Energy Use and Greenhouse Gas Emission Reduction Plan
Gustavus Adolphus College
Draft Vers. 1.0

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Erratum

On page 18, I make the claim that two wind turbines would reduce our green house gas emissions by 75%. I remember an alarm bell going off in my mind that told me something wasn't right with that number—later I checked something related to the wind project and found that my alarm bells were justified.

Two 2-MW wind turbines will reduce our greenhouse gas emissions 40-50%, not 75%. It looks like I divided by the wrong number and then didn't apply the "does this make sense" detector.

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Summary

This energy use and greenhouse gas emission reduction plan places energy planning decisions in the context of overall energy use and investment in energy infrastructure at Gustavus, as well as addressing strategic concerns raised during the 2007 GAC Nobel Conference on energy and climate change.

Strategic Concerns:

This document responds to three primary strategic concerns:

1. Growing energy costs and increased uncertainty of energy supply worldwide.
2. Environmental impacts of fossil fuel energy use, most notably, greenhouse gas emissions and the attendant global climate change.
3. The need and desire for Gustavus to become an environmental leader.

Energy Use and Greenhouse Gas Emissions at Gustavus Adolphus College

From a review of electricity, natural gas, and fuel oil use patterns of recent years, and the national and world context, the following points are highlighted:

1. Due to a combination of increased energy demand (building upgrades and expanded square footage) and energy price increases, campus energy costs have gone from 2.7 to 3.7% of the GAC budget since 1997.
2. The greenhouse gas emissions from GAC electricity and natural gas use during 2006 totaled 22,390 metric tonnes CO_2 equivalent. A majority of those emissions occur off-site from the generation of electricity by the utility that supplies electricity to the St. Peter area.
3. Based on current scientific estimates, a 60-80% global reduction in greenhouse gas emissions is necessary to prevent the most dangerous climate change effects. GAC would have to eliminate more than half of the emissions from its electricity use as well as a portion of heating fuel emissions to achieve such a reduction.

Conservation, Clean Energy and Leadership: Recommendations

Responding to the information presented herein, this plan makes the following specific recommendations. As a package, they will help establish GAC as an environmental stewardship leader for its students and the community:

1. That GAC makes its energy consumption and greenhouse gas emissions a focus of community awareness.
2. That GAC implements a comprehensive and persistent energy conservation program aimed at reducing total energy consumption and greenhouse gas emissions.
3. That GAC establishes a 5-10 year goal of further reducing greenhouse gas emissions to zero by acquiring the most promising clean energy technology, wind turbines, as soon as possible and pursuing other feasible clean energy options in the longer term.

Background

This energy use and greenhouse gas emission reduction plan has been prepared in response to a request from the Gustavus Adolphus College (GAC) Board of Trustees Finance Committee. As was conveyed to the author by Vice-President for Finance, Ken Westphal and President Jim Peterson, the Finance Committee wanted to place decisions related to the acquisition of wind turbines in the context of overall energy use and investments in energy infrastructure at Gustavus. The request from the Finance Committee was also motivated by strategic energy concerns raised during the 2007 GAC Nobel Conference on energy and climate change.

Although there is significant overlap among them, these strategic concerns can be roughly categorized as follows:

A. A high probability of dramatically increased future energy costs, increased volatility those costs, and uncertainty of regular supply. The combination of world economic growth and the likelihood that we have entered an era of slow, but steady decline in oil supplies (known as Peak Oil) means that energy demand and supply are closely matched. With supply and demand nearly matched, minor disturbances (civil unrest in the Middle East and pipeline failures, to name two recent, recurring examples) can disrupt supply and cause rapid rises in price.

B. Various emissions from fossil fuel combustion have long been recognized as pollutants with human health and ecological implications. As this introduction was begun, in fact, parts of Minnesota are under a rare winter air quality alert caused by the interaction of air pollution and weather conditions. Additionally, the impacts of fossil fuel extraction and distribution have been detrimental to our environment, as exemplified by mountain-top removal coal mining and ocean oil spills. It is the recent and rapid shifts in global climate, however, and the very large probability that those shifts are caused by our carbon emissions, that have finally generated a worldwide discussion of fossil fuel emissions and concrete proposals to dramatically reduce those emissions. Some form of global carbon emissions reduction regime would probably have already been enacted had it not been for the intransigence of the current US administration, and such a regime is likely in the near future.

C. Concurrently with the developments of A. and B. above, Gustavus has been moving to make its commitments to environmental stewardship more explicit. Past examples of environmental stewardship have been visible (the Arboretum), programmatic (a long-standing environmental studies program and supporting science departments), and operational (facilities improvements undertaken, particularly since the tornado in 1998), but GAC has not made environmental issues an explicit focus. With the inauguration of the Johnson Center for Environmental Innovation and a developing strategic initiative in environmental stewardship, however, we are poised to make a stronger environmental commitment. That greater commitment to environmental stewardship would by itself have led to a renewed focus on energy use.

This report is a first draft of what should become a regularly updated energy plan for the GAC campus. That energy plan will be road map to guide decision-making as we navigate the strategic challenges of changing energy costs and supply, and developing actions against climate change while we strengthen our environmental commitment. The analysis and recommendations herein are based on readily available data from campus records, but in some areas, further research is necessary to guide firmer recommendations—hence the suggested course of action in many situations is short term action including research to guide longer term steps.

This initial version of the report focuses on campus energy use in the form of electricity, natural gas and fuel oil use. Future work must naturally have a wider focus that includes transportation energy use, including campus operations; faculty, staff, and student travel; and commuting.

In the following sections the discussion is oriented towards answering the following questions that arise from considering the above strategic issues in light of Gustavus' primary educational mission:

1. What energy strategy should we pursue that will protect Gustavus from energy price increases and supply instabilities, including those that may arise from future regulatory changes? To wit, how can we fiscally sustain GAC energy use so that resources can be focused on maintaining and improving quality programs.
2. How should GAC respond to the environmental problems arising here and elsewhere from our energy use in a way that consistently reinforces the educational messages arising form our core values of faith, justice, community, service, and excellence? What GAC energy plan will model the kind of civic leadership we seek to develop in our students?
3. As we aspire to be a leading educational institution through our emerging strategic initiatives, how can our energy plan support an environmental leadership position that will attract quality students and the resources to support them? How will our energy plan make our quality show?

Building Educational and Leadership Connections

Educational and leadership issues[1] noted in the third question above appear at various places in the following discussion, but these concerns are the most fundamental rationale for the entire discussion. To put the ensuing recommendations in context, this section highlights two educational and leadership issues.

Looking internally first, and focusing on the whole learning endeavor we invite our students to join, local and global sustainability are profoundly affected by our energy use. If we are truly preparing future leaders they must have the knowledge and skills to manage the challenges posed by energy questions. While much can be and is done in the classroom through the Environmental Studies program and other related courses and co-curricular activities, understanding among our students is not broad or deep. By deliberately and openly transforming our campus energy operations, we can provide an invaluable context for our students to explore energy issues in and outside the classroom.

[1] These concerns are being dealt with more broadly as part of the environmental stewardship section of the developing strategic plan.

To wit, how we operate our physical plant can support the success of the more formal education efforts.

Stepping back and viewing Gustavus from the outside, as do our perspective students and donors, that imperative becomes stronger. In a recent report on a conference sponsored by the Council of Independent Colleges, the Chronicle of Higher Education reported[2] on two strains of the conference discussion. One focused on the debate among college administrators about the costs and difficulty of meeting the call to become more sustainable, particularly in regard to climate change issues. The other discussed student recruitment, noting that "spirituality, environmentalism, and social consciousness [are] among the most important aspects of campus living and the college's mission" as identified by students.

