RECOMMISSIONING STUDY REPORT

Macalester College
St. Paul, Minnesota

Presented to:

MACALESTER COLLEGE

Mark Dickinson
Director of Facilities Management
Macalester College

Xcel Energy Minnesota
Recommissioning Program

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Substantial Funding by:

Xcel Energy[SM]

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1. Executive Summary

Under the Xcel Energy Recommissioning Program, Edward H. Cook & Associates, P.A. completed a recommissioning study at Macalester College, located at 1600 Grand Ave., Saint Paul, MN. The goal of the Xcel Energy Recommissioning Program is to achieve demand and energy savings in commercial buildings in the Xcel Energy Minnesota service territory. This study focuses on your building's existing equipment and identifies ways to make them run more efficiently. Savings are realized through the systematic evaluation of building systems and implementation of low-cost and no-cost measures targeted to improve system operation and, in many cases, improve occupant comfort.

As a result of these activities, (42) Energy Conservation Opportunities (ECO's) were identified, and are presented in detail in the Summary of Recommendations. For each of the measures engineering estimates of electrical energy and cost saving potential, implementation cost, and simple payback period were performed. These ECO's are described under section 5 of this report.

The estimated **electrical energy savings** for the recommended recommissioning measures totals 728,103 kWh/year and **$77,448 in cost savings**. The estimated **natural gas savings** totals 13,411 MMBtu and **$104,826 in cost savings**. The initial estimated implementation cost for these measures is in the range of $371,500 resulting in a **simple payback of 2.02 years**, before rebates. The final implementation cost estimates or quotes will be provided by the vendors for Macalester College.

These recommendations are broken into three different categories within the rebate form including Recommissioning, Prescriptive and Custom Efficiency. Prescriptive measures can be applied for through Xcel Energy's Energy Conservation Program, as can Custom measures. (Please note that Custom measures need to be pre-approved by Xcel Energy.)

Xcel Energy will also offer to Macalester College an **incentive of up to $65,237** not including Custom rebates, to help offset the cost of implementing recommissioning measures with a payback greater than .75 years.

1.1 Disclaimer

The estimated costs shown for each opportunity are based on previous experience with comparable cost reduction plans in other facilities. While the energy conservation and load reduction measures contained in this report have been reviewed for technical accuracy, Xcel Energy and Edward H. Cook & Associates, P.A. do not guarantee the cost savings or reduction in total energy demand and consumption as presented in the recommendations. Xcel Energy and Edward H. Cook & Associates, P.A. shall, in no event, be liable to Macalester College in the event that the potential energy savings are not achieved.

The recommendations are based on an analysis of conditions observed at the time of the survey, information provided by Xcel Energy and costs based upon the experience of Edward H. Cook & Associates, P.A. on similar projects. Estimated savings are computed on the basis of research by government agencies product literature, and engineering associations. Actual savings will depend on many factors including: conservation measures implemented, seasonal weather variations, fuel price increases and specific energy use practices of the facility's occupants and workers. Performance guidelines provided in the report are for informational purposes only and are not to be construed as a design document. This report is written for energy saving purposes only and should not be used for bid specifications.

Xcel Energy will not benefit in any way from your decision to select a particular contractor or vendor to supply or install the products and measures recommended by Edward H. Cook & Associates, P.A. You are encouraged to ask for the option of contractors or suppliers you have worked with in the past for further information on the suggested measures.

Disturbance, removal or replacement of building material, insulation system, high intensity discharge and fluorescent lamps, lamp ballasts, power factor correction capacitors, starting and running capacitors of motors and other potentially hazardous components that contain asbestos, mercury or PCB's will require proper handling and disposal in accordance with applicable federal and state laws and regulations. It is the customer's responsibility to ensure that the contractor follows such guidelines in implementing the recommendations of this report.

Xcel Energy advises that customers check with their Xcel Energy sales representative to determine the estimated value of their rebate and to verify that the equipment qualifies for Xcel Energy programs prior to implementing any conservation measure. Some measures identified in this report may qualify for an Xcel Energy Custom Efficiency rebate. Custom Efficiency projects require pre-approval prior to purchase and installation. The customer is responsible for submitting project information to their Xcel Energy sales representative to obtain pre-approval for Custom Efficiency projects and to determine the eligible custom rebate amount.

2. Introduction

This report presents the findings resulting from the Recommissioning Study conducted at Macalester College located at 1600 Grand Ave., Saint Paul, MN. The Xcel Energy Recommissioning Program is designed to achieve demand and energy savings in commercial buildings in the Xcel Energy Minnesota territory. Savings are realized through the systematic evaluation of building systems and implementation of low-cost and no-cost measures, targeted to improve system operation and, in many cases, improve occupant comfort.

