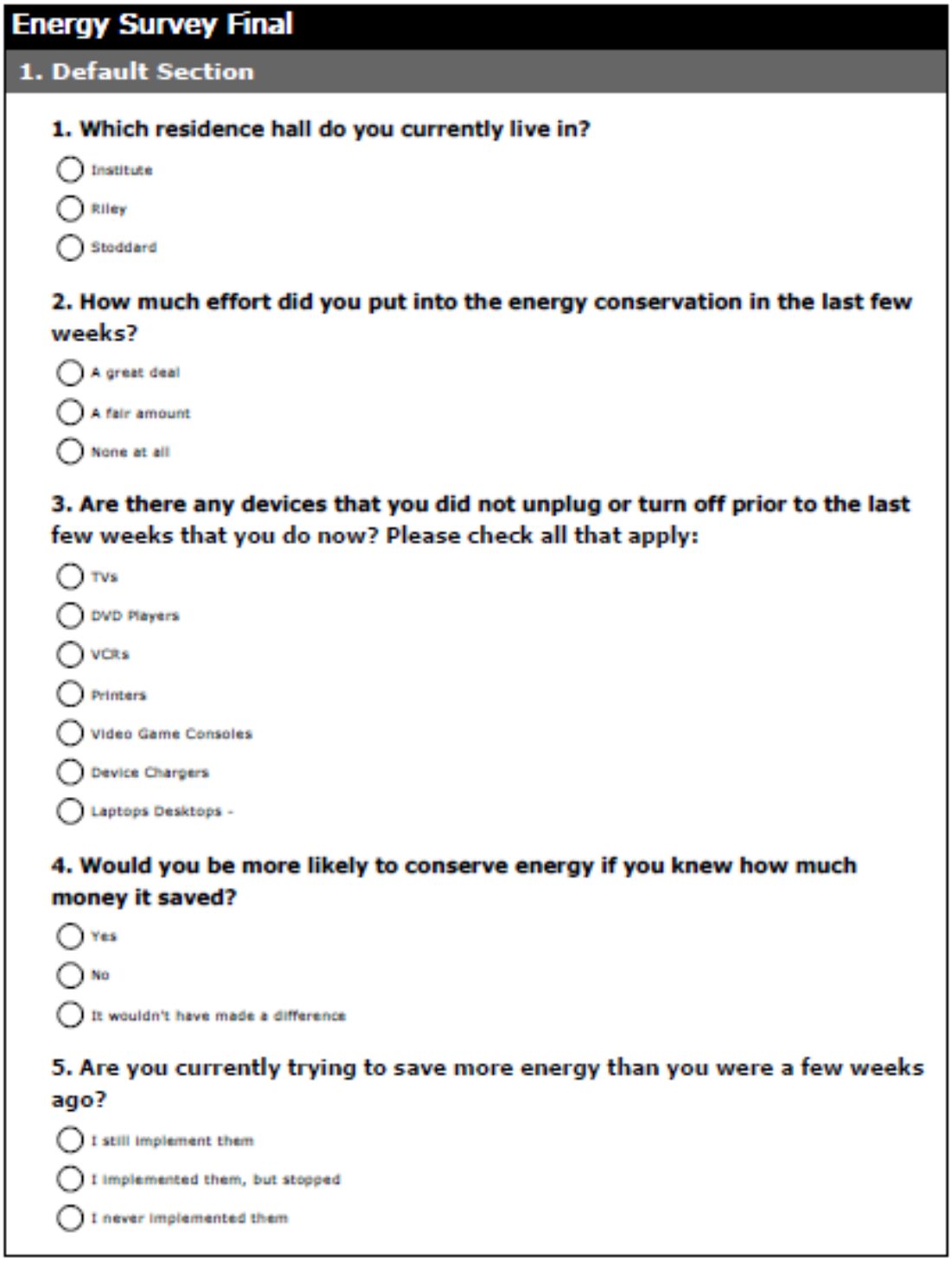
	Response Percent	Response Count
I shut my computer off at night	6.3%	3
I unplug my computer at night	0.0%	0
I set my computer to hibernate or sleep at night	4.2%	2
I leave my computer turned on overnight	0.0%	0
I do not have a desktop computer	**89.6%**	**43**
answered question		**48**
skipped question		**2**

6. When you leave a room, how often do you generally turn off the lights?

	Response Percent	Response Count
Always	**52.0%**	**26**
More than half the time, but not always	32.0%	16
Half the time	6.0%	3
Less than half the time, but sometimes	10.0%	5
Never	0.0%	0
answered question		**50**
skipped question		**0**

Appendix B

1.1 Energy Survey Final



Energy Survey Final

1. Default Section

1. Which residence hall do you currently live in?

- ◯ Institute
- ◯ Riley
- ◯ Stoddard

2. How much effort did you put into the energy conservation in the last few weeks?

- ◯ A great deal
- ◯ A fair amount
- ◯ None at all

3. Are there any devices that you did not unplug or turn off prior to the last few weeks that you do now? Please check all that apply:

- ◯ TVs
- ◯ DVD Players
- ◯ VCRs
- ◯ Printers
- ◯ Video Game Consoles
- ◯ Device Chargers
- ◯ Laptops Desktops -

4. Would you be more likely to conserve energy if you knew how much money it saved?

- ◯ Yes
- ◯ No
- ◯ It wouldn't have made a difference

5. Are you currently trying to save more energy than you were a few weeks ago?

- ◯ I still implement them
- ◯ I implemented them, but stopped
- ◯ I never implemented them