If enacted, the recommendations outlined in the following discussion could simultaneously establish Gustavus as a leader in overcoming the challenges of sustainability and climate change and make ourselves more attractive to the students we want to recruit.

Energy and Green House Gas Trends and Monitoring

Preparation of this report has been greatly facilitated by energy records that have been maintained by Gustavus staff. Although the some of the building labels are cryptic and there could be better organization, the spreadsheets available at http://gustavus.edu/physicalplant/Utilities.cfm represent a valuable resource[3] that has been used in preparing this report. The time span of the data varies—differences in the time scale of the following graphs reflects data readily available at the time this report was prepared.

Another critical resource is an online, real-time database for examining building electrical use found at http://gts.gac.edu/power/. The data collection hardware for this system has been installed incrementally since the 1998 tornado. More recently (2006) Ethan Sommer and Dan Oachs in Gustavus Technology Services prepared the web interface that makes this data more available.

One regrettable, but perhaps unavoidable, gap in data collection is the lack of data on how much energy is delivered in the form of steam to each building. Individual steam meters have been installed in the past but they have proved to be unreliable and difficult to maintain.

Electricity Use

As displayed in Figure 1, GAC electricity use since 1990 has been steady or slightly rising except for a marked jump in the two years after the devastating tornado in early 1998. Presumably, the jump represents the net effect of updates to buildings as they were repaired—particularly the addition of air conditioning—and the addition of a large new

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2 Carlson, Scott. 2008. Presidents of Liberal-Arts Colleges Discuss Dealing with Disasters and Other Topics at Annual Meeting. *The Chronicle of Higher Education.* Jan. 7, 2008. Access at http://chronicle.com/daily/2008/01/1116n.htm

3 Bob Petrich in Physical Plant has been the "point" person in maintaining this database.

facility, the Jackson Campus Center, which included the addition of highly ventilated kitchen space. The increase was probably dampened by modernization of equipment in existing buildings. Since this jump, electrical energy use has again been relatively steady.

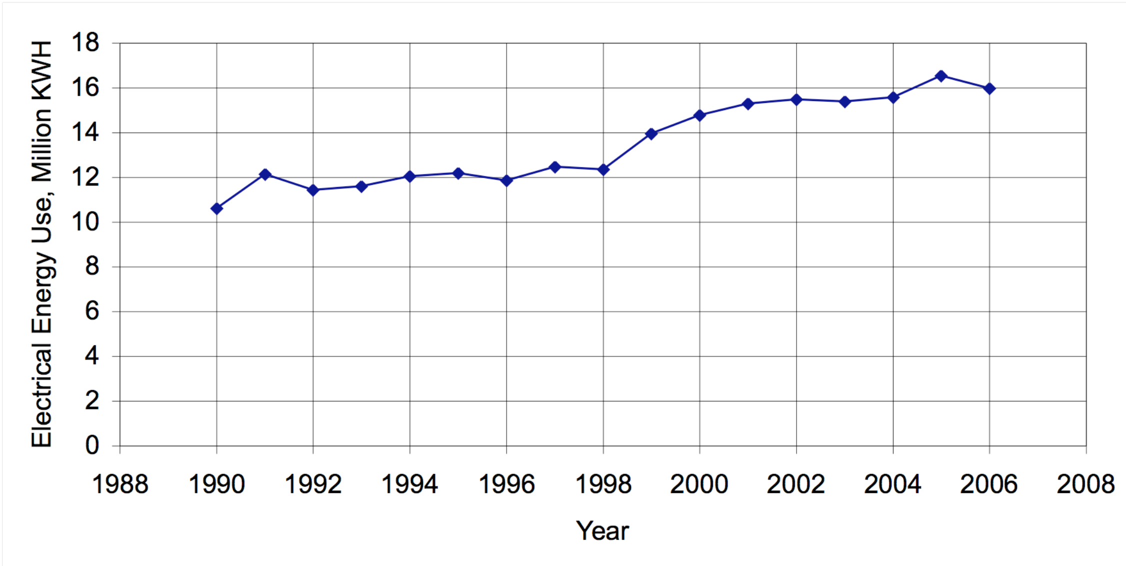

Figure 1. Total GAC electricity use since 1990

The cost of this electrical energy is graphed in Figure 2. Until a rate increase in 2006, the cost generally followed the demand. That rate change increased the college bill on the order of 20% or about $200,000. In 2006, GAC paid an average cost of $0.0757/KWH which represents a combination of usage ($0.0488/KWH consumed) and demand ($14.25/month/peak15-minute KW) charges.

Electricity is supplied to the college by the St. Peter Municipal Electrical Utility (http://www.saintpetermn.gov/finance/) which has an annual budget of $9.9 million—revenue from Gustavus is more than 10% of the annual budget. The city utility is a member of the Southern Minnesota Municipal Power Agency (SMMPA--http://www.smmpa.com/) which supplies electricity to the utility. 94% of that electricity is generated from coal with small fossil fuel and biodiesel fired generating units along with a few wind turbines making up the difference. SMMPA is currently directing its members to engage in demand side management activities to reduce electrical demand by 1.5% per year[4].

[4] Per personal communication from St. Peter city employer Valerie Thrower.

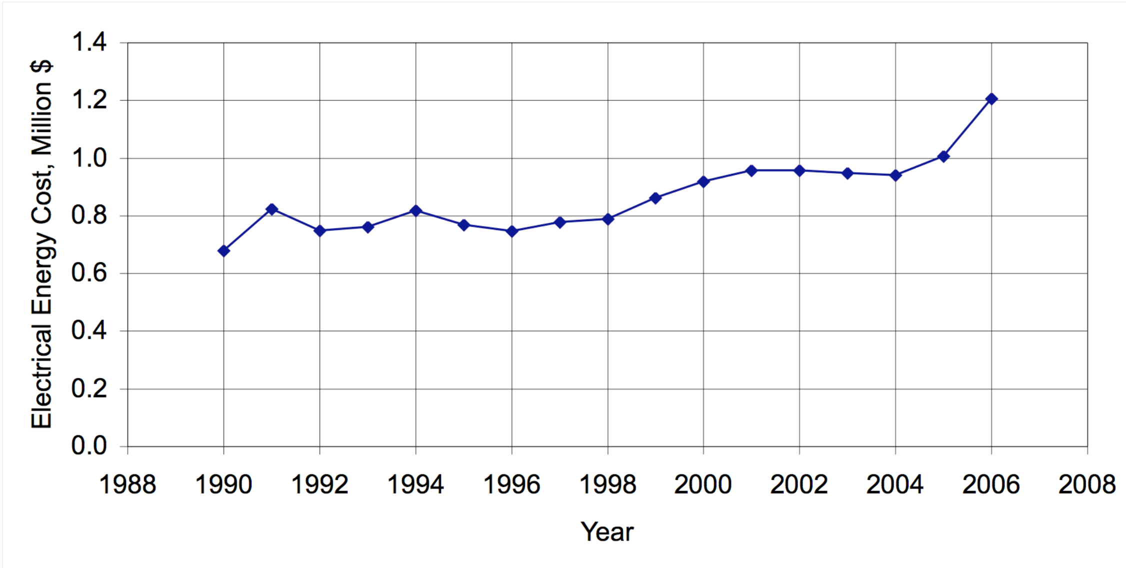

Figure 2. Total GAC electricity costs since 1990.

