# A TOOLKIT FOR IDENTIFYING ENERGY SAVINGS AT COLLEGES AND UNIVERSITIES

by

Eliza S. Davis

Dr. Martin D. Smith, Adviser

May 2012

Masters project submitted in partial fulfillment of the

requirements for the Master of Environmental Management degree in

the Nicholas School of the Environment of

Duke University

2012

## Abstract

Energy-saving projects offer colleges and universities the opportunity to save money, avoid unnecessary greenhouse gas emissions, and achieve the reputational benefits of greater campus sustainability. However school administrators and other campus leaders face institutional, behavioral, and economic barriers to identifying energy-saving opportunities on their own. To address these challenges a "toolkit" was developed to help college and university leaders identify energy-saving upgrades and programs, calculate project costs and savings, and communicate the value of these investments to key stakeholders.

The Toolkit includes a menu of energy efficiency projects appropriate for college and university campuses as well as detailed explanations of how to calculate the expected project costs and savings. This resource walks users through the process of benchmarking and tracking campus energy use over time and introduces key calculations to consider for all energy investments such as net present value, payback period, and avoided greenhouse gas emissions. Additionally the toolkit addresses the importance of education and engagement for successful adoption of energy efficiency programs. Finally, the toolkit includes two case studies about identifying energy-saving projects at universities in North Carolina.

This is a free and accessible guidebook designed for use by school administrators, faculty, staff, and students who want to identify ways for their institutions to save money, reduce energy use, and cut greenhouse gas emissions. The toolkit can be used as an alternative to hiring an energy consultant or enrolling in a green building certification program or as a complementary resource for an institution that already plans to take these steps. The author hopes that the use of this toolkit will encourage community dialogue on environmental issues and will inspire a lasting commitment to sustainability on college and university campuses.

# Table of Contents

## Introduction

Across the country colleges and universities are beginning to recognize the financial and reputational benefits of saving energy and "going green". As of February of 2012 thirty-four colleges and universities, small and large, public and private, have demonstrated their commitment to energy efficiency projects by committing to the Billion Dollar Green Challenge.[1] This program encourages institutions to set money aside in green revolving loan funds to fund future capital-intensive energy-saving projects.

College and university leaders are also looking for ways to become more sustainable as increasing numbers of prospective students consider institutional environmental stewardship as part of their college decision. In their "2009 College Hopes and Worries Survey" Princeton Review found that 66% of survey respondents said they would appreciate information about a school's environmental commitment. Twenty-four percent of the survey participants said that environmental commitment would "very much" affect their choice of which schools to apply to or attend.[2] As of February 2012 six hundred and seventy-six college presidents have signed the American College & University Presidents' Climate Commitment, pledging their dedication to pursue carbon neutrality at their institutions.[3]

While colleges and universities may acknowledge the benefits of saving energy and becoming more sustainable many institutions have yet to take advantage of cost savings from implementing energy-saving projects. Research by McKinsey & Company (2007) suggests that the pursuit of energy efficiency projects in general falls well below levels that would allow organizations to achieve optimal savings.[4] Organizations fail to pursue energy

---

[1] "Billion Dollar Green Challenge. (Visited 2012, January 24). Retrieved from http://greenbillion.org/about/

[2] The Princeton Review, Inc. and U.S. Green Building Council. (2010). *The Princeton Review's Guide to 286 Green Colleges 2010-2011*. Princeton, NJ: The Princeton Review, Inc.

[3] American College & University Presidents' Climate Commitment. (Visited 2012, April 18). Retrieved from http://www.presidentsclimatecommitment.org/

[4] McKinsey & Company. (2009, January). *Pathways to a low-carbon economy: Version 2 of the global greenhouse gas abatement cost curve*.

efficiency projects despite low risks and high returns that defy the traditional investment frontier (Ehrhardt-Martinez and Laitner (2008).[5]

Anderson and Newell (2004) suggest that lack of energy efficiency adoption is partially the result of inadequate availability of information surrounding technology options, equipment performance, and project implementation.[6] This echoes the research of Stigler (1961), which identified the cost of searching for information as a cause of suboptimal outcomes.[7] Anderson and Newell, referencing Ruderman et al. (1987) and Jaffe and Stavins (1991), also note that organizations often show high implicit discount rates in their consideration of efficient technology upgrades that result from incomplete information and various other market failures.[8]

J. Stephenson et al. notes that three of the main hurdles to rational behavior identified by Stern (2007) also apply to the failure to adopt energy efficiency. These hurdles include (1) uncertainty about true costs and benefits (2) conflicting information and objectives (3) and individual drivers and behavior.[9] Jackson (2011) also identified capital rationing, price uncertainties, transaction costs, a gap in information about the performance of equipment, and the short-term decisions of leadership as reasons that the energy efficiency gap remains.[10]

Lawrence et al (2005) identifies technical understanding of the equipment, restrictions on financing options, public policy, and psychological barriers as preventers to energy efficiency adoption. The paper also highlights the concept of bounded rationality in energy efficiency decision-making, or the idea that decisions-makers often fail to see all

---

[5] Ehrhardt-Martinez, Karen and John "Skip" Laitner. (2008, May). *The size of the U.S. energy efficiency market: Generating a more complete picture."*. (p. 29). Washington, DC: American Council for an Energy-Efficient Economy.

[6] Anderson, Soren T. and Richard G. Newell. (2004). Information programs for technology adoption: the case of energy-efficiency audits. *Resource and Energy Economics*, *26*, 27-50.

[7] Stigler, George J. (1961, June). The economics of information. *Journal of Political Economy*, *69*(3), 24.

[8] Anderson & Newell (2004), Pg. 29.

[9] Stephenson, Janet, Barry Barton, Gerry Carrington, Daniel Gnoth, Rob Lawson, and Paul Thorsnes. . (2010). Energy Cultures. *Energy Policy*, *38*, 6120-6129, Pg. 6121.

[10] Jackson, Jerry. (2011). Selling energy efficiency: The energy engineer as investment advisor. *Energy Engineering*, *108*(4), 46-64, Pg. 48.

critical angles of their decisions.[11] The authors suggest that decision-makers often view energy costs as an insignificantly small percentage of total expenditures and fail to connect a decrease in energy costs with a decrease in overall operational costs.[12] Finally, an inability to quantify the actual costs and benefits of executing (or not executing) a project is a barrier to decisiveness on energy efficiency investments.[13]

Within this context the need exists for a tool that addresses the unique barriers to energy efficiency adoption that university administrators face. Such a tool should address the uncertainties about the true costs and benefits of upgrade projects and should explain the best technology options. Such a tool should show users how to calculate not only the energy savings but also the cost savings and greenhouse gas emission savings from each project to demonstrate the environmental benefits and avoided costs to their institution. This would address the challenge of bounded rationality for school decision-makers. The toolkit should discuss rebates and highlight the short payback periods and low and no-cost net investment options for decision-makers focused on short-term gains. Rebates and short payback periods could dissuade fears about high initial capital costs. Finally, the toolkit should present approaches to communicating energy savings in ways that decision-makers understand. If decision-makers clearly comprehend the savings potential of these projects they will be more likely to support the initial investment.

In addition to the challenges preventing initial energy efficiency investment, energy use behaviors create another hurdle to the implementation of projects and the proper use and maintenance of installed upgrades. J. Stephenson et al (2010) explain consumer energy efficiency behavior in the context of three interactive factors: material culture, cognitive norms, and energy practices.[14] The authors note that the importance consumers place on building design and the use of heating and cooling are affected by cognitive issues such as comfort and a commitment to tradition, as well as their material knowledge of the range of

---

[11] Lawrence, Thomas M., Jeffrey D. Mullen, Douglas S. Noonan, and Jay Enck. (2005, September). Overcoming barriers to efficiency. *ASHRAE Journal*, *45*(9), S40-S47, Pg. S41.

[12] Lawrence, Thomas M., Jeffrey D. Mullen, Douglas S. Noonan, and Jay Enck. (2005), Pg. S42.

[13] Lawrence, Thomas M., Jeffrey D. Mullen, Douglas S. Noonan, and Jay Enck. (2005), Pg. S42.

[14] Stephenson, Janet, Barry Barton, Gerry Carrington, Daniel Gnoth, Rob Lawson, and Paul Thorsnes, (2010), Pg. 6124.

energy upgrade options and specific technologies.[15] This research suggests that energy efficiency adoption requires education that considers the ways that people make purchasing decisions and the reasons that they use energy technologies the way the do. The toolkit should therefore not only educate decision-makers about the technology upgrades themselves but also about ways to overcome the behavioral challenges of energy efficiency.

Colleges and universities also face the challenges of limited staff and minimal time to commit to identifying energy-saving opportunities on campus. For schools that do not have the resources to hire a sustainability manager or team, the process of identify energy savings can be daunting. Various certification programs, guidebooks, and energy-saving calculators exist to help schools improve their energy efficiency (please see the Literary Citations section for a detailed analysis of existing resources). However these options can be costly, time-consuming, and too general to help schools identify specific savings for individual upgrades and conservation projects. Within this context a need exists for a toolkit that can help school administrators and students identify specific dollar savings from individual low and no-cost energy efficiency projects on their campuses without the help of costly certification programs or energy management experts.

## Literary Citations

As discussed above, a variety of tools currently exist to help schools identify energy savings. Below is a discussion of the leading energy-saving tools available to colleges and universities. The documents and websites discussed below provided a foundation for *A Toolkit for Identifying Energy Savings at Colleges and Universities* and some of the best resources have been referenced in the Toolkit itself.

### Certification Programs

---

[15] Stephenson, Janet, Barry Barton, Gerry Carrington, Daniel Gnoth, Rob Lawson, and Paul Thorsnes, (2010), Pg. 6124.

Various certification programs exist such as U.S. Green Building Council's LEED certification program for existing buildings, EPA's Energy Star building certification program, and the Association for the Advancement of Sustainability in Higher Education's (AASHE) Sustainability Tracking and Rating system (STAR).

*LEED Certification (U.S. Green Building Council)*

Website: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1988

LEED (Leadership in Energy and Environmental Design) is an internationally recognized certification program for homes, commercial interiors, core & shell, new construction, and schools, healthcare and retail buildings. The program supports sustainability in buildings by helping participants to identify and implement green design, construction, and operation and maintenance opportunities and then ranking completed projects on their overall environmental and health performance.

Benefits of the program include the resources and support provided to participating institutions, the program's engagement of project stakeholders, and the thorough nature of the rating system.

Drawbacks include the expense of participating and the significant time-commitment required on the part of the staff members overseeing the project. LEED project registration for an existing building hoping to achieve certification for operations and maintenance costs $1,200 for a non-member of USGBC and review costs $2,000. [16] This means that certifying 20 buildings, which would comprise a very small college campus, would cost $41,200. This fee does not include the costs of actual upgrades or recertification through the years. The inaccessibility of LEED certification for most colleges and universities is reflected in the fact that of the 4300 institutions of higher education in the United States less than 3% had a LEED certified building as of 2010.[17] Another widely criticized disadvantage is the system's lack of transparency on how certification points are allocated for projects.

---

[16] Green Building Certification Institute. (Visited 2012, January 18). *Building certification fees: Operations & maintenance*. Retrieved from http://www.gbci.org/main-nav/building-certification/fees/om.aspx

[17] The Princeton Review, Inc. and U.S. Green Building Council.,(2010).

*Energy Star for Buildings & Manufacturing Plants (EPA)*
Website: http://www.energystar.gov/index.cfm?c=guidelines.guidelines_index

Energy Star for Buildings & Manufacturing Plants is offered through the U.S. Environmental Protection Agency's (EPA) Energy Star program, established to save energy and cut greenhouse gas emissions by promoting more efficient products through certification and consumer awareness. Energy Star for Buildings & Manufacturing Plants certifies buildings that perform in the top 25% of their industry for energy use efficiency. The program allows participating institutions to make an energy use reduction commitment, assess performance, set goals, create and implement an action plan, evaluate their progress, and recognize achievements through certification.

Benefits of this program include the fact that it is free, that resources and project calculators are accessible to the public online, and that the energy-tracking program is very useful for identifying progress in energy conservation. The Energy Star program offers a useful tool for benchmarking energy use in buildings called "Portfolio Manager" as well as guidebooks and tools for comparing current energy management behaviors with industry best practices. Energy Star also provides a number of calculators, and training programs for participating organizations, however the offerings are not tailored to colleges and universities. The Energy Star for Higher Education offerings will be discussed below.

The primary drawback (in addition to cost) is the fact that the program requires significant leadership on the part of campus administrators and architects or building managers to implement projects.

*STARS (Association for the Advancement of Sustainability in Higher Education)*
Website: https://stars.aashe.org/pages/about/faqs/program-overview.html

Sustainability Tracking Assessment & Rating System (STARS) is a sustainability certification program for colleges and universities that allows schools to track and measure their achievements over time and share sustainability strategies with other institutions.

Benefits of the program include that it is specifically designed for and accessible to institutions of higher learning and that it is inexpensive (the entrance fee to access the tracking tool is only $1200).

The major program drawback is the focus on overall sustainability as opposed to energy efficiency and operations, which are only one element of the ranking system. While environmental education and engagement are important for achieving energy efficiency on a college campus, a campus primarily interested in identifying specific energy cost savings might be less inclined to participate in such a program.

## Calculators

Instead of enrolling in a certification program schools can identify individual projects on their own and enumerate savings using various industry “calculators”. While such calculators can be very accurate (such as the EPA’s Energy Star calculators for appliances) they are not available for all potential projects. However, the calculators are offered in a variety of places throughout the website and no resource exists to walk an organization step by step through all parts of an energy audit, financial calculations, and communications. Users must piece together projects that they want to pursue, which requires a decent understanding of the best upgrade options available. Leading energy savings calculators are included below, however myriad companies provide calculators for specific projects or products as well.

Benefits include the variety of calculators offered for commercial appliances, commercial kitchen products, consumer electronics products, residential heating and cooling products, lighting products, office equipment products, residential appliance products, exit signs, and programmable thermostats.

A few drawbacks include that the calculators do not always incorporate specifics about the age and efficiency of current equipment and the availability of regional rebate opportunities. Overall, the calculators are excellent for general estimations but less useful for more specific calculations.

*Energy Star Calculators*
Website: http://www.energystar.gov/index.cfm?c=bulk_purchasing.bus_purchasing

*Department of Energy Calculators*
Website: http://www1.eere.energy.gov/calculators/

*PECO Smart Ideas Calculators*
Website: https://www.pecosmartideas.com/toolsandcalculators/index.html

*PG&E Calculators*
Website:
http://www.pge.com/myhome/saveenergymoney/resources/appliancecalculator/

## Guidebooks/Case Studies

Another tool for colleges and universities hoping to lower energy costs are the guidebooks and case studies offered through various environmental organizations. Many such guidebooks are provided for free on the Internet and present ideas for identifying energy efficiency savings. These guidebooks often highlight the achievements of specific institutions and present upgrade or behavioral recommendations that apply to most colleges and universities. A list of leading guidebooks is provided below.

Benefits include the accessibility of such guidebooks, the fact that recommendations are based upon the actual experiences of colleges and universities, and the fact that these resources are free. Oftentimes such guides will also include a list of related resources.

Drawbacks include the fact that guidebooks often do not include tools for calculating specific savings for each project. While guides and case studies often give an average savings for universities, or an average savings per project, such savings may not be accurate from one school to another.

Conservationwise from Xcel Energy. "Managing Energy Costs in Colleges and Universities." McGraw-Hill, New York, NY: 2002.

Eagan, David J., Julian Keniry, and Justin Schott. “Higher Education in a Warming World: The Business Case for Climate Leadership on Campus.” National Wildlife Federation, Reston, VA: 2008.

Eagan, David J., Terry Calhoun, Justin Schott, and Praween Dayananda. “Guide to Climate Action Planning: Pathways to a Low-Carbon Campus.” National Wildlife Federation, Reston, VA: 2008.

National Wildlife Federation – Campus Ecology. “American University, Washington, DC, Energy – LED Lighting.” National Wildlife Federation, Washington, DC: 2010.

U.S. Green Building Council. “Western Michigan University College of Health & Human Services, Kalamazoo, Michigan.” U.S. Green Building Council, Washington, DC: 2009.

Humblet, Emmanuelle M., Rebecca Owens, and Leo Pierre Roy. “Roadmap to a Green Campus.” U.S. Green Building Council, Washington, DC: 2010.

Meehan, Peggy. “Hands-On LEED: Guiding College Student Engagement.” U.S. Green Building Council, Washington, DC, 2010.

Other Energy Efficiency Case Study Examples (Not Colleges/Universities):

International Energy Agency. “Promoting Energy Efficiency Investments: Case Studies in the Residential Sector.” IEA Publications, Paris, France: 2008.

United States Environmental Protection Agency - Energy Star. “Lighting Unlimited: Investing in Energy Star.” Environmental Protection Agency.

Other Resources

For Higher Education: Energy Star website

http://www.energystar.gov/index.cfm?c=higher_ed.bus_highereducation

The EPA’s Energy Star website also provides a special section for colleges and universities called Energy Star for Higher Education. The website discusses benchmarking for colleges and universities, student and faculty engagement, and success stories of colleges that have incorporated energy efficiency projects. The site also provides an example of a dorm room outfitted with Energy Star approved products. Additionally the website addresses awards available to colleges and universities and provides tools such as Portfolio Manager for tracking energy savings over time. This is an excellent resource that institutions can use to complement a guide for identifying and tracking the impacts of specific energy-saving projects at their schools.

