# ELECTRICAL SUSTAINIBILITY AT SMITH COLLEGE
## *Student and Institutional Solutions*

BETHANY BURGEE
*Environmental Science and Policy Seminar, Smith College, Northampton MA*

*Abstract.* The United States accounts for 5% of the world's population yet use roughly 30% of the energy generated worldwide (Baird 2003). At Smith College, energy consumption in student residences creates a financial drain through the excessive use of electricity. This research project aims to discover how much energy is being used and what solutions can be implemented to reduce energy consumption across campus. A poll taken of electrical appliances owned by Smith students show that students do not employ environmentally conscious practices in their everyday routine. If students' understanding of environmental awareness was heightened and conservation practices put to use, Smith College could save up to $1,469,076 dollars annually in electricity bills. Improving environmental awareness at Smith can be accomplished by the creation of "green" buildings, investment in alternative sources of energy and creating partnerships with environmental organizations such as the Million Solar Roof Initiative. To heighten student awareness Smith needs to take an active role in applying environmentally friendly practices to campus buildings, in addition to taking on a participatorier role in the environment and in society at large.

INTRODUCTION

In the 21st century developed societies are still extremely dependent on energy derived from fossil fuels such as oil and coal. Resulting from this dependence on fossil fuels is a plethora of environmental problems such as acid rain, dirty air, ozone depletion, contaminated water and global warming that the future generations of today must remedy. Science and engineering continually develop methods to utilizing alternative renewable sources of energy, yet despite innovative technology, these clean sources of energy remain an untapped resource due to political and economical and fiscal reasons.

The use of energy, at Smith and worldwide, has been an increasing concern within the past decade due to the cost increases of natural gas and oil as well as increasing environmental awareness (Greenspan 2003). Improved technologies have not been able to counterbalance the rising cost of natural gas in the States. For instance, the price for natural gas has risen from $2 per million Btu (*B*ritish *t*hermal *u*nits) in 1997 for delivery in 2000 to a projected cost of more than $4 per million Btu for 2009 and the price per barrel of crude oil has nearly doubled (Greenspan 2003). While oil and natural gas prices have slowly been increasing, costs for electrical generation from coal remains relatively low, and though while fairly abundant, production and environmental costs affect the excessive use of coal-burning plants (U.S. House of Representatives 2001). These economical and environmental reasons are cause for Smith to reevaluate electrical consumption and to try and find solutions to mitigate electrical use.

Very few people consider the consequences of excessive electrical use. Electricity is not seen as polluting the environment, yet what is little realized is that electricity is the end product of a successive chain of steps that do pollute the environment with the burning of fossil fuels. Burning of coal and natural gas result in higher concentrations of carbon dioxide in the atmosphere accounting for general trend of global warming. Nearly 52% of the energy generated for the U.S. is still derived from coal ($EPA_1$ 2000). Water can be polluted in oil spills and acid-runoff in coal mining as well as thermal pollution from power plants located in water (Baird 2003). Nuclear power results in nuclear waste that persists in the environment for centuries and oil drilling, strip mining and hydro-dams degrade the environment. The American society uses and wastes a vast amount of electricity, as we account for only 5% of the world's population yet use nearly 30% of the world's annual energy output (Baird 2003). On a smaller level there is much Smith can do to reduce electrical consumption, and can contribute a small part to building a more sustainable society.

Many steps have been taken to improve electrical usage at Smith. For instance, in 1999 over 7,800 light fixtures were replaced in student and academic buildings resulting in a 9.8% decline in energy consumption (White 2002). Renovated and newly built buildings have been constructed with energy-saving technologies in mind. One such example is the new student center whose front façade faces due south, utilizing the sun's thermal energy to help heat and light the building in winter and summer. Yet despite these changes, more can be done to reduce consumption. Lights are on 24-hours a day in most residential buildings and many of the older buildings are not adequately insulated for trapping heat.