The primary objectives of the Recommissioning Program are as follows:

- Reduce energy demand and expenditures
- Reduce operation and maintenance expenditures
- Improve building system control and occupant comfort
- Recommend additional energy saving opportunities on capital projects that are identified during this investigation.

A detailed on-site investigation of the primary energy-using equipment in the building was conducted over several months with building staff, controls vendors and other involved parties for the purpose of identifying energy conservation opportunities and system operating deficiencies. For selected pieces of equipment, inspections were made to verify operation and function.

- Equipment was inspected to confirm operability
- Operating parameters were field measured, and temperatures data-logged using a portable device
- Field readings were analyzed to identify energy saving opportunities, and used to calculate the energy savings potential.

The savings estimates presented in this report are based on the Xcel Energy General Service rate A15 TOD for electricity and Medium Commercial Interruptible Service (rate 106) for natural gas. Electric and gas rates are based upon the most current rates from Xcel Energy that are applied to Recommissioning studies.

The published electrical energy tariffs for these building are:

- Summer and Winter On-peak: $0.085093 per kWh
- Summer and Winter Off-peak: $0.085093 per kWh
- Demand charge per month per KW (June – Sept.)On-peak: $10.26
- Demand charge per month per KW (Oct.- May), On-peak: $6.86
- Demand charge per month per KW (Jan. – Dec.), Off-peak: $1.98

Natural gas prices used for the purpose of this study are: $7.56/Dekatherm (DTH)

3. Building Information

3.1 Contact Information

Service Address:	Macalester College 1600 Grand Ave. Saint Paul, MN 55105-1899
Premise numbers:	Electric (main): 0304088485 Natural Gas (main): 0303566410
Customer Contact:	Mark Dickinson Director of Facilities Management Phone: 651-696-6140 Fax: 651-696-6135 dickinsonm@macalester.edu
Engineering Firm:	Edward H. Cook & Associates, P.A. 809 Goodrich Ave. St. Paul, MN 55105 Phone: 651-298-0940 Mobile: 612-940-8177 edward@cookconsultants.com
Principal Engineer:	Edward H. Cook, P.E.
Xcel Energy Representative:	Sara Terrell Phone: 651-229-2573 Mobile: 612-723-2141
Date(s) study performed:	February, 2009 – April, 2010
Electric Service Provided by:	Xcel Energy
Gas Service Provided by:	Xcel Energy
Type of Buildings:	Liberal Arts College Campus
Building Square Feet:	740,708 square feet total

3.2 Building and Mechanical/Electrical System Description

Macalester College located at 1600 Grand Ave., Saint Paul, MN is a complex of buildings comprising a college campus located in the center of a residential area of St. Paul. The buildings that were included in this study are listed below:

- 77 Mac
- Campus Center
- Carnegie Hall
- Kagin Commons
- Old Main
- Wallace Library
- Weyerhaeuser Chapel
- Weyerhaeuser Hall
- Bigelow Hall
- Doty Hall
- Dupre Hall
- George Draper Dayton Hall
- Turck Hall
- Wallace Hall/30 Mac

Heating and cooling equipment for the buildings consists of multiple VAV air-handling units, single zone air-handlers, and fan coil units. Heating is provided by (3) high pressure steam boilers (25,000; 30,000; and 50,000 lbs/hr) which provide steam to all buildings on the campus through a central piped distribution system. This heating plant operates only during the academic year. Cooling is provided by three 860 ton centrifugal water chillers with chilled water circulating through a primary/secondary/tertiary distribution system to the various buildings on campus. The cooling plant operates only during the late spring to early fall. Temperature and building equipment controls are provided by two Energy Management Systems, Trane Summit and Johnson Controls NAE, the latter serving only one building on the campus. There are pneumatic controls on about half of the building VAV terminal units.

A range of exhaust fans serve the rest rooms, kitchen hoods, and general building exhaust systems.

The building structures are a combination of multiple-level masonry or stone buildings mixed with more modern structures of glass curtain wall and having both pitched and flat roofs. All of the spaces except for some of the residence halls are both heated and air-conditioned all year long. The general operating schedule for the equipment in the academic buildings is 6 AM to 10:00 PM Monday through Friday, 8 AM to 12 PM on Saturday and closed on Sundays. The total square footage of all buildings in the study is 740,708 GSF.