## Objective

*A Toolkit for Identifying Energy Savings at Colleges and Universities* is a guidebook for college and university administrators and students to track their institution's energy use, identify energy efficiency upgrade opportunities and conservation programs, and calculate the individualized costs and savings for implementing these projects on their campuses. The toolkit comprises two case studies of universities that have successfully identified energy savings opportunities as well as the guidebook for tracking energy use and calculating the costs and savings of energy efficiency projects that apply to most campuses. *A Toolkit for Identifying Energy Savings at Colleges and Universities* improves upon current guidebooks that give industry-wide recommendations without the tools to identify site-specific savings. The toolkit was also designed with the hope that existing staff and students could identify the best projects for their school without needing to hire new staff. In this way the toolkit improves upon current energy savings calculators that either require some advanced knowledge of inputs and interpretation of outputs or are too general to calculate site-specific savings. The guide is also free, making it accessible to schools that do not have the funds to buy into certification programs to identify energy savings.

## Methods

The Toolkit was inspired by my summer work with Shaw University through Environmental Defense Fund's (EDF) Climate Corps Public Sector Fellowship. Through this fellowship I performed an assessment of past energy use, an audit of current HVAC and lighting equipment and appliances, and an evaluation of energy use behavior with my Climate Corps partner Jennifer Weiss (Nicholas School MEM Candidate 2012). We then identified eleven energy efficiency projects, many of which were no- or low-cost options, which if implemented could save the university about 16% in annual energy costs. These projects have an average payback period of only 3.28 years while most individual projects have a payback period shorter than one year.[18] We also identified various education and behavioral strategies for decreasing energy use in campus buildings, which we shared with the university in our formal report and presentation. I used the projects and conservation strategies that Jennifer Weiss and I recommended to Shaw University administrators as well as projects that EDF Fellows Matthew Peck and Michelle Williams recommended Winston-Salem State University (WSSU) administrators as the basis for the projects presented in my toolkit.

The Toolkit itself contains two main components. The first component is two case studies, one about Shaw University and the other about Winston Salem State University (both 2011 EDF Climate Corps Public Sector sites). I highlight the projects identified at each site as well as the expected savings from these projects and the challenges and individual successes of the energy-savings identification process for each school. These case studies follow the format of a USGBC or National Wildlife Federation case study, which tend to be 2 to 3-page documents that list achievement numbers as well as an analysis of the energy efficiency project identification process. In this way EDF, Shaw, and WSSU can use my complete case studies as stand-alone documents for publicity purposes.

The second component is the guidebook for conducting a cost/benefit analysis of individual upgrades and energy conservation projects on a college campus. The guidebook walks the user through the calculations for projects such as lighting upgrades, programmable thermostats and air conditioning unit upgrades, vacation building shutdown, appliance consolidation, computer sleep settings, LED exit sign upgrades, and vending machine “misers”. I also included a section on education and engagement, which is

---

[18] Davis, Eliza and Jennifer Weiss. (2011). *Energy efficiency and conservation: Shaw University*. Environmental Defense Fund.

especially important for technologies such as programmable thermostats, which are most effective when set properly by all users. I explain in the Toolkit how to calculate the costs and savings of each project, the payback periods, and the net present values (NPV) of projects. I also discuss the calculations for carbon dioxide equivalent CO2e emissions reduction and tips for communicating savings to stakeholders, based on my work with EDF. Additionally I walk the user through practical issues such as how to identify rebate opportunities, which numbers to use from an electricity or natural gas bill, and who to contact to identify current lighting and upgrade options.

I hope that this *Toolkit for Identifying Energy Savings at Colleges and Universities* will be a useful resource to school administrators and students hoping to save energy, reduce greenhouse gas emissions, and save money for their schools.

# A Toolkit for Identifying Energy Savings at Colleges and Universities

## 1. Introduction

This resource was developed to empower campus leaders at American colleges and universities to identify energy saving opportunities on their campuses without the help of additional staff of external consultants. I was inspired to develop this toolkit during my work as an energy consultant at Shaw University through Environmental Defense Fund's (EDF) Public Sector Climate Corps Fellowship. During my time at Shaw I learned that administrators, students, and staff had an interest in campus sustainability and saving money on operations but were unaware of the range of projects and technologies available and how to evaluate the cost effectiveness of these projects.

Shaw University faced barriers to energy efficiency adoption that I found through further research are common among universities, corporations, and private individuals alike. Not only do organization leaders have inadequate information about technology options, but they also often lack the initial funds to implement projects, they lack the staff to lead new programs, they face organizational challenges such as communication and change management, and they lack the tools to identify potential project savings. Even leaders with an understanding of the value of energy upgrades often fail to communicate energy efficiency programs as investments with annual returns instead of merely as costs. Finally, those organizations that invest in energy efficiency projects often fail to make the crucial commitment to educating their campus or community about how to use and maintain equipment and ultimately fall short of achieving optimal savings.

I designed the Toolkit as a free, accessible, and comprehensive resource that would enable students, faculty, or staff members with no energy background to identify savings on their own. There are two primary components of the Toolkit. First I have provided two case studies to show the actual projects that can be identified on university campuses, the expected energy savings from these projects, and recommendations for overcoming real barriers to adoption. The first case study focuses on Shaw University in Raleigh, NC where I worked with fellow Duke student Jennifer Weiss to identify energy efficiency savings during the summer of 2011. The second case study highlights the work of EDF Climate

Corps Fellows Matthew Peck and Michelle Williams who identified cost-saving projects at Winston-Salem State University in Winston-Salem, NC during the summer of 2011.

Each case study highlights an explanation of the specific energy projects that the Fellows recommended, the percentage of expected annual energy savings from the combined projects and the breakdown of these savings by project, the expected payback period for each project, and the expected avoided carbon dioxide equivalent emissions from implementing the recommendations. The case studies also discuss the specific barriers to project adoption that the Fellows encountered and their recommendations for overcoming these barriers. My thanks to Jennifer Weiss, Matthew Peck, and Michelle Williams, as well as Dr. Jeffrey Smith at Shaw University and Dr. Richard Kabis at WSSU for their generous permission to highlight the Fellows' findings in this Toolkit.

The second element of the Toolkit is the guidebook for identifying energy savings opportunities on your campus. The guidebook highlights projects that can be implemented on a typical university or college campus and explains the technologies themselves as well as the process for calculating the costs and savings of implementing each project over time. Several other projects are included with a less detailed technology and cost-savings analysis, which should be pursued after the easier projects or "low-hanging fruits" have already been implemented. When appropriate the guidebook discusses which projects require the guidance of a contractor to evaluate upgrade options, when to ask your facilities manager for assistance, and when to look for rebate opportunities through your local utility. The guidebook also addresses energy education and environmental engagement activities so your campus can achieve greater savings through the responsible use of energy equipment by students, faculty, and staff. This is an important pairing for the more technical sections of the guidebook because energy efficiency at its core is an issue of informed behavior.

It is my hope that the Toolkit will provide school leaders with the resources to identify energy and cost savings and inspire an institution-wide discussion about the role of sustainability and energy efficiency in your community. Campus sustainability and energy management are ongoing processes that require understanding and adoption by all members of the community. Please use this Toolkit as the first step of many toward developing an engaged, efficient, and sustainable campus.

## 2. Case Studies

This section includes two case studies discussing the process of identifying energy savings at two universities in North Carolina: Shaw University and Winston-Salem State University. Each university hosted two Environmental Defense Fund Climate Corps Public Sector Fellows during  the summer of 2011. The Fellows worked for ten weeks to identify energy saving projects and programs on each campus, they calculated the costs and savings of each project over time, and they recommended ways to overcome barriers to energy efficiency adoption. Jennifer Weiss and I worked with Shaw University and Matthew Peck and Michelle Williams worked with Winston-Salem State University. I am thankful to all three of the other Fellows as well as the staff members at both universities who approved my use of their data for these case studies.

# Shaw University

## *A Case Study*

Shaw University is a private coeducational historically black university founded in 1865. The university's main campus is located in Raleigh, North Carolina and serves over 2700 students annually, 1300 of who are full-time students. Shaw also operates nine Center for Alternative Programs in Education (CAPE) locations throughout North Carolina.(1)

Shaw University hosted two Environmental Defense Fund Climate Corps Fellows, Eliza Davis and Jennifer Weiss, in the summer of 2011. The Fellows spent ten weeks on campus identifying energy-saving opportunities through potential upgrades and energy efficiency programs. This case study presents the findings of the Fellows and was developed with their permission and that of Shaw University leadership.

## Institutional Goals & Best Practices

Shaw University faculty and staff were committed to sustainability before the arrival of the Climate Corps Fellows. Facilities staff had already replaced most incandescent light bulbs with CFLs, upgraded many T-12 fluorescent lamps to less energy-intensive T-8 fluorescent lamps, and replaced the lighting in the campus chapel with LEDs. The university's incoming energy services provider, Piedmont Service Group, had already assisted the school in obtaining grant funding from the North Carolina State Energy Office to help pay for a new chiller. This upgrade alone is expected to save the school about $61,000 annually in avoided energy costs.

The Fellows witnessed the development of the Shaw Green Team during their time at the school. This group of faculty, staff, and students provides a forum for discussion about ongoing campus sustainability initiatives and drives the developing energy and environmental programs on campus. The Green Team continues to meet regularly to encourage implementation of the efficiency upgrades and waste reduction programs recommended by the Fellows, acquire grant funding for projects, and increase sustainability education and engagement on campus.

## Barriers to Energy Efficiency

Despite the notable achievements of Shaw staff, Fellows identified several barriers to more complete energy efficiency adoption on campus:

- Lack of formal sustainability strategy
- No sustainability manager
- Staff time constraints
- Financing challenges

To overcome the first three challenges the Fellows recommended that the administration designate a current staff member to be the Sustainability Director. The Sustainability Director should help identify sustainability priorities in a formal sustainability strategy, coordinate the project implementation process, and lead the education effort on campus. The Fellows also recommended using the savings from low and no-cost energy efficiency projects to establish a separate fund for future energy and sustainability projects to be identified by the Green Team.

## Recommended Projects

The Fellows identified the following projects to help Shaw University save energy and cut greenhouse gas emissions:

**(1) PC and Copier Power Management**: Set sleep settings on all computers, monitors, and copiers to prevent the units from drawing excess power when they are not in use. This simple step can save up to $30 in energy costs per computer per year and about $45 per copier.(2)

**(2) Washing Machine Upgrades**: Work with the washing machine vendor to upgrade campus units to Energy Star® machines. Upgrades would result in energy savings as well as savings on water and sewage fees.

**(3) Consolidate Office Equipment**: Encourage staff members to leave personal printers, mini-fridges, microwaves, and other appliances at home especially when large shared appliances are available in the common areas.

**(4) Install VendingMisers®**: VendingMisers® are devices that can be attached to vending machines to cycle the cooling systems on and off when no one is in the vicinity of the machine. VendingMisers® should be installed on nine of the vending machines on campus that sit in low-traffic areas where the devices offer the greatest savings. Lighting in all machines should also be turned off, which can save up to $100 in energy costs per machine per year.(3)

**(5) LED Exit Signs**: Incandescent lighting in all 322 exit signs around campus should be replaced with LED lamps. Replacing 30-Watt incandescent bulbs with 2-Watt LEDs results in significant energy savings since exit signs must be lit 24-hours a day for safety purposes.

**(6) Summer Dormitory Temperature Setback**: Two of the dormitories on campus are not used during the summer. Thermostats should be set to 85 degrees when these buildings are not occupied. This is a cool enough temperature to prevent mold and moisture issues.

**(7) Lighting**: Replace all T-12 lamps with the appropriate 25-Watt T-8 replacements. Replace all metal halide lamps with 6-lamp T-8 fluorescent fixtures. Replace incandescent bulbs in the auditorium and elevators with appropriate LED substitutes. Rebate programs make these investments especially lucrative.

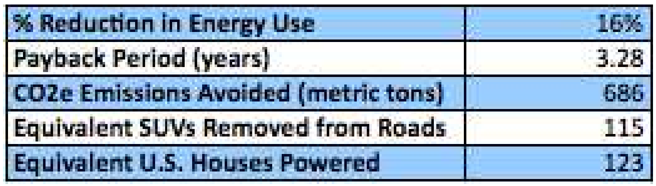
**(8) Programmable Thermostats**: Programmable thermostats allow users to implement temperature “setbacks” to prevent unnecessary energy use when buildings are vacant. Shaw should replace 57 non-programmable thermostats with programmable units. These units qualify for rebates and are expected to lead to annual savings of at least 10% per building.(4)

**(9) HVAC Upgrades**: Shaw should replace aging air conditioning units with newer models to save as much as 35% in energy costs per unit annually.(5) The university should replace the oldest units first since they offer the greatest potential savings from upgrades. Fifty-two units should be replaced in waves over the next five years. Shaw could use the savings from some of the low-cost and no-cost projects to finance these more expensive upgrades.

**(10) Other Projects**: Shaw should repair broken doors, close roof vents in the gymnasium, and fill any holes in walls where drinking fountains and equipment have been removed to prevent heating and cooling losses. Shaw administrators should work with the Purchasing Department to encourage a policy to buy Energy Star® certified products to achieve additional energy savings. Shaw should also purchase “smart” power strips that reduce the power draw from devices when they are not in use. The university should also recommend that students purchase Energy Star appliances and “smart” power strips for their dorm rooms.

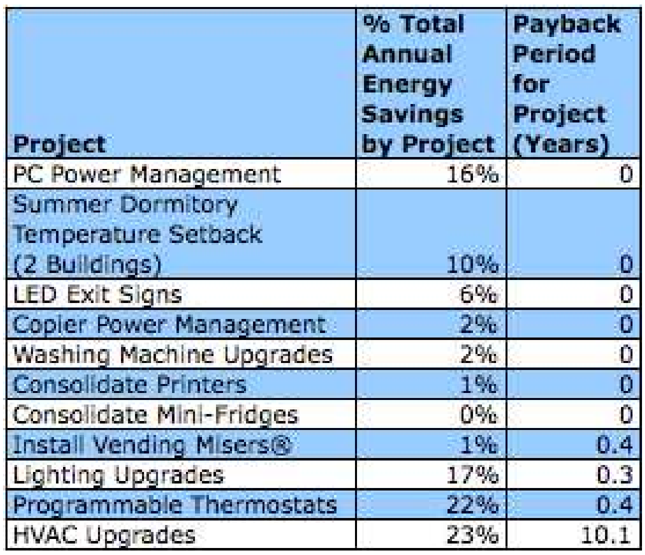
## Total Savings

The Fellows identified the following total annual savings from implementing the projects above:



| | |
|---|---|
| % Reduction in Energy Use | 16% |
| Payback Period (years) | 3.28 |
| CO2e Emissions Avoided (metric tons) | 686 |
| Equivalent SUVs Removed from Roads | 115 |
| Equivalent U.S. Houses Powered | 123 |

A breakdown by project of the 16% annual energy reduction is listed in the table below. Payback periods for each project are also included in this table. (Note: Payback periods take into account available rebates, which is why LED exit signs have a zero payback period. Vending Misers®, lighting upgrades, and programmable thermostats also qualify for significant rebates.)



| Project | % Total Annual Energy Savings by Project | Payback Period for Project (Years) |
|---|---|---|
| PC Power Management | 16% | 0 |
| Summer Dormitory Temperature Setback (2 Buildings) | 10% | 0 |
| LED Exit Signs | 6% | 0 |
| Copier Power Management | 2% | 0 |
| Washing Machine Upgrades | 2% | 0 |
| Consolidate Printers | 1% | 0 |
| Consolidate Mini-Fridges | 0% | 0 |
| Install Vending Misers® | 1% | 0.4 |
| Lighting Upgrades | 17% | 0.3 |
| Programmable Thermostats | 22% | 0.4 |
| HVAC Upgrades | 23% | 10.1 |

## Conclusion

To continue the sustainability momentum on campus the Fellows recommended that Shaw take advantage of training programs through national organizations. They suggested joining Green For All’s College Ambassadors Program, which works to expand job opportunities in the green industry and was designed to engage student leaders at Historically Black Colleges and Universities. They also suggested developing a formal sustainability plan and marketing that plan on the website and in other college materials.

The Fellows noted in their final report that expansion of the cross-functional Green Team would be critical to continuing the momentum created over the summer. They are happy to note that as of April, 2012 the Green Team continues to meet regularly to prioritize sustainability initiatives and plan engagement activities.

## References

(1) Shaw University. (Visited 2011, August). *Shaw University*. Retrieved from http://www.shawuniversity.edu/

(2) Waste Reduction Partners. Sponsored by the State Energy Office N.C. Department of Administration and the U.S. Department of Energy, with State Energy Program funds, in cooperation with Land-of-Sky Regional Council (Waste Reduction Partners) and the NCDPPEA. (2004, February). *Vending Machines - Utility Savings Initiative (USI) - Fact Sheet*. Retrieved from http://www.p2pays.org/energy/Vending.pdf

(3) U.S. Department of Energy. (2012, April 25). *Energy efficiency & renewable energy: Energy savers*. Retrieved from http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12720

(4) Mike Davis, Energy Engineer for Piedmont Service Group, Raleigh, NC. Summer 2011.

(5) Shaw University, (2011).

(6) Photo of Shaw University campus taken by Jennifer Weiss during the summer of 2011.

# Winston-Salem State University

*A Case Study*

Winston-Salem State University (WSSU) is a regional public university located on a 110-acre campus in Winston-Salem, North Carolina. Founded in 1892, WSSU is a historically black university and a member of the University of North Carolina system. The university has a current enrollment of 6,442 students in undergraduate and graduate programs and employs 400 faculty members and over 800 staff members.(1)

WSSU participated in Environmental Defense Fund's Climate Corps Public Sector Program in the summer of 2011. The university hosted two Fellows, Matthew Peck and Michelle Williams, who spent ten weeks on campus identifying energy-saving opportunities to help the school save money and cut greenhouse gas emissions. This case study presents the Fellows' findings and recommendations and was developed with their generous permission and that of WSSU staff.