Natural gas and fuel oil use

Gustavus relies on dual-fuel natural gas and fuel oil boilers to supply primary thermal energy[5] to the campus for space heating and water heating. The dual natural gas/fuel oil arrangement provides the ability to choose the lower cost source of energy at any given time and also provides back-up in case of unexpected or deliberate supply interruptions. GAC has obtained a natural gas price break from CenterPoint Energy by means of an interruptible gas supply agreement that allows CenterPoint to cut off the gas supply to the campus in times of high demand. Fuel oil had been the back-up fuel in those instances also, but more recently the college has made an arrangement with a second natural gas supplier, U.S. Energy Services, Inc., to provide backup for interruptions and also price competition.

Some natural gas is also burned in internal combustion engines to generate electricity for air conditioning at times of high load. Additionally, there are various hot water heating loads across campus and cooking use in the campus center, as well as a few buildings with stand-alone furnaces.

Because of the dual-fuel arrangements, the fuel use values in Figure 3 are reported in BTU values after appropriate conversions. In the record presented here, fuel oil was always a minority part of the heating picture, but because of the dual source arrangement for natural gas, fuel oil use was not a part of the mix in 2006 nor is it likely to play a role in 2007 data.

Because the separate record for central heating plant BTU only begins in 1998, it is not absolutely clear that the thermal energy use on campus stepped up significantly after the post-tornado renovations, but the trend in Figure 3 certainly suggests that this is the case,

[5] Note that part of the campus electrical load also contributes to heating via boiler and pump operations, and powering ventilation fans.

especially for energy consumed in the central heating plant. The Other category may also have risen post-tornado, but that is not clear from the data. The Other category did not show the same increasing pattern as did total central plant energy consumption.

When compared with Heating Degree Days (HDD) in Figure 4, there is some correlation between heating degree days, an indicator of winter weather severity, and the central plant BTU use, but since high energy use does not always accord with the number of heating degree days, there are clearly other sources of variation.

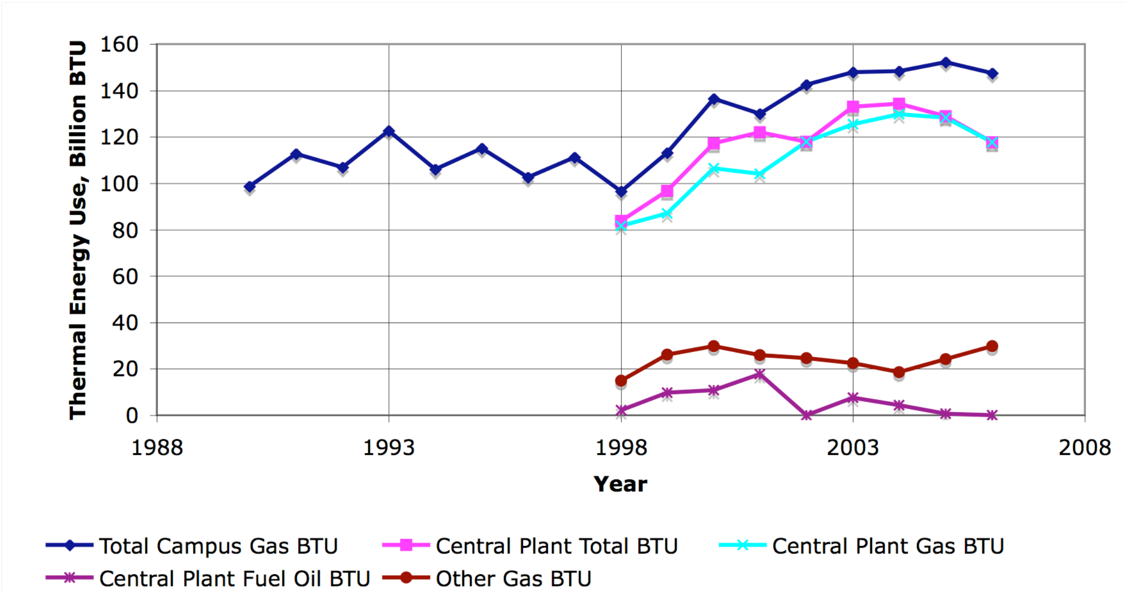

Figure 3. Total GAC natural gas and fuel oil energy use.

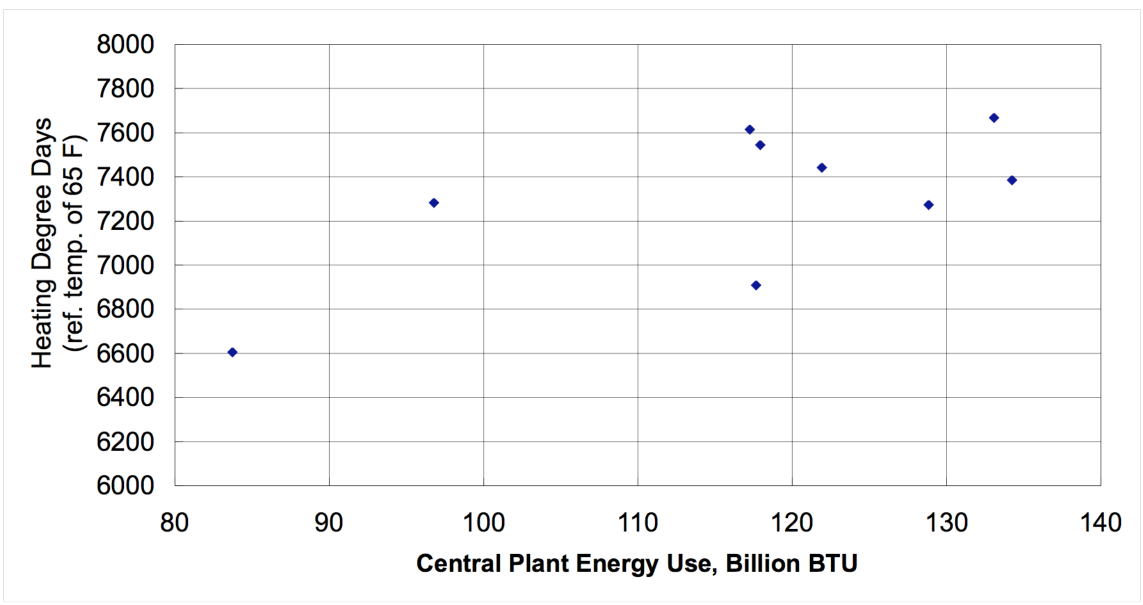

Figure 4. Heating Degree Days (HDD) plotted versus central heating plant natural gas and fuel oil use in BTUs.

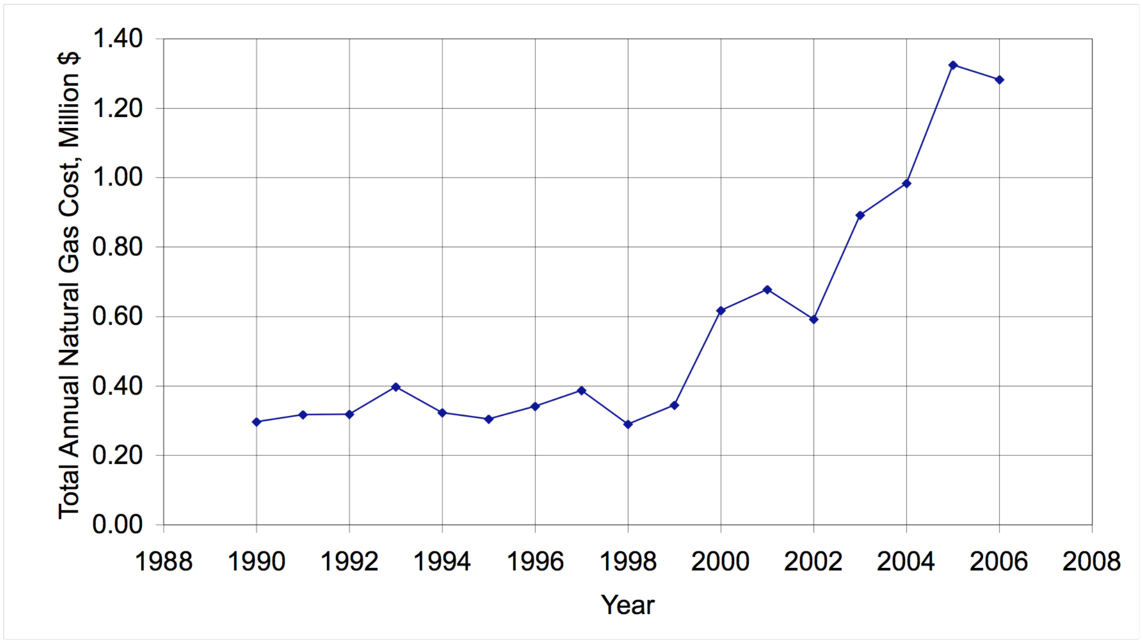

Figure 5. Total GAC natural gas costs from 1990 to 2007.

