

**Ecological Footprint Project:
Analyzing Heating and Cooling of Macalester's Dorms**

By,
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Abstract:

The heating and cooling of buildings is an important topic to consider because the amount of energy consumed in such processes has far-reaching environmental consequences. Onsite resources such as raw statistical data and secondary sources such as journal studies were used to evaluate the efficiency of Macalester College's current heating and cooling of dormitories. It was found that implementing newer environmental technologies and renovating old buildings could markedly enhance heating and cooling efficiency, which would both save money in the long run and lessen the environmental impact of such processes.

Introduction:

Today in America, per capita energy consumption is higher than ever. This is due mostly to the excessive consumption of its citizens. New sources of energy consumption include, for example, the increasing use of high-powered vehicles, the increase of national speed limits, and the use of larger homes that include many energy-consuming appliances. In addition, advances in industrialized agriculture enlist many energy-consuming tools such as tractors, automatic loaders, and combines. In total, highly developed countries such as the United States use 60% of the energy produced worldwide. Our nation's consumption is classified into three categories for interpretation purposes. Industry accounts for 42% of energy consumption, transportation 25%, and buildings 33% (Raven and Berg 2004). Included in the national buildings estimate, is energy used in the buildings on to campus of Macalester College.

In particular, the heating and cooling of dorms on campus is a major cause of energy consumption. Due to the radical swings of Minnesota temperatures, heating and cooling of dorms and other campus buildings has been an issue on the forefront of all administrative discussions. Major concerns arise from the fact that in 2002 alone, Macalester exceeded its combined (electricity and fuel) budget by \$90,512. The amount was largely attributed to an 86% increase in gas prices and an unusually long winter. Macalester reacted to the devastating gas price increase by signing a long-term fuel contract that lowered the price per one hundred thousand BTUs by 75% (Korvela URL). Still, an unpredictable climate always threatens to throw off forecasted budgets and other predictions made about dorm heating and cooling.

It is very important to know about the heating and cooling practices in dorms at Macalester. One might be interested in these figures for many reasons, two of those reasons being that the heating and cooling of dorms has significant environmental and economic impacts on the college and community. Thus, we will be examining the heating and cooling of dorm buildings at Macalester. Furthermore, by signing the Talloires Declaration in 2000, Macalester has committed to being an environmentally responsible campus. This would involve exploring alternative energy sources that are more sustainable. In our research, we discovered many new options such as heat recovery systems, a "kill switch," passive and active solar heating, geothermal cells and PV cells. Each of these methods will be discussed in our paper. We are striving to determine if Macalester is enlisting environmentally friendly practices, in particular with regard to the heating and cooling of its dorms.

Methodology:

In a research project of this nature, the most applicable methodology is conducted through investigative research. Namely, we looked at sources of information regarding the topic of heating and cooling in dormitories. A wide variety of sources were used, including interviews, internet and computer research, book and journal studies, and statistical data obtained directly from Macalester's heating and cooling operation.

The most important site-specific source for information came from the Macalester Physical Plant, which oversees the heating and cooling of the dorms on campus. Macalester's heating plant provided raw statistical data for research and interpretation (the results of which are discussed in the *Results* section). The heating plant was contacted because it oversees the "operation, maintenance and repair of the campus central steam water plant, central chiller plant, energy management and heating ventilation air conditioning (HVAC)" (Physical Plant, URL). Data from the high-pressured steam plant located underneath the Macalester Art Building is especially useful as it provides steam and hot water to 26 campus buildings and 11 privately and college owned houses. The Physical Plant also has raw data from the newly constructed (1996-1997) subterranean Chilled Water Plant located just north of the Art Building. This data is useful because the system provides "chilled water to 13 campus buildings through the use of centrifugal chillers and ice storage (Physical Plant, URL)." An interview with Kevin Maynard, the Mechanical Systems Manager, and Mike O'Connor, the Chief Engineer, would have been helpful. We corresponded with Bev Johnson, Office Manager and Assistant Director to the Physical Plant, who supplied us with raw statistical data from the physical plant.

Research using the class textbook and journal articles assisted in the collection of data regarding renewable energy sources. This data was important as it addressed possible solutions to improving the efficiency of Macalester's heating and cooling operation. The collection of this data was mainly conducted by personal research and involved the usage of Macalester's LESTER program, which contains reserve readings on environmental topics. An article entitled *Renewable Energy: Current and Potential Issues* was of particular interest as it discussed numerous options for renewable energy, asserting that "renewable energy technology could, if developed and implemented, provide nearly 50% of U.S. energy needs; this would require about 17% of U.S. land resources (Pimentel et al. 2002)."