## Institutional Goals & Best Practices

WSSU had made several commitments to energy conservation and campus sustainability before hosting their Climate Corps Fellows. The university has a full-time Sustainability Manager who tracks monthly utilities and implements efficiency measures as part of the Facilities Department. Additionally, WSSU had already completed lighting upgrades to seven buildings as part of an energy performance contract that applies to ten campus buildings. The university hopes to achieve carbon neutrality by 2050.

## Barriers to Energy Efficiency

The WSSU Fellows identified the following challenges to incorporating energy efficiency programs on campus:

- Institutional Engagement
- Environmental Awareness
- Financing
- Equipment Maintenance
- Resistance to Change

To overcome the institutional engagement and environmental awareness barriers the Fellows recommended developing more environmental courses and formally incorporating sustainability into the institution's strategic plan. They also recommended encouraging an environmental student club and pursuing membership in organizations such as Green For All and the Association for the Advancement of Sustainability in Higher Education (AASHE) that provide support for sustainability education and engagement on campus.

The Fellows highlighted the importance of equipment maintenance in achieving energy savings noting that the most cost-effective option is often ensuring the efficient operation of existing equipment. The Fellows also emphasized that because of financial constraints it would be critical to identify the most cost-effective energy-saving upgrades and implement them quickly to start saving money.

## Recommended Projects

The Fellows recommended the following 11 projects:

**(1) Summer Plan for Residence Halls**: Consolidate all summer residents into the dormitory that is least expensive to operate. Turn all thermostats in vacant rooms to 80 degrees, turn off all non-emergency lights, and close blinds to prevent excess heat gain. Leave the HVAC equipment off in vacant buildings only turning systems on one hour every 48 hours to prevent mold and moisture. Employee education and engagement will be crucial to the success of this program. A pilot study in one dormitory showed that HVAC shutdown measures could reduce energy use by 58% per building.(3)

**(2) Thermostat Setbacks: Residence Halls** Increase residence hall thermostat settings to 74 degrees F in the summer and decrease settings in the winter to 68 degrees F. Set thermostats to 55 degrees during winter break. Educate students to “Set It and Forget It” at the recommended temperatures in buildings with standard thermostats. Student education and engagement will be the key to the success of this program. The school should consider a Direct Digital Control (DDC) system for further savings from thermostat settings.

**(3) Thermostat Setbacks: Other Buildings:** Thermostats in other campus buildings should also be set to 74 degrees F in the summer and 68 degrees F in the winter during working hours (6:00 AM to 8:00 PM Monday through Friday). During unoccupied hours (nights and weekends) temperatures should be set to 80 degrees in the summer months and 60 degrees in the winter months. The Fellows recommended installing a Direct Digital Control (DDC) system or installing programmable thermostats, which could be used to set different temperatures for different hours of the day. These equipment recommendations were not included in cost and savings estimates.

**(3) Space Heater Policy:** An estimated 20% of staff members use a space heater for 8 hours a day 113 days per year. Since a single space heater draws about 1500W of power the university should create a policy restricting employee space heaters.(4)

**(4) Vending Misers®:** Purchase Vending Misers® for all 111 cold drink machines and 17 snack machines on campus. These devices use occupancy sensors to cycle the machines off when no one is around and use temperature sensors to avoid excess cooling. Rebates offered by the local utility make this project especially lucrative.

**(5) Exterior Pole Lighting**: Replace existing outdoor lighting with light emitting diodes (LEDs). The existing lamp types include metal halide, high pressure sodium, and multi vapor lighting totaling 610 lamps. While LEDs are more expensive than current lamps they have much longer usable lifetimes (11.4 years versus 1.4-2.7 years for existing lighting). LEDs are expected to use about 90% less energy than the current mix of lamps.(5)

**(6) Interior Lighting**: Replace all 88 CFL exit sign lighting with LEDs. Replace 8 metal halides, 19 high pressure sodium lights, and emergency T-12 and T-8 lighting with appropriate LEDs. 393 T-12 fluorescent lamps should be replaced with T-8 fluorescent tube lighting.

**(7) Occupancy Sensors**: Install occupancy sensors in all restrooms since lights are currently left on in some restrooms for 24 hours a day. This step could reduce bathroom lighting demand by 80%.(6)

**(8) Window Film**: To prevent a high cooling load during summer months WSSU should purchase window film, which reflects sunlight in the summer and helps to retain heat in buildings in the winter.

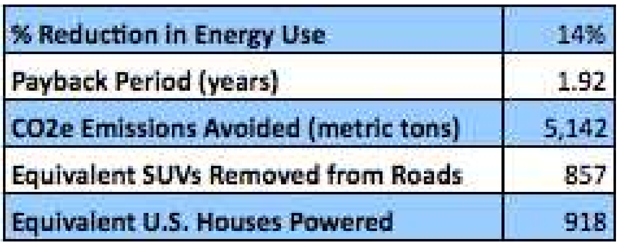
The Department of Energy's Demand Analyzer program (http://www.halcyon.com/byrne) for VEP35 window film was used to calculate estimated savings from window film for nine campus buildings. This project would also benefit from utility rebates.

(9) **Door Repair**: Several buildings on campus have doors with broken retraction mechanisms, which cause them to remain open due to interior airflow. The energy cost from these maintenance issues was calculated based on the area of the doors, velocity of airflow of 5 miles per hour, and a differential in temperatures between the building and outdoors of 30 degrees for 250 days every year. The retraction mechanisms should be fixed for immediate savings.

**(10) Other Projects**: Exterior Insulation and Finish Systems (layered insulated walls) to improve building insulation should be considered for four residence halls with inadequate insulation. WSSU should also consider applying a white coating finish to rooftops to prevent excess heating during summer months.

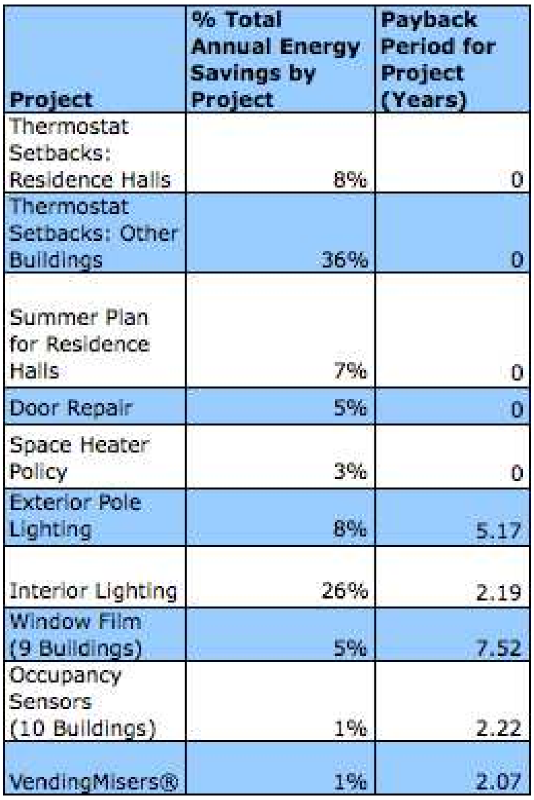
## Total Savings

The combined projects are expected to result in a 14% annual energy savings for WSSU with an average payback period of less than two years. See table below for specific savings.



| | |
|---|---|
| % Reduction in Energy Use | 14% |
| Payback Period (years) | 1.92 |
| CO2e Emissions Avoided (metric tons) | 5,142 |
| Equivalent SUVs Removed from Roads | 857 |
| Equivalent U.S. Houses Powered | 918 |

The distribution of the total annual expected savings by project and the payback period by project are included below:



| Project | % Total Annual Energy Savings by Project | Payback Period for Project (Years) |
|---|---|---|
| Thermostat Setbacks: Residence Halls | 8% | 0 |
| Thermostat Setbacks: Other Buildings | 36% | 0 |
| Summer Plan for Residence Halls | 7% | 0 |
| Door Repair | 5% | 0 |
| Space Heater Policy | 3% | 0 |
| Exterior Pole Lighting | 8% | 5.17 |
| Interior Lighting | 26% | 2.19 |
| Window Film (9 Buildings) | 5% | 7.52 |
| Occupancy Sensors (10 Buildings) | 1% | 2.22 |
| VendingMisers® | 1% | 2.07 |

## Conclusion

The Fellows identified 11 energy efficiency projects on the WSSU campus that are expected to save the school 14% in annual energy costs and decrease CO2 equivalent emissions by as much as 18%. The Fellows hope that these projects will be the first step for WSSU toward a legacy of sustainability and environmental stewardship.

## References

(1) Winston-Salem State University. (Visited 2012, March 20). *About WSSU - About WSSU*. Retrieved from http://www.wssu.edu/about/default/aspx

(2) Photo of the Winston-Salem State University campus taken by Eliza Davis, March 2012.

(3-6) Peck, Matthew and Michelle Williams. (2011) *Energy Efficiency and Conservation: Winston-Salem State University*. Environmental Defense Fund.

## 3. Benchmarking

Successful energy management depends upon the process of setting goals, tracking progress, and evaluating outcomes. Understanding current campus energy use is the foundation for this process. Without identifying a baseline for energy use there is no way to quantify the savings from upgrades and the successes of energy-saving efforts. As all administrators know, it is important for funding purposes to be able to demonstrate not only the expected savings from a project but also the actual savings resulting from investments down the road. Therefore the first exercise in this toolkit is quantifying current consumption by calculating your institution's baseline energy use.

### Calculating Your Baseline Energy Use

Before you can assess the expected savings from individual projects you must understand your institution's current energy use. Quantifying energy use is fairly straightforward if you can access your institution's monthly utilities bills. If your institution does not keep records of your school's monthly energy bills you can request copies from your utility or request to view the records online.

To begin, gather all monthly energy bills (electric and natural gas) for each campus building for the past one to three years. You can usually contact Accounts Payable or the Finance Office to obtain copies of utilities bills but monthly statements may also be available through your Facilities Office if your school generates any of its power on-campus. It is preferable to include more than one year's worth of energy bills in your analysis. This will help to cancel out temperature variation from one year to the next and will help to control for energy use variability.

Once you have compiled bills for as many years as possible sort them by month and by building. Then create a spreadsheet with electricity and natural gas data for each building on campus for which you have utility bills. Your school may not be sub-metered, which means that there may only be one electricity bill and one natural gas bill for the entire campus each month. In this case simply make one spreadsheet for total campus energy use.

You will need to gather monthly energy usage and cost information from these bills. The specific information listed on your bill will vary based on the rate structures for each building on your campus. For instance, for electricity you may be billed at different rates based on the season, or your rates may follow a block structure where usage is billed at increasingly higher rates or increasingly lower rates based on how much energy you have already used that month. Still other rates are based on when energy is used during the day, called Time of Use rates. On-peak usage is charged at a higher rate than off-peak usage to encourage customers to decrease energy-intensive activities during the busiest hours of electricity use during the day. (Note: If your school is billed at Time of Use rates and is spending a lot of money on electricity during on-peak hours, consider identifying the sources of energy use and trying lower usage during these hours to cut costs. For instance, consider turning down the air conditioning or heating in dorms during these hours, turning off unnecessary lighting, or scheduling cleaning crews to work during off-peak hours.)

If you are billed on a seasonal schedule you will notice that rates will change during specific months. If you are billed at an increasing or declining block structure you will notice there are multiple levels of kWh usage and a charge per kWh based on that usage.[19] For instance, a bill that shows 750 kWh at $.10/kWh, 1200 kWh at $.09/kWh and 221 kWh at $.07/kWh would signal a declining block rate with rate changes at 750 and 1200 kWh of usage. You will want to include all three usages and rates in your baseline data. If you are billed on a Time of Use schedule you will see that the usage is charged at On-Peak and Off-Peak rates. You will also see a power fee for kW charged based on the highest power requirement of the institution during peak hours. Natural gas bills may also vary seasonally and may incorporate a variety of rates and fees.

The important thing to remember as you structure your spreadsheet is to clearly separate usage and charges. Include two different sections on each spreadsheet: one for electricity

---

[19] The Source: Utility Enterprise Management. Published First Quarter 2005 by Advanced Engineering and Environmental Services, Inc. Copyright AE2S First Quarter 2005. http://www.ae2s.com/pdf/Source/1stQuarter05.pdf

usage and natural gas usage as each is measured in unique units (kWh versus therms). We will discuss unit conversions between kWh and therms later on. Relevant information to incorporate for each building will include:

- -Building name and address
- -Square footage
- -Meter number (can be found on the meter itself as well as on the bill)
- -Month
- -Year

For All Electricity Bills:

- -Electricity use (kWh)
- -Cost per kilowatt hour
- -Total cost per kWh (kWh * $/kWh)
- -Any charges (separated by type)
- -Sales tax
- -Total bill (Sum of all charges and fees)

For Time of Use rate structures also include:

- -Power (kW)
- -Cost per kW
- -Total cost per kW (kW * $/kW)
- -Peak kVar (This is an abbreviation for kilovolt-amperes reactive. This measures reactive power, which exists when the voltage and current in an alternating current electric system do not change together.)

For Block Structures (Increasing or Declining):

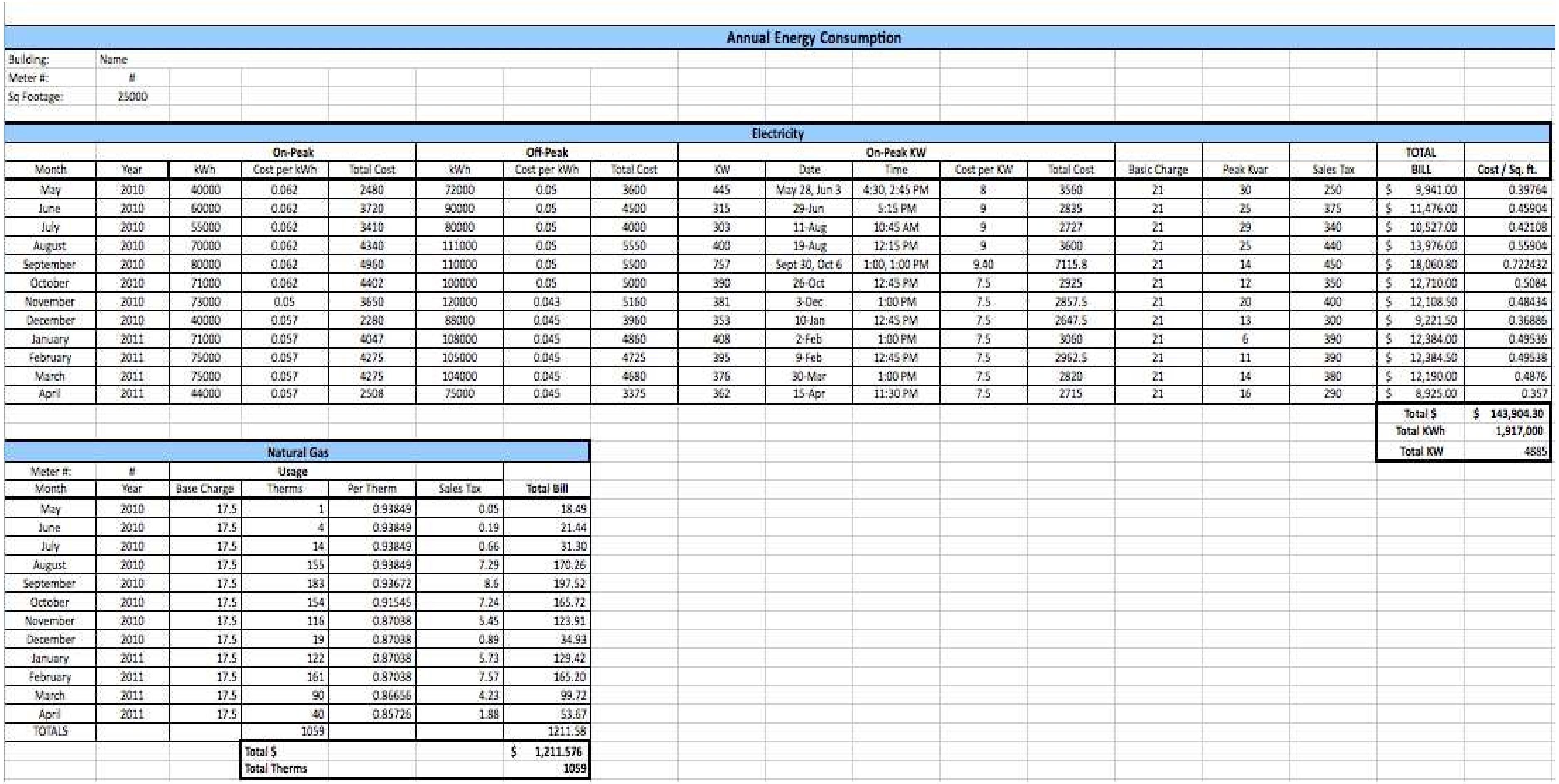
- -Each rate ($/kWh)
- -Electricity use per rate (kWh)
- -Total cost per kWh per each rate (kWh * $/kWh)
- -Total cost overall (all costs added per month)

Natural Gas (NG) Bills:

- -Base Charge (charged whether or not you use any NG that month)
- -Usage (therms)
- -Cost ($/therm)
- -Sales Tax
- -Total Bill

Below is an example of how you can structure your spreadsheet:

**Table 1: Energy Use Per Building Spreadsheet**



Annual Energy Consumption

| | |
|---|---|
| Building: | Name |
| Meter #: | # |
| Sq Footage: | 25000 |

Electricity

| | | On-Peak | | | Off-Peak | | | On-Peak KW | | | | | | | | TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Year | kWh | Cost per kWh | Total Cost | kWh | Cost per kWh | Total Cost | KW | Date | Time | Cost per KW | Total Cost | Basic Charge | Peak Kvar | Sales Tax | BILL | Cost / Sq. ft. |
| May | 2010 | 40000 | 0.062 | 2480 | 72000 | 0.05 | 3600 | 445 | May 28, Jun 3 | 4:30, 2:45 PM | 8 | 3560 | 21 | 30 | 250 | $ 9,941.00 | 0.39764 |
| June | 2010 | 60000 | 0.062 | 3720 | 90000 | 0.05 | 4500 | 315 | 29-Jun | 5:15 PM | 9 | 2835 | 21 | 25 | 375 | $ 11,476.00 | 0.45904 |
| July | 2010 | 55000 | 0.062 | 3410 | 80000 | 0.05 | 4000 | 303 | 11-Aug | 10:45 AM | 9 | 2727 | 21 | 29 | 340 | $ 10,527.00 | 0.42108 |
| August | 2010 | 70000 | 0.062 | 4340 | 111000 | 0.05 | 5550 | 400 | 19-Aug | 12:15 PM | 9 | 3600 | 21 | 25 | 440 | $ 13,976.00 | 0.55904 |
| September | 2010 | 80000 | 0.062 | 4960 | 110000 | 0.05 | 5500 | 757 | Sept 30, Oct 6 | 1:00, 1:00 PM | 9.40 | 7115.8 | 21 | 14 | 450 | $ 18,060.80 | 0.722432 |
| October | 2010 | 71000 | 0.062 | 4402 | 100000 | 0.05 | 5000 | 390 | 26-Oct | 12:45 PM | 7.5 | 2925 | 21 | 12 | 350 | $ 12,710.00 | 0.5084 |
| November | 2010 | 73000 | 0.05 | 3650 | 120000 | 0.043 | 5160 | 381 | 3-Dec | 1:00 PM | 7.5 | 2857.5 | 21 | 20 | 400 | $ 12,108.50 | 0.48434 |
| December | 2010 | 40000 | 0.057 | 2280 | 88000 | 0.045 | 3960 | 353 | 10-Jan | 12:45 PM | 7.5 | 2647.5 | 21 | 13 | 300 | $ 9,221.50 | 0.36886 |
| January | 2011 | 71000 | 0.057 | 4047 | 108000 | 0.045 | 4860 | 408 | 2-Feb | 1:00 PM | 7.5 | 3060 | 21 | 6 | 390 | $ 12,384.00 | 0.49536 |
| February | 2011 | 75000 | 0.057 | 4275 | 105000 | 0.045 | 4725 | 395 | 9-Feb | 12:45 PM | 7.5 | 2962.5 | 21 | 11 | 390 | $ 12,384.50 | 0.49538 |
| March | 2011 | 75000 | 0.057 | 4275 | 104000 | 0.045 | 4680 | 376 | 30-Mar | 1:00 PM | 7.5 | 2820 | 21 | 14 | 380 | $ 12,190.00 | 0.4876 |
| April | 2011 | 44000 | 0.057 | 2508 | 75000 | 0.045 | 3375 | 362 | 15-Apr | 11:30 PM | 7.5 | 2715 | 21 | 16 | 290 | $ 8,925.00 | 0.357 |
| | | | | | | | | | | | | | | | | **Total $** | **$ 143,904.30** |
| | | | | | | | | | | | | | | | | **Total KWh** | **1,917,000** |
| | | | | | | | | | | | | | | | | **Total KW** | **4885** |

Natural Gas

| Meter #: | # | | Usage | | | |
|---|---|---|---|---|---|---|
| Month | Year | Base Charge | Therms | Per Therm | Sales Tax | **Total Bill** |
| May | 2010 | 17.5 | 1 | 0.93849 | 0.05 | 18.49 |
| June | 2010 | 17.5 | 4 | 0.93849 | 0.19 | 21.44 |
| July | 2010 | 17.5 | 14 | 0.93849 | 0.66 | 31.30 |
| August | 2010 | 17.5 | 155 | 0.93849 | 7.29 | 170.26 |
| September | 2010 | 17.5 | 183 | 0.93672 | 8.6 | 197.52 |
| October | 2010 | 17.5 | 154 | 0.91545 | 7.24 | 165.72 |
| November | 2010 | 17.5 | 116 | 0.87038 | 5.45 | 123.91 |
| December | 2010 | 17.5 | 19 | 0.87038 | 0.89 | 34.93 |
| January | 2011 | 17.5 | 122 | 0.87038 | 5.73 | 129.42 |
| February | 2011 | 17.5 | 161 | 0.87038 | 7.57 | 165.20 |
| March | 2011 | 17.5 | 90 | 0.86656 | 4.23 | 99.72 |
| April | 2011 | 17.5 | 40 | 0.85726 | 1.88 | 53.67 |
| TOTALS | | | 1059 | | | 1211.58 |
| | | | **Total $** | | | **$ 1,211.576** |
| | | | **Total Therms** | | | **1059** |

As you can see above, the total bill column on the right is a summation of the total fees and taxes. To the right of the total bill column you can calculate the cost of electricity per square foot, which allows you to compare the cost of electricity by building (total electricity cost/# square feet). At the bottom of the table is a summation of costs, kW of power, and kWh of electricity used for your electric bills as well as the total cost and therms for natural gas. These numbers will be used to calculate total energy use and costs across campus after you have compiled data by building.

Once you have compiled data by building you will want to create another spreadsheet of data summarizing energy use across campus. This spreadsheet can combine data on electricity and natural gas usage.

-Building name
- Meter #s (both electric and NG)
-Square footage

Then for electricity you will need:
    -Total energy use (kWh)
    -Total energy demand (KW)
    -Total annual electric bill

For NG you will need:
    -Total energy use (therms)
    -Total energy use kWh*
    -Total annual gas bill

*You will want to convert total energy use in therms to total energy use in kWh in order to combine electricity and NG use to quantify total overall energy use on campus. To convert therms to kWh simply perform this basic calculation:

**Unit Conversion Calculation**

Therms to kWh:

Total NG use (therms) * 29.3 = Total NG use in kWh

Now that you have NG usage in kWh you can account for your total energy use on campus. Create the following columns on your spreadsheet:

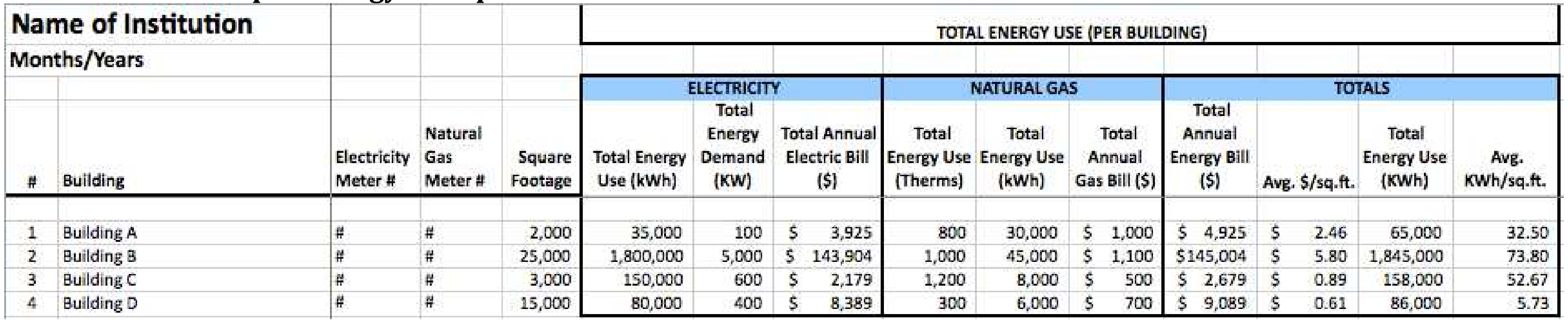
-Total energy bill in $ (Total electricity bill + Total NG bill)

-Average $ per square foot (Total energy bill/Total square footage of campus buildings)
-Total energy use (Total kWh of electricity + Total kWh of NG)
-Average energy intensity (Average kWh/Total square footage of campus buildings)

(Note: The ratio between natural gas prices and electricity is not a fixed one as each price changes in response to factors that affect the separate market for each resource, such as resource supplies, regional demand, and the effects of regulation on resource extraction and final pricing. If you want a more accurate and current ratio for these unit conversions contact your utility to identify the current ratio between electricity and natural gas prices for your region as well as the price ratio between electricity generated by coal versus electricity generated from natural gas. In some cases, in anticipation of increasing electricity prices institutions have considered switching buildings heated by electricity to natural gas, however this involves costly infrastructure adjustments. Where universities generate their own electricity on campus some schools have chosen to switch from coal-fired power to natural gas. If you are considering such a switch be sure that industry experts are assessing the lifetime costs of the transition. Both coal and natural gas prices may change dramatically as a result of future regulations such as a price on carbon dioxide emissions or increased regulation of natural gas extraction practices.)

Below is an example of how you can efficiently organize your school’s Total Energy Use spreadsheet:

**Table 2: Total Campus Energy Use Spreadsheet**



| **Name of Institution** | | | | | TOTAL ENERGY USE (PER BUILDING) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months/Years | | | | | | | | | | | | | | |
| | | | | | ELECTRICITY | | | NATURAL GAS | | | TOTALS | | | |
| # | Building | Electricity Meter # | Natural Gas Meter # | Square Footage | Total Energy Use (kWh) | Total Energy Demand (KW) | Total Annual Electric Bill ($) | Total Energy Use (Therms) | Total Energy Use (kWh) | Total Annual Gas Bill ($) | Total Annual Energy Bill ($) | Avg. $/sq.ft. | Total Energy Use (KWh) | Avg. KWh/sq.ft. |
| | | | | | | | | | | | | | | |
| 1 | Building A | # | # | 2,000 | 35,000 | 100 | $ 3,925 | 800 | 30,000 | $ 1,000 | $ 4,925 | $ 2.46 | 65,000 | 32.50 |
| 2 | Building B | # | # | 25,000 | 1,800,000 | 5,000 | $ 143,904 | 1,000 | 45,000 | $ 1,100 | $145,004 | $ 5.80 | 1,845,000 | 73.80 |
| 3 | Building C | # | # | 3,000 | 150,000 | 600 | $ 2,179 | 1,200 | 8,000 | $ 500 | $ 2,679 | $ 0.89 | 158,000 | 52.67 |
| 4 | Building D | # | # | 15,000 | 80,000 | 400 | $ 8,389 | 300 | 6,000 | $ 700 | $ 9,089 | $ 0.61 | 86,000 | 5.73 |

Now that you have calculated your total energy use you know a baseline number with which you can compare future energy use after implementing energy efficiency upgrades and energy use behavioral programs. You can truly track your progress and the benefits of your investments. Keep in mind, however, that temperature variation from year to year, changes in electricity and natural gas prices, and other factors will influence your energy costs as well. Despite these complications, it is always good to have some baseline with which to compare future years.

Your calculation of total energy intensity in particular allows you to identify the buildings on your campus that are "energy hogs". Compare each individual building's electricity and/or natural gas energy intensity per square foot with the campus average to determine where you should start implementing upgrades. However, keep in mind that some buildings will be more energy intensive by nature based on their uses. For instance, science centers and data centers will have higher energy intensities due to the equipment housed in these buildings. While there may be unique efficiency opportunities related to such equipment, do not assume that these buildings will offer the greatest potential for savings. Use energy intensity as one factor in your decision of which buildings to target for upgrades while considering the specific uses of each building.

Note: If you would like more assistance with benchmarking your institution's energy use the EPA Energy Star program offers an excellent tool called Portfolio Manager at the following website:

http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

---

## 4. HVAC

Heating, ventilation, and air conditioning (HVAC) make up over 50% of the total energy use of schools and educational institutions.[20] As HVAC operations are the highest energy use category at schools, upgrading to newer equipment and increasing the efficiency of existing equipment can lead to huge efficiency savings. There are two primary ways to improve the efficiency of HVAC appliances. Facilities crews can clean and maintain current units or they can replace older units.

Simply performing a "tune-up" of existing systems can lead to significant savings. The Environmental Protection Agency (EPA) Energy Star program recommends the following steps for maintaining your heating and air conditioning systems:

-Lubricate elements of units that move
-Tighten all of the electrical components
-Examine controls to make sure they are functioning properly
-Inspect and unplug clogged condensate drains
-Clean and regularly change air filters[21]

For the heating units Energy Star suggests regularly inspecting the gas pressure, gas/oil connection points, the heat exchanger and the burner combustion system for faults.[22] For air conditioning units Energy Star recommends checking the refrigerant levels for central air conditioners, cleaning the condenser air conditioning coils as well as the evaporator, and cleaning and adjusting the elements of the blower as needed.[23] Fixing problems with airflow that are caused by clogged or leaking blower components can improve the entire air conditioning system's efficiency by about 15%.[24] Check with your Facilities Department on campus to ensure that all crewmembers are taking these steps to preserve and maintain the efficiency of your existing HVAC units.

---

[20] Waste Reduction Partners. (Revised 2008, October). *Self-assessment guide for energy saving opportunities. Adapted from handbook of energy engineering, 4th edition, EIA and NREL 2000*. Sponsored by the State Energy Office, N.C. Department of Administration and the U.S. Department of Energy.
[21] U.S. Environmental Protection Agency. (Visited 2012, February 14). *Maintenance checklist: Energy Star*. Retrieved from http://www.energystar.gov/index.cfm?c=heat_cool.pr_maintenance
[22] Ibid.
[23] Ibid,
[24] Ibid.

In many cases more significant energy and cost savings can be achieved by replacing old air conditioning units with newer more efficient models. All air conditioning units as well as heat pumps are assigned a Seasonal Energy Efficiency Ratio (SEER) rating, which indicates the amount of cooling a unit delivers in relation to the energy it uses to operate. Newer efficient units have higher SEER ratings. Any unit produced since January 26, 2006 has a SEER rating of at least 13 as required by law.[25] Units produced before this date could have SEER ratings as low as 6.[26] An upgrade from a 10 SEER unit to a 13 SEER unit represents a 30% improvement in the unit's efficiency, which translates into a 30% energy savings for that unit as well.[27]

To identify the SEER rating for your air conditioning units first identify the manufacturing company and the model and serial number for each unit, which can be found on the label affixed to the unit. Call the manufacturer of each unit and request the SEER rating for all units if this information is not provided on the unit tag itself. To identify the difference in efficiency between your current unit and a newer unit, you can assume that every number increase in the SEER rating corresponds to 8-10% less energy use as long as the brand, capacity factor, and other details remain the same.[28] Therefore a SEER 13 unit uses 8-10% less energy than a SEER 12 unit. If you would prefer to identify a more precise savings estimate, the following calculation is commonly used in the HVAC industry[29]:

(1-(old unit SEER rating/new unit SEER rating)) for example 1-(12/13) = .077

This calculation shows that upgrading from a 12 SEER rating to a 13 SEER rating represents about a 7.7% decrease in the total power consumption of the unit, which means a 7.7% savings in annual costs from switching units. This does not include annual savings in avoided maintenance costs from using newer equipment, which means that this is a conservative estimate of your expected annual savings.

---

[25] U.S. Department of Energy. (Visited 2012, February 15). *Energy savers: Central air conditioners*. Retrieved from http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12440

[26] Ibid.

[27] Ibid.

[28] WebHVAC.com. (Visited 2012, February 15). *HVAC SEER ratings: Webhvac.com*. Retrieved from http://www.webhvac.com/2011/07/hvac-seer-ratings/

[29] Conversation with Mike Davis, Energy Engineer at Piedmont Service Group, Raleigh, NC, summer 2011.

This calculation gives you a general estimate of savings from upgrades, however to compute a more accurate cost-benefit analysis and estimated savings from upgrades you will need to follow a more involved process. Calculating your current energy use, your potential energy use savings, and your project costs and benefits for HVAC equipment is a challenging prospect. However, you can follow the steps below to gain a general idea of potential savings before you commit to actually purchasing new units.

The analysis below evaluates both air conditioning unit upgrades and programmable thermostats. Programmable thermostats are excellent tools to help your institution save energy and money quickly and effectively. They allow you to store temperature settings for different times of the day. The user can program “setbacks” at night, on weekends, and during other periods of the day when the building is unoccupied. The Department of Energy estimates that for setbacks of eight hours or longer you can expect as much as a 1% cost savings on heating and cooling *per degree of setback*. [30]

Note: If you wish to evaluate cost savings from upgrades to HVAC equipment other than air conditioning units and programmable thermostats, such as strip heaters, boilers, cooling towers, air handlers, or chillers, you could perform a similar analysis. However, keep in mind that these systems may be powered by electricity, heating oil, or natural gas. Speak with your Facilities Department to determine what type of heating and cooling equipment you have and the individual unit elements across campus. Then speak to your preferred HVAC contractor or vendor to determine how to identify current energy use for existing equipment and how to calculate expected energy cost savings from upgrades and rebate programs. They may be able to perform a simplified calculation of costs and savings from upgrades for you.

---

[30] U.S. Department of Energy. (Visited 2012, February 26). *Energy savers: Thermostats and control systems*. Retrieved from http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12720

To evaluate the costs and benefits of upgrading your air conditioning equipment and installing programmable thermostats, you will need to build another set of Excel spreadsheets as you did to calculate your energy use baseline above. Gather the following inputs to create the first air conditioning spreadsheet, which will be for programmable thermostats only.

<ins>Programmable Thermostat Inputs</ins>:

**Building Name**

**Unit ID**: Ask the Facilities Department if each unit has a separate ID. If not simply identify the units as A, B, C… for each building and note where they are located around the building. This will be useful information for the Facilities Department to have as the school plans for unit upgrades in the future.

**Manufacturer**: Carrier, Lennox, Trane, etc. (Found on the unit label.)

**Model #**: Found on the unit label.

**Size in tons**: This deals with the capacity of the unit. The number of tons can be found on the unit label itself.

**Year**: Found on the unit label.

**SEER Rating**: The SEER rating relates to the efficiency of the unit. Call the manufacturer if this is not provided on the unit itself.