Appendix B

1.2 Energy Survey Final

Energy Survey Final

6. Would you be willing to participate in future competitions that help to save energy?

- ◯ Yes
- ◯ No
- ◯ Only if there is a good reward

7. Did you become any more aware of energy conservation or other related topics in the past couple of weeks?

- ◯ Yes
- ◯ No

8. Do You. (please check all that apply)

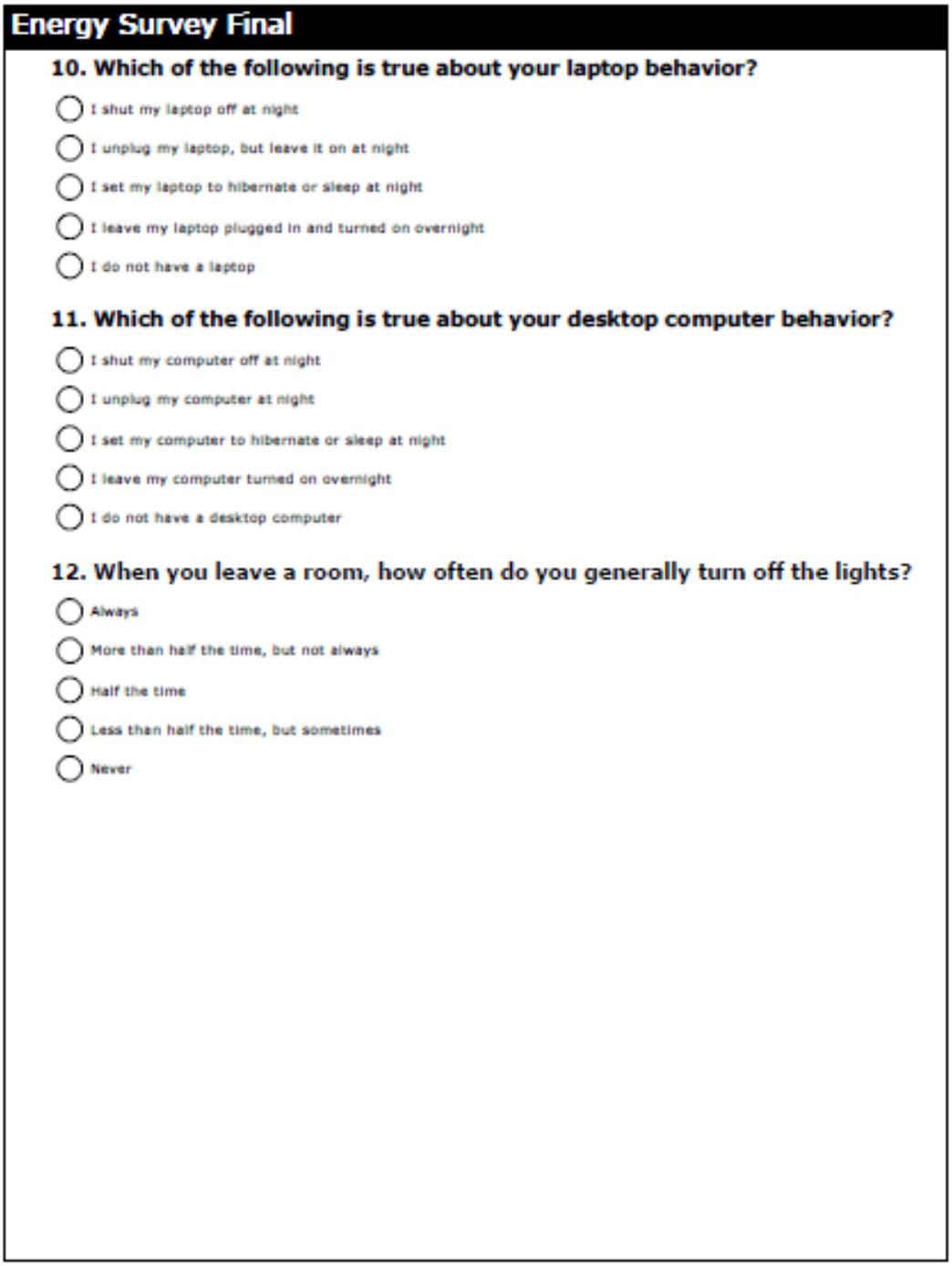
	Use in your room	Leave plugged in overnight	Leave turned ON overnight
Television(s)	☐	☐	☐
DVD Player	☐	☐	☐
VCR	☐	☐	☐
Printer	☐	☐	☐
Fan(s)	☐	☐	☐
Video Game Console (s)	☐	☐	☐
Desk Lamp(s)	☐	☐	☐
Floor Lamp(s)	☐	☐	☐
Microwave	☐	☐	☐
Extension Cord(s)	☐	☐	☐
Device Charger(s)	☐	☐	☐
Refrigerator	☐	☐	☐

9. Power Strips

	Yes	No
Do you use powers strips?	◯	◯
Do you unplug or turn off your power strip at night? (If you do not use power strips please leave blank)	◯	◯

Appendix B

1.3 Energy Survey Final



Energy Survey Final

10. Which of the following is true about your laptop behavior?

- ◯ I shut my laptop off at night
- ◯ I unplug my laptop, but leave it on at night
- ◯ I set my laptop to hibernate or sleep at night
- ◯ I leave my laptop plugged in and turned on overnight
- ◯ I do not have a laptop

11. Which of the following is true about your desktop computer behavior?

- ◯ I shut my computer off at night
- ◯ I unplug my computer at night
- ◯ I set my computer to hibernate or sleep at night
- ◯ I leave my computer turned on overnight
- ◯ I do not have a desktop computer

12. When you leave a room, how often do you generally turn off the lights?

- ◯ Always
- ◯ More than half the time, but not always
- ◯ Half the time
- ◯ Less than half the time, but sometimes
- ◯ Never

Appendix B

2.1 All Buildings Survey II Data

Energy Survey Final

1. Which residence hall do you currently live in?

	Response Percent	Response Count
Stoddard	44.3%	35
Institute	11.4%	9
Riley	44.3%	35
answered question		79
skipped question		0

2. How much effort did you put into the energy conservation in the last few weeks?

	Response Percent	Response Count
A great deal	15.2%	12
A fair amount	54.4%	43
None at all	30.4%	24
answered question		79
skipped question		0

Appendix B

2.2 All Buildings Survey II Data

3. Are there any devioes that you did not unplug or turn off prior to the last few weeks that you do now? Please oheok all that apply:

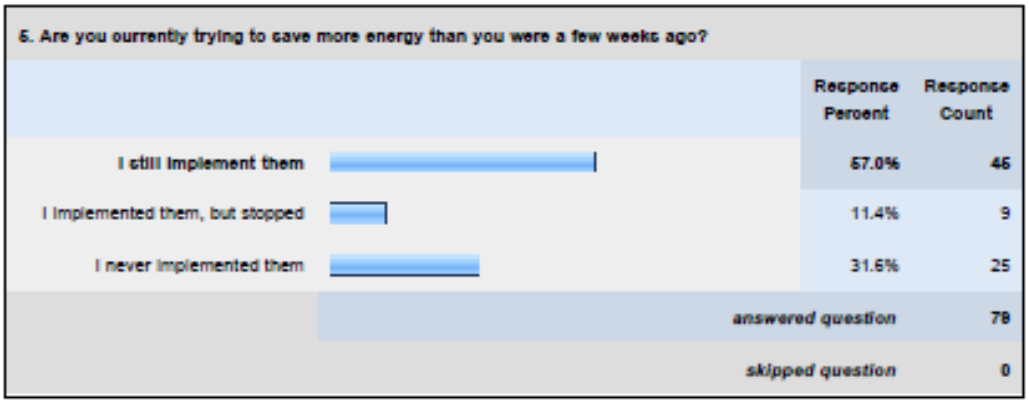
	Response Percent	Response Count
TVs	9.4%	5
DVD Players	0.0%	0
VCRs	0.0%	0
Printers	7.5%	4
Video Game Consoles	5.7%	3
Device Chargers	28.3%	15
Laptops Desktops -	49.1%	26
answered question		53
skipped question		26

4. Would you be more likely to oonserve energy if you knew how muoh money it saved?

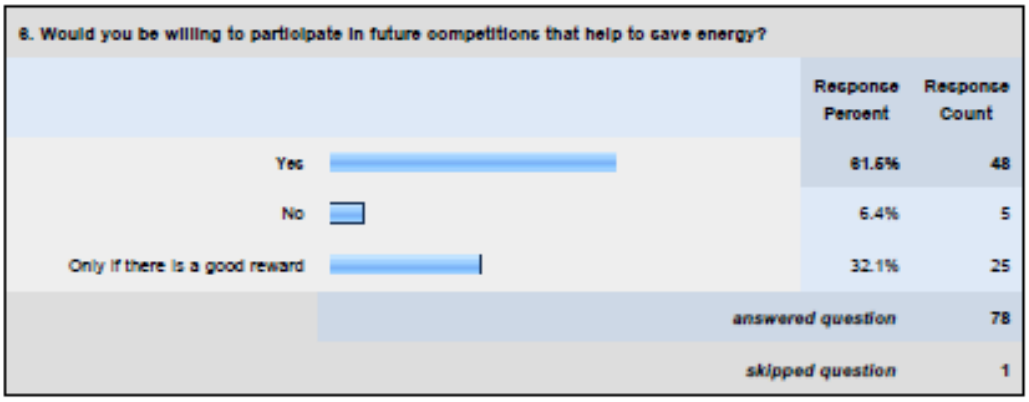
	Response Percent	Response Count
Yes	70.8%	68
No	6.3%	5
It wouldn't have made a difference	22.8%	18
answered question		78
skipped question		0