3.3 Energy Profile Summary

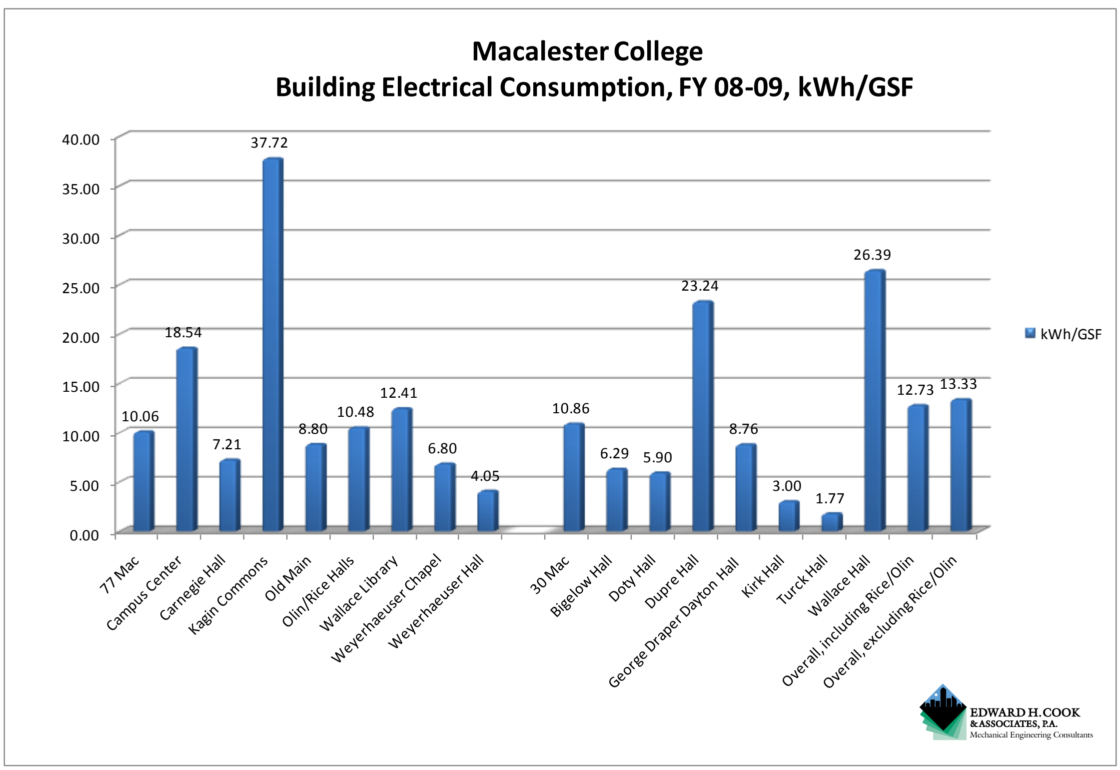
The charts on the following pages depict electrical and steam consumption for the combination of the buildings in the study.

Electric consumption for the twelve months of the last fiscal year for these buildings is based on meter readings from electrical meters installed by the college.

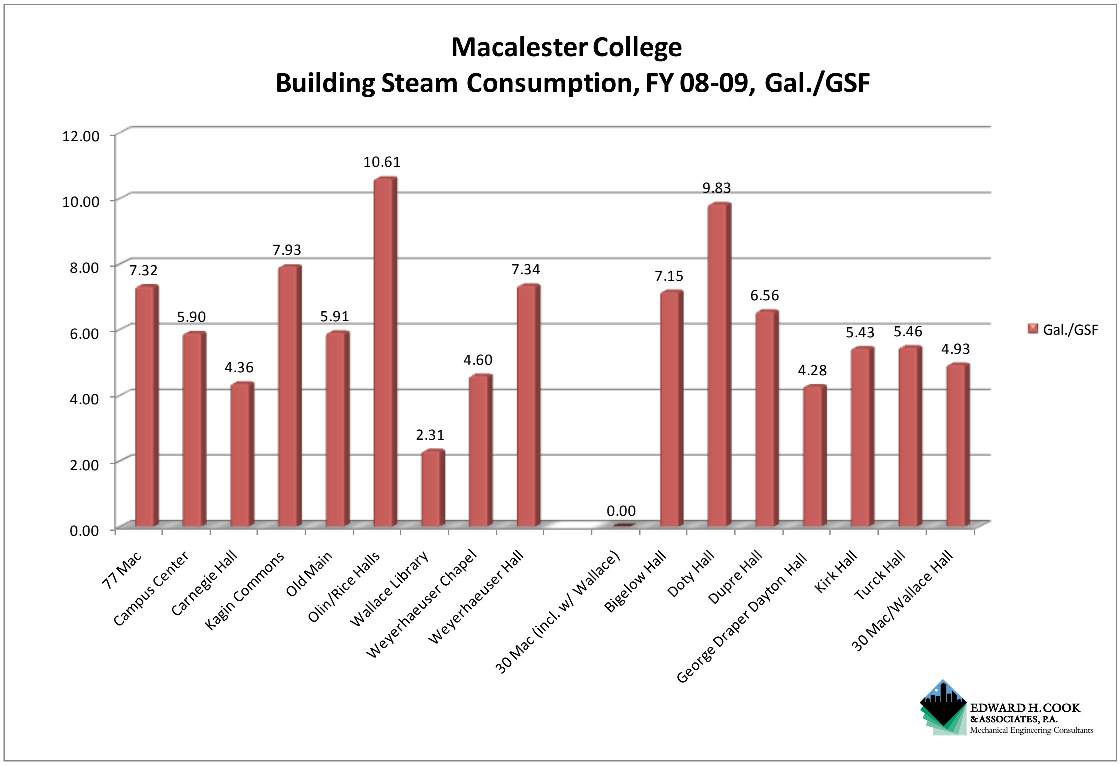
Steam consumption for these same twelve months is based on steam condensate meters which have been installed in these buildings by the college.