**KW per ton**: Found on the unit label.

**# Hours Occupied**: This is the number of hours a day a building or specific room that the AC unit services is used. 12 hours is a good estimate for an office building or classroom building,[31] however certain facilities including data centers and residence halls must operate HVAC equipment 24 hours per day. Use your judgment based on the primary uses of the building in question and the equipment in each building. When in doubt, ask your facilities staff about the number of hours that HVAC equipment needs to run for specific buildings or rooms you are evaluating.

**# Hours of Setback during Nights and Weekends**: This is the number of hours a day you set the temperature back to higher levels in warm months. Setbacks usually occur at night,

---

[31] Mike Davis, Energy Engineer at Piedmont Service Group, Raleigh, NC. Summer 2011. Conversation with Jennifer Weiss.

on weekends, or other times when buildings are unoccupied. 12 hours is a good estimate for # hours of setback, assuming 12 hours a days are occupied and the other 12 are not.[32]

**Run Time during Day**: This is the percentage of the daylight hours during which the unit is running. A good estimate is 60% of the time.[33]

**Run Time at Night**: The percentage of the nighttime hours during which the unit is running. A good estimate is 40% of the time.[34]

**Run Time at Night With Setback**: This is the amount of time the unit would be running during nighttime hours if a temperature setback were imposed (higher temperatures set at night via programmable thermostat when no one is using the building or room). 20% is a conservative estimate.[35]

**Electricity Charge**: This will vary by location and utility but you should have it in the spreadsheet you already created for benchmarking energy use. Electricity use is calculated in $ per kWh.

**# Days Used per Year**: Average number of days the air conditioning and heating on your campus are used during the year. This will vary based on where your institution is located and how extreme the seasons are in your region of the country. Ask your Facilities Department, your HVAC vendor, or your utility for an estimate on the number of days that air conditioning is used during the average year.

**Cost of Thermostat**: This is the average cost of a programmable thermostat that you would use to program and control the temperature settings at your university. Call your air conditioning vendor/contractor to determine an average price for a programmable thermostat or you can search online for prices for the size air conditioning units you plan to control with the devices. A basic programmable thermostat costs about $150 as of August 2011.[36]

**Rebates**: Any rebates available per programmable thermostat purchased.
To analyze the costs and benefits of programmable thermostats only follow the steps below.

<u>Programmable Thermostat Intermediate Outputs:</u>

Using the data gathered above you can perform the following calculations:

---

[32] Ibid.

[33] Ibid.

[34] Ibid.

[35] Ibid.

[36] From online searches of units in summer 2011 and confirmed by Mike Davis, Energy Engineer at Piedmont Service Group, Raleigh, NC.

**Estimated Energy Cost w/o Setback**: The expected annual energy expenditure for air conditioning without a temperature setback. You calculate this through the following steps:

= Size in tons * kWh per ton * ((# Hours Occupied * Run Time during Day) * $ per kWh * # Days Used per Year) + (# Hours Setback during Nights and Weekends) * Run Time at Night with No Setback * $ per kWh * # Days Used per Year))

**Estimated Energy Cost with Setback**: The expected annual energy expenditure for air conditioning if a basic temperature setback is incorporated:

= Size in tons * kW per ton * (# Hours Occupied * Run Time during Day) * $ per kWh * # Days Used per Year) + (# of Hours Setback during Nights and Weekends) * Run Time at Night With Setback * $ per kWh * # Days Used per Year)

**Total Annual Energy Savings ($)**:

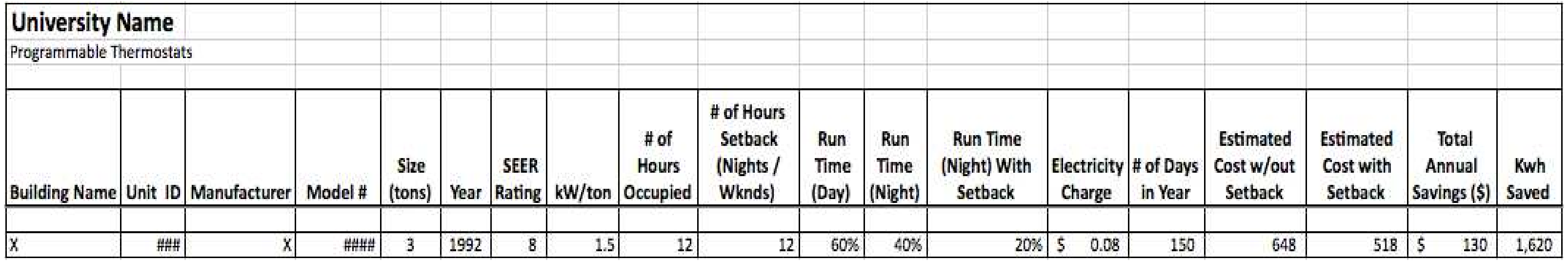
= Estimated Cost without Setback – Estimated Cost with Setback.

**kWh Saved**:

= Total Annual Savings / $ per kWh

An Example of the layout for your spreadsheet is below:

## Table 3: Programmable Thermostat Intermediate Outputs



**University Name**

Programmable Thermostats

| Building Name | Unit ID | Manufacturer | Model # | Size (tons) | Year | SEER Rating | kW/ton | # of Hours Occupied | # of Hours Setback (Nights / Wknds) | Run Time (Day) | Run Time (Night) | Run Time (Night) With Setback | Electricity Charge | # of Days in Year | Estimated Cost w/out Setback | Estimated Cost with Setback | Total Annual Savings ($) | Kwh Saved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | |
| X | ### | X | #### | 3 | 1992 | 8 | 1.5 | 12 | 12 | 60% | 40% | 20% | $ 0.08 | 150 | 648 | 518 | $ 130 | 1,620 |

To evaluate the savings potential from upgrading air conditioning units you will need to make another spreadsheet. Gather the following information, much of which you can simply copy from the Programmable Thermostats spreadsheet that you just made:

Air Conditioning Unit Inputs:

**Building Name**
**Unit ID**
**Manufacturer**
**Model #**
**Size in Tons**
**Year**
**SEER Rating**
**KW per ton**

**Upgraded SEER Rating**: The SEER rating of the unit you plan to purchase. Assume 13 if you want to be conservative as this is the lowest SEER rating for any device that you can currently buy.

**KW per ton for New Unit**: Gather this information from an air conditioning vendor for each individual unit you plan to purchase. KW per ton for the new units will vary depending on the size and type of the units you need to replace.

**Price per ton New Unit**: The cost per ton for a new unit. This will be an average price based on the variety of units you plan to install. You can ask your preferred air conditioning vendor or the company that you plan to purchase new units from on an estimate of the cost per ton for a new 13 SEER unit (the least energy efficiency unit you can buy today) to give you a conservative estimate of the cost of all replacement units you plan to purchase. However, a good estimate as of the summer of 2011 was about $1800/ton for units that handle less than 10 tons and about

**# Hours Occupied**
**# Hours of Setback during Nights and Weekends**
**Run Time during Day**
**Run Time at Night**
**Run Time at Night With Setback**
**Electricity Charge**
**# Days Used per Year**
**Cost of Thermostat**

Air Conditioning Unit Intermediate Outputs:

**Estimated Energy Cost with Old Units**

= Size in tons * kW per ton * ((# of Hours Occupied * Run Time During Day) * $ per kWh * # Days Used per Year) + # of Hours Setback during Nights and Weekends) * Run Time at Night) * $ per kWh * # Days Used per Year)

**Estimated Energy Cost with Upgrade**

= Size in tons * kW/ton New Unit * ((# of Hours Occupied * Run Time during Day) * $ per kWh * # of Days Used per Year) + (# of Hours Setback during Nights and Weekends) * Run Time at Night) * $ per kWh * # Days Used per Year))

**Total Annual Energy Savings Upgrade Only**

= Estimated Energy Cost with Old Units - Estimated Energy Cost with Upgrades

**kWh Saved**

= Total Annual Savings Upgrade Only / $ per kWh

**Approximate Cost of New Unit**

= Size in Tons * Price per ton New Unit

**Labor Cost**: Cost of labor to install new air conditioning unit. (No labor cost is listed for programmable thermostats alone as the school's Facilities Department could do this without the help of a contractor and the time commitment would be negligible. If you prefer you can include the cost of labor on your campus.)

**Rebates**

This calculation will vary based on whether any rebates are offered through your utility and what type of rebate is offered. Contact your utility to determine if any rebates are available for HVAC units and if so how the rebate is calculated. If a rebate is offered based on the size of the unit you can calculate the rebate per unit as follows:

= Size in Tons * Rebate per ton in Dollars

If the rebate is calculated per unit there would simply be the rebate per unit to consider.

If the rebate is calculated by avoided kWh use the rebate would be calculated as follows:

= kWh Saved * Rebate per kWh

Final Savings for Programmable Thermostats, Upgrades, and Projects Combined

Once you have the information above you can make your final calculations for air conditioning unit upgrades and programmable thermostat purchases.

Programmable Thermostats Only

**Initial Capital Cost**: This is calculated by summing the individual costs of all of the programmable thermostats you plan to purchase.

= (Total # of Thermostats * Price Per Thermostat)

**Net Investment**: This is the cost of the programmable thermostats less the rebates offered by your utility.

= Initial Capital Cost - Total Rebates

**Total Saved (Programmable Thermostats Only)**: Expected kWh saved from installing programmable thermostats and programming a setback.

= Sum of kWh Saved from All Programmable Thermostats Installed

**Total Energy Cost Savings (Programmable Thermostats Only)**:

= Total Saved for Programmable Thermostats Only * $ per kWh

**Payback Period (Years)**: The number of years it would take to pay back your net investment through energy cost savings.

= Net Investment / Total Energy Cost Savings for Programmable Thermostats Only

Note: Payback periods are useful when comparing projects with comparable annual operating expenses because they give you a general idea of the best investments based on how quickly you will pay off the initial investment and begin to benefit from energy cost savings. Universities often make investment decisions based on payback periods however this is not the most holistic factor in evaluating the value of an investment to your institution. Energy efficiency projects should be treated like any other financial investment by weighting the value of investing in that project over time. This requires the use of a discount rate to acknowledge that money in the hand today is worth more to the institution than the promise of the same amount of money in the hand five years from now. The net present value (NPV) of a project incorporates this concept of the time value of money and also acknowledges the lifetime of the individual project and should therefore be used to identify whether or not to pursue an upgrade or energy-saving program. NPV calculations are discussed in the next section.

Air Conditioning Units Only

**Initial Capital Cost**: This is calculated by summing the individual costs of all of the units you plan to purchase.

= (Total # of Thermostats * Price Per Thermostat)

**Net Investment**: This is the cost of the programmable thermostats less the rebates offered by your utility.

= Initial Capital Cost - Total Rebates

**Total Saved (Programmable Thermostats Only)**: Expected kWh saved from installing programmable thermostats and programming a setback.

= Sum of kWh Saved from All Programmable Thermostats Installed

**Total Energy Cost Savings (Programmable Thermostats Only)**:

= Total kWh Saved for Programmable Thermostats Only * $ per kWh

**Payback Period (Years)**: The number of years it would take to pay back your net investment through energy cost savings.

= Net Investment / Total Energy Cost Savings for Air Conditioning Units Only

You will notice that the payback period for programmable thermostats is very low (usually less than a year) while the payback period for new air conditioning units is very high (often ten years or more). It is therefore recommended that you combine these projects as the savings from the programmable thermostats will help to pay off the long-term costs of the air conditioning units. While your university could choose to do the programmable thermostats alone, HVAC units do lead to long-term energy savings as well. Therefore you should not overlook new air conditioning units simply because they have a long payback period. This is especially true because the lifetime of air conditioning units is about 20 years and they tend to deteriorate over time, which leads to required maintenance costs. This means that you may have to replace some of your oldest HVAC units in the next few years anyway.

To combine the calculations above to incorporate the costs and savings of both programmable thermostats and upgrading to new air conditioning units, follow the steps below:

Programmable Thermostats and Air Conditioning Units Combined

**Initial Capital Cost**: This is calculated by summing the individual costs of all of the units and programmable thermostats you plan to purchase.

= (Total # of Thermostats * Price Per Thermostat) + (Total # of Units * Price Per Unit)

**Net Investment**: This is the cost of the programmable thermostats less the rebates offered by your utility.

= Initial Capital Cost - Total Rebates for Programmable Thermostats and AC Units

**Total kWh Saved (Programmable Thermostats and AC Units)**: Expected kWh saved from installing programmable thermostats and programming a setback.

= Sum of kWh Saved from All Programmable Thermostats and AC Units Installed

**Total Energy Cost Savings (Programmable Thermostats and AC Units)**:

= Total kWh Saved for Programmable Thermostats and AC Units * $ per kWh

**Payback Period (Years)**: The number of years it would take to pay back your net investment through energy cost savings.

= Net Investment / Total Energy Cost Savings for Programmable Thermostats and AC Units

It is recommended that you replace old air conditioning units with the highest SEER rated units that your institution can afford and that still yield positive net present values (NPVs) as units with higher SEER ratings will lead to even greater annual energy savings. We will calculate the Net Present Value of a project in the next section. Seek to purchase Energy Star® rated products whenever possible, as this rating ensures high energy cost savings.

Do not replace all of your units at the same time. Replacing a smaller number of units every year, starting with the oldest and most damaged units, will help the school to spread the cost of new upgrades over many years. This will prevent the devastatingly expensive challenge of replacing the entire fleet of units when they all begin to deteriorate around the same time. Consider creating a 5, 10 and 20-year plan for heating and air conditioning replacements to prioritize which units to upgrade first and to help plan for future expenses.

### 5. Net Present Value (NPV)

The net present value of an investment measures the profitability of a project over its lifetime with the understanding that the value of future returns from today's investment diminishes over time. To use a concrete example for calculating the NPV we will use our air conditioning projects discussed above (upgrades and programmable thermostats). In this case the NPV would be the value of an investment in air conditioning unit upgrades and programmable thermostats over the operational lifetime of these pieces of equipment. To calculate the NPV you will need to make assumptions about the following values:

**Lifetime of the Project**: The lifetime of the project depends on how long the equipment in question is expected to last and varies depending on the type of equipment. For air conditioning units and programmable thermostats, 20 years is an appropriate assumption.[37]

**Discount Rate**: This will vary based on institution. Ask your Purchasing or Finance Department if the institution has a discount rate that they use when evaluating large purchases. If your school does not use a discount rate to evaluate purchases consider using a 4% discount rate, which is the real discount rate that the EPA Energy Star program uses for energy efficiency calculations .[38] The default discount rate for the EDF Climate Corps

---

[37] Environmental Defense Fund. 2011 Climate Corps Financial Analysis Tool – Underlying Assumptions.

[38] U.S. Department of Energy. (Visited 2012, April 24). *Energy Star*. Retrieved from http://www.energystar.gov/index.cfm?fuseaction=search.showResults&entqr=0&access=p&output=xml_no_dtd&sort=date:D:L:d1&ie=UTF-

Financial Analysis Tool is 5%, which is a fairly high discount rate, however this tool is used for Fellows calculating savings for private sector corporations as well, which tend to have higher discount rates for equipment purchases. When in doubt seek the advice of your Purchasing and Finance Departments.

Calculate the NPV of a Project:

1. Calculate your annual cash flow for the project. This involves the following calculation:

Total Energy Cost Savings (Programmable Thermostats and AC Units) - Net Investment (Programmable Thermostats and AC Units)

We will assume that the cash flow for all years of a project will be the same, which is a simplification since electricity prices will likely increase over time, maintenance costs could fluctuate over time, and depreciation would affect cash flows as well. However, for a simplified analysis, we will assume an even cash flow over the lifetime of the project.

If it is standard practice to include depreciation and maintenance costs for your institution's purchases, feel free to incorporate them into your annual cash flows. Neither the Shaw study nor the WSSU study took depreciation into account. We will not incorporate taxes in this analysis as universities are typically tax-exempt entities. Note: Remind all contractors of your tax exempt status when they create quotes for potential equipment purchases.

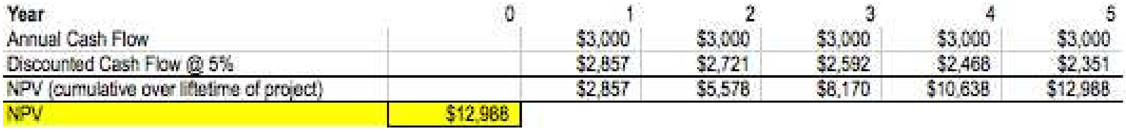
2. Assuming the total savings is consistent for every year of the project's lifetime (in this case 20 years) the next step is to project a discounted cash flow. To construct a discounted cash flow, create a spreadsheet with 20 columns for the 20 years of the project's lifetime. In the first column, which represents the first year after the project has been implemented, take the value calculated in step one and divide it by (1 + discount rate) ^ year. If you use a 5% discount rate, in year one the calculation should be: net energy savings / (1.05)^1. In year two the calculation should be: net energy savings / (1.05)^2, etc. Apply this calculation to all years of the project.

---

8&as_sitesearch=www.energystar.gov/ia/business/bulk_purchasing&client=default_frontend&q=commercial&filter=0&ud=1&site=default_collection&oe=UTF-8&proxystylesheet=default_frontend&ip=128.121.47.99&start=20.

3. Next calculate NPV for each year of the project by adding the total of the year before to each subsequent year's total. For instance, year two would be equal to the discounted cash flow from year 1 + the discounted cash flow for year two. Year three would be equivalent to the total just calculated for year two plus the discounted cash flow for year three. See below for an example of how to structure this cash flow. The NPV for the final year will be equivalent to the NPV for the entire project. Therefore if you have a 5-year project lifetime and the NPV after five years is $12,968 as below, this will also be the total NPV of the project. In the case of air conditioning units, you will look for the NPV of the project over twenty years, but you may choose to present the NPV of the project after different periods of time to your administration. For instance, you could present the NPV of the project after five years, ten years, and twenty years.