Appendix B

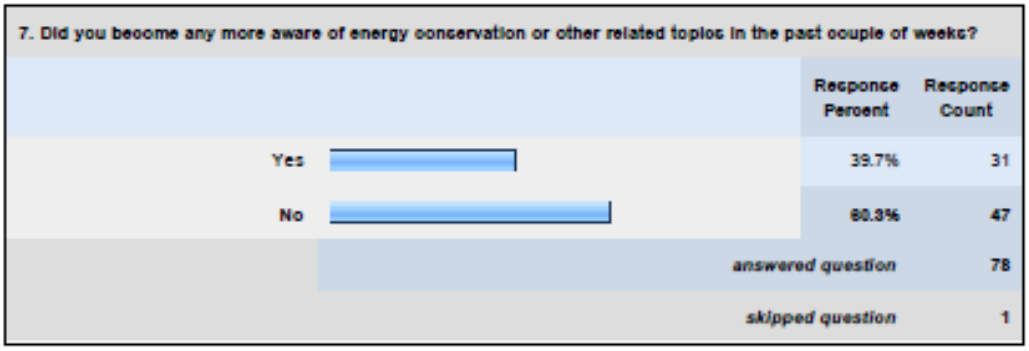
2.3 All Buildings Survey II Data



5. Are you currently trying to save more energy than you were a few weeks ago?	Response Percent	Response Count
I still implement them	57.0%	45
I implemented them, but stopped	11.4%	9
I never implemented them	31.6%	25
answered question		79
skipped question		0



6. Would you be willing to participate in future competitions that help to save energy?	Response Percent	Response Count
Yes	61.6%	48
No	6.4%	5
Only if there is a good reward	32.1%	25
answered question		78
skipped question		1



7. Did you become any more aware of energy conservation or other related topics in the past couple of weeks?	Response Percent	Response Count
Yes	39.7%	31
No	60.3%	47
answered question		78
skipped question		1

Appendix B

2.4 All Buildings Survey II Data

8. Do You. (please check all that apply)				
	Use in your room	Leave plugged in overnight	Leave turned ON overnight	Response Count
Television(s)	92.7% (51)	85.5% (47)	1.8% (1)	55
DVD Player	94.4% (17)	55.6% (10)	0.0% (0)	18
VCR	80.0% (4)	60.0% (3)	0.0% (0)	5
Printer	98.7% (58)	76.7% (46)	30.0% (18)	60
Fan(s)	93.6% (44)	66.0% (31)	29.8% (14)	47
Video Game Console(s)	96.4% (27)	67.9% (19)	0.0% (0)	28
Desk Lamp(s)	98.7% (58)	70.0% (42)	0.0% (0)	60
Floor Lamp(s)	71.4% (5)	71.4% (5)	14.3% (1)	7
Microwave	95.5% (84)	88.1% (59)	19.4% (13)	67
Extension Cord(s)	93.9% (82)	90.9% (60)	31.8% (21)	66
Device Charger(s)	97.3% (71)	67.1% (49)	19.2% (14)	73
Refrigerator	96.0% (72)	94.7% (71)	72.0% (54)	75
			answered question	78
			skipped question	0

9. Power Strips			
	Yes	No	Response Count
Do you use powers strips?	93.7% (74)	6.3% (5)	79
Do you unplug or turn off your power strip at night? (If you do not use power strips please leave blank)	25.7% (19)	74.3% (55)	74
		answered question	78
		skipped question	0

Appendix B

2.5 All Buildings Survey II Data

10. Which of the following is true about your laptop behavior?

	Response Percent	Response Count
I shut my laptop off at night	**50.6%**	**40**
I unplug my laptop, but leave it on at night	2.5%	2
I set my laptop to hibernate or sleep at night	40.5%	32
I leave my laptop plugged in and turned on overnight	2.5%	2
I do not have a laptop	3.8%	3
answered question		79
skipped question		0

11. Which of the following is true about your desktop computer behavior?

	Response Percent	Response Count
I shut my computer off at night	11.8%	9
I unplug my computer at night	0.0%	0
I set my computer to hibernate or sleep at night	3.9%	3
I leave my computer turned on overnight	2.6%	2
I do not have a desktop computer	**81.6%**	**62**
answered question		76
skipped question		3

Appendix B

2.6 All Buildings Survey II Data

12. When you leave a room, how often do you generally turn off the lights?

	Responce Perent	Response Count
Always	84.8%	61
More than half the time, but not always	29.1%	23
Half the time	3.8%	3
Less than half the time, but sometimes	2.5%	2
Never	0.0%	0
answered question		79
skipped question		0

Appendix B

3.1 Institute survey II Data

Energy Survey Final

1. Which residence hall do you currently live in?

	Response Percent	Response Count
Stoddard	0.0%	0
Institute	**100.0%**	**9**
Riley	0.0%	0
answered question		9
skipped question		0

2. How much effort did you put into the energy conservation in the last few weeks?

	Response Percent	Response Count
A great deal	33.3%	3
A fair amount	**66.7%**	**6**
None at all	0.0%	0
answered question		9
skipped question		0

Appendix B

3.2 Institute Survey II Data

3. Are there any devices that you did not unplug or turn off prior to the last few weeks that you do now? Please check all that apply:

	Response Percent	Response Count
TVs	0.0%	0
DVD Players	0.0%	0
VCRs	0.0%	0
Printers	0.0%	0
Video Game Consoles	16.7%	1
Device Chargers	**50.0%**	**3**
Laptops Desktops -	33.3%	2
answered question		6
skipped question		3

4. Would you be more likely to conserve energy if you knew how much money it saved?

	Response Percent	Response Count
Yes	**66.7%**	**6**
No	0.0%	0
It wouldn't have made a difference	33.3%	3
answered question		9
skipped question		0

Appendix B

3.3 Institute Survey II Data

5. Are you currently trying to save more energy than you were a few weeks ago?

	Response Percent	Response Count
I still implement them	44.4%	4
I implemented them, but stopped	**55.6%**	**5**
I never implemented them	0.0%	0
answered question		9
skipped question		0

6. Would you be willing to participate in future competitions that help to save energy?

	Response Percent	Response Count
Yes	66.7%	6
No	0.0%	0
Only if there is a good reward	33.3%	3
answered question		9
skipped question		0

7. Did you become any more aware of energy conservation or other related topics in the past couple of weeks?

	Response Percent	Response Count
Yes	55.6%	5
No	44.4%	4
answered question		9
skipped question		0

Appendix B

3.4 Institute Survey II Data

8. Do You. (please check all that apply)

	Use in your room	Leave plugged in overnight	Leave turned ON overnight	Response Count
Television(s)	**100.0% (7)**	85.7% (6)	0.0% (0)	7
DVD Player	**100.0% (4)**	25.0% (1)	0.0% (0)	4
VCR	0.0% (0)	0.0% (0)	0.0% (0)	0
Printer	**100.0% (7)**	71.4% (5)	14.3% (1)	7
Fan(s)	**100.0% (8)**	75.0% (6)	50.0% (4)	8
Video Game Console(s)	**100.0% (5)**	40.0% (2)	0.0% (0)	5
Desk Lamp(s)	**100.0% (7)**	71.4% (5)	0.0% (0)	7
Floor Lamp(s)	**100.0% (1)**	0.0% (0)	0.0% (0)	1
Microwave	**100.0% (9)**	**100.0% (9)**	11.1% (1)	9
Extension Cord(s)	**100.0% (8)**	75.0% (6)	37.5% (3)	8
Device Charger(s)	**100.0% (8)**	62.5% (5)	37.5% (3)	8
Refrigerator	**100.0% (9)**	**100.0% (9)**	66.7% (6)	9
			answered question	**9**
			skipped question	**0**