Though individual buildings are not sub-metered for exact units of electricity being consumed, Jack Doherty of Physical Plant firmly believes that the residential buildings consume the most electricity on campus. This is no big surprise considering the increasing amount of appliances students own and that residential buildings are occupied 24 hours a day as opposed to academic buildings that are shut down at night. Many students leave appliances idle when not in use rather than turning them off, creating what is known as standby energy use. In one study that observed homes in Northern California calculated the standby energy used accounted for 6-26% of the homes' annual electricity use (Sanders 2001).

It is imperative that individuals, and Smith College as a whole, become more environmentally conscious of how to conserve energy. The purpose of this research is to find how much energy is used at Smith and ways in which to mitigate consumption. The aim of this project is to find solutions to reduce consumption on a student-based level as well as to investigate larger-term macro-solutions that will put Smith on the forefront of environmental sustainability among higher-learning institutions.

## METHODOLOGY

*Information for this project was gathered from the following resources:*

Interviews:

Jack Doherty – Electrical Forman of Smith College Physical Plant

Doug LeBlanc – Western Massachusetts Electrical Company Representative

Research:

Texts and Internet resources using the *Google* search engine (See Works Cited)

Informal emails between MA Electric and W. MA Electric Company employees

Informal conversations with current Smith students

Electrical Use Poll of Comstock House (Fig.1)

## RESULTS

*Student Impact*

Nearly all homes and buildings have an electrical meter that measures how many kilowatt-hours of electricity being consumed for that given unit. Smith College has centralized electricity, meaning a certain quantity is supplied and then Smith delivers specific amounts of electricity to each building. Smith College buildings do not however have individual meters, thus making it impossible to determine which buildings on campus consume the most electricity. Jack Doherty, Physical Plant Engineer, has little doubt that residence buildings consume the most electricity on Smith campus. This belief is based on the fact that student residences are occupied 24 hours a day in addition to the increasing number of students with personal computers and other electrical appliances. On average, Smith College uses 2 million kilowatt-hours per year (Doherty 2004). The average electrical input to Smith dormitories is 120/208 volts. Further broken down, each student room has at least one dedicated circuit of 20 amperes for approximately four outlets as well as a television and Internet hookup (Doherty 2004). Though four outlets do not seem exorbitant, in a survey of electrical appliances, 98% of students own a surge protector – adding up to eight additional plugs per room.

In a survey conducted in Comstock house (80 out of 80 people were surveyed) students were asked to check off electrical appliances that were currently being used in their room (Figure 1). Using this as a prototype for the whole student body (2,369 students), approximately 97.5% own a computer. All students are likely to have additional lighting in their rooms, and 98% of the student body is apt to own a surge protector. The appliances, broken down into four categories, Educational, Entertainment, Necessary and Additional represent electrical appliances in an average room of a Smith student (Figure 2). Though it cannot be determined which buildings consume the most electricity, residential buildings are a large contributor to electrical waste. Out of the residential buildings, dormitories located within the Quadrangle are apt to consume more electricity as they serve a larger population of students.

Every electrical appliance in which more than 60 percent of students owned and operated was individually calculated for total amount of watts used, hours per day that the appliance would be in use, and the number of days per year that the appliance could be in operation (Figure 3). The numbers are based on the most extreme value. For instance, the number of days during the school year (September 1st through to May 8th) excluding days in which students must vacate their residences for holiday amounted to 235 days per year. Some items were adjusted such as additional lighting (desktop lamps): two separate calculations were made based on the assumption that electrical use would be higher during winter months (October – April) and longer during daylight-savings months (Sept – Oct and Apr – May). Also alarms clocks and refrigerators were assumed to be in constant use for 251 days of the school year (includes holidays) since students are not likely to unplug these appliances while on break. Total kilowatt hours for every appliance was then multiplied by the Massachusetts Electric Utility Company's cost per kilowatt-hour (6.802cents/Kwh) and a dollar amount per year per student was found (Massachusetts Electric$_1$ 2004). In total, assuming the average student uses and operates the electrical appliances in Figure 3, the resulting cost is $1,478.30 per student per year (Figure 4). If the Comstock Electrical Survey percentages are applied to the greater student body (2,362 Smith residence capacity), it can be estimated that Smith College pays a minimum of $3,174,440.59 a year for student electricity use. This estimate does not include the 78 other academic and buildings on campus. There is an average of 59 students per house, with the largest occupancy in Wilson House (n=100) and the smallest number of students in 150 Elm (n=12). That means on average, Smith residence houses consume $86611 for 12733-kilowatt hours per year.