**Table 4: Example of an NPV calculation**



| Year | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Annual Cash Flow | | $3,000 | $3,000 | $3,000 | $3,000 | $3,000 |
| Discounted Cash Flow @ 5% | | $2,857 | $2,721 | $2,592 | $2,468 | $2,351 |
| NPV (cumulative over lifetime of project) | | $2,857 | $5,578 | $8,170 | $10,638 | $12,988 |
| NPV | $12,988 | | | | | |

---

## 6. Communicating your Savings

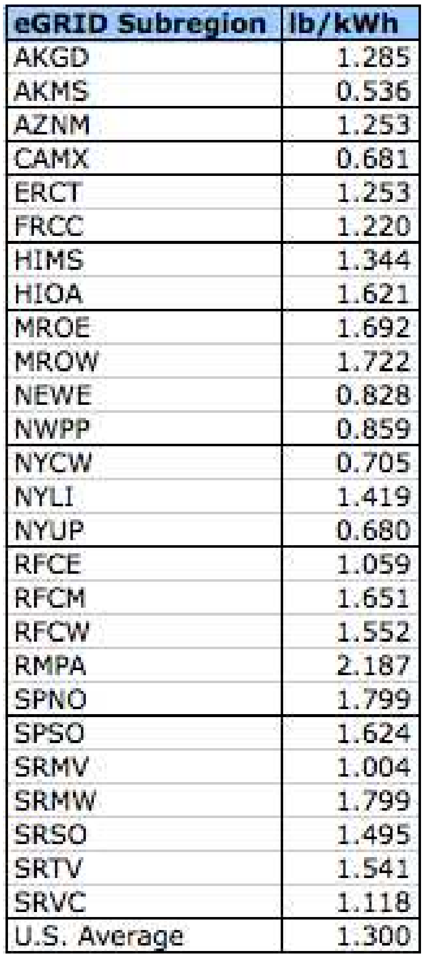
Once you have determined your potential energy savings in kWh, the next challenge is to communicate these savings to the decision-makers at your institution. Tons of avoided emissions and kWh saved are difficult units to appreciate especially if you do not work in the energy industry. A better way to explain these savings is in terms of the equivalent number of houses that could be powered with your electricity savings or the number of passenger vehicles taken off the road that your avoided emissions represent. To calculate these examples, you will first need to calculate the carbon dioxide equivalent emissions (CO2e) reduced from electricity savings as follows:

<u>CO2e Emissions Reduced from Electricity Savings</u>:

emissions factor * (annual electricity savings from investments in kWh per year/2204)

To find the emissions factor for your region, which corresponds to the amount of CO2 equivalent emissions that result from the burning of specific types of fossil fuels in your region, use the chart below[39]. All region acronyms correspond to the map directly below the chart, which shows the boundaries of each region.[40]

**Table 5: Emissions Factors by Region**



| eGRID Subregion | lb/kWh |
|---|---|
| AKGD | 1.285 |
| AKMS | 0.536 |
| AZNM | 1.253 |
| CAMX | 0.681 |
| ERCT | 1.253 |
| FRCC | 1.220 |
| HIMS | 1.344 |
| HIOA | 1.621 |
| MROE | 1.692 |
| MROW | 1.722 |
| NEWE | 0.828 |
| NWPP | 0.859 |
| NYCW | 0.705 |
| NYLI | 1.419 |
| NYUP | 0.680 |
| RFCE | 1.059 |
| RFCM | 1.651 |
| RFCW | 1.552 |
| RMPA | 2.187 |
| SPNO | 1.799 |
| SPSO | 1.624 |
| SRMV | 1.004 |
| SRMW | 1.799 |
| SRSO | 1.495 |
| SRTV | 1.541 |
| SRVC | 1.118 |
| U.S. Average | 1.300 |

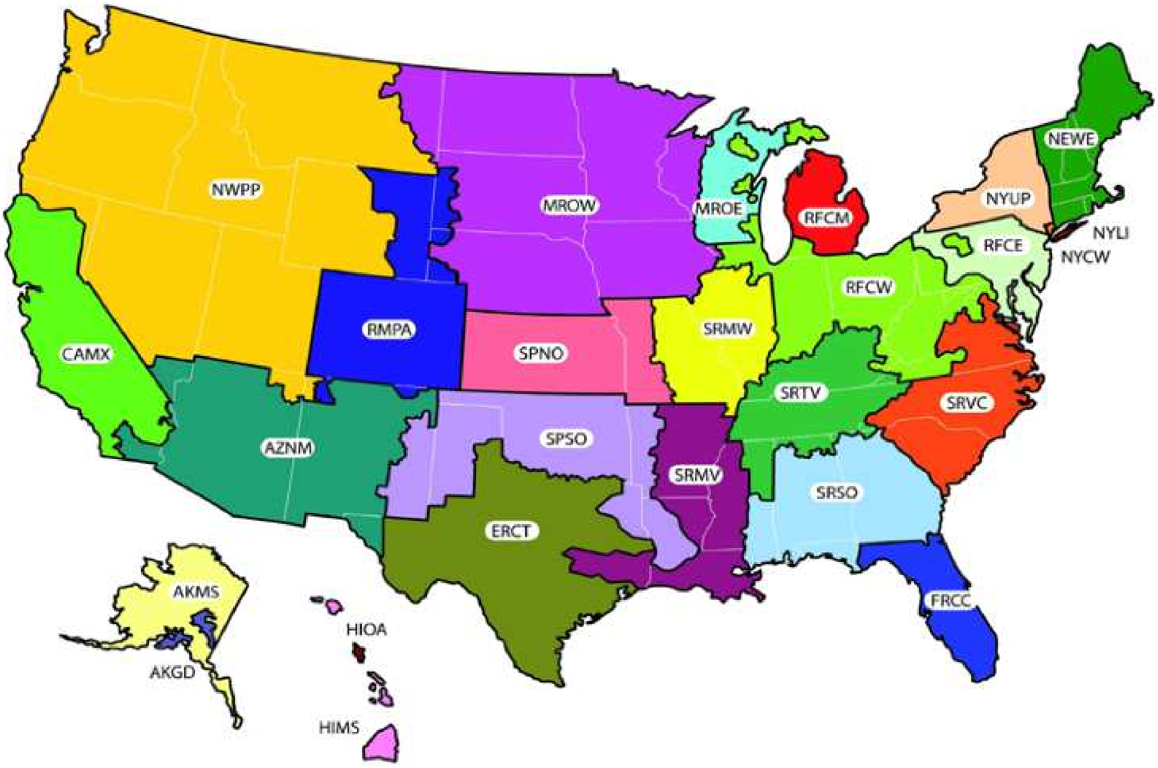
---

[39] U.S. Environmental Protection Agency. (2010). *eGRID 2010 version: 1.0 (year 2007 values): eGRID Subregion Emissions - greenhouse gases*. Retrieved from http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_1_year07_SummaryTables.pdf (Note: This chart was developed by Environmental Defense Fund for their Climate Corps Financial Analysis Tool based on the EPA's eGRID 2010 Version 1.0 (Year 2007 values).)

[40] U.S. Environmental Protection Agency. (Visited 2012, April 24). *eGRID - Clean Energy – U.S. EPA: EPA eGRID 2010 Version 1.1 Year 2007 GHG Annual Output Emissions Rates* . Retrieved from http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

*This chart was adapted from one developed by EDF from the eGRID2010 Version 1.1 Year 2007 GHG Annual Output Emission Rates.

**Image 1: Map of Regions Corresponding with Emissions Factors**



Now you can calculate the number of American houses that could be powered by your expected annual electricity savings:

Equivalent American Households Powered:

= annual electricity savings from investments in kWh per year/ annual electricity used by a typical American home

Annual electricity used by a typical American home in 2011 = 11,496 kWh[41]

---

[41] U.S. Energy Information Administration. (Last Updated 2011, December 06). *How much electricity does an American home use? - FAQ – U.S. Energy Information Administration (EIA)*. Retrieved from http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3

Finally, you can calculate the equivalent number of average passenger vehicles taken off of the roads:

Equivalent Passenger Vehicles Removed from Roads:

= estimated indirect co2e emissions reduction from electricity savings in metric tons / metric tons CO2e from an average passenger vehicle per year

Annual CO2e emitted by an average passenger vehicle = 5.1 metric tons CO2e[42]

Use these comparisons when communicating avoided emissions to students, faculty and staff, school administrators, board members, the public, and the press. Making the real energy and CO2 emissions understandable to stakeholders is a significant step in achieving buy-in and getting your projects approved. These energy and emissions savings comparisons along with the cost savings from projects will be an impressive toolkit in communicating the value of your recommended action plan.

## 7. Temperature Setback

As discussed in the HVAC and programmable thermostats section above, large savings can be achieved by changing thermostat settings by only a few degrees. Your campus may or may not already have a policy for thermostat settings across campus. If you have an energy management system in place that centrally controls temperatures across campus, it would be very easy to change the temperature settings by a few degrees across campus. If your heating and cooling are controlled by individual thermostats across campus, encouraging people to set thermostats higher in the summer and lower in the winter will be more an exercise in energy education and behavioral change. Technologies are only as effective as their human operators. If employees and students do not understand or care about setting thermostats properly then campus-wide energy saving programs will be ineffective. The issue of education and campus engagement is addressed below in chapter thirteen.

---

[42] U.S. Environmental Protection Agency. (Last Updated 2011, November 02). *Calculations and references: Clean energy*. Retrieved from http://www.epa.gov/cleanenergy/energy-resources/refs.html

The average thermostat is set between 65 and 70 degrees during heating months (winter) and between 72 and 78 degrees during cooling months (summer).[43] Decreasing temperatures by a single degree for 8 hours a day can save as much as 1% in heating and cooling costs.[44] While specific savings and efficient settings will differ by region and local temperature variation the values recommended here are based upon national averages used by the Department of Energy on their Energy Savers website. Committing to a temperature increase of a degree or two across campus for cooling months (for instance 72 degrees to 74 degrees) or a two-degree decrease in heating temperatures in winter months (say 70 degrees to 68 degrees) therefore could result in a savings of 2-4% of your current heating and cooling bill. To calculate expected energy savings from a campus-wide setback, simply multiply your current energy use by 2, 3 and 4% to determine the range of electricity savings (kWh) from such a program. Then multiply expected energy savings by $/kWh to determine an estimate for cost savings from the effort.

Programmable thermostats will be useful for implementing such a temperature change across campus. If you educate employees and students about the importance of leaving thermostats as they are set to achieve energy savings and prevent unnecessary greenhouse gas emissions and then set thermostats at cost-efficient temperatures with setbacks when rooms are not in use, you can achieve optimal savings. Consider applying stickers near thermostats around campus to remind occupants not to change the settings. A “go green” message or the school’s mascot could be used as a fun and gentle reminder not to tamper with the devices.

---

[43] Sponsored by the State Energy Office, N.C. Department of Administration, with State Energy Program Funds, in cooperation with Land-of-Sky Regional Council (Waste Reduction Partners) and the NCDPPEA. (Revised 2010, April). *Setback temperature control: Utility Savings Initiative (USI) – Fact Sheet*. Retrieved from http://portal.ncdenr.org/c/document_library/get_file?uuid=6f993424-2f12-459c-8526-099318b59c3d&groupId=38322.

[44] Department of Energy website. Energy Savers: Thermostats and Control Systems. http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12720. Visited 2/26/2012. Last updated 2/09/2011.

## 8. Seasonal Building "Shutdown"

While some buildings on a college or university campus are used year-round such as administrative buildings, laboratories, and libraries, others may remain vacant during the summer months. At some schools whole floors of buildings or entire buildings are not used during summer vacation. In these cases the school can implement a temperature "setup" or a building "shutdown". This simply involves setting and holding the thermostats in vacant floors and buildings at higher temperatures during the summer months when they are not in use.

If you choose to implement a temperature "setup" it is important to maintain airflow and hold temperatures at levels that prevent moisture and mold issues. The EPA Energy Star website recommends setting building temperatures as high as 85 degrees when people are away during the summer months.[45] The Department of Energy notes that increasing temperatures by 10 to 15 degrees for only eight hours a day can save about 10% on your energy bill.[46] Increasing a thermostat typically set between 70 to 75 degrees to 85 degrees when the building is unoccupied would achieve this setback and holding temperatures at these levels 24-hours a day a could save you even more in energy costs.

Calculating the savings from a typical temperature "setup" is fairly straightforward. You will need to start by looking at the energy use spreadsheet you made earlier for the building in which you plan to implement the "setup". To simplify this calculation we will make the assumption that setting your thermostats to cool to 85 degrees for a summer month will use a similar amount of energy as one of your least costly heating/cooling months for the previous year. This is often a month in the spring or fall. Find the lowest energy use months for each year for which you have campus energy use data and average them to estimate baseline energy use without heating or cooling. This calculation will

---

[45] Energy Star website. Selected Topic. http://energystar.supportportal.com/ics/support/KBAnswer.asp?questionID=21828&hitOffset=165+140+11&docID=489. Visited Sunday February 26, 2012. Last modified 10/3/2011.

[46] Department of Energy website. Energy Savers: Thermostats and Control Systems. http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12720. Visited 2/26/2012. Last updated 2/09/2011.

assume that lights are still being used, exit signs are still operating, etc. and will help you to identify the savings from the temperature “setup” alone. It will also give you a more conservative estimate for savings than assuming no energy use at all. Use the kWh equivalent for all energy use calculations (energy conversion calculations can be found in the Benchmarking section) as it will be easier to calculate total cost savings, payback period, NPV, and car and home equivalencies if energy use is calculated in kWh.

To find a general estimate of savings for a summer “setup” or building shutdown you will also need to average the energy use for summer months for the past year (or two or three if you have the data). Therefore average your energy use for May through August for the past year or however many years for which you have data. Using multiple years may give you a better estimate that controls for unusually hot years. To find the expected savings from a summer “setup” perform the following calculation:

(Summer Month Energy Use Average – Baseline Energy Use Average) * 3 months or length of summer break at your institution

This will give you the expected savings for implementing a summer temperature “setup” for the full summer vacation in the chosen building. You can perform this calculation for all buildings that you plan to keep vacant during the summer. To ensure that you achieve optimal savings by “shutting down” buildings during the summer months, make sure that all non-emergency lights are turned off, water heaters are turned off, and all doors are kept closed when the building is not in use.

Once you have the expected energy savings in kWh, you can calculate the expected cost savings by multiplying the energy savings by the price of electricity ($/kWh). The cost of implementing this project will be $0, with the exception of labor, which makes the payback period 0 years (immediate). This assumes that the cost of labor on campus is zero, which is of course not true. You can incorporate the costs of labor on your campus for all projects discussed in the Toolkit. To determine the specific labor cost of implementing this measure, simply calculate the time needed to set each thermostat, which will be one or two minutes per unit, and the time required to travel between thermostats on campus. It may take several days to reset thermostats if you have many rooms with individual thermostats on your campus. Simply multiply the hourly cost of labor by the number of hours you expect this task will take. Speak with your facilities manager to determine a reasonable estimate of the time required for this task.

We will ignore the opportunity cost of labor here although you should consider the added cost of taking a maintenance or facility worker off of another job to complete this task. However, if you are not taking into account the avoided labor from new equipment from other sections of the Toolkit, such as avoided maintenance costs from having to change LED lighting for exit signs less often than incandescent lamps or CFLs, you may want to ignore labor costs with the expectation that these gains and losses would balance out. (This was the tack that Jennifer Weiss and I took for most projects in the case of Shaw University).

Then you can calculate the NPV of the investment as above. Your calculations will be conservative as a significant drop in energy usage will likely affect your total demand, which could result in additional cost savings from your utility. As you will see, "setup" or "shutdown" projects yield very high energy and cost savings with no added expense to the school and little time commitment in terms of increasing thermostat settings. If dormitories will be vacant for several weeks over winter vacations as well, consider a temperature setback for colder months to save on heating costs. Use the same process as above but use winter temperatures instead of summer temperatures to calculate energy savings.

## 9. Lighting

Lighting accounts for 20% of all energy use at schools.[47] This means that any savings in the area of lighting could have a significant impact on total energy savings for your campus.

---

[47] Waste Reduction Partners, (2008), Pg. 3.

The level of savings from lighting projects will vary dramatically by institution based on the variety of existing lighting across campus, the rebate options available through your utility, and whether your institution owns or leases existing outdoor lighting.

The first step in identifying potential lighting savings is to perform an audit of all lighting across campus. This is a great project for a group of students to perform. Try to engage a student club or Greek organization to perform this service for the school.

### Image 2: Common Types of Indoor Lighting[48]

---

[48] All photos taken by Eliza Davis and Jennifer Weiss, (2011) *Energy Efficiency and Conservation: Shaw University*. Environmental Defense Fund.

Lighting: Clockwise from top left: (1) Metal halide, (2) T-12 versus T-8 lamps, (3) LED, (4) CFL, (5) CFL, (6) Incandescent, (7) CFL.

Introduce the most common types of lighting to the students by walking through a building with them and explaining the lighting types and differences that they should notice. If a facilities staff member is not available to help with this task, have students leaf through a current lighting catalog by a leading lighting vendor. (Voss Lighting has an excellent online catalog with pictures of different lighting types. Any major lighting company will have a good online catalog.) If you already have a preferred lighting vendor for your campus, ask if they could walk to the campus with the students to point out the different types of lighting and help the students with the audit. A good lighting expert will provide this service for the school free of charge as long as the school shows an interest in purchasing lighting from them in the future.

