Building a Sustainable Science Center

The Monitoring and Use of Renewable and Efficient Energy

Jessica Hill

Assisted by:
Allison Crosby
Amanda Wenczel

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ABSTRACT
Smith College has committed to building a LEED certified science center. The Engineering and Chemistry Building, the first of three buildings, is being designed for basic green certification. With the combination of Allison Crosby and Amanda Wenczel's research, it is proposed that a silver certification is financially viable and therefore must be realized. This paper is focused on the application of renewable and efficient energy use, as well as the need to properly monitor and record all aspects of energy and water flow. It is recommended that Smith implement fluorescent light bulbs, efficient hand driers, proper window and wall insulation, solar panels and adequate energy and emission monitors. Recently, the college has signed onto a Campus Sustainability Pledge. Creating an energy efficient, environmentally friendly building is the first major step taken towards supporting this agreement.

INTRODUCTION

Scientists, activists and everyday people around New England are trying to make the urgent problem we face known, recognized and resolved. The dramatic rise in climatic temperature over the last few decades has caused increasing alarm as greenhouse gas emissions have risen steadily. Limited natural resources have also been recklessly used, without concern for what the future may bring or require. Many people are trying to change these fundamental aspects of the unsustainable lifestyle that is thriving in society today.

Liberal Arts colleges have often been looked at as role models for instilling dramatic social change. Since the people present on a campus, both students and professors alike, are there to learn, it seems a logical progression that schools would lead the way in presenting different and new lifestyles. Awareness of the environmental problem that the world is facing has increased as more students realize the repercussions even the smallest of actions has. For this reason, the growing number of universities that are actively creating sustainable campuses is not surprising.

As the world becomes increasingly environmentally aware, green technology has become more accessible and economically feasible. Though, in general, there is a higher upfront cost than "regular" building techniques, usually within five years the renewable technology has paid for itself and is, essentially, creating a profit. There are different government incentives available to help, support and encourage companies, schools and even homes to use renewable energy sources. Since the demand for green sources has only started to substantially grow recently, the development of more efficient, longer-lasting, and cheaper technology is rising as well. All of these advancements demand attention as it becomes more apparent that a drastic change in lifestyle must occur from the use of less-efficient limited resources to less-polluting renewable ones.

Smith College's Science Center

Smith College, Northampton, MA, is one of many institutions that has recognized the environmental problem of today, and is acting accordingly. In 2002-3, a new campus center was built with green concepts underlying the design. Though no green accreditation was attempted at the time, it was created with this as a future probability. In the spring of 2004, Smith signed onto the Clean Air, Cool Planet Campus Sustainability Pledge, agreeing to create a more environmentally friendly campus and to comply with the regulations set by the 1997 Kyoto Protocol.

The college is now in the process of designing and building a new science center. At the end of the development, there will be three new buildings added to the campus, in addition to a new, large green space where a parking lot and street now lie. The first step in this project is the creation of the Engineering and Chemistry Building, with the intentions of breaking ground in the spring of 2006. This 75,000 sq ft building will house all engineering, computer science, chemistry, biochemistry and molecular biology. The LEED certified architects, Bohlin, Cywinski and Jackson, chosen specifically for their experience with environmentally friendly projects, were given a $45 million budget to design a certifiably green building that contains all of the necessary chemistry and biology laboratories. A Sustainability Committee, made up of students, faculty and staff, is involved in the development of the design. Once the design is approved, a smaller subcommittee will be formed and remain active throughout the development of the building.

LEED certification[1]

With the continuous awareness and demand for sustainable living, the United States Green Building Council (USGBC) set a national standard: LEED certification. Recognition from Leadership in Energy and Environmental Design (LEED) involves registering a project when it is first being developed, and maintaining contact with a LEED certified member throughout its construction so that the best, and most feasible options for the building are always being considered. Once a project is complete, the points awarded towards the certification are divided into six components:

Sustainable Sites: Choosing a location that has minimal environmental impact, including protection of open space, local access to public transportation, bicycle storage.

Water Efficiency: Reducing water use, minimizing or removing the use of potable water for irrigation and wastewater

Energy and Atmosphere: Using efficient, renewable energy sources and green power, monitoring gas emissions, water and air circulation

Materials and Resources: Reusing and recycling building materials, using locally grown or manufactured materials

Indoor Environmental Quality: Monitoring effectiveness of air circulation, temperature control, use of low-emission materials, use of daylight

Innovational Design: Additional points can be obtained for using a new, environmentally friendly design or technology

Different levels of certification (certified, silver, gold, platinum) are awarded depending on the number of points obtained.