Previously mentioned was wasting electricity via standby usage. This simply refers to appliances that run continuously even when not in use, such as alarm clocks, VCR's and computers in hibernation. Refrigerators, surge protectors, alarm clocks, fans and commonly computers are always running in Smith dormitories. Total amount of electricity with these five appliances is roughly 21,930-kilowatt hours per year, or $1,773 dollars. If a student were to be more conservative in consumption simply by shutting off the computer and fan when not in use (a reduction of 7 hours), turning the surge protector off at night (reduces use by 12 hours), and defrosting the fridge during breaks (minus 16 days of use) could significantly reduce electricity. The total kilowatt-hours could be reduced to 6,703-kilowatt hours, over a 30% reduction in consumption and would save $722 dollars per year per student, a 40% yearly savings (Figure 5).

*Institutional Impact*

On a larger institutional level it is important to know what practices Smith employs and how it contributes to the electrical consumption on campus. There are 78 academic, office and other miscellaneous buildings on campus. Some of the buildings that consume more electricity are the computer labs, residence kitchens, and gym facilities (Doherty 2004). There are eight computer labs on campus with 12+ computers in operation as well as many other smaller computer labs specific for departmental use. There are currently 20 kitchens in full operation. General electrical kitchen appliances (i.e. stoves, microwaves, ovens, refrigerators, freezers, mixers, etc.) are in use for approximately 13 hours during regular dining times (from 6:30 am – 7:00pm). The gym facility has 36 exercise machines, 39 viewing screens (with cable), 4 DVD/VCR players, a music system and air conditioning ($\text{Smith}_1$ 2004). With a 100-person limit exercising at any one time, the new Olin Fitness Center certainly contributes to mass consumption of electricity. Overall Smith academic buildings use only what electricity is necessary. Besides the libraries and 24-hour computer labs, the majority of academic buildings are shut down by nine at night and reopened at seven in the morning.

On the institutional level Smith is capable of making larger-scale changes to reduce electricity consumption in addition to becoming a role model and setting examples for students to follow. A large-scale change includes implementing alternative clean energy sources to help mitigate reliance on fossil fuels for electricity. Today, most renewable energy being used occurs on a much larger scale than Smith could support. It is therefore necessary to know what is available and at what scale and cost so that it could be applied to Smith campus. The most common forms of renewable energy are geothermal power, hydroelectric power, solar energy and wind power. The following subsections briefly summarize each form of renewable energy source and how it could be applied to Smith College campus. These suggestions are a continuation of Richard Whites proposal to creating a Smith College Sustainability Center and are simply ideas in which Smith could invest in creating a more sustainable campus.

*Geothermal Heat*

Unlike some areas of the United States, Massachusetts does not a particularly geothermal hotspot. What is commonly unknown is that much of the earth's surface holds heat to some extent; the upper ten feet of the earth's surface maintains a temperature of 10-16 degrees Celsius (U.S. Dept. of Energy$_1$ 2004). This ground heat can be utilized on a small scale by a geothermal heat pump system.

A geothermal heat pump system consists of ground pipes that use water as a medium to extract heat from the earth. In winter heat is removed from the earth via water and transported into the building to heat the surroundings. In the summer the process is reversed where heat in the house is translocated into the ground. Geothermal heat pumps can meet up to half the homes or businesses hot water needs (U.S. Dept. of Energy$_1$ 2004). The typical cost of a heat pump system is $3,500 USD per ton capacity depending on relative square footage (1 ton capacity needed for approx. 550 ft$^2$). For a 1,500-square foot house running on a GHP system electrical costs are $1 per day for heating and cooling (U.S. Dept. of Energy$_2$ 2004). Geothermal heat pumps would not be feasible for the larger buildings on campus, but some of the smaller buildings such as 150 Elm, Tenny House and Hopkins House would be of feasible size to implement such a project.