Have students do a walk-through of every building on campus. Have them take pictures of the different types of lighting and note how many of each type occur in each building. They should include the length of the bulb in the case of tube fluorescents (2-foot, 3-foot, 4-foot, 6-foot, etc.), the types of fixtures and ballasts if known (2-bulb electronic ballast fixture, etc.) and the number of bulbs in each fixture. Note: Check with your facilities manager about types of fixtures and ballasts in different buildings or have them walk the campus with you to help identify fixtures and ballasts, which are discussed in more detail below. The students should check every room in every building, including closets, bathrooms, and basement areas. In the case that they cannot see the bulb itself (it is covered by the fixture or is too high) have them take a picture of the fixture and have a facilities staff member check the device later on for the exact type and wattage of the bulb. Make sure that all photos note where the type of lighting can be located in the building to make it easier to find the fixtures later on.

After the students have completed the indoor audit, perform the same process for outdoor lighting. Ask your facilities staff if the school leases the outdoor lighting from the local utility or if the school owns these fixtures. If the lighting is leased there is little the school can do to influence upgrades. However, any lighting that the school owns should be included in your audit.

After the students have compiled complete lists for each building and outdoor areas, compile a master list by building and double-check the lighting types with your facilities manager or lighting vendor. Ask for them to note the wattage per bulb for each type of lighting listed in the audit. In the case that they cannot tell the type or wattage of the lighting from the photograph, set up a time to walk the campus with them and check any lighting about which they are unsure. After checking with your specialists, you should have a complete list of indoor and outdoor lighting on campus in terms of types of lighting, numbers of each type of bulb per building, and the wattage from that type of bulb. These figures will allow you to calculate your current energy use from lighting.

## Calculating Your Current Energy Use from Lighting

You may choose to separate your calculations for lighting energy use by building and even by room type. To identify current energy use by building you will need the following information:

**Area/Type of Fixture**: This includes the rooms of the building in which the lamps are found and the type of fixture (2-bulb fixture, 4-bulb fixture, chandelier, sconce, etc.) For a fluorescent tube lamp you will also want to include the type of ballast (magnetic or electronic) and the number of bulbs that the ballast controls (2-lamp electronic ballast, 3-lamp magnetic ballast, etc.). A ballast controls the voltage of the magnetic or electronic charge that ionizes gas particles and creates light in fluorescent tube lighting. A ballast for fluorescent tube lighting will look like a rectangular plastic strip set into the fixture with outgoing wires on each end. Ballasts for screw-base or pin-base CFLs are attached to the base of the bulb (under the large white plastic piece). T-12 bulbs have magnetic ballasts and T-8s usually have electronic ballasts (although sometimes they are fit into existing magnetic ballasts, which results in a less efficient lighting process). Since it can be time-consuming and difficult to identify how many bulbs that a ballast controls if you are not familiar with lighting, ask the facilities manager in charge of lighting or your lighting vendor to help you identify the ballast types on your campus. If either person is already familiar with the lighting on campus they may be able to tell you what ballast types are found in each lighting fixture without even walking the campus.

**Type of Lamp**: This is the type of lamp associated with each type of fixture determined above. This should include not only the type of lamp (screw-base CFL, pin-base CFL, T12 or T8 fluorescent tube, metal halide, various LEDs, etc.) but also the wattage and the number of bulbs in that type of fixture.

**# of Fixtures**: This is the number of each type of lamp (above).

**# of Lamps**: This is the total number of lamps per type of fixture found throughout the building.

**Input Watts Per Fixture**: Ask your lighting specialist for this information as input wattage is dependent on fixture type and ballast type for fluorescents and can be difficult to calculate on your own.

**Total Watts for Existing Lighting**:

# of Fixtures * Input Watts Per Fixture

**Hours Lighting Type Used per Year**: This is the number of hours that the type of lighting is turned on per day. This will vary based on location. For instance, hallway lighting in dormitories may be on 24 hours a day while the lighting in an administrative office may typically be turned off on weekends. Find an average number of hours that each type of lighting is used per day then multiply that by 365 to find the average number of hours that the lighting is used per year.

**Total kWh in Existing Lighting**:

(Total Watts/1000) * Hours Lighting Type Used per Year.

**Annual Energy Cost from Lighting in Existing Lighting**:

Total kWh for Existing Lighting * Cost of electricity per kWh

### Identifying Lighting Upgrade Opportunities

If you are happy with your current lighting vendor, speak to them about the best energy-saving lighting upgrade opportunities on your campus. They will know the most appropriate styles of lighting for each space and can ensure that any replacements you make will continue to provide an adequate amount of lighting for the purpose of each room. If you do not have a specific lighting supplier that you trust, consider asking other universities or large businesses in your area if they have a preferred lighting vendor that they would recommend.

There are a few lighting upgrades that should be completed immediately because of their short payback periods and ensured savings. Any incandescent lighting on your campus should be replaced right away. Replacing a 75-Watt incandescent bulb with a 19-Watt CFL translates into a savings of 189 kWh per year assuming 65 operating hours each week. While the cost savings will vary based on your utility, if the CFL replacement costs $3 and your electricity cost is $0.08/kWh, this translates into an annual cost savings of $20 per light bulb replaced without factoring in the avoided labor costs from CFLs.[49] This is the energy cost savings only, meaning that no rebates were factored into the savings. Check with your utility to determine whether they offer rebates per bulb or per avoided kWh (if they provide rebates), which would make this investment even more lucrative. To determine specific savings per project look to the Calculating Energy Savings from Lighting Upgrades section below.

Another upgrade opportunity with significant savings potential is replacing T12 fluorescent tube lighting with T8 fluorescent tube lighting.[50] T12 lamps can be identified by their diameter of 1.5 inches while T8 lamps are 1 inch in diameter. Replacing just one 32-Watt T12 with a 25-Watt T8 saves 24 kWh per year. If you have many T12s to replace, this could be a large energy and cost savings for your institution. This translates into a $1.92 savings per bulb in electricity costs alone assuming an electricity cost of $0.08/kWh. Some utilities provide rebates either per bulb or per kWh saved for T12 to T8 upgrades, which could further increase your annual savings and would also lower your initial capital costs for this project. Also consider removing lamps from over-lit areas as some utilities provide rebates for “de-lamping”. Consult your lighting vendor on which areas could be de-lamped to ensure that you maintain the required foot-candle levels for safety purposes.

There may be many more cost-saving lighting upgrade opportunities on your campus. Upgrading metal halide fixtures (often used in gymnasiums) and high-intensity discharge

---

[49] Environmental Defense Fund. 2011 Climate Corps Financial Analysis Tool. (Note: This information was based upon CFL pricing and electricity costs from PG&E)
[50] Waste Reduction Partners. October, (2008), Pg. 22.

(HID) lamps to high bay T8 fluorescents or even T5 fluorescents, and in some cases upgrading incandescent bulbs or CFLs to Light-emitting diodes (LEDs) can also lead to long-term savings.[51] LEDs can result in significant savings despite their initial cost due to a combination of very low wattage per lamp and much lower maintenance costs because of the extended lifetimes of various types of LEDs. Check with your lighting vendor to identify the best lighting upgrade options for your institution. Then follow the steps in the section below to identify the energy and cost savings from potential lighting upgrades.

Calculating Energy Savings from Lighting Upgrades

Once you have determined the best upgrade options for your institution by speaking with your lighting vendor, ask your vendor to provide the following information about the proposed lighting upgrades:

**-Type of Lamp**
**-# of Fixtures** (From Existing Lighting Above)
**-Type of Ballast**
**-# of Lamps** (This may or may not be the same as the number of existing lamps)
**-Input Watts per Fixture after Upgrade**

**Total Watts per Fixture**:

# of Fixtures * Input Watts per Fixture after Upgrade

**Total Watts:** Total Watts per Fixture * # of Fixtures

**Total kWh (Upgrade)**:

(Total Watts/1000) * Hours Lighting Type Used per Year

You will find the Hours Lighting Type Used per Year above.

**Annual Energy Cost from Lighting after Upgrade**:

kWh Reduction * Cost of electricity per kWh

Calculating Net Investment, Payback Period, And Savings from Lighting Upgrades

---

[51] Waste Reduction Partners, (2008), Pg. 22.

As with the HVAC upgrades, you will want to identify to total cost of you investment in lighting, the payback period for this investment, the annual savings, and the NPV of lighting upgrades. Follow the steps below to arrive at these values.

**Total Cost of Upgrades**: Sum the total cost of all upgrades considered for all buildings on campus.

**Total Rebates**: This will vary based on the type of rebate, which could be a set rate per kWh saved or per lamp replaced/de-lamped. Check with your utility to determine the rebates available. You can calculate the total rebates as follows:

value of the rebate * either kWh saved or total number of lamps upgraded or de-lamped

**Net Investment**:

Total Cost of Upgrades – Total Rebates

**Total Annual Energy Cost Savings from Lighting**:

Annual Energy Cost from Existing Lighting – Annual Energy Cost from Lighting after Upgrade

**NPV**: Calculate as discussed above in the HVAC section using the cash flow method. The NPV will be different based on the lifetime of each type of lamp. Find the NPVs for each lighting type and then evaluate each type of lamp upgrade separately. While you may want to average the NPVs of projects later on you must keep in mind that a critical element of the NPV calculation is the lifetime of the project. Therefore you should keep NPVs separate per project and should avoid averaging them unless all project lifetimes are the same.

**Payback Period**: You will want to calculate the payback period as demonstrated in the HVAC section, however the payback periods will be different for each type of lighting as the lifetime of each investment will vary based on the lamp type. When you have calculated the payback period for each type of lighting you can average these to find the average payback period for the entire lighting investment.

You can also calculate that total CO2e emissions avoided by the lighting upgrades as well as the equivalent number of cars removed from the roads and American households powered as calculated for the HVAC projects above.

---

## 10. LED Exit Signs

A related project to lighting is upgrading incandescent or CFL exit signs to LED exit signs. Exit signs must be lit at all times for safety reasons, which means that the bulbs inside each sign are using electricity 8,760 hours a year. This means that any reduction in wattage for these signs would save energy every hour of every day throughout the year. Upgrading from a 30-Watt incandescent-lit exit sign to a more efficient 2-Watt LED-lit sign would save about 245 kWhs per sign every year. This translates into a savings of $19.60 in electricity costs per sign each year. Switching from a 14-Watt CFL-lit sign to an LED sign would result in an annual savings of $11.20 per sign. These savings are based on electricity prices of $0.08/kWh and do not include added savings from avoided maintenance costs.

The payback period for replacing incandescent-lit exit signs with LED exit signs is less than two years.[52] However, rebates from your utility for upgrading your exit signs could help to decrease the net investment for the project and would help to achieve an even shorter payback period. Utilities that offer rebates for LED exit sign purchases typically give a set rebate per sign. Depending on the size of the rebate it is possible to find LED exit signs that cost less than the rebate amount. This means your school would make money from the project beyond the annual electricity savings.

To calculate the energy and cost savings from upgrading current exit signs to LED exit signs, first identify all exit signs in all buildings on your campus. Then ask the Facilities Department how the exit signs are lit around campus. If there is any discrepancy about the type of exit sign (incandescent, CFL, LED) simply open the exit sign box and check the bulbs. Once you have accounted for all exit signs on your campus (both numbers and types of lighting) you can calculate the energy savings from the proposed upgrades.

<u>Energy Savings from LED Exit Sign Upgrades:</u>

kWh Existing Exit Signs – kWh Upgraded Exit Signs

Both existing and upgraded exit signs can be calculated as follows:

---

[52] Waste Reduction Partners, (2008) Pg. 22.

((Total Watts per Sign * Total # Signs)/1000) * 8760 hours

Cost Savings from LED Exit Sign Upgrades:

Energy Savings * Cost of Electricity ($ per kWh)

Once you determine the cost per sign from your lighting vendor (lighting vendors often sell LED exit signs as well), the rebates available through your utility, and any costs for installation by your Facilities Department you can calculate your initial capital cost, net investment, payback period, and NPV as you did above for HVAC and lighting upgrades. You can also calculate your CO2e emissions, the equivalent number of cars removed from the road, and the equivalent number of American houses powered as calculated above.

## 11. VendingMisers®

Another project related to lighting is the installation of devices known as VendingMisers® on your vending machines across campus. Vending machines draw electricity for lighting and/or cooling 24-hours a day, 365 days a year in addition to the energy used when an item is actually purchased. The VendingMiser®, offered by USA Technologies, is a device that cycles a vending machine on and off to conserve energy when the machine is not in use. The device uses passive infrared sensors to determine whether or not a room is occupied, then shuts the machine off when the area is unoccupied.[53] To ensure that drinks stay cold the VendingMiser® cycles the cooling capacity on and off in one to three-hour periods.[54]

VendingMisers® can be purchased online at the USA Technologies website for between $181 and $199, however college discounts are available for large orders.[55] Similar devices are available through the same company for large drink coolers. Note: VendingMisers®

---

[53] USA Technologies. (Visited 2012, February 26). *USA Technologies: Energy Management*. Retrieved from http://www.usatech.com/energy_management/downloads/USATech_vendingmiser.pdf

[54] Ibid.

[55] *USA Technologies Online Store - Vending Misers*. (Visited 2012, February 26). Retrieved from http://store.usatech.com/vendingmisers.aspx

may not be appropriate for machines that sell sandwiches, fresh fruits and vegetables, or dairy-based snacks due to health code temperature requirements for such machines.

VendingMisers® offer an expected savings of 46% of the typical energy use of a vending machine.[56] The devices are most appropriate in areas that do not see regular foot traffic throughout the entire 24-hour day, such as a gymnasium hallway or an office break room. A busy area such as a dormitory hallway would not be the ideal placement for a Vending Miser® as the sensor device would be triggered regularly, leading to much lower energy savings from the Miser device. In heavy traffic areas it may make more sense to simply turn the light off in the vending machine or de-lamp the machine altogether (take out the bulb). Turning off the lights in a vending machine can save up to $100 in energy costs per machine per year (assuming an electricity price of 6.39 cents/kWh).[57]

To calculate the Net Investment for VendingMisers®, determine the number of devices you want to purchase, determine the cost of the devices as quoted by the vendor, and subtract any rebates available for the devices through your utility. Directions for installation are included so a facilities staff member can install the devices. The vending machine operators are often willing to install these devices either free of charge or at a minimal fee. You can also request that the vending machine operators turn off lighting or remove light bulbs from lit machines

To calculate the energy savings and cost savings from this project you will first need to know the current energy use for the machines on your campus. You can measure the current energy use of a vending machine easily with an inexpensive device called a Kill A Watt and then average the kWh used for several of the vending machines on campus to find an average energy use per machine.

---

[56] USA Technologies. (Visited 2012, February 26). *USA Technologies: Energy Management*. Retrieved from http://www.usatech.com/energy_management/energy_vm.php.

[57] Waste Reduction Partners. Sponsored by the State Energy Office, N.C. Department of Administration, with State Energy Program Funds, in cooperation with Land-of-Sky Regional Council (Waste Reduction Partners) and the NCDPPEA. (2004, February). *Vending Machines: Utility Savings Initiative*. Retrieved from http://www.p2pays.org/energy/Vending.pdf

Recommended Energy Monitoring Product: Kill A Watt

You can find the current energy use of your vending machines with a Kill A Watt monitor ($16-$27 online).[58] P3 International manufactures and sells these products. Simply plug the Kill A Watt into the wall and then plug the vending machine into the Kill A Watt and leave the device for 24-hours. Check the device after 24-hours to determine the kWh usage per day of the vending machine. Any expected energy and cost savings can be estimated based on this current daily energy usage.

Finally you can calculate the payback period and NPV as calculated in the HVAC section.

## 12. Computer, Monitor, and Large Printer Sleep Settings

Computers, monitors, and printers draw electricity even when they are not being used. Newer computers, monitors, and many large combined printer/copiers have “sleep mode”, “standby”, or “hibernate” settings. Such settings switch the devices into lower power-drawing modes after a chosen number of minutes of inactivity. Some institutions may not yet have set the power-saving modes on their computers, monitors, and printers. Sometimes schools have already set the sleep modes on their monitors but have not considered these settings for their computers or printers.

The EPA estimates that setting sleep modes or standby settings on computers and monitors can save as much as $50 per computer per year in unnecessary energy costs.[59] To determine the average annual kWh of energy use on your campus from inactive computers and monitors, use the Kill A Watt discussed above. Consider measuring the energy use of inactive computers over the weekend in rooms where staff and students will not be using

---

[58] Google search of “Kill A Watt” at 4:36 PM on 2/26/2012. Retrieved from: http://www.p3international.com/products/special/P4400/P4400-CE.html.

[59] U.S. Environmental Protection Agency. (Visited 2012, February 26). *Energy Star: Power manage computers to save up to $50 per computer annually*. Retrieved from http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_low_carbon_join.

the computers. (You are only concerned with the energy use that occurs when computers and monitors are not being used). Use your findings to determine the annual energy and cost savings for setting the sleep modes on every university-owned computer and monitor on your campus. You can also use the Kill A Watt to track energy use of inactive printer/copier machines in offices areas.

This is another no-cost project with a payback period of zero, which means that energy cost savings would begin immediately. Ask your IT Department to set all of the sleep modes on all university-owned computers, monitors, and copiers on campus. The EPA recommends setting the sleep mode to turn on after inactivity of 30-60 minutes, although they note that a shorter wait before activating the hibernate setting leads to even greater savings.[60] If your school's computers use the Windows operating system, Energy Star offers free software that will allow your IT Department to centrally manage the sleep/hibernate settings on campus computers.[61] You can access this tool at the following website: http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_ez_gpo

To calculate the NPV and equivalent savings in number of cars and number of American homes powered, follow the steps listed in the HVAC and NPV sections above.

## 13. Remove Unnecessary Office Appliances

Offices are filled with appliances ranging from personal printers to coffee makers, mini-fridges to space heaters, fans to televisions and microwaves. Some of these appliances, such as fans, use very little energy, while others, such as space heaters and mini-fridges, use considerable amounts of energy every year. In some cases appliances can be consolidated and in other cases you should recommend that faculty and staff remove them altogether.