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[1] "Leadership in Energy and Environmental Design." U.S. Green Building Council. http://www.usgbc.org/leed/leed_main.asp

LEED Applied to Smith

The architects and appropriate committees of the Engineering Building have gone through the LEED check sheet and agree that basic certification is feasible. However, silver certification, the next level up, is also within reach. Research has been done on each of the points that were in question; most could become definite contributions to the sustainable quality of the building, while some points are not realistically attainable.

This proposal has a focus on the four possible points in the *Energy and Atmosphere* section of the certification. The possibility of optimizing energy by 30% would be difficult because of the numerous laboratories in the building. There are, however, many small changes that can be implemented to maximize energy efficiency. Providing 5% of the building's energy with an on-site renewable energy source, such as using solar panels, is a realistic, and economically feasible goal. The measurement and verification of carbon dioxide emissions, water and air circulation, lighting use and quality is a necessary aspect of a building that teaches, instead of one that merely has classrooms. The use of Green Power, bought from an outside source such as MassElectric, is the last point that is a realistic goal for Smith College that would start the transition of the entire campus, not just the new science center, to a more sustainable and environmentally friendly lifestyle.

METHODS

The three group members, Allison Crosby, Jessica Hill and Amanda Wenczel, gathered information on all six components of the LEED certification through a series of interviews. One climate control panel was attended and research was conducted on the different possibilities to increase the level of certification, as well as on already existing green buildings and their sustainable use policies.

Interviews

On March 3, 2004, biology professor L. David Smith provided general information regarding the building, Smith College professors involved in different committees and ideas on how to direct and conduct our research. Tom Litwin, the Director of the Clark Science Center, was contacted on April 2 and 14, and talked about the budget, deadlines, as well as individuals, committees and their roles. Geology professor John Brady was interviewed on April 2, in regard to his role played on the Programming Committee. The location of the new buildings, the commitment towards being green and a few of the intentions of how to achieve this goal were discussed. Margaret Rackas, the chemistry professor in charge of chemical safety and waste disposal on campus, was met with on April 8. The main topics covered in this interview were about how chemical waste is treated, how it is transported, where it is taken, and the responsibility Smith has involving the chemicals it owns. A meeting with Bob McCullough, the Manager of Capital Projects at Smith College, was set up for April 12. He shared information on LEED, water flow, use of rainwater for non-potable needs, the source of building materials, energy sources and uses, and heating and cooling systems.

Lecture

A panel on Global Warming and Sustainability at Smith was attended on April 14, 2004. Three lecturers talked for about 10 minutes each, followed by Carol Christ, the president of Smith College, who signed the Clean Air, Cool Planet Campus Sustainability

Pledge. The first lecturer, Steve Ruth, stated that there was solid proof that global warming exists; the problem was a social uncertainty, not a lack of scientific evidence. The second speaker, Mia Divine, discussed the high amounts of greenhouse gas emissions due to electricity and more efficient, renewable energy sources such as solar and wind power, that should be implemented instead of the commonly used burning of coal. Lastly, Ned Raynolds, a representative from Clean Air, Cool Planet, tried to show an optimistic side by discussing the numerous companies and universities that are committed to decreasing greenhouse gas emissions and following the 1997 Kyoto Protocol.

Research

Numerous published and online sources were used to accumulate all of the information needed to propose the most realistically environmentally friendly building possible. In order to go in-depth on certain topics, the research was divided among the three group members. Crosby studied different aspects of *Water Efficiency*, *Indoor Environmental Quality*, and *Innovative Design*, while Wenczel researched *Sustainable Sites* and *Materials and Resources*. The *Energy and Atmosphere* section, involving optimizing energy use, renewable energy sources (both on- and off-site) and monitoring all aspects of energy flow within the building, was researched by Hill, which is culminated in this paper. Most information for this section was found online, from exact requirements by LEED, examples of functioning, green buildings to different economically feasible options for energy sources and the most efficient uses of electricity. Since most of this technology is rapidly developing, there are few published works that are as up-to-date as reliable Internet sources are. However, as all Internet sites should be, these websites were read through with scrutiny, especially since some were company sites selling energy-efficient products.