Full size charts and individual building consumption charts are located in Appendix C.

3.3.1 Electrical Consumption



3.3.2 Steam Consumption



3.4 Energy Consumption Benchmarks

It is sometimes useful to compare energy consumption of buildings with similar construction, HVAC systems and occupancy in the same geographic area to obtain an understanding of how a certain building or group of building's performance ranks among others of its type in a certain region.

For the buildings in this study the overall annual energy consumption for the most recent twelve month reporting period was as follows:

Electrical: 8,907,985 kWh

Combined Building Area: 668,085 GSF

kWh per GSF = 13.33

Steam (Condensate): 40,300,000 MBtu

Combined Building Area: 677,147 GSF

Btu per GSF = 59,500

<u>BENCHMARK</u>

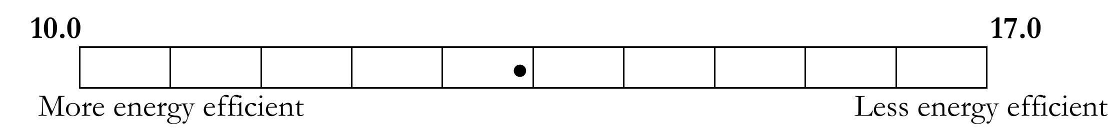
For similar type buildings in this geographic region:

Electrical: ranges from **10 to 17 kWh/GSF**

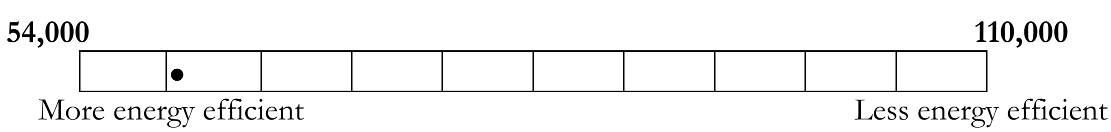
Steam (Condensate): ranges from **54,000 to 110,000 BTU/GSF**

<u>Macalester College Recommissioning Study Buildings</u>

Electrical: 13.33 kWh/GSF



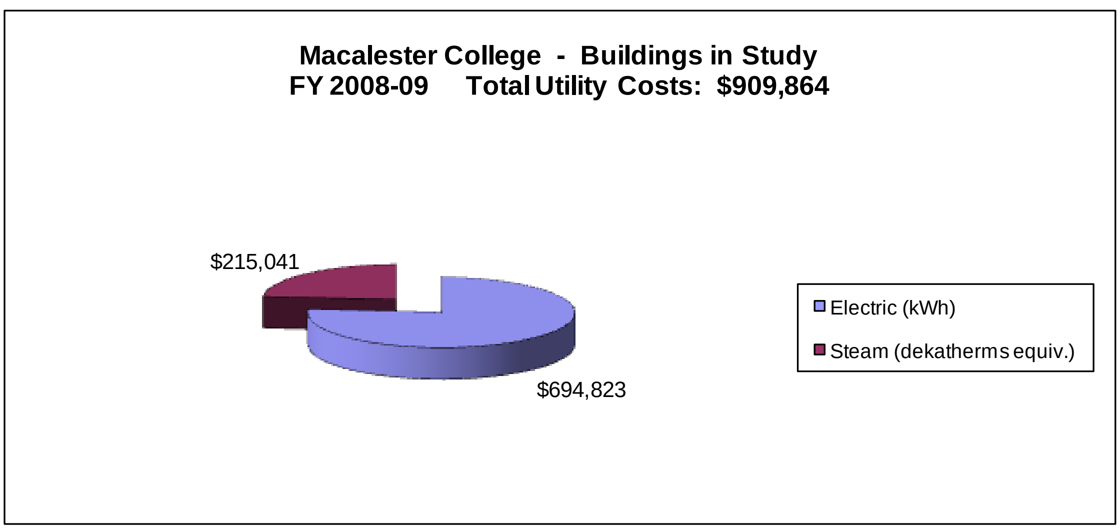
Steam (Condensate): 59,500/GSF



3.5 Electric and Natural Gas Utility Summary

	Annual Cost 2008-09
Electric:	
General Service Rate A-15, TOD	$694,823
Steam (Dekatherms equivalent):	
Medium Interruptible Service	$215,041
Total Electric & Gas Costs	**$909,864**