9. Power Strips

	Yes	No	Response Count
Do you use powers strips?	**88.9% (8)**	11.1% (1)	9
Do you unplug or turn off your power strip at night? (if you do not use power strips please leave blank)	12.5% (1)	**87.5% (7)**	8
		answered question	**9**
		skipped question	**0**

Appendix B

3.5 Institute Survey II Data

10. Which of the following is true about your laptop behavior?

	Response Percent	Response Count
I shut my laptop off at night	**77.8%**	**7**
I unplug my laptop, but leave it on at night	0.0%	0
I set my laptop to hibernate or sleep at night	11.1%	1
I leave my laptop plugged in and turned on overnight	0.0%	0
I do not have a laptop	11.1%	1
answered question		**9**
skipped question		**0**

11. Which of the following is true about your desktop computer behavior?

	Response Percent	Response Count
I shut my computer off at night	25.0%	2
I unplug my computer at night	0.0%	0
I set my computer to hibernate or sleep at night	0.0%	0
I leave my computer turned on overnight	0.0%	0
I do not have a desktop computer	**75.0%**	**6**
answered question		**8**
skipped question		**1**

Appendix B

3.6 Institute Survey II Data

12. When you leave a room, how often do you generally turn off the lights?

	Response Percent	Response Count
Always	**55.6%**	**5**
More than half the time, but not always	44.4%	4
Half the time	0.0%	0
Less than half the time, but sometimes	0.0%	0
Never	0.0%	0
answered question		9
skipped question		0

Appendix B

4.1 Stoddard Survey II Data

Energy Survey Final

1. Which residence hall do you currently live in?

	Response Percent	Response Count
Stoddard	**100.0%**	**35**
Institute	0.0%	0
Riley	0.0%	0
answered question		35
skipped question		0

2. How much effort did you put into the energy conservation in the last few weeks?

	Response Percent	Response Count
A great deal	17.1%	6
A fair amount	**51.4%**	**18**
None at all	31.4%	11
answered question		35
skipped question		0

Appendix B

4.2 Stoddard Survey II Data

3. Are there any devices that you did not unplug or turn off prior to the last few weeks that you do now? Please check all that apply:

	Response Percent	Response Count
TVs	8.0%	2
DVD Players	0.0%	0
VCRs	0.0%	0
Printers	8.0%	2
Video Game Consoles	0.0%	0
Device Chargers	32.0%	8
Laptops Desktops -	**52.0%**	**13**
answered question		**25**
skipped question		**10**

4. Would you be more likely to conserve energy if you knew how much money it saved?

	Response Percent	Response Count
Yes	**62.9%**	**22**
No	5.7%	2
It wouldn't have made a difference	31.4%	11
answered question		**35**
skipped question		**0**

Appendix B

4.3 Stoddard Survey II Data

5. Are you currently trying to save more energy than you were a few weeks ago?

	Response Percent	Response Count
I still implement them	**62.9%**	**22**
I implemented them, but stopped	11.4%	4
I never implemented them	25.7%	9
answered question		35
skipped question		0

6. Would you be willing to participate in future competitions that help to save energy?

	Response Percent	Response Count
Yes	**62.9%**	**22**
No	5.7%	2
Only if there is a good reward	31.4%	11
answered question		35
skipped question		0

7. Did you become any more aware of energy conservation or other related topics in the past couple of weeks?

	Response Percent	Response Count
Yes	38.2%	13
No	**61.8%**	**21**
answered question		34
skipped question		1

Appendix B

4.4 Stoddard Survey II Data

8. Do You. (please check all that apply)

	Use in your room	Leave plugged in overnight	Leave turned ON overnight	Response Count
Television(s)	**88.0% (22)**	80.0% (20)	4.0% (1)	25
DVD Player	**83.3% (5)**	66.7% (4)	0.0% (0)	6
VCR	**66.7% (2)**	**66.7% (2)**	0.0% (0)	3
Printer	**92.3% (24)**	76.9% (20)	30.8% (8)	26
Fan(s)	**100.0% (15)**	66.7% (10)	26.7% (4)	15
Video Game Console(s)	**90.0% (9)**	60.0% (6)	0.0% (0)	10
Desk Lamp(s)	**95.7% (22)**	73.9% (17)	0.0% (0)	23
Floor Lamp(s)	**66.7% (2)**	**66.7% (2)**	33.3% (1)	3
Microwave	**90.0% (27)**	86.7% (26)	16.7% (5)	30
Extension Cord(s)	85.7% (24)	**92.9% (26)**	25.0% (7)	28
Device Charger(s)	**93.5% (29)**	64.5% (20)	22.6% (7)	31
Refrigerator	90.6% (29)	**93.8% (30)**	68.8% (22)	32
			answered question	**35**
			skipped question	**0**

9. Power Strips

	Yes	No	Response Count
Do you use powers strips?	**94.3% (33)**	5.7% (2)	35
Do you unplug or turn off your power strip at night? (if you do not use power strips please leave blank)	33.3% (11)	**66.7% (22)**	33
		answered question	**35**
		skipped question	**0**

Appendix B

4.5 Stoddard Survey II Data

10. Which of the following is true about your laptop behavior?

	Response Percent	Response Count
I shut my laptop off at night	**45.7%**	**16**
I unplug my laptop, but leave it on at night	2.9%	1
I set my laptop to hibernate or sleep at night	42.9%	15
I leave my laptop plugged in and turned on overnight	5.7%	2
I do not have a laptop	2.9%	1
answered question		**35**
skipped question		**0**

11. Which of the following is true about your desktop computer behavior?

	Response Percent	Response Count
I shut my computer off at night	2.9%	1
I unplug my computer at night	0.0%	0
I set my computer to hibernate or sleep at night	5.9%	2
I leave my computer turned on overnight	2.9%	1
I do not have a desktop computer	**88.2%**	**30**
answered question		**34**
skipped question		**1**

Appendix B

4.6 Stoddard Survey II Data

12. When you leave a room, how often do you generally turn off the lights?

	Response Percent	Response Count
Always	**71.4%**	**25**
More than half the time, but not always	28.6%	10
Half the time	0.0%	0
Less than half the time, but sometimes	0.0%	0
Never	0.0%	0
answered question		**35**
skipped question		**0**

Appendix B

5.1 Riley Survey II Data

Energy Survey Final

1. Which residence hall do you currently live in?

	Response Percent	Response Count
Stoddard	0.0%	0
Institute	0.0%	0
Riley	**100.0%**	**35**
answered question		**35**
skipped question		**0**

2. How much effort did you put into the energy conservation in the last few weeks?

	Response Percent	Response Count
A great deal	8.6%	3
A fair amount	**54.3%**	**19**
None at all	37.1%	13
answered question		**35**
skipped question		**0**

Appendix B

5.2 Riley Survey II Data

3. Are there any devices that you did not unplug or turn off prior to the last few weeks that you do now? Please check all that apply:

	Response Percent	Response Count
TVs	13.6%	3
DVD Players	0.0%	0
VCRs	0.0%	0
Printers	9.1%	2
Video Game Consoles	9.1%	2
Device Chargers	18.2%	4
Laptops Desktops -	**50.0%**	**11**
answered question		**22**
skipped question		**13**

4. Would you be more likely to conserve energy if you knew how much money it saved?

	Response Percent	Response Count
Yes	**80.0%**	**28**
No	8.6%	3
It wouldn't have made a difference	11.4%	4
answered question		**35**
skipped question		**0**

Appendix B

5.3 Riley Survey II Data

5. Are you currently trying to save more energy than you were a few weeks ago?

	Response Percent	Response Count
I still implement them	**54.3%**	**19**
I implemented them, but stopped	0.0%	0
I never implemented them	45.7%	16
answered question		**35**
skipped question		**0**

6. Would you be willing to participate in future competitions that help to save energy?

	Response Percent	Response Count
Yes	**58.8%**	**20**
No	8.8%	3
Only if there is a good reward	32.4%	11
answered question		**34**
skipped question		**1**

7. Did you become any more aware of energy conservation or other related topics in the past couple of weeks?

	Response Percent	Response Count
Yes	37.1%	13
No	**62.9%**	**22**
answered question		**35**
skipped question		**0**

Appendix B

5.4 Riley Survey II Data

8. Do You. (please check all that apply)

	Use in your room	Leave plugged in overnight	Leave turned ON overnight	Response Count
Television(s)	**95.7% (22)**	91.3% (21)	0.0% (0)	23
DVD Player	**100.0% (8)**	62.5% (5)	0.0% (0)	8
VCR	**100.0% (2)**	50.0% (1)	0.0% (0)	2
Printer	**100.0% (27)**	77.8% (21)	33.3% (9)	27
Fan(s)	**87.5% (21)**	62.5% (15)	25.0% (6)	24
Video Game Console(s)	**100.0% (13)**	84.6% (11)	0.0% (0)	13
Desk Lamp(s)	**96.7% (29)**	66.7% (20)	0.0% (0)	30
Floor Lamp(s)	66.7% (2)	**100.0% (3)**	0.0% (0)	3
Microwave	**100.0% (28)**	85.7% (24)	25.0% (7)	28
Extension Cord(s)	**100.0% (30)**	93.3% (28)	36.7% (11)	30
Device Charger(s)	**100.0% (34)**	70.6% (24)	11.8% (4)	34
Refrigerator	**100.0% (34)**	94.1% (32)	76.5% (26)	34
			answered question	**35**
			skipped question	**0**

9. Power Strips

	Yes	No	Response Count
Do you use powers strips?	**94.3% (33)**	5.7% (2)	35
Do you unplug or turn off your power strip at night? (if you do not use power strips please leave blank)	21.2% (7)	**78.8% (26)**	33
		answered question	**35**
		skipped question	**0**

Appendix B

5.5 Riley survey II Data

10. Which of the following is true about your laptop behavior?

	Response Percent	Response Count
I shut my laptop off at night	**48.6%**	**17**
I unplug my laptop, but leave it on at night	2.9%	1
I set my laptop to hibernate or sleep at night	45.7%	16
I leave my laptop plugged in and turned on overnight	0.0%	0
I do not have a laptop	2.9%	1
answered question		**35**
skipped question		**0**

11. Which of the following is true about your desktop computer behavior?

	Response Percent	Response Count
I shut my computer off at night	17.6%	6
I unplug my computer at night	0.0%	0
I set my computer to hibernate or sleep at night	2.9%	1
I leave my computer turned on overnight	2.9%	1
I do not have a desktop computer	**76.5%**	**26**
answered question		**34**
skipped question		**1**

Appendix B

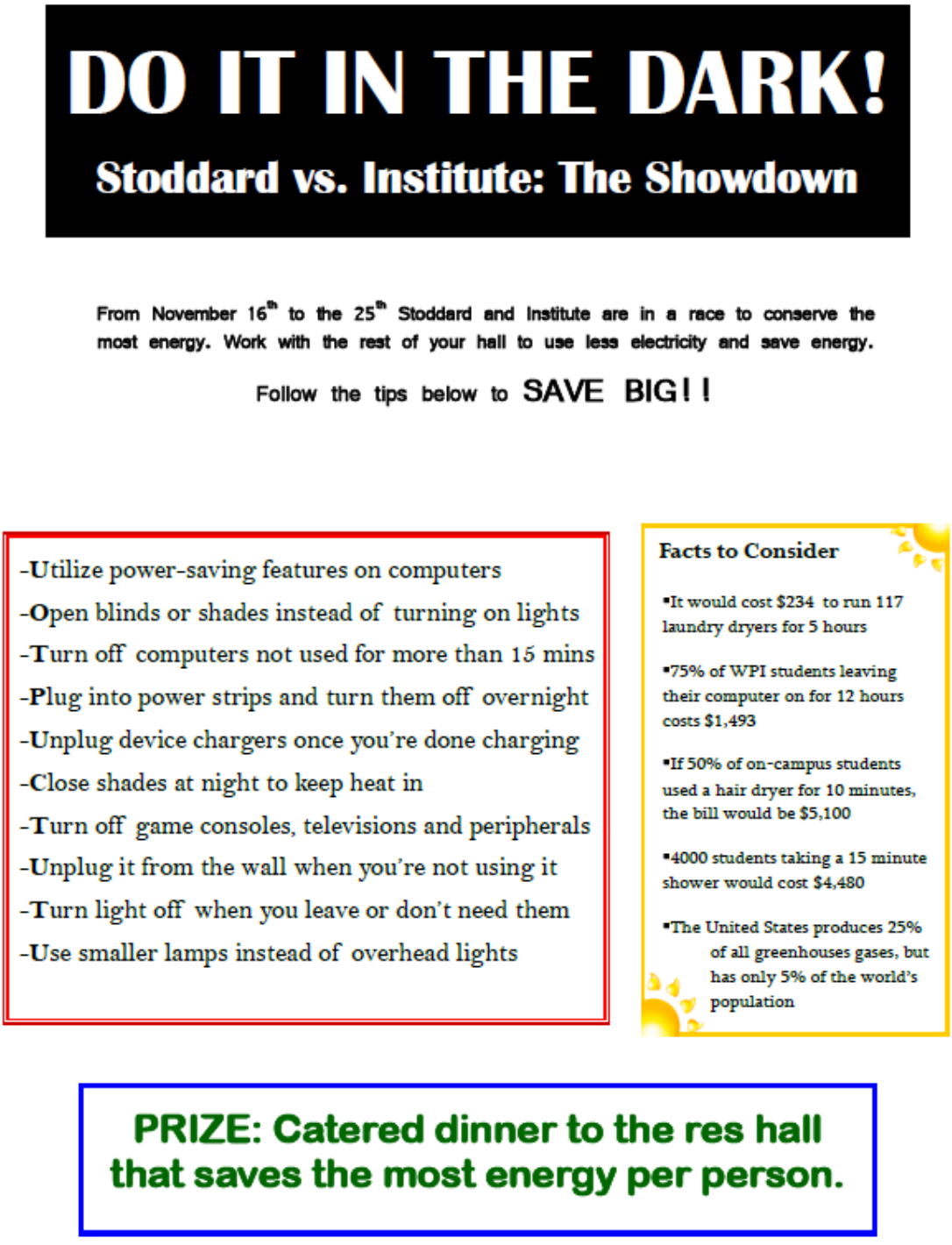
5.6 Riley Survey II Data

12. When you leave a room, how often do you generally turn off the lights?

	Response Percent	Response Count
Always	**60.0%**	**21**
More than half the time, but not always	25.7%	9
Half the time	8.6%	3
Less than half the time, but sometimes	5.7%	2
Never	0.0%	0
answered question		**35**
skipped question		**0**

