Loyola/Notre Dame Library

Expansion & Renovation

Baltimore, MD

Thesis Research

Sustainability: Energy Efficiency Efforts in Universities Across the United States

Thesis Research

Sustainability: Energy Efficiency Efforts in Universities Across the United States

The word "sustainability" has become a popular craze in the 21st century. In particular, the building industry is a leader in making this trend come to life. What this means is that building owners are looking for ways to build and maintain a building that will save them money over time. Less maintenance to be done on a building will preserve the systems of a building, ensuring a longer lasting life. At universities, energy efficiency has become the latest sustainable effort. Ways to reduce energy consumption, while reducing $C0_2$ emissions has swept across the news all over the United States. Not only is an excessive amount of energy being used in buildings terrible for the environment, but it also drives up annual costs of energy. Lighting and maintenance of building systems are two big energy cost drivers. Hence the reason I have chosen to incorporate this research into both my thesis depth and breadth studies.

Before presenting solutions directly related to energy conservation for the Loyola/Notre Dame Library, a compilation of research was gathered first. This research is based on ten universities across the United States that are doing well enforcing energy efficiency plans and making good use of renewable resources. According to the College Sustainability Report Card, these schools were ranked as some of the highest scores for various reasons, Penn State included. It seems that every school included in the research is doing something different based on geographical location. For example, what works in sunny states does not work as well in cloudy states. Universities were chosen based on a public internet search of schools that are actively pursuing sustainable efforts. Geographical location also played a role in universities chosen to be surveyed.

As previously stated, this research study focuses on energy efficiency and renewable resources at ten different universities across the U.S. In sections C, D, and E of this report, these energy efficiency efforts will be implemented into the corresponding re-design analyses.

[See corresponding research sources in Appendix B.1]

Thesis Research

1. Arizona State University

Energy Conservation:

- **24-month Energy Conservation Project Upgrading Utilities Infrastructure**
  - Retrofitting lighting systems
  - Replacing motors, chiller, and cooling tower
  - Upgrading HVAC systems
  - Insulating steam pipes
  - Initiating a boiler- blow-down heat recovery system
  - Installing direct digital control systems for new central plant equipment
  - Installing thermal energy storage controls

Encompassing 80 buildings, the retrofits generated by this project will reduce energy consumption by about 33 million kWh per year and will decrease emissions by approximately 69,069,000 pounds of carbon dioxide every year!

- **Mandated Heating and Cooling Temperatures**
  - Campus classrooms are heated to no higher than 68 degrees Fahrenheit and are cooled to no lower than 78 degrees Fahrenheit
  - Many buildings are being shut down on nights and on weekends

Renewable Resources:

- **Solar Powered Parking Structure**
  - Roof of structure houses a 30 kW photovoltaic system that generates energy for internal lights and provides shade for parked cars during the day.
  - Receptors produce energy during peak hours of the day more than 300 days a year in sunny Arizona.

- **Contract with Solar Developers**
  - Trying to establish ongoing business relationships with solar developer(s) to solarize 310,000 SF of ASU building roofs, and to use the facilities as a key educational component of the Global Institute of Sustainability (ASU's sustainability initiative).

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2. Bowdoin College

Energy Conservation:

- Both of the College's boilers will reduce greenhouse gas emissions further by running on a mix of natural gas and #2 oil.
- A dorm energy conservation competition takes place on campus every October.
- Supports bio-diesel use in campus vehicles and buildings (much cleaner than regular #2 oil, reducing CO_2 emissions by 78%)

Renewable Resources:

- Investigating the possibility of installing solar panels on the athletic center
- The college signed an agreement with a local, certified low-impact hydropower facility to match any non-renewable sources the College uses from the grid with hydropower energy.
    - The college will run on 100 percent renewable energy
- Four buildings at the college use biodiesel B20 for heating fuel
- The campus steam plant utilizes all waste vegetable oil from Bowdoin's dining services fryolators (roughly 1,000 gallons in 2007)

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3. Massachusetts Institute of Technology (MIT)

Energy Conservation:

- Carried out a recent Carbon Emissions Inventory
- Retrofitted many campus lights with more efficient models
- Converted their diesel truck fleets to cleaner fuels
- MIT Community Solar Power Initiative has installed 25 solar photovoltaic power system
- Automated building control system ensures that classrooms, conference rooms, and other gathering places are only heated, cooled, and ventilated when they need to be