Chart of Utility Costs for recent twelve month period:



4. Recommissioning Investigation Findings

The investigation phase of the recommissioning project involved conducting several site visits, observing and recording operating conditions, reviewing available operating data to verify equipment operation and establishing a basis for calculating and estimating the potential for energy savings in each of the operating systems.

Equipment Investigated

The energy-using equipment in the HVAC systems, listed in Appendix D, was the subject of the recommissioning investigation. In general, the recommissioning effort focused on the following equipment:

- Air-handling units
- Heating/cooling equipment
- Hot water reheat and radiation systems
- Exhaust fans
- Heating/cooling pumps
- Fan/coil units
- Digital and pneumatic temperature control systems

Recommissioning Procedures

During the investigation, information was collected using trend logs, data loggers and from visual observation that led to an understanding of the basic operating parameters of the systems and conclusions were drawn based on that information. Following multiple site visits over many months additional information was obtained about the condition and functioning of the building systems. This data was then factored into the calculations of energy savings for each of the ECO's identified.

5. Energy Conservation Opportunity Analysis

The table entitled ECO Recommendations Summary, presented in Appendix A1, describes all the recommissioning actions included in this recommissioning study. The results of the Recommissioning Tool calculations and additional detailed electrical and thermal energy savings calculations are presented in Appendix B. The estimated implementation costs are based on discussions with qualified vendors and include equipment, labor, materials and engineering time. Because of the general nature of the definition and the scope of work, some variation between estimated costs and firm quotations should be anticipated. A description of each recommended recommissioning measure is provided below:

ECO #	Energy Conservation Opportunity Description
1	Modify discharge and mixed air reset control on all air-handling units by changing from reset by outside air to reset based on building demand
2	Readjust start and end times of air-handler operation to match building occupancy as closely as possible
3	Provide reset of VAV air-handler discharge static pressure for all AHU's when there is limited cooling demand from the space being served
4	Modify control strategy for heating pump operation to allow individual building heating pumps to be energized based on building demand instead of outside air temperature
5	Separate operating schedules of exhaust fans serving rest rooms from air-handlers so that they can be scheduled independently
6	Modify enthalpy/economizer control program to utilize outside vs. return air dry bulb comparison when chilled water for cooling is not available
7	Modify control sequence on AHU start-up to keep the OA dampers closed until occupancy, unless the AHU's are in economizer mode and the space is calling for cooling
8	Modify operation on all air-handler heating valves to allow them to remain under control when the unit is turned off
9	Modify cooling control algorithm to ensure that the outside air dampers on all air-handlers are 90% open before the cooling valve opens
10	Connect (14) recirculating domestic hot water pumps to the EMS and program to operate on building occupancy
11	Restore night setback/setup control function to all heated/cooled spaces in the academic buildings
12	Install occupancy sensors in select areas to control operation of the electronic VAV terminal units and lighting in Campus Center, Kagin and Dayton Halls to allow for reduced operation when the space is