RESULTS

Optimize Energy Performance, 30% New, 20% Existing

There are a large number of chemistry and biology labs in the new building, all of which use and waste a high amount of energy. There are, however, seemingly small changes to increase efficiency that can make a considerable positive impact environmentally and economically. Proper insulation and triple-glazed windows minimize heat and cooling loss.[2] Using compact fluorescent light bulbs drastically decreases the amount of wattage used for the same amount of light produced. The initial cost is about twice as much as incandescent light bulbs, though the lifespan is usually 10 times of that expected from an ordinary bulb. Using fluorescent tubes with electronic ballasts increases their efficiency up to 30% and therefore decreases the wattage used and heat released.[3] Modern energy-efficient hand driers use little electricity, and remove a large component of solid waste.

Renewable Energy Source, 5%

Biomass: The use of biomass, in general, seemed to be expensive and, since it is still combustion, produces greenhouse gasses, though to a lesser extent that coal alone. The

[2] "Bicentennial Hall Green Features." Middlebury College. http://www.middlebury.edu/offices/enviro/recognition/bihall_green_features.htm

[3] "Efficient Lighting: Saving Money, Protecting the Environment." Department of Environmental Protection, Pennsylvania. http://www.dep.state.pa.us/dep/deputate/pollprev/lighting/compact.htm

most economically feasible way for biomass to be used is co-firing it with a coal burning system.[4]

Wind: Wind powered turbines require specific locations to be cost efficient, since their initial cost seems expensive. High above ground level, on the top of a hill with minimal obstructions (buildings or trees) to the wind is best. Once in the appropriate location, however, the slightest increase in wind speed exponentially increases the energy produced. There is little cost for upkeep and no greenhouse gasses are produced with this form of energy, other than in the making of the turbine.[5]

Solar: There are three kinds of solar panels available, monocrystalline, polycrystalline and amorphous, respectively decreasing in cost and efficiency. Though the initial cost is expensive[6], with no annual cost most photovoltaics pay for themselves in less than 5 years. Their lifespan is over 20 years, they require virtually no maintenance, and can withstand most weather conditions. Since they are angled, snow usually melts off quickly. However, some models lose efficiency when they overheat. Also, an alternate energy source or rechargeable battery is required at night once the sun has set[7].

Measurement and Verification

As people become more aware of the damage caused by gas emissions, wasted energy and heat, measurement and verification has become an increasingly essential part of many buildings. The International Performance Measurement and Verification

[4] "Electricity from Biomass/Technologies at Work." Department of Energy, Biopower. http://www.eere.energy.gov/biopower/basics/ba_efb.htm

[5] Divine, Mia. "Sustainability at Smith" lecture. Smith College, Northampton, MA. April 14, 2004.

[6] "Photovoltaics." Energy Efficiency and Renewable Energy, U.S. Department of Energy. http://www.eere.energy.gov/RE/solar_photovoltaics.html

[7] "Solar Panels." Alternative Technology Association. http://www.ata.org.au/basics/bassolar.htm

Protocol was created in 1997, and set the standards around the world. Being able to accurately monitor and record energy, water, lighting, heat, and gas emissions is the goal, however, there is a balance between cost and accuracy. There are different ways to make these measurements, though how precise and accurate is deemed necessary can vary the cost from feasible to expensive.[8] [9]

Green Power

Different sources of green energy are available from MassElectric as an option for the consumer's entire or partial source of electricity. However, currently this is only available to residences and small businesses.[10]

DISCUSSION

Optimize Energy Performance, 30% New, 20% Existing

Due to the number of laboratories present in the science building, this high level of efficient energy use is not realistic. The equipment, necessary cooling systems and fume hoods all use a high level of electricity, air circulation, heat and water that this is not financially viable. However, there are simple ways that Smith can increase energy efficiency and decrease the negative environmental impact, even if the desired LEED level is not attainable. Being willing to put in the initial investment to be sustainable, usually pays off within the first five years the building is in operation. Simple changes, such as using and providing new fluorescent light bulbs, can decrease the amount of electricity used, and decrease cooling needs as well, since less heat is being produced as a

[8] "International Performance Measurement and Verification Protocol." http://www.ipmvp.org/

[9] Kumar, S. "Measurement and Verification of Energy Savings." Energy User News. http://www.energyusernews.com/eun/cda/articleinformation/features/bnp__features__item/0,,16252,00+en-uss_01dbc.html

[10] "Frequently Asked Questions." Massachusetts Electric. http://www.nationalgridus.com/masselectric/faq/faq_result.asp?Code=renewable

by-product of light.[11] Triple-glazed windows and thicker insulation, like that used in Middlebury's Bicentennial Hall, decrease the amount of heating or cooling lost, saving them over $20,000 a year.[12] Though this is a bigger investment than changing light bulbs, the payoff is drastically higher as well.