Historical natural gas cost data is displayed in Figure 5. At first glance, the rise in costs seems to be precipitated by the renovations, repairs, and construction after the 1998 tornado, but closer examination points to rising natural gas prices as the culprit. The total natural gas bill increased in proportion to the BTU usage increase from 1998 to 1999, but then began a cost escalation that has been almost universally out of proportion with demand—this cost escalation occurred during a time of low heating demand relative to historical Minnesota weather patterns. The price per BTU inflation is actually understated by this graph as it includes one winter period (December 2000 to January 2001) when a majority of heating BTUs came from fuel oil.

From 1998 to 2006, the average natural gas price GAC paid went from $0.30/therm[6] to $0.87/therm—the price approximately tripled. During the same time period, natural gas use increased about 50%. As a result of the dual increase in price and usage, the natural gas bill increased almost 4 times during the same time period. While fuel oil costs have been neglected here, it should be noted that fuel oil prices per gallon nearly tripled since 1998[7].

Greenhouse Gas Emissions

Given the current climate change debate centered around the role of greenhouse gas emissions, come kind of greenhouse gas emission or carbon footprint inventory is fast becoming a standard reporting item for larger institutions. Furthermore, President Jim Peterson has recently signed the American College and University Presidents Commitment on Climate Change. As part of that commitment, Gustavus will need to

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[6] 1 therm = 100,000 BTU of gas

[7] www.oilnergy.com/1heatoil.htm#since78

prepare an annual inventory of greenhouse gas emissions from our operations as well as a plan for reducing those emissions. The following is a first rough estimate of our emissions from electricity, natural gas and fuel oil use—a complete inventory will eventually need to include estimates of emissions from faculty, staff and student business and educational travel (surface and air travel) as well as faculty and staff commuting.

Procedurally, the estimate of green house gas emissions is based on emission factors that quantify the greenhouse gas output from each energy source in terms of equivalent metric tons of CO_2[8]. Table 1 presents the factors for the three main GAC campus energy sources.

Table 1. Greenhouse gas emission factors.[9]

Energy source	GHG emission factor	Units
Electricity	0.00091233	metric tonnes CO_2e/KWh
Natural gas	0.053	metric tonnes CO_2e/MMBTU
Fuel oil	0.0714	metric tonnes CO_2e/MMBTU

Multiplying by our total electricity use by the appropriate factor, we have 2006 GAC greenhouse gas emissions from electricity of 14,580 metric tonnes CO_2 equivalent. Similarly, the emissions from natural gas were 7,810 metric tonnes CO_2 equivalent (no fuel oil was used in 2006). Hence, the total GAC emissions from these two energy sources were 22,390 metric tonnes CO_2 equivalent.

The results of similar calculations for other years are displayed in Figure 6. This figure also shows the sum of electricity, fuel oil and natural gas greenhouse gas emissions[10]. To put this emissions profile in context, Table 2 gives greenhouse gas emissions levels for several higher education institutions.

For reference, the 2007 UN Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report[11] concludes that 60-80% reductions in greenhouse gas emissions by 2050 are necessary for a best possible case scenario of global warming prevention. A 60% reduction in GAC greenhouse gas emissions would take the level to 8,960 metric tonnes whereas an 80% reduction would take the level to 4,480 metric tonnes.

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[8] The three main greenhouse gases from energy production are considered in this analysis: carbon dioxide, methane and nitrogen oxide. Each has a different greenhouse gas effect—the relative affects are accounted for in the calculations and the results are expressed as equivalent amounts of carbon dioxide (CO_2e).

[9] These factors are drawn form the Clean Air-Cool Planet greenhouse gas emissions calculator (http://www.cleanair-coolplanet.org/for_campuses.php) which draws from EPA and the UN Intergovernmental Panel on Climate Change (IPCC) protocols. The electricity values are based on the generating mix for this region.

[10] Fuel supply chain emissions (i.e. refinery emissions or coal mining emissions) are not considered here.

[11] http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf

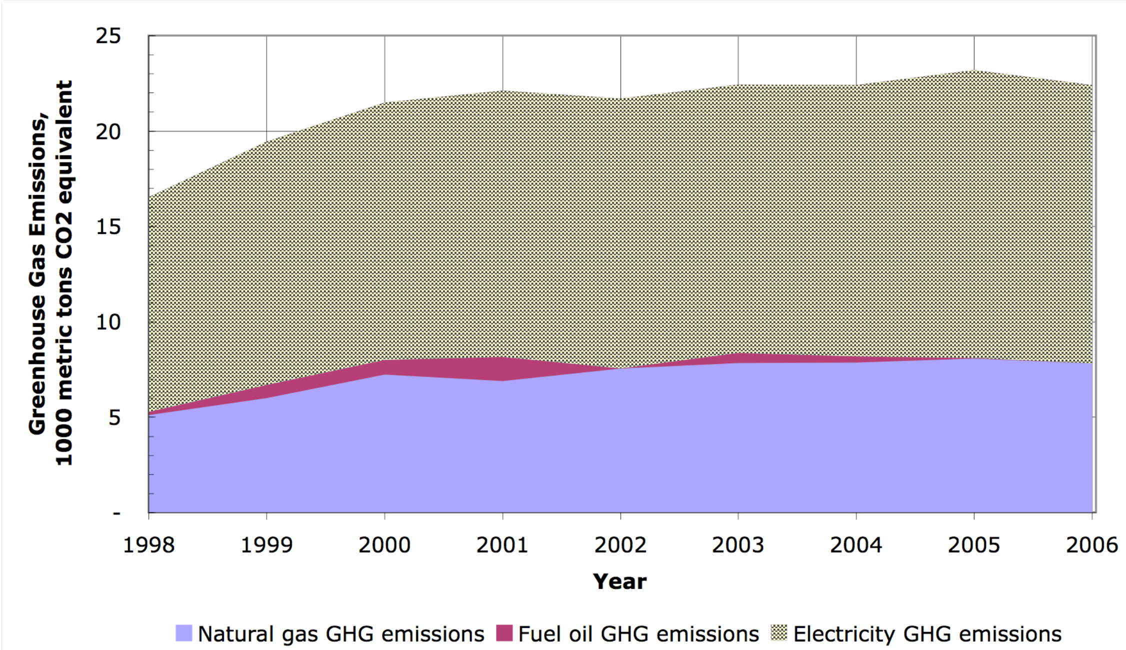

Figure 6. GAC greenhouse gas emissions from natural gas, fuel oil, and electricity use for 1998 to 2006.

Table 2. Greenhouse gas emissions at other higher education institutions.