*Hydroelectric Power*

Hydroelectric power accounts for 12% of the world's energy, making it the country's largest renewable energy source (National Hydropower Association 2004). Hydroelectric power has environmental drawbacks such as degradation of water quality, alteration of seasonal fish migration and increases in methane concentrations (Baird 2003). The only option for hydroelectric power at Smith is the current damn holding back the Mill River creating Paradise Pond.

Professor Guswa and his engineering class measured the Mill River flow rate at 200cubic feet per second (CFS). The maximum extractable power for the 12-foot drop is 200Kw. It must be noted that this measurement was taken during the spring when river flow is apt to be higher than normal, therefore power generation is more likely to range around 55-80kW with a 75CFS flow rate (Guswa 2004). Colin Kerr, of Windstream Power Systems Incorporated, recommends a crossflow micro-hydro turbine for the dam. Further research into prices of crossflow turbines and installation fees is needed to obtain an initial cost value; however, with a crossflow turbine running continuously approximately 736,000kWh per year could be generated. If this energy were sold to the utility company for 4cents a kWh, Smith College could yield a profit of $30,000 annually (Kerr 2004).

*Solar Energy*

The use of solar cells on buildings and homes has become increasingly popular within the past decade. There are numerous ways to exploit the sun's light including engineering homes designed to take in more sunlight, installing solar modules on rooftops, and using the thermal energy to heat pools and water storage tanks. The few emissions generated by solar energy is in the manufacturing of the solar cells; however, these cells have an average life of twenty years and can prevent 3 million tons of carbon dioxide ($CO_2$) emissions over their lifespan ($EPA_2$ 2004).

All of the rooftops on Smith College buildings are currently a waste of a potential energy source. Solar panels can be installed almost anywhere the sun shines. In June 1997, the U.S. Department of Energy devised the Million Solar Roof Initiative (MSRI). The mission is to install solar energy systems on one million U.S. buildings by the year 2010. If Smith College were to become a partner with the MSRI, the college would have to commit to installing 500 solar energy systems by 2010 (U.S. Department of $Energy_3$ 2004). The cost of such a project would be financially assisted by the Initiative in finding government grants to fund the project. Many incentives exist to alleviate the initial start-up cost of the MSRI effort.

If solar panels were installed on Smith buildings, the optimal locations would be on buildings where the panels could face due south and have a slight tilt so that snow coverage will fall off in winter months. Even roofs that are flat are able to mount solar panels at an angle so as to optimize total sunlight absorbed (Figure 6). Depending on the type of solar panel the cost of a standard panel averages to $600 for 120-watt output. Depending on sunlight during the better part of the year, electricity can be produced for $0.14 per kWh ($NERL_1$ 2004). Estimated calculations for Worcester Massachusetts with a crystalline solar panel installed at a 42.3-degree angle and the cost of 6.802 cents/kWh would generate $419 per year (Figure 7). At an initial cost of $600 per panel the solar system would start generating benefits after only the first year, and this is without any government assistance.

*Wind Power*

Not very many areas in Massachusetts have enough wind power to generate electricity ($NREL_2$ 2003). Wind power is very dependent on magnitude and variability of the wind. Though a wind turbine on Smith Campus is not feasible, the funding or sponsorship of a wind turbine in other areas of Massachusetts would show Smith's interest in sustainability through the use of clean alternative energy. A typical 10-kilowatt home wind turbine system costs between $25,000 and  $35,000 to install. For instance one 80-foot wind turbine costs $28,660 to install. Annual output is approximately $38,073kWh/year (WTIC 2004). If this electricity were sold to the utility company at $0.055 per kWh the turbine would generate $2,094 per year. Unfortunately it would take fourteen years for the turbine to pay for itself, yet on the positive side it would reduce greenhouse gas emissions, and after the initial cost recovery period would be pure profit for decades to come.