Appendix C

1.1 Energy Conservation/Competition Poster



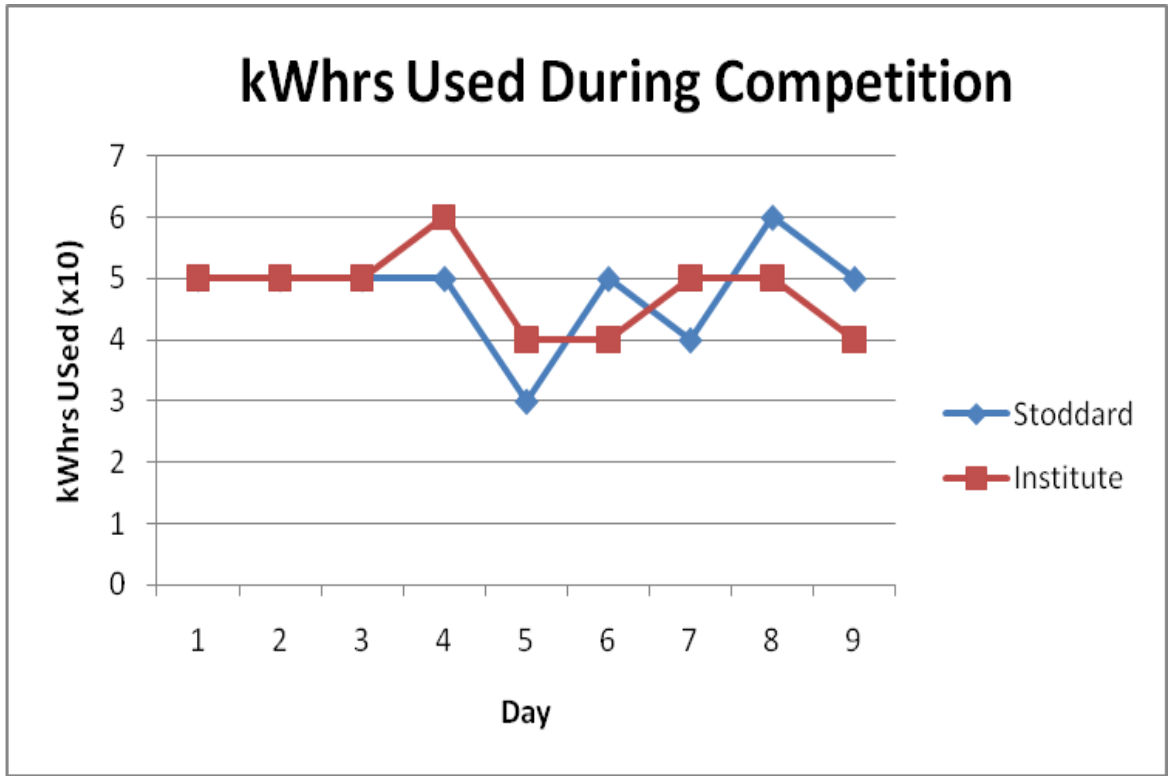
Appendix C

1.2 Results-Chart Poster

	% energy reduced by Stoddard	% energy reduced by Institute
Day 1	4.25	6.25
Day 2	4.25	6.25
Day 3	4.25	6.25
Day 4	4.25	1.05
Day 5	11.91	6.25
Day 6	10.63	9.37
Day 7	12.46	8.92
Day 8	9.04	8.59
Day 9	8.51	10.41