Institution/ Location	Enrollment (approx.)	Year	Greenhouse gas emissions, metric tonnes CO_2 equivalent	Notes/Source
Williams College, Massachusetts	2100	2006	29,700	Approx. 10% due to commuting and travel. http://blogs.williams.edu/sustainability/2007/09/24/report-on-greenhouse-gas-emissions-during-fiscal-year-2007/
Bates College, Maine	1700	2006	19,971	First GHG inventory in 2001. http://www.bates.edu/x166375.xml
Luther College, Iowa	2500	2006	19,988	Comprehensive inventory. http://environment.luther.edu/files/sustainability%20talk%20sept%2007.ppt

Energy and Green House Gas Trends and Monitoring: Conclusions and Recommendations

Relative to the three strategic issues outlined in the introduction and the data presented here, the following observations apply:

1. In 2006, the total costs for electricity and natural gas were almost $2.5 million dollars or about 3.7% of a $67.9 million total GAC budget. By contrast, the same energy costs were less than half that value in 1997 and made up only 2.7% of a $42.6 million budget. While the budgetary impact is minor compared to other costs (i.e. personnel budgets), any significant cost increases are eventually passed on to students in the cost of tuition. Recent increases in petroleum prices have not yet been felt in the wider energy markets, but those affects will appear in time.
2. In regards to greenhouse gas emissions, the long-term need for dramatic reduction (60-80%) puts the spotlight on GAC electricity use. Because our electricity source, SMMPA, generates more than 90% of its power from coal, electricity is our largest source of greenhouse gas emissions and the most obvious target for reductions. While natural gas use would also have to decrease to meet an 80% reduction target, coal-generated electricity's other impacts (non-CO_2 air pollution and mining activities) speak to making it the priority focus.
3. The scrutiny applied here to GAC energy use represents the kind of awareness we need to instill in our students. An overall institutional awareness of energy use would be a teaching asset.

Steps to reduce the cost and environmental impacts will be discussed below, but the following recommendation includes steps that will enhance the environmental education emphasis discussed in the introductory section and will support further energy conservation efforts:

> To foster campus-wide attention to energy issues, the data used to prepare this section should be given a more prominent place in the campus information space. In a joint effort between Physical Plant, College Relations, and the Johnson Center for Environmental Innovation, campus energy data should be made visible in campus publications, especially the website. While some of this work can be incorporated into ongoing activities, like the work of developing a more complete greenhouse gas inventory by the Johnson Center, there must be an administrative commitment to making this a routine, priority activity.

Energy Conservation

Whether motivated by environmental concerns or by cost issues, most discussions about reducing energy begin by noting that conservation is always the most-cost effective and logical first step to reducing energy use. The following section examines energy conservation options at GAC and presents some recommended steps to reduce energy consumption.

Before beginning that discussion, it is important to recognize some relevant nuances that appear in conservation discussions:

The terms "energy conservation" and "energy efficiency" are often used interchangeably in discussion, but it is important to recognize that while the US economy has become markedly more energy efficient (in terms of energy use per GDP) in the last 30 years, overall energy consumption has increased[12].

If the challenge we face were simply one of energy supply, technical efficiency gains would be the proper focus of discussion. But given the short and long-term environmental problems engendered by fossil fuels, the story of more efficient but increasing total energy use becomes more threatening. The rising US demand for energy is paralleled by a global increase in demand met largely by fossil fuels—as efficiency and demand race neck and neck down the track, they are fast being overtaken by environmental challenges, particularly global climate change.

As a result, the following discussion focuses on real energy conservation: a reduction in GAC fossil fuel use that will also produce a reduction in greenhouse gas emissions.

Also, the following discussion divides the conservation effort into hardware (what can be accomplished through design and equipment choice) and software (how we operate the hardware and the choices we all make as individuals. While this computer metaphor allows an easy specification of what steps to take, it should be recognized that there are significant interactions between the two. Occupancy sensors, for example, help conserve energy, but may also encourage a careless attitude towards turning off lights that could carry over into areas where there are no occupancy sensors. The ultimate success of a GAC energy conservation effort will depend on how well we as a community learn to make use of the campus hardware.

Past Efforts--Hardware

The oil shocks of the 1970s stimulated energy conservation steps at Gustavus that mirrored efforts across the US. Additionally, the damage caused by the 1998 tornado and subsequent recovery efforts prompted renovations and energy management steps that would have otherwise taken longer to implement. The rapid response required for tornado recovery also meant that some good ideas were not implemented.

Based on discussions with Warren Wunderlich, Director of Physical Plant, the following list represents energy conservation-related activities of recent years:

1. Ongoing conversions to more efficient lighting.
2. Extension of the central chilled water system, allowing the replacement of less efficient individual air conditioning units.
3. Dual fuel capacity on 50% of cooling capacity, allowing cost savings.
4. Partial improvements in window glazing (mostly as a part of tornado repairs).
5. Replacement of electric motors with variable-frequency drives.
6. Variable volume ventilation systems.
7. Boiler and burner upgrades.
8. Heating control upgrades in North and Sorenson Halls.

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[12] http://intensityindicators.pnl.gov/total_highlights.stm

9. Ongoing addition of occupancy sensors to control lighting.
10. The construction of low-energy use computers by Technology Services and widespread adoption of LCD monitors.
11. Use of electric vehicles by Physical Plant staff and hybrid vehicles by Safety and Security and Admissions.

The net increase in GAC energy use since the tornado would likely have been greater without these steps, yet the upward trend demonstrates the point mentioned above: efficiency is necessary but insufficient for reducing our energy use.

It is also notable that the partial implementation of some of these improvements (occupancy sensors, for example) is not reflective of a lack of commitment to the energy saving program, but rather points to the lack of personnel resources to move the projects forward quickly.

Past Efforts-Software

In discussions with faculty and staff, it is clear that while many individuals are personally concerned about campus energy use, there has not been a campus-wide effort to develop habits of living and working that reduce energy use. None-the-less, two notable efforts came to light in the preparation of this document.

In early 2006, a group described as the *Energy and Environmental Issues Task Force* reviewed electricity consumption patterns and prepared a specific set of recommendations focused on actions that conserved electricity. The recommendations do not appear to have been presented to the campus community with administrative support, but the effort demonstrated a growing attention to the issue[13].

In February 2007, the GAC Campus Greens, the student environmental organization, and the Environmental Studies faculty, lead GAC's entry into the Energy Wars, an energy reduction competition between Minnesota colleges. This effort, which resulted in a 6% reduction in electricity use during February, broadened the discussion of energy conservation on campus, particularly among students.

The Energy Wars contest has evolved into a national effort this year under the title of National Campus Energy Challenge[14]. The Gustavus effort for this year's contest is currently under development.

Planned Investments in Energy Conservation

Future investments in energy conservation and efficiency that have been "on the table" include (not listed in priority order):

1. Additional modifications to the primary boilers burners to improve efficiency.
2. Improvements to heating controls, particularly in Gibbs Hall.
3. Window upgrades.

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[13] See Appendix 1.

[14] http://climatechallenge.org/ncec

4. Shift to E-85 (ethanol) and biodiesel in college vehicle fleet.[15]
5. Ongoing lighting improvements, including more efficient lighting as well as better control systems (e.g. occupancy sensors and daylight harvesting).
6. Insulation improvements.

Of the 6 investments listed above, the window upgrades, insulation improvements, and the lighting improvements are steps with the most significant savings potential (as well as notable cost implications) and the steps for which the most information is available. More detailed information on these can be found in Appendix 2.