---

[60] Ibid.

[61] Ibid.

Small printers and mini-fridges are leading candidates for consolidation. If there is a shared copier/printer available for each department or a large refrigerator in the hallway break room, encourage staff members to use these resources instead of bringing in individual appliances. A small 2-by-2-by-3-foot refrigerator can draw about 60 Watts of power and uses about $42 worth of energy every year (based on real Kill A Watt measurements at Shaw University and an $0.08/kWh price for electricity).[62] A small printer draws about 10 Watts in power even when not in use and results in a cost of about $7 per year (based on an $0.08/kWh price for electricity).[63] You can perform your own Kill A Watt measurements to determine the current energy usage that could be eliminated by appliance consolidation. This is another no-cost project that would result in immediate energy savings. Calculate the NPV, CO2e emissions, and car and U.S. home equivalents as discussed in the sections above.

Space heaters are highly energy intensive using up to 1500 Watts of power.[64] If a staff member used a single space heater for 8-hours a day for only 30 days of the year it would cost $28.80 (assuming an electricity price of $0.08/kWh). Schools should encourage employees to eliminate space heaters by educating staff members about the true energy cost of these appliances. The savings from eliminating space heaters and other energy intensive appliances can be calculated by using the Kill A Watt to measure current energy usage and multiplying that by the total number of space heaters and the cost of electricity. The payback period would be zero and other calculations such as NPV, CO2e, and car and American home equivalencies can be computed as discussed in the previous sections.

## 14. Other Project Recommendations

### Air Sealing and Maintenance

---

[62] From real Kill A Watt measurements on the Shaw University campus conducted by Eliza Davis and Jennifer Weiss during the summer of 2011. *Energy Efficiency and Conservation: Shaw University*. Environmental Defense Fund.

[63] Ibid.

[64] Peck, Matthew and Michelle Williams. (2011). *Energy Efficiency and Conservation: Winston-Salem State University*. Environmental Defense Fund, Pg. 19.

Often the most cost-effective measure for saving energy is maintaining and repairing current buildings and equipment. As discussed above, properly cleaning, insulating, and maintaining individual pieces of heating and air conditioning equipment around campus can achieve significant HVAC savings. Fixing air leaks in buildings or improving your "building envelope" can also achieve savings. During your walks around campus, look for doors that do not close all the way, windows that are left open in air-conditioned buildings, spaces where air escapes between doors and doorjambs or thresholds, and holes left in walls where equipment has been removed. Also consider replacing aging insulation that has become compacted and no longer prevents heat loss and gain. The EPA Energy Star program estimates that 25% to 40% of all building heating and cooling costs are the result of air leaks.[65] These sources of heating and cooling loss cost your school money and easy repairs to door closing mechanisms, caulking, and insulation can lead to meaningful savings.

Window Film

Heat is both gained and lost through windows that lack insulation. Window film is a product that can be applied to windows to prevent solar heat gain in the summer and heat loss in the winter. The use of window film can therefore reduce the need for excess air conditioning and heating. Window film will be most cost-effective for the buildings (and even more specifically the faces of buildings) that receive the most sunlight during the day. If trees or the shadows of other buildings block sunlight to the buildings on your campus, window film will not be a worthwhile investment. However, if there are buildings on your campus that receive full direct sunlight on one or more of their faces window film could be a good energy-saving decision. Work closely with a window film vendor to identify specific savings from a project on your campus. Be sure that the vendor bases all estimates upon the measurements and energy uses unique to the buildings under consideration.

---

[65] U.S. Environmental Protection Agency. (Visited 2012, April 24) *Change for the better with Energy Star®: Air sealing: Building envelope improvements.* Retrieved from http://www.barrierst.com/knowledgebase/AirSealing_buildingenvelopes.pdf

Note: If the vendor encourages you to purchase window film based upon generalized industry data and will not run a customized analysis of costs and savings based on the specifics of each building *do not* invest in the product.

## ENERGY STAR® Purchasing Program

ENERGY STAR® products have been certified by the U.S. Environmental Protection Agency's ENERGY STAR® program to be more efficient and better for the environment than non-certified appliances and equipment. For instance, copiers, fax machines, and other pieces of imaging equipment that are ENERGY STAR® certified are 40% more efficient than equivalent non-certified office equipment.[66]Work with your Purchasing Department to implement a program to require ENERGY STAR® certified product purchases for new computers, monitors, copiers, printers, refrigerators, televisions, washing machines, and other energy intensive products. Make the business case for energy efficiency with your Purchasing Department, as the amount of cost savings from ENERGY STAR® products is compelling. For more information on the specific energy savings from ENERGY STAR® purchases, visit the ENERGY STAR® Qualified Products website at the following address: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.

## Appliances in Student Dormitories

Student dormitories are filled with computers, televisions, mini-fridges, microwaves, and other energy-intensive appliances. Encourage new students during orientation to purchase ENERGY STAR® products when possible, or even institute a policy for the number of appliances or types of appliances allowed in dormitory rooms. Often students do not understand that appliances draw power even when they are not in use or they do not prioritize energy savings because they are not directly paying for their utilities. A useful product for saving energy in dormitories is the "smart" power strip. These advanced power strips sense when appliances are turned off or are not in use and cut off the power

---

[66] U.S. Environmental Protection Agency. (Visited 2012, April 24). *Imaging equipment: Energy star(r)*. Retrieved from http://www.energystar.gov/index.cfm?fuseaction=find_a_product.ShowProductGroup&pgw_code=IEQ.

flow to those appliances. In this way students can avoid the hassle of unplugging appliances every time they leave their rooms but the school can still benefit from decreased "phantom" plug load or the power draw that occurs when appliances are left plugged in. Consider purchasing a "smart" power strip for each dormitory room or encourage students to buy "smart" strips instead of extension cords or normal power strips. If the school decides to purchase "smart" power strips for rooms include them in the initial room inventory forms and explain that a fee will be charged if power strips are removed. "Smart" power strips should be considered for classrooms and administrative offices around campus as well.

### Green Revolving Loan Fund

Green revolving loan funds are funds specifically set aside for energy efficiency and sustainability projects that achieve annual cost savings. Such funds give individual grants for specific energy efficiency and campus sustainability projects. Any savings from energy upgrades on campus are then returned to the fund for future projects. These funds can also be used for education and engagement activities, which may not result in any savings but further the sustainability and greenhouse gas emission reduction goals of the institution. Green revolving loan funds can be managed by a joint committee of faculty, students, and staff and can be useful educational tools for project financing, grant writing, and budgeting.

Two students at Macalester College in St. Paul, MN implemented a Clean Energy Revolving Loan Fund in 2006 with an original grant from the school's Environmental Science Department and Macalester College Student Government of $27,000.[67] This fund allowed the school to pursue a lighting project in 2008 to save about $40,000 in annual energy costs.[68] To learn more about the Clean Energy Revolving Fund (CERF) at Macalester, visit the CERF website: [http://www.macalester.edu/cerf/](http://www.macalester.edu/cerf/)

---

[67] Diebold, Asa and Timothy Den Herder-Thomas. (2007). *Creating a campus sustainability revolving loan fund: A guide for students.* (p. 7). Association for the Advancement of Sustainability in Higher Education. Retrieved from http://www.aashe.org/documents/resources/pdf/CERF.pdf

[68] Ibid.

A guide for student implementation of Sustainability Revolving Loan Funds is provided through the Association for the Advancement of Sustainability in Higher Education at the following website: http://www.macalester.edu/cerf/reports/creatingacampussustainabilityrevolvingfund.pdf.

## 15. Education and Engagement

Energy efficiency at its core is an exercise in responsible energy use behavior. If your school installs the most efficient lighting, appliances, and heating and air conditioning equipment but people do not effectively use or adequately maintain the equipment you cannot hope to achieve optimal energy savings. For this reason education programs for everyone on campus, from students to faculty and staff members, and campus engagement in energy efficiency programming are important steps to saving energy, cutting costs, and "going green".

To start the sustainability discussion on your campus consider forming a "Green Team" or multi-functional group of faculty, students, and staff to identify energy-saving programs and environmental initiatives on your campus. Shaw University created their Green Team in the summer of 2011 including professors from the Environmental Science and Physics Departments, staff from the Facilities Department, members from the Transportation Department, Student Affairs representatives, Residence Life advisors, and student leaders. The green team meets regularly to identify priorities, plan educational events for the student body, apply for grant funding, and inform each other about all of the ongoing environmental initiatives on campus.

Holding competitions between residence halls or between individual colleges at a university is a great way to educate students about resource use and inspire conservation. Give students a list of recommended ways to save energy, including turning off lights, using less heating or air conditioning, using the stairs instead of elevators, and unplugging appliances. Measure the energy use by building for one month then reward the winning team with a pizza party or special event. Student groups could help to publicize this event and the university could take the opportunity to host speakers, implement recycling activities, or teach the student body about ways to save energy by holding thematic events throughout the month of the competition.

Another way to build awareness on campus includes hosting faculty speaking events where professors with experience in energy and the environment can share their work with students and other staff. Additionally schools can develop a sustainability pledge that new students can sign when they arrive on campus. This pledge can act to remind students about all of the ways they can save energy, reduce water use, and decrease waste on campus before they move into the dormitories. Finally, include students in the process of identifying energy and environmental projects on your campus and develop opportunities to reward the best cost-saving sustainability recommendations.

## 16. Conclusion

This Toolkit provides the potential projects, example calculations, and recommended education and engagement programs to help save your campus money and reduce greenhouse gas emissions. As you work to identify and implement campus projects remember that the students, faculty, and staff at your institution will be the best resources for identifying existing inefficiencies and developing future energy-saving programs. I hope that the use of this Toolkit will not only help your school to cut its energy costs but will also allow your college or university community to achieve its sustainability goals.

## 17. Acknowledgements

I could not have created this Toolkit without the generous support of several individuals who I would like to acknowledge.

I would first like to thank my Master Project Adviser, Dr. Martin D. Smith, for his excellent guidance throughout the writing process. I would also like to thank Dr. Jeffrey Smith, VP of Student Affairs & Administration at Shaw University and Dr. Richard Kabis, Director of Sustainability at Winston-Salem State University (WSSU) for allowing me to use the data gathered by their 2011 EDF Climate Corps Public Sector Fellows for this project. Thank you as well to Matthew Peck and Michelle Williams, who worked as EDF Climate Corps Public Sector Fellows at WSSU, for allowing me to use their data for this project. I also appreciate the support of Jennifer Weiss, fellow Master of Environmental Management Candidate 2012 at the Nicholas School and my Climate Corps partner at Shaw University for allowing me to use our findings for this project. I greatly appreciate the support of Jill Logeman and David Fox, my summer supervisors at Environmental Defense Fund, for their approval of my use of all 2011 Climate Corps Public Sector Excel models and data, which provided the basis for my calculation explanations.

Finally I would like to thank Shaw University and the members of the Shaw Green Team in particular for hosting me as a Climate Corps Fellow during the summer of 2011 and for inspiring this project.

# References

American College & University Presidents' Climate Commitment. (Visited 2012, April 18). Retrieved from http://www.presidentsclimatecommitment.org/

Anderson, Soren T. and Richard G. Newell. (2004). Information programs for technology adoption: the case of energy-efficiency audits. *Resource and Energy Economics*, *26*, 27-50.

Billion Dollar Green Challenge. (Visited 2012, January 24). Retrieved from http://greenbillion.org/about/

Davis, Eliza and Jennifer Weiss. (2011). *Energy efficiency and conservation: Shaw University*. Environmental Defense Fund.

Diebold, Asa and Timothy Den Herder-Thomas. (2007). *Creating a campus sustainability revolving loan fund: A guide for students*. (p. 7). Association for the Advancement of Sustainability in Higher Education. Retrieved from http://www.aashe.org/documents/resources/pdf/CERF.pdf

Ehrhardt-Martinez, Karen and John "Skip" Laitner. (2008, May). *The size of the U.S. energy efficiency market: Generating a more complete picture."*. (p. 29). Washington, DC: American Council for an Energy-Efficient Economy.

Energy Star website. Selected Topic. http://energystar.supportportal.com/ics/support/KBAnswer.asp?questionID=21828&hitOffset=165+140+11&docID=489. Visited Sunday February 26, 2012. Last modified 10/3/2011.

Environmental Defense Fund. 2011 Climate Corps Financial Analysis Tool.

Environmental Defense Fund. 2011 Climate Corps Financial Analysis Tool – Underlying Assumptions.

Google search of "Kill A Watt" at 4:36 PM on 2/26/2012. Retrieved from: http://www.p3international.com/products/special/P4400/P4400-CE.html.

Green Building Certification Institute. (Visited 2012, January 18). *Building certification fees: Operations & maintenance*. Retrieved from http://www.gbci.org/main-nav/building-certification/fees/om.aspx

Jackson, Jerry. (2011). Selling energy efficiency: The energy engineer as investment advisor. *Energy Engineering*, *108*(4), 46-64, Pg. 48.

Lawrence, Thomas M., Jeffrey D. Mullen, Douglas S. Noonan, and Jay Enck. (2005, September). Overcoming barriers to efficiency. *ASHRAE Journal*, *45*(9), S40-S47, Pg. S41.

McKinsey & Company. (2009, January). *Pathways to a low-carbon economy: Version 2 of the global greenhouse gas abatement cost curve*.

Mike Davis, Energy Engineer at Piedmont Service Group, Raleigh, NC, summer 2011.

Peck, Matthew and Michelle Williams. (2011). *Energy Efficiency and Conservation: Winston-Salem State University*. Environmental Defense Fund,Pg. 19.

Shaw University. (Visited 2011, August). Shaw University. Retrieved from http://www.shawuniversity.edu/

Stephenson, Janet, Barry Barton, Gerry Carrington, Daniel Gnoth, Rob Lawson, and Paul Thorsnes. . (2010). Energy cultures. *Energy Policy*, *38*, 6120-6129, Pg. 6121.

Stigler, George J. (1961, June). The economics of information. *Journal of Political Economy*, *69*(3), 24.

The Princeton Review, Inc. and U.S. Green Building Council. (2010). *The Princeton Review's Guide to 286 Green Colleges 2010-2011*. Princeton, NJ: The Princeton Review, Inc.

*USA Technologies Online Store - Vending Misers*. (Visited 2012, February 26). Retrieved from http://store.usatech.com/vendingmisers.aspx

USA Technologies. (Visited 2012, February 26). *USA Technologies: Energy Management*. Retrieved from http://www.usatech.com/energy_management/downloads/USATech_vendingmiser.pdf

U.S. Department of Energy. (Visited 2012, April 25). *Energy efficiency & renewable energy: Energy savers*. Retrieved from http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12720

U.S. Department of Energy. (Visited 2012, February 15). *Energy savers: Central air conditioners*. Retrieved from http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12440

U.S. Department of Energy. (Visited 2012, February 26). *Energy savers: Thermostats and control systems*. Retrieved from http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12720

U.S. Energy Information Administration. (Last Updated 2011, December 06). *How much electricity does an American home use? - FAQ – U.S. Energy Information Administration (EIA)*. Retrieved from http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3

U.S. Environmental Protection Agency. (Last Updated 2011, November 02). *Calculations and references: Clean energy*. Retrieved from http://www.epa.gov/cleanenergy/energy-resources/refs.html

U.S. Environmental Protection Agency. (Visited 2012, April 24) *Change for the better with Energy Star®: Air sealing: Building envelope improvements.* Retrieved from http://www.barrierst.com/knowledgebase/AirSealing_buildingenvelopes.pdf

U.S. Environmental Protection Agency. (Visited 2012, April 24). *eGRID - Clean Energy – U.S. EPA: EPA eGRID 2010 Version 1.1 Year 2007 GHG Annual Output Emissions Rates* . Retrieved from http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

U.S. Environmental Protection Agency. (Visited 2012, April 24). *Energy Star*. Retrieved from http://www.energystar.gov/index.cfm?fuseaction=search.showResults&entqr=0&access=p&output=xml_no_dtd&sort=date:D:L:d1&ie=UTF-8&as_sitesearch=www.energystar.gov/ia/business/bulk_purchasing&client=default_frontend&q=commercial&filter=0&ud=1&site=default_collection&oe=UTF-8&proxystylesheet=default_frontend&ip=128.121.47.99&start=20.

U.S. Environmental Protection Agency. (Visited 2012, February 26). *Energy Star: Power manage computers to save up to $50 per computer annually*. Retrieved from http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_low_carbon_join.

U.S. Environmental Protection Agency. (Visited 2012, April 24). *Imaging equipment: Energy star(r)*. Retrieved from http://www.energystar.gov/index.cfm?fuseaction=find_a_product.ShowProductGroup&pgw_code=IEQ.

U.S. Environmental Protection Agency. (Visited 2012, February 14). *Maintenance checklist: Energy Star*. Retrieved from http://www.energystar.gov/index.cfm?c=heat_cool.pr_maintenance

Waste Reduction Partners. (Revised 2008, October). *Self-assessment guide for energy saving opportunities. Adapted from handbook of energy engineering, 4th edition, EIA and NREL 2000*. Sponsored by the State Energy Office, N.C. Department of Administration and the U.S. Department of Energy.

Waste Reduction Partners. Sponsored by the State Energy Office, N.C. Department of Administration, with State Energy Program Funds, in cooperation with Land-of-Sky Regional Council (Waste Reduction Partners) and the NCDPPEA. (2004, February). *Vending*

*Machines: Utility Savings Initiative (USI) – Fact Sheet*. Retrieved from http://www.p2pays.org/energy/Vending.pdf

WebHVAC.com. (Visited 2012, February 15). *HVAC SEER ratings: Webhvac.com*. Retrieved from http://www.webhvac.com/2011/07/hvac-seer-ratings/

Winston-Salem State University. (Visited 2012, March 20). *About WSSU – About WSSU*. Retrieved from http://www.wssu.edu/about/default/aspx