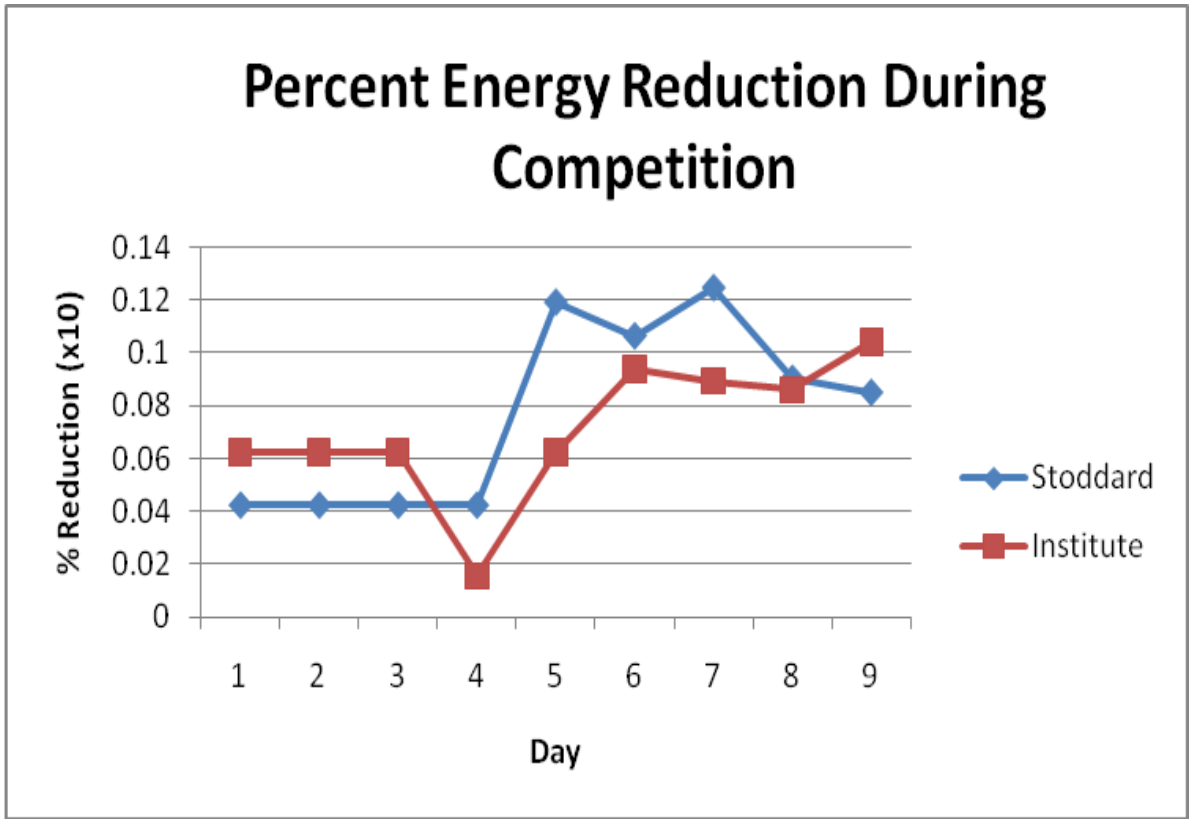
Appendix D

1.1 kWhrs Used During Competition



Appendix D

1.2 Percent Energy Reduction During Competition



Appendix D

1.3a Base Readings

Stoddard	005	001	002	004	005	006	007	013	014	015	030	050	kWhrs Used	Used/Person	Avg. Used/Person	%Reduction
Residents	072249	03.11.09	10 58	07792	02883	000.30	000.30	04909	000.32	000.33	001.800	00 093	--	--	--	--
176	072249	03.11.09	19 36	07794	02885	000.30	000.30	04909	000.32	000.33	001.800	00 093				--
Base Avg	072249	04.11.09	09 18	07797	02885	000.30	000.30	04911	000.32	000.33	001.800	00 093	5	0.028409091	0.028409091	--
0.029672	072249	04.11.09	19 25	07799	02887	000.30	000.30	04911	000.32	000.33	001.800	00 093				--
	072249	05.11.09	09 25	07802	02888	000.30	000.30	04914	000.32	000.33	001.800	00 093	5	0.028409091	0.028409091	--
	072249	05.11.09	19 09	07804	02890	000.30	000.30	04914	000.32	000.33	001.800	00 093				--
	072249	06.11.09	08 42	07808	02891	000.30	000.30	04917	000.32	000.33	001.800	00 093	6	0.034090909	0.03030303	--
	072249	07.11.09	00 29	07813	02894	000.33	000.34	04918	000.33	000.34	001.800	00 093				--
	072249	07.11.09	09 15	07815	02894	000.33	000.34	04920	000.33	000.34	001.800	00 093	7	0.039772727	0.032670455	--
	072249	07.11.09	19 50	07817	02894	000.33	000.34	04922	000.33	000.34	001.800	00 093				--
	072249	08.11.09	09 09	07821	02894	000.33	000.34	04926	000.33	000.34	001.800	00 093	6	0.034090909	0.032954545	--
	072249	08.11.09	19 11	07823	02894	000.33	000.34	04928	000.33	000.34	001.800	00 093				--
	072249	09.11.09	09 10	07826	02895	000.33	000.34	04931	000.33	000.34	001.800	00 093	5	0.028409091	0.03219697	--
	072249	09.11.09	19 22	07828	02897	000.33	000.34	04931	000.33	000.34	001.800	00 093				--
	072249	10.11.09	09 07	07830	02897	000.33	000.34	04933	000.33	000.34	001.800	00 093	4	0.022727273	0.030844156	--
	072249	10.11.09	19 38	07832	02899	000.33	000.34	04933	000.33	000.34	001.800	00 093				--

072249	11.11.09	09 16	07834	02899	000.33	000.34	04935	000.33	000.34	001.800	00 093	4	0.022727273	0.030934343	--
072249	11.11.09	19 12	07836	02899	000.33	000.34	04937	000.33	000.34	001.800	00 093				--
072249	12.11.09	09 12	07839	02899	000.33	000.34	04940	000.33	000.34	001.800	00 093	5	0.028409091	0.029671717	--
072249	12.11.09	22 06	07843	02902	000.33	000.34	04940	000.33	000.34	001.800	00 093				--
072249	13.11.09	09 09	07845	02902	000.33	000.34	04942	000.33	000.34	001.800	00 093	6	0.034090909	0.030113636	--
072249	13.11.09	21 28	07848	02905	000.33	000.34	04943	000.33	000.34	001.800	00 093				--
072249	14.11.09	19 55	07853	02905	000.33	000.34	04947	000.33	000.34	001.800	00 093				--
072249	14.11.09	09 27	07851	02905	000.33	000.34	04945	000.33	000.34	001.800	00 093	6	0.034090909	0.030475207	--
072249	15.11.09	09 13	07856	02905	000.33	000.34	04950	000.33	000.34	001.800	00 093	5	0.028409091	0.03030303	--

1.3b Base Readings Times and Dates

Run Off East Date and Time (Accuracy purposes)					kWhrs Used	Used/Person	Avg. Used/Person	%Reduction
Institute	23730	000.37	03:11:09	10:35:00	--	--	--	--
Residents	23732	000.37	03:11:09	19:14:04				
72	23735	000.37	04:11:09	08:59:06	5	0.069444444	0.069444444	--
Base Avg	23737	000.37	04.11.09	19:06:23				
0.074074	23740	000.37	05.11.09	09.04.48	5	0.069444444	0.069444444	--
	23742	000.37	05.11.09	18.46.55				

23745	000.37	06.11.09	08.27.34	5	0.069444444	0.069444444	--
23749	000.37	07.11.09	00.15.20				
23751	000.37	07.11.09	09.02.40	6	0.083333333	0.072916667	--
23753	000.37	07.11.09	19.33.41				
23756	000.37	08.11.09	08.53.33	5	0.069444444	0.072222222	--
23758	000.37	08.11.09	18.59.24				
23761	000.37	09.11.09	08.57.46	5	0.069444444	0.071759259	--
23763	000.37	09.11.09	19.08.00				
23767	000.40	10.11.09	08.54.32	6	0.083333333	0.073412698	--
23769	000.40	10.11.09	19.21.04				
23772	000.40	11.11.09	09.03.10	5	0.069444444	0.072916667	--
23775	000.40	11.11.09	19.00.00				
23778	000.40	12.11.09	09.01.25	6	0.083333333	0.074074074	--
23780	000.40	12.11.09	21.51.33				
23783	000.40	13.11.09	08.58.05	5	0.069444444	0.073611111	--
23786	000.40	13.11.09	21.15.46				
23788	000.40	14.11.09	08.59.19	5	0.069444444	0.073232323	--

23790	000.40	14.11.09	19.40.40				
23793	000.40	15.11.09	09.01.58	5	0.069444444	0.072916667	--
23806	000.28	17.11.09	18.55.26				

1.3c Base Readings East

East	005	001	002	004	005	006	007	013	014	015	030	050	kWhrs Used	Used/Person	Avg. Used/Person	%Reduction
Residents	031049	03:11:09	19:14:04	08051	03262	000.90	000.91	04788	000.98	001.00	1.0000	12	--	--	--	--
227	031049	04:11:09	08:59:06	08060	03264	000.90	000.91	04795	000.98	001.00	1.0000	12	--	--	--	--
	031049	04.11.09	19:06:23	08067	03271	000.90	000.91	04795	000.98	001.00	1.0000	12				
	031049	05.11.09	09.04.48	08076	03273	000.90	000.91	04802	000.98	001.00	1.0000	12	16			
	031049	05.11.09	18.46.55	08082	03280	000.90	000.91	04802	000.98	001.00	1.0000	12				
	031049	06.11.09	08.27.34	08091	03282	000.90	000.91	04809	000.98	001.00	1.0000	12	15			
	031049	07.11.09	00.15.20	08102	03291	000.90	000.91	04811	000.98	001.00	1.0000	12				
	031049	07.11.09	09.02.40	08107	03290	000.90	000.91	04816	000.98	001.00	1.0000	12	16			
	031049	07.1109	19.33.41	08114	03290	000.90	000.91	04823	000.98	001.00	1.0000	12				
	031049	08.11.09	08.53.33	08122	03290	000.90	000.91	04832	000.98	001.00	1.0000	12	15			
	031049	08.11.09	18.59.24	08130	03290	000.90	000.91	04839	000.98	001.00	1.0000	12				
	031049	09.11.09	08.57.46	08139	03291	000.90	000.91	04847	000.98	001.00	1.0000	12	17			