	vacant
13	Install occupancy sensors in select areas to control operation of the pneumatic VAV terminal units and lighting in Carnegie, Library, Old Main and 30 Mac to allow for reduced operation when the space is vacant
14	Modify chilled water supply software algorithm to allow chilled water pumps in the buildings to energize on building demand rather than when the chiller plant energizes
15	Provide feedback from select academic buildings to allow the chiller plant to be energized based on schedule, demand and outdoor air enthalpy
16	Reset chilled water temperature at the main chiller plant in response to overall campus building space demand
17	Install a separate DX cooling unit to provide cooling for the laboratory animals and allow the chilled water plant to be energized independently
18	Remove inlet vanes and install variable frequency drives (VFD) on supply air-handlers in the Library, Carnegie, & 30 Mac (3 total)
19	Install variable frequency drives (VFD) and remove inlet vanes on return air fans in Carnegie and Weyerhauser Halls, and Library AHU-3 return fan (5 total)
20	Install hand-set interval timers for the grill, kitchen and bakery exhaust fans in the Campus Center so that the units operate only as needed
21	Install a CO_2 sensor in the return air of Campus Center AHU-1 for monitoring and adjusting minimum outside air delivered during occupied periods
22	Install an occupancy sensor in the Game Room of the Campus Center so that the air-handler operates only when the space is occupied
23	Install humidity sensor and controls in the lower level of the Campus Center to allow AHU-1 to cycle on during unoccupied periods only when conditions require humidity control
24	Install variable frequency drives (VFD) on air-handlers serving the Campus Center dining room to operate at reduced speed when the space is marginally occupied
25	Reduce heat loads in the Campus Center Bookstore through lighting improvements and add additional cooling capacity to the Bookstore and Print Shop to allow the discharge air temperature of AHU-2 to be raised from a continuous discharge of 59°
26	Install controls and a damper in the outdoor air intake of Campus Center make-up air unit MUA-2 to allow use of penthouse relief air for make-up prior to using untempered outside air
27	Install a unit heater in Kagin Hall Room 203 to allow air-handler AT-2 to cycle on unoccupied temperature in the main space rather than the small storage room
28	Modify controls to Chapel air-handler S-1 to allow unit to operate only when the space is occupied or on a call for heating/cooling
29	Provide a hot water reset control for the 77 Mac building

30	Install variable frequency drives (VFD) on exhaust fans serving rest rooms and other spaces in the residence halls to operate at reduced airflow during periods of limited occupancy
31	Reset heating water temperature for the residence halls by using feedback from the occupied spaces
32	Restore night setback control function to residence halls by applying heating water temperature depression during late night to early morning hours
33	Provide separate schedules for each of the exhaust/make-up fans in Doty, Dupre and Bigelow Halls so that they can be scheduled independently
34	Modify controls to allow cycling of AHU-1 serving Dayton Hall VAV's during periods of low activity or marginal occupancy
35	Replace existing (32 or 28) watt fluorescent lamps with 25 watt lamps
36	Install occupancy sensors in the hallways of residence halls that currently operate continuously
37	Provide daylighting sensors to reduce lighting levels in south and west-facing rooms in the Library and Campus Center
38	Install occupancy sensors to control lighting in rest rooms of Carnegie, Old Main, 77 Mac, Weyerhauser and Doty Halls
39	Install photocells in the Chapel ambulatory area to turn off lights when the ambient level exceeds a certain level
40	Convert 3-way heating water valves on AHU's to 2-way, install VFD on heating pumps, and provide for pressure control (5 VFD's, 6 controls total)
41	Insulate remaining bare sections of steam/condensate piping in the attic of Bigelow Hall
42	Insulate exterior walls of boilers 1 & 2 in the heating plant, and various steam accessories including valve bonnets

6. Operations, Maintenance and Other Recommendations

While performing this recommissioning study, a number of observations were made regarding the operation and/or condition of various pieces of heating and cooling equipment or control systems located within the building. From these observations several recommendations have been generated which are listed in this section. In general, these items are intended to improve building operations and maintenance or increase system reliability and they may also reduce energy consumption.

#	Issue	Description	Recommendation
1.	Continuous commissioning and maintenance of Energy Management Systems	To operate at peak performance requires that additional time be allocated for observing, adjusting, repairing and maintaining the digital and pneumatic control systems on campus	Reallocate work time from existing staff or hire additional staff to perform tasks related to the operation and maintenance of the two automation and related control systems on campus
2.	Energy Management System floor plan graphics	There are currently only 3 buildings that have floor plans on the graphics: Campus Center, Rice/Olin and 77 Mac	Provide floor plans with temperature setpoints and 5-color spectrum for actual temperature variance from setpoint for all academic buildings
3.	Energy Management System air-handler graphics	There are few graphics that depict air-handlers and heat exchangers which provide useful information to system operators	Provide air-handler and heat exchanger graphics for all air-handlers, heat exchangers and pumps in the academic buildings and residence halls
4.	Monitor for viewing EMS graphics	To fully observe all of the graphic details a larger (22” or more) monitor is desirable	Procure a larger monitor for EMS viewing
5.	Energy usage monitoring	The existing electrical and steam condensate meters can be connected to the EMS for building energy use tracking	Connect the meters to existing field controllers and program to read out on the EMS
6.	Campus Center vs. Student Center nomenclature	On the automation system there are two names for the same building which makes it confusing to identify schedules, trends and operating parameters	Rename all equipment and points associated with Student Center to Campus Center, and restart trends with new names
7.	Return heating water temperatures	There are no sensors that indicate the temperature of return heating water so it is difficult to determine	Install surface temperature sensors on all heating water return piping and tie in to the