Outside of windows and lighting, however, the short list above suggests a shortage of options. More likely, however, the list points to a shortage of information about the best conservation steps to take. Based on available data, engineering knowledge, and discussions with Warren Wunderlich, several areas of interest and concern have been identified:

1. A breakdown of thermal energy (heating and cooling from the central plant) is not available to guide decision-making.

2. Two buildings, the Lund Athletic Center and the Jackson Campus Center, are the largest electricity consumers on campus and presumably the largest consumers of heating and cooling energy based on square footage. These buildings have complex and multifaceted mechanical systems as well as multiple user groups.

3. The design of the cooling systems on many buildings necessitates the reheating of cooled air to manage a balance between proper cooling and dehumidification. It is probable (but not certain) that alternate methods of dealing with humidity could significantly reduce energy use.

New Buildings and Future Renovations

Gustavus is just entering the design process for a new building (sometimes called the new "Social Sciences Building" with only partial accuracy) and will be renovating older buildings in the future, with Anderson Social Science Center the likely next candidate for renovation. While these projects are undertaken for programmatic reasons, they represent an energy conservation challenge and opportunity.

The challenge, as illustrated above by the post-tornado rise in energy use, is that new buildings add square footage to the campus and renovations often add new energy consuming features like air conditioning, increased ventilation and added square footage. But new buildings also represent the chance to install the best, most-efficient equipment and to design in light of the current energy realities; and renovations allow fixes for past energy problems.

During January 2008, architects for the new building are being selected. The selection criteria in the Request for Qualifications document used in this process explicitly ask for expertise in "green" building and energy efficient design. To date, however, the

[15] Not necessarily a conservation or efficiency measure, but a possible way to reduce greenhouse gas emissions.

discussions have not focused on the critical question of what design standard should be applied—how efficient are we going to expect this building to be?

Energy Conservation: Conclusions and Recommendations

Drawing from the foregoing discussion, recommendations about GAC energy conservation options must respond to the following:

1. The need for real reductions in energy—efficiency alone only slows the rate of growth. Likewise, new construction and renovations tend to increase energy demand even when more energy efficient designs are used.
2. While a shift to renewable energy sources might allow greenhouse gas emission reductions without energy use reductions, the investments required for any changes in energy infrastructure are so large that conservation is the best first option.
3. Despite the good data available, particularly for electricity use, there are important gaps in our knowledge particularly in regards to thermal energy. Furthermore, the sophistication of some campus energy systems (air conditioning systems including the dual fuel system) makes it harder to measure their efficiency or determine what improvements could be made.

Reflecting these observations and the overall goals outlined in the introductory Background section, the following are conservation recommendations for the GAC campus. They are presented in a rank order that reflects logical dependencies (e.g. data collection before action) and ease/cost of implementation:

A. Implement a campus-wide energy conservation program. This would build on current conservation efforts and include the following components
    a. Awareness and educational events on an ongoing basis. These should include classroom and co-curricular activities for students as well as a consistent attention to staff and faculty energy use, along with an explicit recognition that the conservation orientation is something that students should take with them when they leave Gustavus.
    b. Demonstration of administration commitment by establishing standards (thermostat settings, for example) and best practices (Energy Star appliances).
    c. Development a positive feedback incentive program that encourages conservation efforts. Example: Dollar value of energy savings allocated to a fund for energy saving improvements or renewable energy purchases.
    d. Measurement of performance through the monitoring efforts outlined above.

B. Building on the energy monitoring and awareness effort outlined in the monitoring section above, GAC should strive to develop a better understanding of energy use and conservation options through the following steps:
    a. Internal review and analysis. By reviewing available data and focused investigations (building walk-throughs, for example) we should develop a

thorough understanding of energy use in all of our facilities and what steps can be taken to reduce energy use. This effort must be supported by the allocation of sufficient resources (particularly personnel time).

b. More thorough engineering analysis. Depending on the adequacy of the results in a., we may need to hire outside engineering expertise for individual building or mechanical system analysis at minimum to a full-scale campus analysis at the extreme. The cost of this effort will have to be seen as an investment to be paid for by future energy savings.

c. The results of a. and b. should become part of our community energy awareness.

C. Continue current and planned efforts to improve energy infrastructure:

a. Implement the highest impact, most cost effective programs outlined in the *Planned Investments* section above, allocating sufficient resources to expedite the work.

b. Implement the highest value conservation measures identified in B. and develop a comprehensive plan to fund and implement further improvements.

c. Develop an energy standard for all new construction and renovations that reflects our energy conservation goals.

Renewable Energy/Carbon Neutral Energy

The fact that fossil fuel resources are finite makes it a foregone conclusion that our society will eventually transition to a non-fossil fuel economy most likely based on some mix of renewable energy. The timetable, however, has always been "sometime in the future." The growing recognition that fossil fuel generated carbon emissions are rapidly changing the global climate has made defining "sometime" an urgent activity.

A January 2007 report[16] by the American Solar Energy Society, for example, outlined a concerted strategy that links energy conservation steps with the adoption of various forms of renewable energy to envision a 60% reduction in US greenhouse gas emissions by 2030. Time frames such as these move "sometime" into the long range planning horizon of Gustavus and other institutions of higher learning.

For the least disruption to the status quo, this transition would be the domain of the utility companies that have traditionally provided Gustavus with energy. The nature of most renewable energy sources, however, is diffuse and decentralized. As a result, the centralized structure of the most utilities is not always optimal for renewable energy adoption. Furthermore, such adoption will not be without added costs and it will be

[16] http://www.ases.org/climatechange/

necessary to explore new and creative models for implementing new energy sources as quickly as possible.

Since most college campuses like Gustavus are large energy consumers and have centralized energy distribution systems, they become logical players in the innovations that are taking place. Hence, we are seeing campuses all across the US explore new energy supply arrangements that often involve some measure of institutional ownership and operation of energy supply capacity. St. Olaf College and Carleton College, two of Gustavus' peer institutions, both own wind turbines, for example. The University of Minnesota-Morris and Iowa State University have or will have soon have implemented biomass schemes to supply campus energy.

These arrangements typically meet a interacting set of goals: energy cost savings, hedging against future energy supply and cost instability, green house gas emission reductions, and demonstrating community leadership.

Alternatively, some campuses have pursued a carbon offset or renewable energy credit strategy by which they pay a supplemental fee or tax based on per unit energy consumption. That fee or tax is, theoretically, used to ensure that the transition to renewable energy and lower carbon emissions is occurring elsewhere in the energy supply chain in proportion to the energy consumption of the institution paying for the fee or tax. There are some concerns about the validity and effectiveness of this approach, but there is also a growing effort to ensure that such credits accomplish their purpose[17].

Properly done, an offsetting strategy can reduce greenhouse gas emissions and demonstrate community leadership, but offsets will not reduce energy costs or hedge against future price increases. Even programs that recommend offsets suggest that energy conservation and local energy generation options should be pursued first[18].

The following sections explore renewable energy options available to Gustavus in light of these considerations, looking for the options that will have most value (least cost for most energy production/carbon emission reduction) for Gustavus. Besides considering individual energy sources, the interactions of some options are considered in a search for integrated solutions.

Wind energy

Worldwide and in the US, there has been a rapid growth in wind-generated electricity capacity, with Minnesota playing a major role in that expansion. While the wind resource in St. Peter is not as large as in western Minnesota, there is still considerable potential. Analysis by Gustavus faculty and staff suggest a significant economic benefit from generating a portion of our electrical load with wind turbines. As a result, there has been an ongoing effort to acquire two utility scale (2 to 2.5 MW) wind turbines stymied mainly by the lack of available turbines due to rapid wind industry growth.