Renewable Resources:

- Waste heat from boilers is used to warm buildings in winter and chill water in the summer
- Researching possible wind energy potential for Northeast
- Installed solar panels on several of its buildings

4. Northeastern University

Energy Conservation:

- Carbon emissions inventory in process
- University's total energy usage has decreased by 9% since 2005 when energy conservation action plan was launched
- University has spent $5.4 million to pursue energy efficiency, equipping 2,000 rooms with occupancy sensors
- 51 buildings were retrofitted
    - Energy costs for lighting at NU have decreased by approximately 25 percent
    - Savings to the university are projected at $270,000 annually

Renewable Resources:

- Student center features a 90-panel solar array that produces over 21 kilowatts of power

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5. Oregon State University

Energy Conservation:

- OSU has completed a draft greenhouse gas inventory, over a year ahead of schedule
- Sustainability audits are performed by facilities services to determine behavioral changes, equipment, or infrastructure changes that need to be made
- A highly efficient cogeneration plant is being designed that will reduce campus carbon emissions by 38 percent

Renewable Resources:

- OSU will purchase 100 percent renewable electricity starting fall 2008, reducing current greenhouse gas emissions by about 60 percent
- OSU purchases offsets (RECs or green tags) equivalent to about 75 percent of campus electrical consumption
    - A student fee of $8.50/student/term supplies funding for this purchase
- Awning installation to block high angled summer light while still allowing in low angled winter light
- Campus solar power
    - Photovoltaic panels reduce reliance on grid power
    - University saves money while reducing environmental impacts from traditional energy sources

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6. Pennsylvania State University

Energy Conservation:

- Penn State has finalized its greenhouse gas inventory and has committed to make a 17 percent reduction in greenhouse gas emissions by 2012, dropping its emissions to below 1996 levels
- Upgrading technology to better control heat and lighting
- Installing new insulation in roofs and around piping to decrease heat loss
- Replacing incandescent bulbs in EXIT signs with energy efficient LEDs
- Finding ways to make older buildings more energy efficient
- Ensuring that ALL new buildings comply with the guidelines established by the Leadership in Environmental Design (LEED) Green Building Rating System

Renewable Resources:

- Using wind power for 10 percent of its energy
- The emissions reduction plan includes annual purchases in excess of 20 percent of their electric power from renewable resources, making it the third largest university purchaser of renewable energy
- Installing solar panels on several campus buildings
- Switching to alternative fuels like biodiesel, compressed natural gas, and hydrogen for all farm equipment and Office of Physical Plant vehicles

Penn State's Energy Program:

- The University meters all utilities to the facilities on the University Park Campus. This includes electricity, water, steam, and gas. In addition, the Central Control System (CCS) monitors the electrical load on the main feeders to and around campus, and the steam and water distributed to the campus distribution systems. Chilled water metering is being added as work continues on the Chilled Water Campus Loop.

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Penn State's Continuous Commissioning Process:

- Investigate and document the condition of the mechanical systems
- Solve existing problems in the building within the capabilities of the installed system
- Optimize building energy systems and formalize operational procedures
- Measure and document the energy savings and comfort improvements
- Provide on-going monitoring of system operation

Benefits of Continuous Commissioning are:

- Improvements in building comfort within the capabilities of the installed system, which will reduce complaints and increase productivity
- Reduction in building energy costs
- Reduction in maintenance costs
- Improvements in technical knowledge of the operating personnel
- Pay back typically in two - four years

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7. University of California

Energy Conservation:

- Eight campuses have joined the California Climate Action Registry to track their greenhouse gas emissions
- Save Energy manages student-run conservation programs on six campuses
- Leader in commissioning efforts
    - Reduced energy use by examining building operations and fixing and improving damaged or inefficient systems
    - University saves money while reducing environmental impacts from traditional energy sources
- Saved more than 2.1 million kWh for installing variable speed drives, chillers, and indoor fluorescent lighting
- Combined annual savings of more than 2.3 million kWh through a retrofit of chiller optimization controls, LED traffic signals and room occupancy lighting controls

Renewable Resources:

- The university has committed to purchasing 20 percent of its grid-purchased electricity from renewable energy sources by 2010, and to producing 10 megawatts of onsite renewable energy by 2014
- UC has 60 kW of photovoltaic capacity
- New 100-133 kW PV system to be installed on academic building in 2008
- RECs contributed 2.3 million kWh of electricity in 2007
- Wind turbine used for small-scale wind energy applications

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8. University of North Carolina

Energy Conservation:

- Lighting upgrades, an Energy Star program, a cogeneration plant, carbon emissions inventories and other programs demonstrate the University's commitment
- 9,000 feet of aging hot water pipes and 7,000 feet of steam lines have been replaced since 2,000
    - Since new lines are better insulated and larger in diameter, more net energy is delivered to campus buildings
- A five-million-gallon thermal storage tank reduces the peak campus electrical demand by 10 Megawatts
- An investment of $ 1 million in 2006 has saved the campus $263,799 over the course of one year.
    - Lighting replacement projects, retro-commissioning of existing buildings so they work as designed (or better), and improvement to HVAC equipment were all included in this action (reduced maintenance, longer equipment life, and improved work environment not included in cost)

Renewable Resources:

- Solar thermal panels for heating purposes on one new dormitory and students voting for $4, and later $8, fee increases in order to provide funding to purchase renewable energy credits
- The energy services department is actively pursuing alternative energy sources for central plants including landfill gas, animal waste methane, and wood biomass

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9. University of Vermont

Energy Conservation:

- Centralized Building Controls
  - The temperature and ventilation on the buildings are controlled through time and scheduling programs with specified set points
- Efficient Hockey Rink
  - The ice rink technology contains an advanced filtration system that removes 95% of the impurities in the water used to make the rink ice
- IPAC™ Cooling System
  - The UVM heating plant was retrofitted with an IPAC™ cooling system. This system was primarily established to maintain a consistent cooling method for the boiler feed pumps, but the added benefit is that it conserves water and electricity over the old system
- Efficient Washing Machines
- Light Emitting Diode (LED) Exit Signs
- Campus Lighting Upgrades
- Energy Efficient Mini- Fridges
- Motor Upgrades
  - The campus energy standard for new buildings and major renovations to ventilation fans is to install high efficiency or premium motors for heating, cooling, and ventilation. These efficient motors offer a energy savings of 25-33% and the pay back is on average three to four years
- Occupancy Sensors
- Sleep Mode™
- Thermostat Setbacks
- Vending Miser
  - All vending machines now have built in motion sensors that power down the lighting and cooling systems after 15 minutes of inactivity

Renewable Resources:

- Used Motor Oil Reuse

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- The UVM Physical Plant Automotive Shop now has a new heating system to help it through the Vermont winters. An EPA approved "Clean Burn" used oil heating furnace was purchased and now supplies the shop with heating needs. It is fueled with the 600-1000 gallons of waste oil that the shop previously disposed of every year. It takes waste engine oil, transmission fluid, and hydraulic fluid; alleviating the costs of heating the shop and the removing of fluids from University vehicles.

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10. University of Washington

Energy Conservation:

- The university has implemented energy conservation projects, which are saving more than 43 million kilowatt-hours per year, and continues to implement more complex projects through reinvestment of energy cost savings
- Heating thermostats in most buildings set to 65-68 degrees
- De-activated light fixtures in 49 campus buildings, which reduced annual kWh per year by 4,818,000; avoided costs per year: $240,902
- Installed “vending miser” similar to UVM
- Adjusted building ventilation systems to operate at lower speeds in 40 campus buildings
- Installed Variable Speed Drives on supply and return fans in various campus buildings
- Monitored energy consumption, utility costs, and energy conservation information and communicated it to the campus

Renewable Resources:

- All of the Seattle campus electrical purchases are 100 percent renewable
- Waste-oil heater to provide warmth needed for the staff who works in the large Service Center area. Any remaining oil not used to heat the shop is recycled, finding its way back into the very cars it first lubricated.
- Re-use program: 320 tons of material was diverted from the landfill by recycling collected materials