One particular spot in Western Massachusetts has great potential for a wind turbine farm: the northern range of the Berkshires, including Mount Greylock. Mount Greylock has an elevation of 3,491 feet, making it the highest peak in Massachusetts (Mt. Greylock 2003). The minimum speed for a wind turbine to be effective is 8m/s; wind on the mountain range has been measured at greater than 22mph (>9.5m/s) (True Wind Solutions 2003). Located in the Adams and Williamstown counties, this area is also served by the same electrical company as Smith, the Massachusetts Electrical Company. Any energy generated and fed into the utility company would then be available for Smith to purchase as green energy.

There are many other ways in which Smith can help become more sustainable besides investing in such large-scale renewable energy projects. As a customer of Massachusetts Electric, Smith is able to purchase green power while still keeping MA Electric as their utility company. Currently Massachusetts Electric, a subsidiary of National Grid USA obtains the majority of its electricity from the burning of coal and nuclear power (Massachusetts Electric $Company_2$ 2004). By establishing a partnership with a GreenUp Energy Provider Company, Smith can invest in power generated by wind, hydro and solar technologies. The downside to this investment is that to purchase green power there is an additional cost ranging from 0.95 to 2.2 cents depending on which company is the provider (Massachusetts Electric $Company_2$ 2004). Because there is no economic incentive to switch energy providers, it is unlikely that Smith will invest in this option while prices exceed that of normal electrical costs.

## DISSUCSION

*"Smith endeavors to produce graduates distinguished by their intellectual capabilities, their capacity for leadership, their ethical values and their readiness to contribute to the betterment of the world."*
*Smith College Mission Statement (Smith$_2$ 2004)*

Smith students pay a phenomenal tuition rate of \$38,886 per year (Smith$_3$ 2004). Nearly \$9,730 of this (or 25% of the total cost) is reportedly for room and board. It is therefore a student mentality that the price they pay entitles them to have every amenity in their room; environmental consciousness does not save the students money, so it does not factor into their daily actions. Other college students forced to live off campus after their first year learn the benefits of turning off additional lights, taking shorter showers, and the extra costs of utilities such as internet or cable. Smith students are so sheltered from the 'real world' cost of electricity that it is no wonder that students exploit the electrical availability while living at Smith. As discussed in the results, student conservation at Smith could save up to 40% of yearly costs per student (Figure 5). If student's electrical conservation were to save money in room and board costs, students would have the incentive to reduce electrical consumption. However Smith cannot reduce the cost with the assumption that students will change their behavior.

One way that Smith might alleviate electrical use is to install sub-metering on all campus buildings. With sub-metering, Smith has more awareness of what buildings are consuming the most energy. It allows Smith to gain control over the most expensive buildings and can then focus on ways to reduce consumption on a more individual basis. For instance if a building is seen to consume more electricity than others, Smith could take action a number of ways: replace old bulbs with energy-efficient fluorescent lighting, install better insulating windows to reduce heat loss, implement safety lighting or movement-sensitive lighting so that lights can be turned off at night, replace old washers and dryers with efficient energy-efficient models, and turn off soda/candy machines during break periods.

Smith could also allocate one house to be an environmentally sustainable house where many of the techniques and renewable energy sources described above would be implemented to make a self-sufficient student house. This would not only be an educational enterprise increasing awareness across campus, but the house would become a model for other students and student housing renovations to follow. The house could have solar panels on the rooftop, composting toilets (toilet systems that clean and reuse water), improved lighting and heating technology, and could run on renewable energy supplied by the electrical company.

Purchasing green power or installing alternative methods of energy is just one way of increasing involvement in environmental sustainability. Another way to educate students is through a restructuring of academic programs offered in the Smith curriculum. A required first-year seminar on environmental practices would be one way to teach all students about being more environmentally conscientious in everyday practices. Though Smith does offer environmental courses, the institution has applied relatively few of their teachings to the campus. If Smith were to take a more aggressive role in conservation and sustainability, the institution would serve as a teacher and role model for student behavior to mimic. Current president, Carol Christ, has taken a few steps in the right direction with the signing of a partnership between Smith College and Clean Air Cool Planet as well as building the new science center for LEED certification.