031049	09.11.09	19.08.00	08147	03299	000.90	000.91	04847	000.98	001.00	1.0000	12				
031049	10.11.09	08.54.32	08156	03301	000.90	000.91	04854	000.98	001.00	1.0000	12	17			
031049	10.11.09	19.21.04	08165	03309	000.90	000.91	04854	000.98	001.00	1.0000	12				
031049	11.11.09	09.03.10	08172	03310	000.90	000.91	04862	000.98	001.00	1.0000	12	16			
031049	11.11.09	19.00.00	08179	03310	000.90	000.91	04868	000.98	001.00	1.0000	12				
031049	12.11.09	09.01.25	08188	03310	000.90	000.91	04877	000.98	001.00	1.0000	12	16			
031049	12.11.09	21.51.33	08197	03319	000.90	000.91	04878	000.98	001.00	1.0000	12				
031049	13.11.09	08.58.05	08204	03319	000.90	000.91	04884	000.98	001.00	1.0000	12	16			
031049	13.11.09	21.15.46	08212	03327	000.90	000.91	04884	000.98	001.00	1.0000	12				
031049	14.11.09	08.59.19	08219	03321	000.90	000.91	04891	000.98	001.00	1.0000	12	15			
031049	14.11.09	19.40.40	08226	03327	000.90	000.91	04898	000.98	001.00	1.0000	12				
031049	15.11.09	09.01.58	08235	03327	000.90	000.91	04907	000.98	001.00	1.0000	12	16			
031049	16.11.09	08.57.18	08250	03328	000.90	000.91	04922	000.98	001.00	1.0000	12	15	--	--	--
031049	17.11.09	09.02.51	08266	03337	000.90	000.91	04929	000.98	001.00	1.0000	12	16	0.070484581	0.070484581	--
031049	17.11.09	18.55.26	08273	03344	000.82	000.83	04929	000.00	000.00	1.0000	12				
031049	18.11.09	09.02.46	08282	03346	000.83	000.85	04936	000.76	000.77	1.0000	12	16	0.070484581	0.070484581	--
031049	19.11.09	08.55.16	08299	03355	000.87	000.89	04943	000.80	000.81	1.0000	12	17	0.074889868	0.07195301	--
031049	20.11.09	08.54.43	08314	03364	000.87	000.89	04950	000.80	000.81	1.0000	12	15	0.066079295	0.070484581	--
031049	21.11.09	08.54.27	08330	03372	000.87	000.89	04957	000.80	000.81	1.0000	12	16	0.070484581	0.070484581	--
031049	22.11.09	09.41.23	08346	03372	000.87	000.89	04973	000.82	000.83	1.0000	12	16	0.070484581	0.070484581	--

031049	23.11.09	08.59.46	08362	03373	000.87	000.89	04988	000.82	000.83	1.0000	12	16	0.070484581	0.070484581	--
031049	24.11.09	08.55.07	08378	03382	000.87	000.89	04995	000.82	000.83	1.0000	12	16	0.070484581	0.070484581	--
031049	25.11.09	08.50.17	08392	03390	000.87	000.89	05002	000.82	000.83	1.0000	12	14	0.061674009	0.069505629	--

1.3d Base Readings Ellsworth, Fuller, and Founders

Ellsworth	005	001	002	004	005	006	007	013	014	015	030	050
	30915	03.11.09	10:50:16	09450	03487	001.49	001.49	05963	001.52	001.52	1.0000	12
	030915	03.11.09	19:31:42	09456	03493	001.49	001.49	05963	001.52	001.52	1.0000	12
	030915	04.11.09	09:15:14	09469	03495	001.49	001.49	05973	001.52	001.52	1.0000	12
	030915	04.11.09	19:21:03	09480	03506	001.57	001.58	05973	001.52	001.52	1.0000	12
	030915	05.11.09	09.20.56	09495	03510	001.57	001.58	05985	001.52	001.52	1.0000	12
	030915	05.11.09	19.04.33	09506	03521	001.57	001.58	05985	001.52	001.52	1.0000	12
	030915	06.11.09	08.40.33	09521	03524	001.57	001.58	05997	001.53	001.54	1.0000	12

Fuller	005	001	002	004	005	006	007	013	014	015	030	050
	800681	03.11.09	10 42	08167	02959	001.41	001.42	05208	001.32	001.35	1.800	00 093
	800681	03.11.09	19 26	08174	02966	001.41	001.42	05208	001.32	001.35	001.800	00 093

	800681	04.11.09	09 10	08186	02969	001.41	001.42	05217	001.39	001.42	001.800	00 093
	800681	04.11.09	19 16	08196	02978	001.41	001.42	05217	001.39	001.42	001.800	00 293?
	800681	05.11.09	09 15	08209	02981	001.41	001.42	05228	001.47	001.50	001.800	00 093
	800681	05.11.09	18 57	08220	02991	001.54	001.55	05228	001.47	001.50	001.800	00 093
	800681	06.11.09	06 35	08235	02995	001.78	001.79	05240	001.78	001.79	001.800	00 093
Founders	005	001	002	004	005	006	007	013	014	015	030	050

Appendix D

1.4 Competition Readings Institute and Stoddard

Stoddard	005	001	002	004	005	006	007	013	014	015	030	050	kWhrs Used	Used/Person	Avg. Used/Person	%Reduction
	072249	16.11.09	09 09	07860	02905	000.33	000.34	04954	000.33	000.34	001.800	00 093	--	--	--	--
	072249	17.11.09	09 13	07865	02908	000.33	000.34	04956	000.33	000.34	001.800	00 093	5	0.028409091	0.028409091	0.042553191
	072249	18.11.09	09 14	07870	02911	000.26	000.27	04959	000.27	000.28	001.800	00 093	5	0.028409091	0.028409091	0.042553191
	072249	19.11.09	09 07	07875	02913	000.28	000.28	04962	000.29	000.30	001.800	00 093	5	0.028409091	0.028409091	0.042553191
	072249	20.11.09	09 07	07880	02916	000.28	000.28	04964	000.29	000.30	001.800	00 093	5	0.028409091	0.028409091	0.042553191
	072249	21.11.09	09 07	07883	02918	000.28	000.28	04965	000.29	000.30	001.800	00 093	3	0.017045455	0.026136364	0.119148936
	072249	22.11.09	09 52	07888	02918	000.28	000.28	04970	000.29	000.30	001.800	00 093	5	0.028409091	0.026515152	0.106382979
	072249	23.11.09	09 11	07892	02921	000.29	000.29	04976	000.30	000.30	001.800	00 093	4	0.022727273	0.025974026	0.124620061
	072249	24.11.09	09 06	07898	02921	000.29	000.29	04976	000.30	000.30	001.800	00 093	6	0.034090909	0.026988636	0.090425532
	072249	25.11.09	09 02	07903	02924	000.29	000.29	04979	000.30	000.30	001.800	00 093	5	0.028409091	0.027146465	0.085106383

kWhrs Used Used/Person Avg. Used/Person %Reduction

Institute

23799	000.42	16.11.09	08.57.18	6	--	--	--
23804	000.42	17.11.09	09.02.51	5	0.069444444	0.069444444	0.0625
23809	000.30	18.11.09	09.02.46	5	0.069444444	0.069444444	0.0625
23814	000.32	19.11.09	08.55.16	5	0.069444444	0.069444444	0.0625
23820	000.32	20.11.09	08.54.43	6	0.083333333	0.072916667	0.015625
23824	000.32	21.11.09	08.54.27	4	0.055555556	0.069444444	0.0625
23828	000.32	22.11.09	09.41.23	4	0.055555556	0.06712963	0.09375
23833	000.34	23.11.09	08.59.46	5	0.069444444	0.067460317	0.089285714
23838	000.34	24.11.09	08.55.07	5	0.069444444	0.067708333	0.0859375
23842	000.34	25.11.09	08.50.17	4	0.055555556	0.066358025	0.104166667