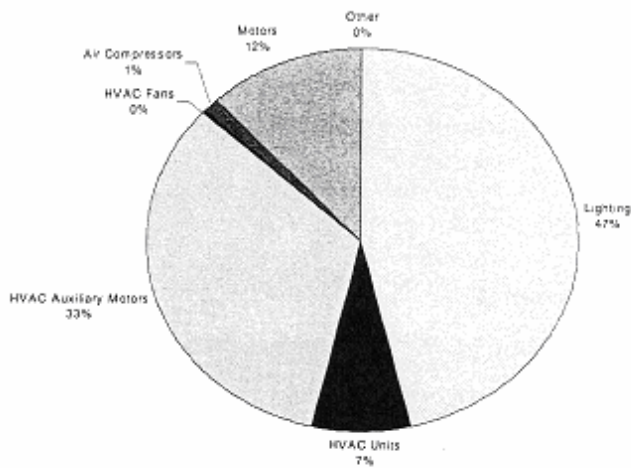
Internet resources were particularly helpful because they provide access to both similar research projects conducted elsewhere, on other campuses for instance, and to Macalester's own already existing environmental programs. For example, information is provided on Macalester's website regarding the introduction of Peace Coffee and about the experiments conducted with the wind turbine, which is a possible future source of significant amounts of energy).

Most of the data was collected via personal research and communication with authorities in charge of heating and cooling at Macalester College (mainly from the Physical Plant). Methods exclusively entailed the collection and interpretation of existing data for the benefit of understanding the entire heating and cooling system at Macalester.

Results:

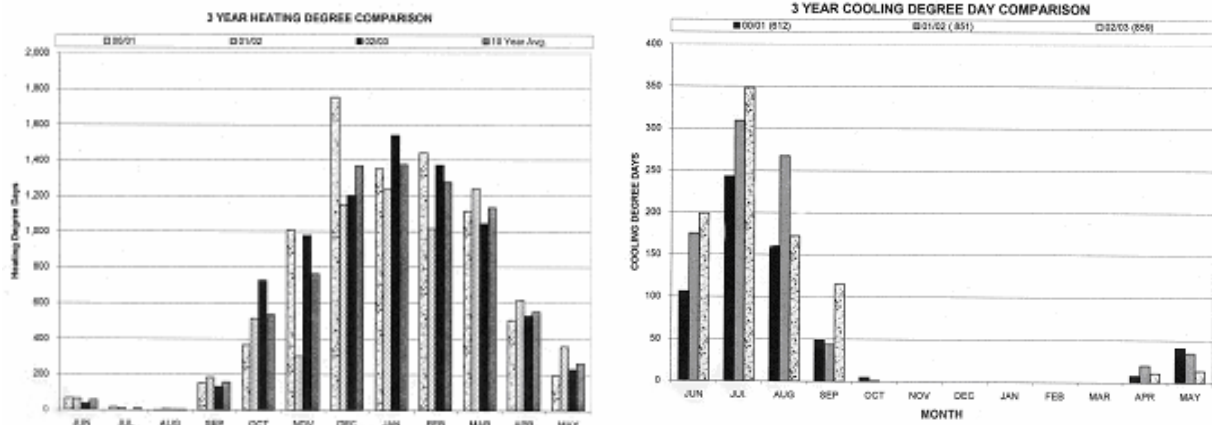
We found that the heating and cooling of Macalester's buildings consumes a large portion of the campus' total electricity usage. The motors for the systems and the systems themselves account for 40% of the total electricity costs as can be seen in the following table:

Figure 1: Share of Annual Electricity Cost by End Use

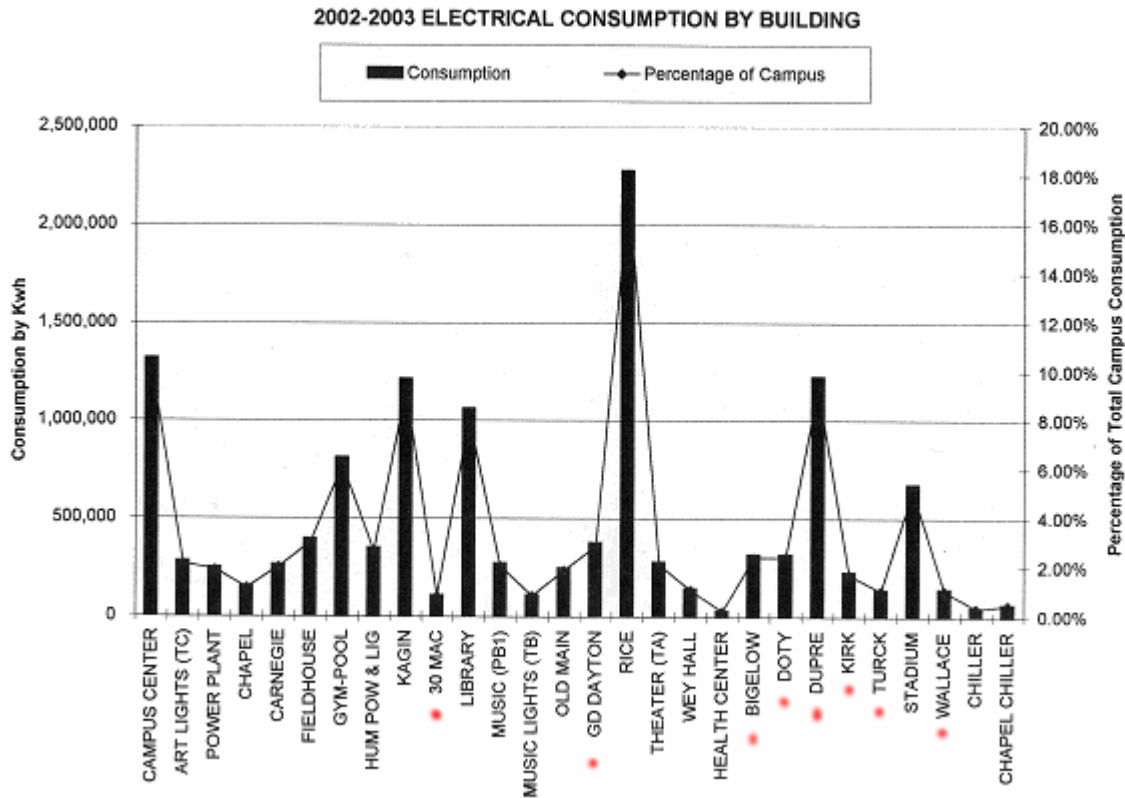


The amount of heating or cooling that takes place in the dorms at any given time depends greatly on the temperature outside. Here in Minnesota, we have several months of extreme cold in the winter and several months of hot temperatures in the summer. To put this in to perspective as far as heating and cooling buildings is concerned degree-days are used. Degrees days are a unit for measuring the extent that the outdoor daily average temperature falls below, or falls above 65 degrees Fahrenheit. One degree day is counted for each degree below (for heating) or above (in the case of cooling) the base, for each calendar day on which the temperature goes below or above the base. The number of heating degree days are highest from December to March and the number of cooling degree days highest from June to September as can be seen in the following graphs:

Figure 2:



The amount of electricity used, varies greatly by building. The amount of electricity each building uses depends greatly on how big the building is and on what kinds of energy saving features are installed. Dupre, the biggest dorm and one of the older dorms, uses by far the most energy whereas 30 Mac, a relatively new and small dorm, used much less. The following figure shows electrical consumption by building, but it is important to note that lighting and other uses of electricity are included along with energy used for heating and cooling:



Dorms are currently arranged with some energy efficiency in mind. For example, almost all dorm rooms have a method of adjusting the temperature in the rooms individually and the newest dorm, George Draper Dayton, was constructed to allow the most individual control of internal heating (Wiedemer). Most every dorm room, however, has the ability to adjust the temperature individually. Even so, many students claim that there dorms are too hot (Nethercut)

In addition, it is important to note a trend towards air-conditioning dorms. Both 30 Mac and GD Dayton, the two newest dormitories on campus are air-conditioned.

Discussion:

Minnesota’s bitterly cold winters and hot summers necessitate the use of effective means of both heating and cooling. In looking at energy consumption of dorms, the two newest dorms, 30 Mac and George Draper Dayton, use much less energy than older dorms, such as Dupre, even though these dorms are air-conditioned. Granted, Dupre is the largest dorm on campus, but it uses at least twice as much energy as all of the other residence halls, even those that are somewhat similar in size. This finding indicates that Macalester’s new buildings are more energy efficient than the older buildings on campus. Perhaps it might be worthwhile for the

college to remodel some of its older buildings in order to make them more energy efficient. Though the initial cost of doing this would be high, greater energy efficiency saves money in the long run.