To summarize that work with up-to-date cost figures, two 2-MW turbines could, by conservative estimates, generate about 60% percent of our electrical energy consumption

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[17] http://www.tufts.edu/tie/tci/carbonoffsets/ratings.htm

[18] http://www.carbontrust.co.uk/carbon/briefing/offsets.htm

while costing about $6.4 million. The actual dollar value of that electricity will vary depending on how it affects our KW demand charges. Continuing the conservative estimation, the value might about 50% of our current electric bill, or about $600,000. This represents an 11-year payback under conservative assumptions.

Based on the greenhouse gas emissions analysis above, the wind-generated electricity would reduce the greenhouse gas emissions by 74% based on the 2006 data. Although the percentage reduction will be less when the transportation fuel emissions are factored into our emissions inventory, the combination of favorable economics and very significant emissions reductions makes wind energy a leading option for Gustavus.

Biomass

The agricultural context of St. Peter as well as the wood resources of the Minnesota River valley offer a potential biomass resource for energy. Utilizing that resource would not only require a plant for burning the biomass, but also developing the infrastructure for fuel collection and delivery. While the fuel cycle would be carbon neutral (the carbon emissions would be, in effect, taken up by the plants producing the biomass) careful design and management would be required to minimize other emissions. District Energy[19] of St. Paul, MN, has clearly demonstrated the technical, environmental, and economic feasibility of a similar scheme using Twin Cities area wood waste.

Despite these challenges, an interesting synergy would be possible with a good public or private partner. A utility peaking power plant is located near the campus—a biomass cogeneration power plant located near that peaking plant could sell electricity to the grid and GAC, and also thermal energy to GAC. The energy benefits and greenhouse gas emission reductions would depend on the ultimate configuration of the plant, but there is clearly a potential biomass option. Since biomass generation capacity can be operated at a constant rate, it can serve as a base load complement to the more variable wind resource.

Photovoltaics

Photovoltiaics offer the simplicity of long-term, trouble free operation after a straight-forward installation, but with distinct disadvantage of high capital costs--typically $8-10 per watt of installed capacity[20]. These costs translate into photovoltaic electricity costs more than three times the current cost of electricity for Gustavus[21] without any government incentives. Despite these unfavorable numbers, there may still be a place for photovoltaics on the GAC campus. With demand charges of $14.25/month/peak15-minute KW, there are significant opportunities for "peak shaving"—generating power at time when it will reduce the peak demand charges. Successful implementation of this

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[19] http://www.districtenergy.com/

[20] http://www.solarbuzz.com/Moduleprices.htm

[21] Estimated using methods similar to http://www.solar4power.com/solar-power-sizing.html

strategy with photovoltaics may require some short-term storage using technologies that are not yet cost competitive[22]. This possibility is still being explored.

Solar Thermal

Solar thermal technology, capturing solar energy directly as heat, comes in two forms: 1) Concentrating solar power (CSP) plants that use the heat to make steam and generate electricity; and 2) systems that capture and store the thermal energy for water and space heating, usually using flat plate collectors. CSP plants are currently economical as peaking power plants in the US Southwest, but not in the Midwest. Option 2, however, represents a mature technology that, depending on the application, is often cost competitive with fossil fuel energy. While this technology may not offer dramatic advantages, there are a number of possible applications on the GAC campus to investigate:

a. Solar water heating. At numerous locations across campus, gas-fired water heater supply hot water when the central boiler plant is shut down during summer months.
b. Supply heat for pool heating in Lund Center.
c. Thermal energy for reheat in air conditioning systems.
d. Space heating for new construction[23]

Geothermal

Ground source geothermal systems extract heating and cooling energy from the earth using heat pumps and pipes in wells or trenches. Although installation costs are high due to expense of installing the pipes in the ground, this technology is very viable in Minnesota. But while geothermal systems use electricity very efficiently, the relatively high "carbon footprint" of electricity generation can mean they offer little or no reduction in greenhouse gas emissions.

For the electrical generation profile at Gustavus, a heat pump might extract (from the ground) 3.3[24] times the electrical energy used in operation. This means that the greenhouse gas emissions factor for the geothermal energy would be about 0.081 metric tonnes CO_2e/MMBTU—more than that for natural gas or fuel oil.

If wind-generated electricity were used for heat pump operation when available, it may be possible to have favorable economics and greenhouse gas reductions, but with costly investment in infrastructure. The possible synergism is worth further investigation.

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[22] Ginley, D. and P. Denholm. 2007. Energy Storage: Getting Past the Gridlock. *Solar Today*, Jan/Feb 2007. pp. 36-39.

[23] This technology is difficult to retrofit for space heating in existing buildings but can be more readily integrated into new buildings.

[24] This value is known as the coefficient of performance (COP). http://www.mnpower.com/hvac/specials/GHP/rebate.htm

Passive Solar

Passive solar technology is mentioned here for completeness. Since it involves building solar heat capture and retention capacity into the building, it is more properly considered (and will be examined as part of that effort) with the new buildings and renovation standards mentioned above.

Renewable Energy/Carbon Neutral Energy: Recommendations

Of the renewable energy sources outlined above, the wind option has the highest economic and greenhouse gas reduction potential. Combined with successful conservation efforts, the wind turbines could enable Gustavus to exceed an 80% reduction in green house gas emissions within two or three years. If significant opportunities from the other options prove feasible and are implemented, Gustavus has the potential to become a carbon neutral campus in 5-10 years.

Given the opportunities presented in the preceding paragraph, and the energy supply and climate change imperatives outlined in the introductory section, the following recommendations lay out a path for Gustavus to become leader in reducing fossil fuel energy use and greenhouse gas emissions:

1. Develop and implement the wind energy plans that have already developed. Although this represents a significant capital investment, the economics are favorable and the potential results impressive. Wind industry growth and turbine shortages pose challenges, but Gustavus should exert every effort possible to move forward and acquire wind turbines.
2. The other options described above should be more thoroughly explored and the most promising approaches considered for adoption.
3. The current trend in energy development includes various creative partnerships. The suggested collaboration involving a biomass plant is but one example of how profit and non-profit organizations can create innovative solutions. Under the auspices of the Johnson Center for Environmental Innovation, the effort to develop cleaner energy resources should explore the value of such arrangements for the college.

Recommendations Summary: Setting and Reaching the Goal

The following repeats the recommendations developed in the preceding discussion, establishing appropriate near-term goals by which progress can be measured. Responding to the three strategic questions from the introduction, these recommendations are intended to:

1. Reduce GAC energy costs where possible, and ensure more certain energy supplies and costs in the future.
2. Reduce the environmental impacts of GAC energy consumption through conservation and a shift to more environmentally benign sources of energy.
3. Establish Gustavus as an environmental leader that attracts students, donors, and community recognition.

In terms of energy, the ideal future scenario is a GAC campus where total energy use is constant or declining year-to-year even as we develop the quality of our educational program. Concurrently, net greenhouse gas emissions would decline by 80% in three years and be reduced to zero in 5-10 years.

Monitoring and Energy Awareness

To foster campus-wide attention to energy issues, Gustavus energy data and information should be given a more prominent place in the campus information space. In a joint effort between Physical Plant, College Relations, and the Johnson Center for Environmental Innovation, campus energy data should be made visible in campus publications, especially the website. While some of this work can be incorporated into ongoing activities, like the work in developing a more complete greenhouse gas inventory by the Johnson Center, there must be an administrative commitment to making this a routine, priority activity.

Goal: *A link to a comprehensive energy information page will be on the Gustavus Adolphus website home page by August, 2008.*

Conservation Plan

A. Implement a campus-wide energy conservation program. This would build on current conservation efforts and include the following components

a. Awareness and educational events on an ongoing basis. These should include classroom and co-curricular activities for students as well as a consistent attention to staff and faculty energy use, along with an explicit recognition that the conservation orientation is something that students should take with them when they leave Gustavus.