Many other liberal arts colleges have taken this same route and have since become leaders in the forefront of environmental sustainability. For instance, the University of Vermont has installed solar panels in areas where pedestrians can visibly see them (Clean Air Cool Planet 2004). Tufts University has committed to building a Solar Residence Hall where 150 students will reside living off of solar power; Macalester College has installed a wind turbine on campus, and other colleges such as Bates, Bowdoin, Harvard, and Middlebury have taken significant measures to heighten environmental awareness and education (Clean Air Cool Planet 2004). Higher education is a breeding ground for revolutionary movements, and as society is on the cusp of an environmental transformation, Smith College has an opportunity to step up as a leader.

In order to reduce electrical consumption at Smith, the college needs to target the student body as well as to step up as a leader in its own actions so that students and faculty have a role model by which to follow. One way to do this is in Robert White's suggestion of creating a Center for Sustainability. Creating a center is an ideal way to get the ball rolling on more specific ideas such as discussed in this paper. This Center could offer courses in sustainability; work in cooperation with the Environmental Science Department to improve the curriculum; act as a liaison to partnerships with environmental organizations, the Board of Trustees and other institutions to form alliances; strategize and implement alternative sources of energy; and devise ways to heighten student awareness of energy consumption. It could serves as the hub for the student-run environmental groups such as the Bad Seeds, GAIA and Amnesty International. The Center could bring together the student body, faculty, other universities, government sectors and national organizations for the main purpose of creating a more sustainable society.

Creating a Sustainability Center, purchasing green power, restructuring the curriculum to be more environmentally centered, installing alternative sources of energy-generating technology on campus, and installing sub-metering to target out the biggest consumers are all solutions that Smith can take in order to step up as a leader in the environment. Smith College's mission statement emphasizes their dedication to producing intellectual leaders who will contribute to the betterment of the world. Included in this mission should be, at minimum, a desire to generate environmentally conscious graduates. Smith should take measures to heighten energy awareness not only to reduce costs and electricity, but also to set an example in which others can follow, to become an educational leader in the environment and to help protect and sustain our environment for future generations.

*"The conservationist's most Important task, if we are to save the earth, is to educate."*

\- ***Peter Scott****, founder chairman of the World Wildlife Federation, quoted in the Sunday Telegraph, November 6, 1986.*

## APPENDICES

**Figure 1: Bottom Left: Chart of Poll for Comstock residents on electrical use in individual rooms. The left column is the most common electrical appliance used, the right column is the percentage of students (n=80) that own and operate the appliance.**

COMSTOCK HOUSE – 80 Residences
Please check all of the following that apply. I have the following items in my room:

**Refrigerator……………………….83%**
**Stereo Player……………………...75%**
**Television………………………….75%**
**Hair Dryer………………………..63%**
**Computer………………………….98%**
**Printer……………………..………93%**
**Christmas Lights…………………35%**
**Additional Lighting……………..100%**
**Hot Plate………………………..…7%**
**Water Heater Pot………..………43%**
**VCR/DVD Player………………..53%**
**Surge Protector………………….98%**
**Alarm Clock……………………..98%**
**Scanner…………………………..10%**
**Fan………………………………..73%**

**Figure 2: Right: Pie chart dividing electrical appliances listed in Figure 1 into four categories: Necessary, Entertainment, Educational and Superfluous (Additional).**