Another issue to consider is the energy required to heat and cool dorms in the months when very few students are on campus. With the exception of athletes, there are almost no students on campus during the months of January, June, July, and August. Thus, the necessity of air conditioning for dorms must be questioned. Because there are significantly fewer cooling degree-days in September than during June, July, and August, it may not be absolutely necessary to air condition dorms during this time. Use of air conditioning in areas where there are few or no students wastes energy. The same goes for heating dorms in January. Because there are so few students on campus, it might be beneficial to reduce the amount of heat provided to the dorms during this month. There is no need to keep unoccupied space at the same temperature as occupied space. Keeping unoccupied space at the minimal temperature needed to prevent pipes from freezing would greatly reduce the amount of energy needed to heat these spaces.

Clearly, Macalester's heating and cooling practices could be much more sustainable than they currently are. Though generally thought of as limited to single-family dwellings, alternative sources of energy can make a difference in a building as large as a dormitory. One possible alternative to traditional heating and cooling methods is what is known as a heat recovery system, which reuses the latent heat produced in a traditional system to warm buildings (ASU Magazine URL). The initial cost of implementing this system of producing heat is high, but it saves money in the long run especially when one considers the externalities associated with the production of energy. Another, easier to implement, system that would help to promote sustainability is a "kill switch" that would automatically shut off heat or air conditioning to a room if a window was opened, reducing a good deal of wasted energy (ASU Magazine URL). This method is a policy into which Macalester should seriously look, as many students are prone to opening their windows in the winter in order to combat the overheating of their dorm. Hotels have been using "kill switches" for years with much success (ASU Magazine URL).

Solar energy is also a viable alternative to traditional heating and cooling methods. Passive solar heating, which uses the sun's energy to heat buildings without the aid of pumps or fans to distribute the heat, is well suited to areas that receive a large amount of sunlight on a daily basis (Raven and Berg 2004). Large, south facing windows take in a lot of sunlight, which, in turn, heats areas of the building near the windows. Buildings that rely on passive solar energy for heating and cooling must be well insulated in order to retain the heat from the sun (Raven and Berg 2004). However, the other kind of solar heating, active, may be better suited for areas such as Minnesota that do not receive large amounts of sunlight on a regular basis because the collected energy can be stored and used at a later date. Active solar heating uses the aid of pumps or fans to distribute collected heat (Raven and Berg 2004). Solar panels, a common form of active solar heating, utilize panels that collect energy. This energy is then transferred to a liquid where it is pumped through a heat exchanger and then used for heating (Raven and Berg 2004). Solar panels, though costly now, could become a much more economically feasible means of generating heat in the future because of the continued rise in the cost of fossil fuels (Raven and Berg 2004). Active solar heating also has another advantage over passive solar heating in that one can apply this technology to buildings that already exist. Passive solar heating, because it relies so much on the structure of the building it is heating, is much better suited to new construction.

Many of Macalester's peer institutions have much more sustainable heating and cooling practices than can be found on its own campus. The Lewis Center for Environmental Studies at Oberlin College in Oberlin, Ohio is a prime example of sustainable architecture (Raven and Berg 2004). Geothermal wells, which rely on the heat the Earth produces naturally, are the primary means of heating the Lewis Center. The Lewis Center also utilizes PV cells, which use the sun's heat to produce electricity that then can be stored in a battery to produce electricity. Oberlin sells the extra electricity it produces in the summer months, when sunlight is high to the Ohio power grid and then buys the electricity back from the grid when sunlight is low in the winter (Raven and Berg 2004). The Lewis Center also has triple paned windows to hold in heat in the winter and keep from wasting energy.

The University of Wisconsin at River Falls (UWRF) has also become a model for sustainable energy use through the utilization of the resources it has. In fact, the institution was recently named as one of 14 colleges and universities committed to energy conservation and reducing consumption and is one of the most energy efficient schools in the entire 22 member University of Wisconsin system (UWRF URL). UWRF has reduced its energy consumption greatly through committing itself to simple practices. These practices include keeping occupied space temperatures at or below 68 degrees Fahrenheit, keeping unoccupied spaces at or below 60 degrees Fahrenheit, opening blinds during the day to let in sunlight and closing them at night to retain heat, and making sure windows are shut when heating and cooling systems are in use. Macalester can implement these practices at no additional cost to the college. In turn, it will be saving both money and the environment.

Conclusion:

Macalester College uses a significant amount of energy to heat and cool its dormitories. To reduce the environmental effects of such processes there are many solutions that the college can look into. These range from solutions as simple as educating students about how they can control the heat in their rooms to solutions as complex as installing solar panels. Whatever improvements made will not only benefit the environment, but will also conserve funds in the long run as gas and electricity prices continue to rise.

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