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Results

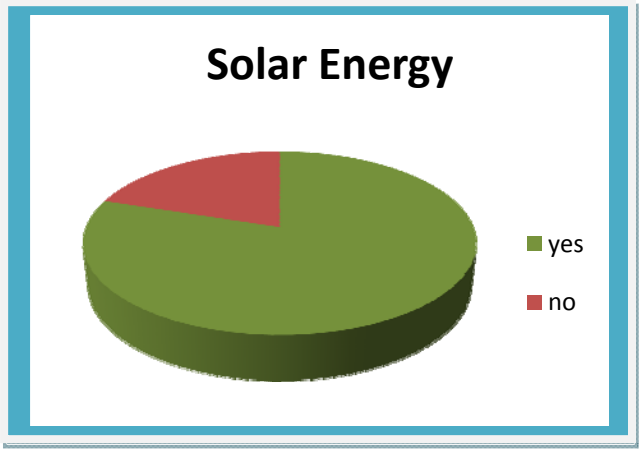
After conducting research on these top 10 sustainable schools, it has been determined what different universities are doing in different geographical locations across the U.S., as predicted. What may work in one location may not work in another. For example, solar energy has become quite the hot commodity; however, solar energy may not be the way to go for a university such as The University of Washington, and here is why:

NUMBER OF SUNNY DAYS A YEAR

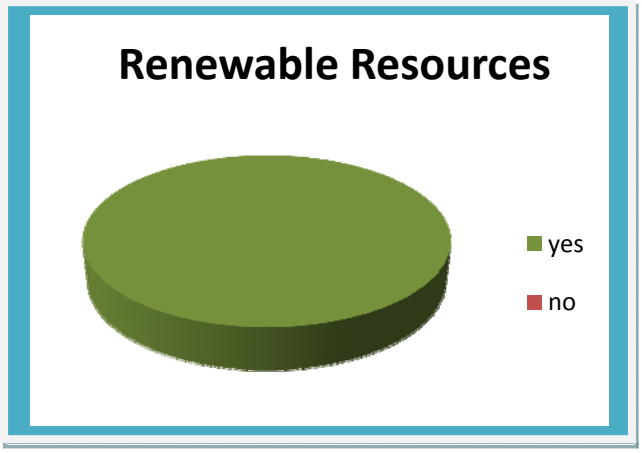
Arizona State University (Phoenix, AZ)	**211**
University of California (Santa Barbara, CA)	**176**
University of North Carolina (Chapel Hill, NC)	**109**
Bowdoin College (Brunswick, ME)	**101**
Northeastern University (Boston, MA)	**98**
Massachusetts Institute of Technology (Cambridge, MA)	**96**
Oregon State University (Corvallis, ORE)	**68**
Pennsylvania State University, (State College, PA)	**67**
University of Vermont (Burlington, VT)	**58**
The University of Washington (Seattle, WA)	**58**

Phoenix, AZ has over 3 times more sunny days than Seattle, WA and Burlington, VT. It makes sense that the University of Washington is not implementing solar energy as much as Arizona State. To make up for the lack of sun energy, they definitely make up for it by implementing 100% renewable energy use through electricity purchases. The University of Vermont is also taking a similar approach using the renewable resource strategy-used motor

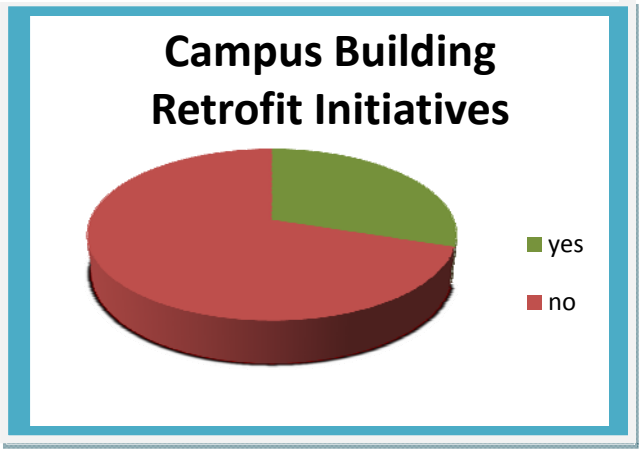
oil reuse so save on heating costs. Listed below are some of the other sustainable solutions for these top ten schools.