		if the system is using more energy than necessary	EMS
8.	Building static pressure sensors – Carnegie and Library	There are no sensors to determine if the building static pressure is being properly relieved by the return air fan/dampers	Install building static pressure sensors to use both in measuring and controlling building static pressure
9.	Winter operation of chilled water pumps in Kagin Hall	The automation system trend identified the chilled water pumps running during the month of November when the chiller plant was no longer in operation	Review the software program and sensor calibration or perform other troubleshooting to determine why the pumps are not operating correctly
10.	Kagin air-handler AT-2 operating with minimum air during unoccupied heating cycle	During unoccupied periods when AT-2 needs to run for heating the space, the minimum setting of outdoor air remains although it is not required and is energy inefficient	Review the software program and determine if there is an error, or if it needs to be modified
11.	Kagin air-handler AT-2 in continuous operation during January, 2010	Air handler AT-2 ran on occupied cycle the entire month of January	Review the software program and determine if there is an error or if some other factor prevented the unit from turning off as normally scheduled
12.	Trends for chilled water plant	There are currently no trends of the operating parameters for this large chiller plant so that efficiency and performance can be tracked	Arrange for trending of all variable parameters in the chiller plant, including chilled water and condensing water temperatures, pump and chiller operating parameters
13.	Chapel air-handler S-1 in continuous operation	Trends show that air handler S-1 ran during periods when it was scheduled to be off	Review the software program and determine if there is an error or if some other factor prevented the unit from turning off as normally scheduled
14.	Chapel air-handler S-2 hot deck temperature fluctuation	Trends show that air handler S-2 hot deck is hunting between 75° and 95°	Review the software program and determine if the PID loop needs tuning or if there are other factors that are causing the hunting to occur
15.	Chilled water pump Campus Center	It was observed that the balance valve was closed to a setting of under 50% flow, according to the pointer arrow on the triple duty valve	This valve (along with all others on pumps with variable frequency drives) should be opened to 100% because there is no reason to restrict flow on a variable pumping system

16.	Campus Center AHU-2 and MUA #2 discharge air control	There is wide variation in the temperature between actual and setpoint, although the chilled water valve is 100% open	Review the mechanical equipment and the software program and determine what factors are causing this variation to occur
17.	Campus Center AHU-3 chilled water valve	There is severe hunting of this chilled water valve resulting in a 15° variance in discharge air temperature	Review the software program and determine if the PID loop needs tuning or if there are other factors that are causing the hunting to occur
18.	Campus Center AHU-3 mixed air damper	There is severe hunting of this actuator resulting in a 20° variance in mixed air temperature	Review the software program and determine if the PID loop needs tuning or if there are other factors that are causing the hunting to occur
19.	Campus Center AHU-4 mixed air and discharge air temperature swings	There is wide variation in these temperatures throughout the day (10°), indicating that the control system is not functioning properly	Review the mechanical equipment and the software program and determine what factors are causing this variation to occur
20.	Campus Center Game Room AHU-4 mixed and discharge air control	There is wide variation in the temperature between actual and setpoint, indicating that the control system is not functioning properly	Review the mechanical equipment and the software program and determine what factors are causing this variation to occur
21.	Campus Center MAU-3 discharge air temperature swings	There is wide variation in these temperatures throughout the day (20°) in the heating mode, indicating that the control system is not functioning properly	Review the mechanical equipment and the software program and determine what factors are causing this variation to occur
22.	Campus Center AHU-4 return air dampers	The airflow is operating in the reverse direction from the return/relief dampers; this could be caused by the return air fan operating below design airflow, or other factors	Review the mechanical equipment operating parameters and troubleshoot to determine what factors are causing this to occur
23.	Weyerhauser Hall exhaust fan EF-3	This fan is creating excessive noise that can be observed both within and outside the building	Perform troubleshooting to find out if the fan is experiencing mechanical issues that could lead to operational failure
24.	Kagin room 102 high air flow	It appears that there is a leaking reheat coil because there is high air flow into the space, even though there is limited heat gain from the space	Perform troubleshooting to find out if the reheat coil is leaking, or whether this is a software issue
25.	Kagin entry	This space is fully heated and	Program for a seasonal floating

	foyer	cooled, but because it is all glass, uses much energy to accomplish this	temperature setpoint to allow higher temperature fluctuations
26.	Library lower level mechanical room exhaust fan and dampers	The exhaust fan is running, however the dampers to allow outside air into the space are disconnected, thereby rendering the exhaust fan useless for cooling the space	Perform troubleshooting to find out if the damper is experiencing mechanical issues or if there are other control or programming issues that need to be corrected

7. MnTAP Steam Optimization Pilot Project

During the course of this Recommissioning Study under a separate project, entitled the Xcel Energy Steam System Optimization Study, the Minnesota Technical Assistance Program (MnTAP) completed a steam system study at Macalester College. The goal of the Xcel Energy Steam System Optimization Study was to identify ways to save natural gas in college campus steam systems in St Paul, Minnesota. This study focused on existing steam equipment in the central steam plant and the distribution system served by the steam plant. The results of this study are included in this report so that all current opportunities for energy efficiency improvements are located in the same document.