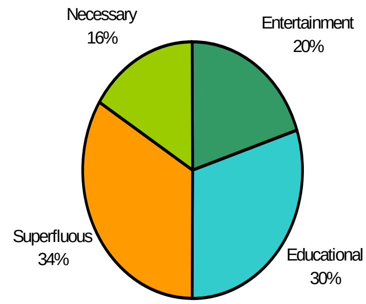


**Figure 3: Top ten electrical appliances electrical demand in kWh and total cost per student**

| Item | Total Watts | Hours/day being used | Days per year being used | KWh/year | Cost per year per student ($/yr) |
|---|---|---|---|---|---|
| Computer | 288 W | 12 | 235 d/yr | 821kWh/yr | $55 |
| Printer | 95.2 W | 6 | 235 d/yr | 134.2 kWh /yr | $9.13 |
| Desktop lamp (Oct-Apr) | 75 W | 9 | 139 d/yr | 93.8 kWh /yr | $6.38 |
| Desktop lamp (Sept-Oct, Apr-May) | 75 W | 6 | 96 d/yr | 43.2 kWh /yr | $2.94 |
| Surge protector | 1875 W | 24 | 235 d/yr | 10575 kWh /yr | $719.3 |
| Hair Dryer | 1600 W | 0.166 | 235 d/yr | 62.4 kWh /yr | $4.24 |
| TV | 69 W | 4 | 235 d/yr | 64.86 kWh /yr | $4.40 |
| Refrigerator | 1725 W | 24 | 251 d/yr | 10391.4 kWh /yr | $706.82 |
| CD player | 75 W | 4 | 235 d/yr | 70 kWh /yr | $4.79 |
| Clock radio | 10 W | 24 | 251 d/yr | 60.24 kWh /yr | $4.09 |
| Fan | 102 W | 15 | 60 d/yr | 91.8 kWh /yr | $6.24 |

*Please note that the above figures are estimates based on observed student behavior for four years

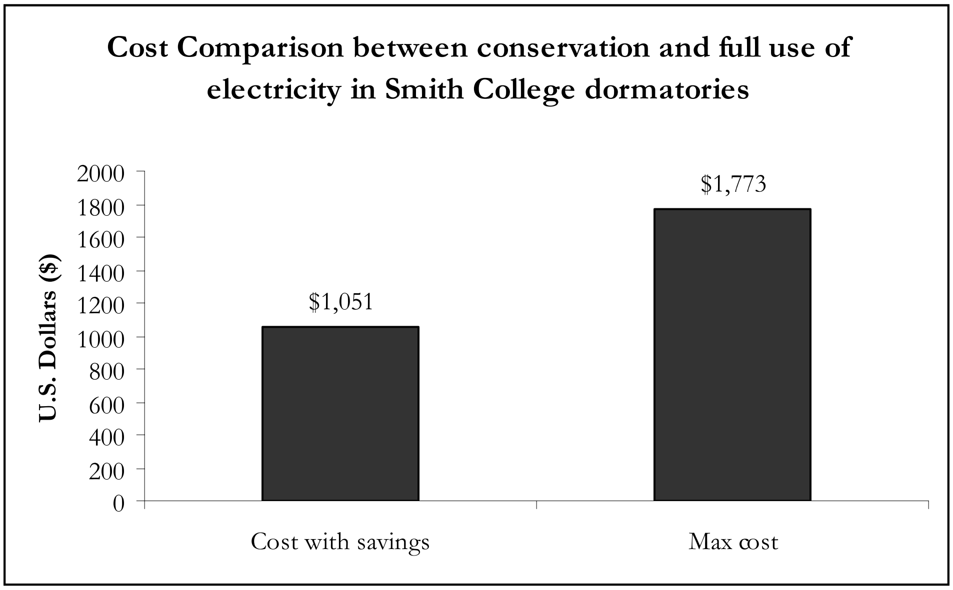
- Total watts was calculated by multiplying volts by the current (amps) for each individual appliance
- Hours/day was estimated based on personal use
- Days per year was calculated by adding together all the days Smith students are allowed to reside in dormitories, including J-term. Please note that during January electrical consumption is apt to be lower due to fewer students in dormitories.
- For desktop lamps, hours per day was calculated by estimating the number of days with daylight savings hours versus winter hours
- Cost of kilowatt hour is based on Massachusetts Electric Company cost of 6.802 cents/KWh
- Television hours per day was based on data from The National Institute on Media and the Family: http://www.mediafamily.org/about/background.shtml