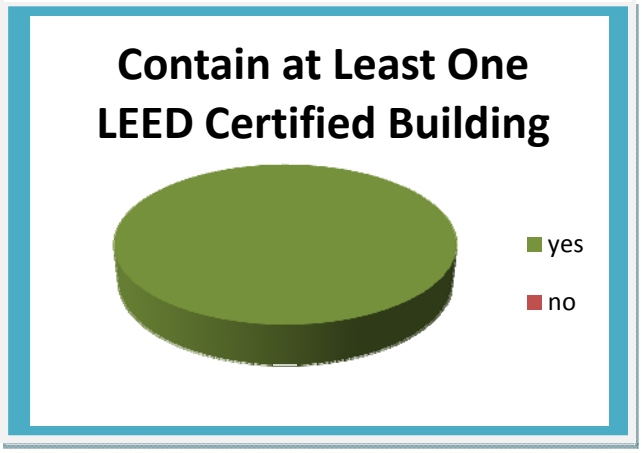
Eight out of ten of the schools have implemented or are in the process of implementing the use of solar energy through panels on campus buildings. Those two that are not using solar energy are using great alternative renewable resources as previously stated.



Similarly, if all but two schools are using solar panels, and the two schools are using other means of renewable resources, then all ten of the schools are using renewable resources.



Building Retrofitting is another great way to replace old fixtures and equipment with new ones that run more efficiently, saving the building life cycle costs. It is still a rather new idea. Penn State plans to retrofit light fixtures in many buildings across campus in hopes to save $1 Million/year!



LEED certified buildings are becoming mandatory for most of the universities surveyed in this research, especially for new construction and recently constructed buildings. Some universities are even implementing a minimum Silver rating for all new LEED rated buildings.

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LEED CERTIFIED BUILDINGS SUMMARY

Arizona State University	
Biodesign A, Tempe campus	Gold
Biodesign B, Tempe campus	Platinum
ISTB I, Tempe campus	Gold
ISTB II, Tempe campus	Silver
ISTB III, Polytechnic campus	Gold
Student Union	Certified
Arizona Biomedical Collaborative	Certified
UA–ASU College of Medicine	Certified
Hassayampa Academic Village, Tempe	Certified
Bowdoin College	
Osher Hall	Silver
West Dorm Building	Silver
Massachusetts Institute of Technology	
Brain and Cognitive Science Complex	Silver
Sloan School of Management building	Gold
Northeastern University	
3 buildings under construction to be…	Silver
Oregon State University	
Weatherford Hall	Certified
Kelley Engineering Center	Gold
The Pennsylvania State University	
Forest Resources Building	Silver
Stuckman Family Center-SALA Building	Certified
University of California	
UCSB Bren School of Environmental Science and Management	Platinum
UCD Tahoe Environmental Research Center	Platinum
UCI Palo Verde Expansion	Gold
UCM Central Plant	Gold
UCM Kolligian Library	Gold
UCM Garden Suites and Lakeview Dining	Silver
UCLA LaKretz Hall	Silver
UCSB Marine Science Research Building	Certified
Existing Building: UCSB Girvetz Hall	Silver
Existing Building: UCOP Franklin Street Building	Silver
UCSF HSW Dentistry Lab	Certified

University of California	
UCSB Bren School of Environmental Science and Management	Platinum
UCD Tahoe Environmental Research Center	Platinum
UCI Palo Verde Expansion	Gold
UCM Central Plant	Gold
UCM Kolligian Library	Gold
UCM Garden Suites and Lakeview Dining	Silver
UCLA LaKretz Hall	Silver
UCSB Marine Science Research Building	Certified
Existing Building: UCSB Girvetz Hall	Silver
Existing Building: UCOP Franklin Street Building	Silver
UCSF HSW Dentistry Lab	Certified
University of North Carolina	
The North Carolina Botanical Garden's Visitor Education Center (Under construction)	Platinum
University of Vermont	
Dudley H. Davis Center	Gold
University of Washington	
UW Tacoma Phase 2B	Silver
Merrill Hall Center for Urban Horticulture	Silver
Nordheim Court Student Housing	Certified
Benjamin Hall Interdisciplinary Research Building	Gold

Thesis Research

Sustainable Solutions for Loyola/Notre Dame Library

Inspired by this research study, some of the more attainable energy conservation methods reviewed at the ten different universities across the U.S. will be applied to the re-design analyses for the library. Below are the main areas of focus for each of the following three analyses:

- **Renewable Resources:** The sun is one of the greatest renewable resources that is often times not exploited as much as it should be. Solar energy will be explored in clever ways to make the most of heating, cooling, and day lighting needs for the library. The complete analysis for this is available in Section D (Mechanical Breadth).