The results of the study are summarized in the table below, and are also shown on the Xcel Energy Engineering Assistance Study ECO form in Appendix B.

ECO	Location	ECO Description	Savings (Decatherms)	Savings ($)	Implementation Costs
1	25,000 lb/hr Boiler or the 50,000lb/hr boiler	Install O2 trim system	1,700 150,980 kWh	$17,400 gas $9500 elec	$92,100[11]
2	between Kirk, Carnegie, and Art buildings.	Overwrap 2" of insulation on 431 ft of 5" and 262 ft of 8" steam line	165	$1,650	$12,800
3	Campus Wide	Overwrap 2" of insulation on an estimated additional 2750 ft of 5" and 300 ft of 8" steam line	750	$7,500	$55,700
4	between Kirk, Carnegie, and Art buildings.	Insulate 4 expansions joints	48	$480	$300
5	Oil Pocket	Re-insulate the condensate tank with 2" of insulation	37	$370	$2,600

6	Oil Pocket	Insulate 12.3 ft of 1" and 3" diameter condensate line between Kirk, Carnegie, and Art Buildings.	2.7	$30	$120
7	Oil Pocket to Kirk,	Repair 3 ft of water damaged insulation	0.8	$10	$50

8. Building Envelope Heat Loss Study

During the heating season of 2009-2010, a student attending Macalester college, Karoline Hart, undertook a project to evaluate building envelope heat loss at several buildings on campus using a thermal imaging camera to locate areas of heat loss. The results of her study are included in this report so that all current opportunities for energy efficiency improvements are located in the same document. A copy of her report and recommendations are included in Appendix D of this report.

9. Economic Summary

1. Potential Annual Electrical Energy Savings: 728,103 kWh
2. Potential Annual Natural Gas Savings: 13,411 MMBtu
3. Potential Annual Electrical Cost Savings: $77,448
4. Potential Annual Natural Gas Cost Savings: $104,826
5. Potential Annual Other Cost Savings: $2,000
6. Estimated Implementation Cost: $371,500
7. Simple Payback = Implementation Cost/Annual Cost Savings = 2.02 yrs., before rebates; 1.66 yrs., after rebates, not including Custom rebates

8. Measurement of Energy

Following the implementation of the measures to reduce energy consumption it is beneficial to verify that the reductions that were projected have actually been achieved. There are commercially available software programs like Metrix, E-Cap and Vykon that can track consumption and take into account weather and other variables in analyzing energy data. Energy Star, which is a program sponsored by the EPA and Dept. of Energy also has a tool that can be used for tracking and benchmarking energy consumption. These programs usually require some specialized training in order to achieve meaningful results.

The firm of Edward H. Cook & Associates, P.A. also provides the service of analyzing energy data and creating energy models that take into account weather variations and other predictors. The product of this service is a comprehensive electrical and thermal (fuel) consumption report that normalizes the factors that impact energy consumption and presents them in a clear and useful format. Using statistical techniques that involve multiple linear regression analysis a model is created that can be used to confirm the outcomes of energy efficiency improvement efforts.

For More Information

In addition to the energy conservation measures recommended in this report, Xcel Energy offers cash rebates. Eligibility requirements can be discussed with your Xcel Energy representative or by contacting the Xcel Energy Business Solutions Center at 1-800-481-4700 for more information about qualifying for cash rebates and special discount rates.

Xcel Energy is hopeful that this information is valuable to you as a customer and that you will consider implementing the strategies that are outlined in this report.

9. Appendixes

Appendix A:

- **Xcel Energy Rebates**
- **Appendix A1, ECO Recommendations Summary**
- **Appendix A2, ECO Energy Summary**

Appendix B:

- **Xcel Energy Recommissioning Tool Report**
- **ECO Engineering Analysis and Calculations, ECO's: 8, 10, 18, 19, 37, & 39 through 42**
- **MnTAP Rebate Form**

Appendix C:

- **Building Utility Consumption and Costs**
  - **Total Electric and Steam**
  - **Electric Consumption**
  - **Steam Consumption**
- **Xcel Energy Recommissioning Tariffs**

Appendix D:

- **Campus Layout**
- **Building Equipment Inventory**
- **Building Envelope Thermal Imaging Report**

Appendix E:

- **Photos, pages 1-10**
- **Maintenance & Operations Issues**
- **Trend Logs**