   Goal: *Work with the faculty (especially the Environmental Studies faculty), the academic deans, the Center for Vocational Reflection and the Dean of Students to develop programming by January 2009.*

b. Demonstration of administration commitment by establishing standards (thermostat settings, for example) and best practices (Energy Star appliance purchase policy, for example).

   Goal: *Develop a list based on feasible, high impact approaches and propose to the administration by March 2008.*

c. Development a positive feedback incentive program that encourages conservation efforts. Example: Dollar value of energy savings allocated to a fund for energy saving improvements or renewable energy purchases.

   Goal: *Develop a concrete proposal for adoption by the GAC administration considering institutional structures and culture by January 2009.*

d. Measurement of performance through the monitoring efforts outlined above.

   Goal: *Incorporate this into the monitoring and awareness activity above.*

B. Building on the energy monitoring and awareness effort outlined in the monitoring section above, GAC should strive to develop a better understanding of energy use and conservation options through the following steps:

a. Internal review and analysis. By reviewing available data and focused investigations (building walk-throughs, for example) we should develop a thorough understanding of energy use in all our facilities and what steps can be taken to reduce energy use. This effort must be supported by the allocation of sufficient resources (particularly personnel time).

Goal: *Working with Physical Plant staff, fully review all buildings and rank the energy consuming activities/equipment in each building. Develop a list of cost-effective actions, an implementation schedule, and a funding plan by January 2009.*

b. More thorough engineering analysis. Depending on the adequacy of the results in a., we may need to hire outside engineering expertise for individual building or mechanical system analysis at minimum to a full-scale campus analysis at the extreme. The cost of this effort will have to be seen as an investment to be paid for by future energy savings.

Goal: *Depending on the schedule and results of a., seek consultants to guide conservation steps.*

c. The results of a. and b. should become part of our community energy awareness.

Goal: *The activities of a to c can be publicized on the energy data website mentioned above.*

C. Continue current and planned efforts to improve energy infrastructure:

a. Implement the highest impact, most cost effective programs outlined in the *Planned Investments* section above, allocating sufficient resources to expedite the work.

Goal: *Projects underway by May 2008.*

b. Implement the highest value conservation measures identified in B. and develop a comprehensive plan to fund and implement further improvements.

Goal: *Dependent on the results of B.b.*

c. Develop an energy standard for all new construction and renovations that reflects our energy conservation goals.

Goal: *Use the design process for the new building to inform the course of action.*

Clean Energy Adoption

A. Develop and implement the wind energy plans that have already developed. Although this represents a significant capital investment, the economics are favorable and the potential results impressive. Wind industry growth and turbine shortages pose challenges, but Gustavus should exert every effort possible to move forward and acquire wind turbines.

Goal: *Project financing and engineering plans in place by mid-2008 with an on-going focused effort to acquire turbines.*

B. The other clean energy options described above should be more thoroughly explored and the most promising approaches considered for adoptions.

Goal: *Most promising and feasible options identified by mid-2008. Preliminary feasibility studies and funding plans done by late 2008.*

C. The current trend in energy development includes various creative partnerships. The suggested collaboration involving a biomass plant is but one example of how profit and non-profit organizations can create innovative solutions. Under the auspices of the Johnson Center for Environmental Innovation, the effort to develop cleaner energy resources should explore the value of such arrangements for the college.

Goal: *Efforts by the Johnson Center concurrent with A. and B.*

Acknowledgements

The patient answers and explanations of Bob Petrich and Warren Wunderlich were essential to the preparation of this document.

Appendix 1—Energy Initiative Document from 2006

Electricity Conservation

From 2001-2004 electricity consumption at Gustavus was fairly constant at about 15 million kwh per year. In 2005 it increased to over 16 million kwh at a cost of just over $1 million. About 50% of our bill is for usage and the other 50% is a demand charge. On March 1, 2006, our usage rate increased from 3.15 cents/kwh to 4.88 cents/kwh. The demand charge stayed the same. Thus, we can expect an annual increase of approximately $250,000 in electrical charges.

A goal to reduce electricity consumption by 4-5% has been set for the next fiscal year. We are hoping to implement some technological and behavioral modifications next year to accomplish this goal. From previous analyses we know that lighting and computers account for 50% or more of campus electrical use so our efforts will focus mainly on these two areas. The specific recommendations below were developed mainly by the Energy and Environmental Issues Task Force which was formed after the first community conversation.

Computers

- All computers should be shut off at night.
- All computers should go into a low-energy hibernation mode or be turned off when not in use during the day.
- Computers should be configured to shut off easily and to start up as quickly as possible to encourage students and staff to shut them down.
- NO screensavers should EVER be used (they don't extend the life of your monitor - they only waste electricity) - monitors can easily be set to turn off rather than go to a screensaver.
- Students are encouraged to bring LCD (flat panel) monitors or use laptop computers.
- All monitors purchased by the college should be LCD monitors. Heavy use monitors, such as those in computer labs, should be given priority over office computers when replacing the older monitors with LCD monitors.

Lighting

- Students and employees are encouraged to use compact fluorescent bulbs in their rooms and offices.
- Turn off the lights! Never leave lights on in your room or office while you are gone.
- Lights should be turned off in academic buildings after regular class hours (this is usually done at midnight) ALL lights in buildings should be shut off after building hours. Motion sensors could be used for safety concerns
- Motion sensors should be installed in appropriate areas such as bathrooms, classrooms and hallways

- Light-sensing switches are recommended for areas that receive sufficient natural lighting during certain daylight hours. The cafeteria and Lund arenas are good examples.
- Continue to update lighting fixtures on campus

Other Misc

- Plans in progress for energy conservation in each building on campus
- Pop machines – 44 on campus, each costing ~$300 per year (Vending misers)
- Lights in Lund Forum ~ $5/hour to run, roughly $20,000 per year
- Lights in Hockey Arena ~ $2/hour to run, $8,000 per year

Appendix 2—Potential Building Energy Efficiency Upgrades[25]

A. Lighting in the Lund Center

Forum upgrade to T-5 lighting

Total cost--$20,171

Total wattage reduction—40 KW

Annual savings:

Percent time "on"	Savings at $0.08/kWH	Simple payback
10%	$2,803	7.2 years
40%	$11,213	1.8 years

Arena upgrade to T-5 lighting

Total cost--$11,424

Total wattage reduction—14.2 KW

Annual savings:

Percent time "on"	Savings at $0.08/kWH	Simple payback
10%	$987	11.6 years
40%	$3,947	2.9 years

Assuming 40% "on" time, these two improvements together would reduce total GAC electrical energy use by 1.3%.

B. Window upgrades[26]

Three buildings--Sohre Hall, North Hall and Christ Chapel (all with similar quality windows)

Total window upgrade cost—$594,000

Total annual energy savings—3,960 MMBTU (2.7% of 2006 natural gas use)

Total annual cost savings (@$1/therm natural gas cost)—$39,600

Simple payback—15 years

[25] Data collected and analyzed by Warren Wunderlich, Director of Physical Plant

[26] Based on fairly simple engineering estimates. The size of the investment would justify a more thorough examination of the costs and benefits.

C. Insulation upgrade[27]

Building	Upgrade cost	Annual energy savings,	Annual cost savings (@$1/therm natuaral gas cost	Simple payback
Norelius Hall	$499,640	4,991 MMBTU	$49,914	10 years
Rundstrom Hall	$88,544	1,100 MMBTU	$10,997	8 years

Total energy savings represent about 4% of 2006 natural gas costs.

[27] Similar investments on several other campus buildings would have paybacks on the order of 16-19 years if this analysis is correct, but the total magnitude of the savings would be much less.