Renewable Energy Source, 5%

According to Mia Divine, 33% of all greenhouse gas emissions in the United States are due to electricity. This is because 54% of American electricity is produced by burning coal. Only 9% of electricity is created through renewable sources, such as biomass, wind and solar power.[13] The use of biomass can be expensive, especially since, unlike some other renewable sources, there is an annual cost, as biomass must be continuously purchased to produce energy. Though it burns much more efficiently than coal, it is still a combustion process, producing an increase in greenhouse gas emissions. Smith should not use biomass combustion as a form of renewable energy because it does not burn coal to produce heat and steam. Creating a co-firing unit would not only be a step away from the goal of decreasing gas emissions, but would have a high initial cost, as well as a constant annual cost.

An on-site source of wind power does not seem realistic either. The location of the new science building, being surrounded by other buildings and trees, is not the ideal place to create a wind turbine. The lack of undisturbed wind would not create enough constant energy to easily pay off the high initial cost of building the turbine.

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[11] "Efficient Lighting: Saving Money, Protecting the Environment." Department of Environmental Protection, Pennsylvania. http://www.dep.state.pa.us/dep/deputate/pollprev/lighting/compact.htm

[12] "Bicentennial Hall Green Features." Middlebury College. http://www.middlebury.edu/offices/enviro/recognition/bihall_green_features.htm

[13] Divine, Mia. "Sustainability at Smith" lecture. Smith College, Northampton, MA. April 14, 2004.

Solar energy, on the other hand, seems feasible for the budget and needs of Smith's new project. Since the aim is only 5% of the building's energy, photovoltaics are a realistic endeavor. The initial cost is higher than merely buying more electricity, however, once it has been installed, there is virtually no other cost involved for the next few decades. In an attempt to encourage renewable energy in the United States, the government provides different funding incentives for residences and businesses willing to install solar panels.[14] The quality of the solar panel is entirely dependent on the amount of money that Smith is willing to invest. However, there is a correlation between expense and efficiency of the photovoltaic. Since they require extremely little maintenance and there is no annual cost, solar panels seem to be the best option for Smith to use an on-site renewable energy source.

Measurement and Verification

The technology used to accurately measure the change in gas emissions, energy use and distribution, and water flow throughout a building has been improving rapidly in the last decade. With an international standard being set, it has become increasingly more important to be able to monitor and report the expected and true impact a building has on the surrounding area. Smith College is determined to make the new project a building that teaches, as well as houses classrooms. Just by walking around the building, it should be apparent that all aspects of energy flow are being measured and that Smith is acting accordingly.[15],[16] There is, however, a tight correlation between accuracy of the monitoring technology and the cost. Since Smith is committed to having this information,

[14] "Massachusetts Incentives for Renewable Energy." Database of State Incentives for Renewable Energy. http://www.ies.ncsu.edu/dsire/library/includes/map2.cfm?CurrentPageID=1&State=MA
[15] McCullough, Bob. Personal contact. Smith College, Northampton, MA. April 12, 2004.
[16] Litwin, Tom. Personal contact. Smith College, Northampton, MA. April 2 and 14, 2004.

it is essential that the proper investment be made into measurement and verification technology.

Green Power

Using the green energy available through MassElectric is not currently a possibility since it is only available to residences and small businesses. There are other providers of green energy, though their availability to Smith is not clear with the relationship the college has with MassElectric.

RECOMMENDATIONS

1. Fluorescent light bulbs
2. Energy efficient hand driers
3. Thick windows and walls for maximum insulation
4. Solar panels
5. Energy and water flow, emissions monitor

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4. "Efficient Lighting: Saving Money, Protecting the Environment." Department of Environmental Protection, Pennsylvania. http://www.dep.state.pa.us/dep/deputate/pollprev/lighting/compact.htm

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