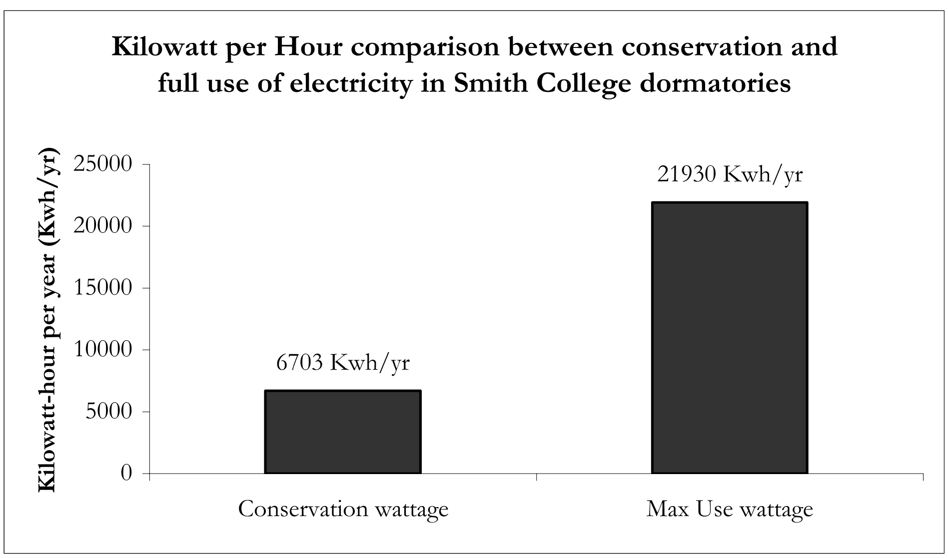
**Figure 4: Annual cost of electricity per student and per student body**

| | |
|---|---|
| Total cost per student* | $1478.39 / year |
| Total cost per student body** | $3,174,440.59 / year |

*Based on the assumption that the students owns and operates all appliances listed in Chart 1
**Based on percentages from Comstock survey applied to campus body of 2362 students (total # of students in houses) for all appliances listed in Chart 1

**Figure 5: Above: Chart comparison between how much money Smith College could save if students conserved energy. Cost with savings refers to when electrical appliances are shut off for duration of time as opposed to always being plugged in.**
**Below: Comparison between kWh/year usage for when electrical appliances are shut off as compared to when they are not.**



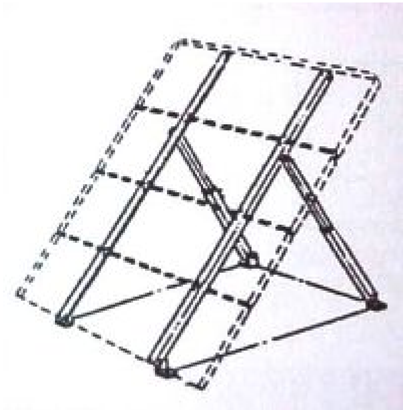


**Figure 6: Solar Panel positioned at an angle to capture maximum amount of sunlight. This method would be applied best to Smith rooftops that are flat and face due south.**

**Figure 7: Energy Production per solar unit installed. Monthly figures show how much energy can be produced and the monetary amount generated from using solar panels.**

Energy Production
Per Solar Unit Installed

| Month | Energy (kWh) | Energy Value ($) |
|---|---|---|
| 1 | 426 | 28.98 |
| 2 | 500 | 34.01 |
| 3 | 588 | 40.00 |
| 4 | 551 | 37.48 |
| 5 | 590 | 40.13 |
| 6 | 560 | 38.09 |
| 7 | 605 | 41.15 |
| 8 | 576 | 39.18 |
| 9 | 529 | 35.98 |
| 10 | 506 | 34.42 |
| 11 | 377 | 25.64 |
| 12 | 355 | 24.15 |
| Year | 6163 | 419.21 |

**Figure 8: A percent breakdown of Massachusetts Electrical Company's power sources.**

| Power Source | Total Percent of Energy Generated |
|---|---|
| Biomass | 3% |
| Coal | 17% |
| Hydro: Large | 4% |
| Hydro: Small | 3% |
| Imported Power | 14% |
| Municipal Trash | 3% |
| Natural Gas | 16% |
| Nuclear | 27% |
| Oil | 13% |

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