- **Building Retrofitting:** Since the building is already undergoing retrofits because it is a renovation and expansion, no additional lighting re-design will be necessary. Luckily, all light fixtures are being replaced with T-8 fluorescent bulbs and other types of energy saving fixtures.

- **"Turn out the Lights" Initiative:** In the recent news, there is a lot of talk about climate change and ways to fight global warming. The turn out the lights initiative is a global awareness act getting people to turn off lights when they are not being used. Why not make this initiative a part of everyday practice? Many universities are making this a part of their campus culture and strategy already!

  If a room is bright enough, there would be no need to turn on excessive lighting in a given space. The complete analysis for this daylight distribution analysis is available in Section E (Lighting Breadth).

"To waste, to destroy our natural resources, to skin and exhaust the land instead of using it so as to increase its usefulness, will result in undermining in the days of our children the very prosperity which we ought by right to hand down to them amplified and developed."

~*Theodore Roosevelt*, seventh annual message, 3 December 1907

THESIS RESEARCH WORKS CITED

1. ARIZONA STATE UNIVERSITY

Global Institute of Sustainability.
http://sustainability.asu.edu/giosmain/campus/buildings.htm. Jan. 23, 2008.

Global Institute of Sustainability.
http://sustainability.asu.edu/giosmain/campus/energy.htm. Jan. 23, 2008.

2. BOWDOIN COLLEGE (MAINE)

Sustainable Bowdoin: Green Living.
http://www.bowdoin.edu/sustainablebowdoin/green-living/energy.shtml.

3. MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT)

MIT Team Analyzes Wind Energy Potential in Northeast. Stauffer, Nancy. Jan. 2, 2006.
http://www.physorg.com/news9495.html.

The Environment at MIT. July 30, 2007.
http://web.mit.edu/environment/commitment/conservation.html.

4. NORTHEASTERN UNIVERSITY (BOSTON)

Northeastern University Campus Retrofit Profile. Conservation Services Group.
http://www.csgrp.com/pdf/northeastern.pdf.

Northeastern University College of Sustainability Report Card 2008.
http://www.endowmentinstitute.org/report2008/profile109.pdf.

5. OREGON STATE UNIVERSITY

Campus Sustainability Assessment. University of Oregon. May 2007.
http://sustainability.uoregon.edu/indicators/UO%20Sustainability%20Report.pdf

University of Oregon Energy Project: Research, Education and Alternative Energy. June 2004. http://www.uoregon.edu/~ecostudy/elp/pdfs.html/UOEnergyreport.pdf.

6. PENNSYLVANIA STATE UNIVERSITY

Office of Physical Plant: Energy Program. http://energy.opp.psu.edu/energy-programs.

University Initiatives. Mar. 22, 2007. http://www.takecharge.psu.edu/initiatives.shtml.

7. SUSTAINABLE ENDOWMENTS INSTITUTE

College Sustainability Report Card 2008.
http://www.endowmentinstitute.org/sustainability/ExecutiveSummary2008.pdf.

8. UNIVERSITY OF CALIFORNIA

Energy Management Success Story. Energy Management at the University of California, Santa Barbara: At the Top of the Learning Curve.
http://energy.ucsb.edu/presentations/SCEUCSBCaseStudy.pdf.

Dewey, Jim and Schauland, Ryan. UCSB Energy FY 2007 Annual Report.
http://energy.ucsb.edu/presentations/AnnualReport_2007.pdf.

9. UNIVERSITY OF NORTH CAROLINA

The University ofNorth Carolina at Chapel Hill 2007 Campus Sustainability Report.
http://sustainability.unc.edu/Portals/0/Documents/2007%20Sustainability%20Report_web.pdf.

10. UNIVERSITY OF VERMONT

Energy Efficiency Projects at UVM.
http://www.uvm.edu/~energy/?Page=Energy%20Efficiency%20Projects.html#Lighting_Upgrades.

The University of Vermont: Environmental Design in New and Renovated Buildings Policy
http://www.uvm.edu/~uvmppg/ppg/facil/greenbuilding.pdf.

11. UNIVERSITY OF WASHINGTON

University of Washington Facilities Services Focus on Environmental Sustainability.
http://www.washington.edu/admin/pts/images/Sustainability%20Report%202004s.pdf.