

Energy Usage in McMaster Libraries

Service Learning Project

Arts and Science 3BB3, Technology and Society

April 2011

| | |
|---|----|
| Introduction | 3 |
| 1. Room-by-Room Laptop Usage Analysis..... | 4 |
| Introduction and Methods..... | 4 |
| Results and Analyses | 4 |
| Suggestions to the Library Administration..... | 6 |
| Conclusion..... | 6 |
| 2. Year-to-Year Analysis of Energy Consumption in Thode and Mills Libraries | 7 |
| Methods | 7 |
| Results Summary..... | 13 |
| Conclusion..... | 14 |
| 3. Technology Comparison..... | 15 |
| Introduction and Methods..... | 15 |
| Photocopiers/Printers..... | 15 |
| Microfilm Printers/Scanners..... | 17 |
| Televisions..... | 18 |
| Computers..... | 20 |
| Miscellaneous | 25 |
| Monitors..... | 28 |
| Conclusion..... | 30 |
| 4. Mills' Computers: Potential Energy and Monetary Savings | 32 |
| NightWatchman Software Analysis | 32 |
| Facebook Usage in McMaster Libraries..... | 34 |
| Conclusion..... | 38 |

Introduction

Simon Gooding-Townsend and Jennifer Payne

The primary objective of this project was to analyze energy usage in McMaster libraries, in hopes of enabling cost savings through energy savings and increased awareness of energy usage. The project applies specifically to the Mills, Thode, and Innis libraries, with the bulk of the research being done on Mills. This project was conducted as a service learning component of Dr. Michael Egan's Arts and Science 3BB3 Technology and Society class, in cooperation with Anne Pottier, Associate University Librarian, and Kate Whalen, manager of the Office of Sustainability. Our tutorial was directed by teaching assistant Ruth Collings.

The project is comprised of four parts:

- i) a comparison of energy usage from year to year and an analysis of trends
- ii) an inventory of library technology and its energy usage and comparison with alternatives
- iii) a room-by-room analysis of laptop usage,
- iv) an examination of computer energy usage, including use of Facebook and potential implementation of NightWatchman software.

1. Room-by-Room Laptop Usage Analysis

Robin Eles, Sean Lemon, Nina Strazęula, Anasuiya Surendran and Mike Wexler

Introduction and Methods

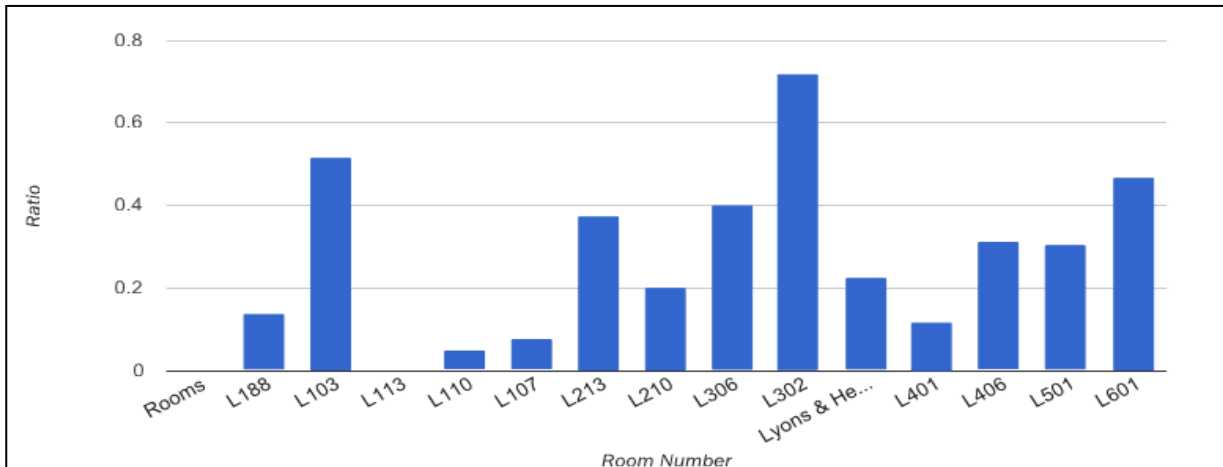
This section explored student energy usage from room-to-room in Mills Memorial Library, focusing specifically on laptop use.

Mills Library was surveyed for rooms with the most student usage; the following rooms were selected to survey: L188, L103, L113, L110, L107, L213, L210, L306, L302, Lyons Media Centre, L401, L406, L501, L601. During the week of March 7th to 11th, 2001, at 8:30 am, 11:30 am, 2:30 pm, 5:30 pm and 8:30 pm, each room was surveyed to determine the number of students present and the number of laptops plugged into an outlet. To find out which rooms had a higher proportion of students charging laptops, the number of charging laptops was divided by the number of students present in the room. These data were used to evaluate student energy usage over the course of a day, and to compare usage between rooms.

Results and Analyses

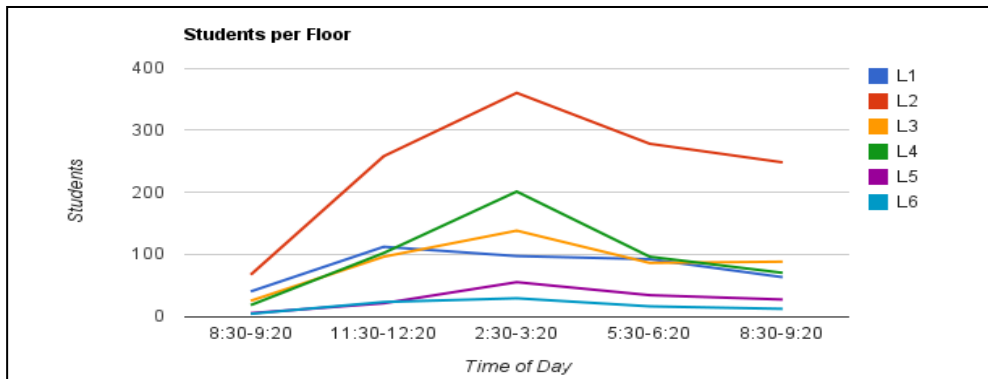
Overall, most rooms had a laptop to student ratio of less than 0.4 laptops/student present, as shown in Figure 1. Room L302 had a higher ratio than most, at 0.7 laptops/student. This is not surprising considering this area is primarily used as a laptop area. Rooms L103 and L601 also had a higher than 0.4 laptop/student ratio; these are the main study areas on the first and sixth floors, respectively. One explanation for the high ratio on these two floors is a lack of desktop computer availability; thus, these two floors may attract students who want to work on laptops.

Figure 1. Room-by-Room average laptop to student ratio (Mills Memorial Library).



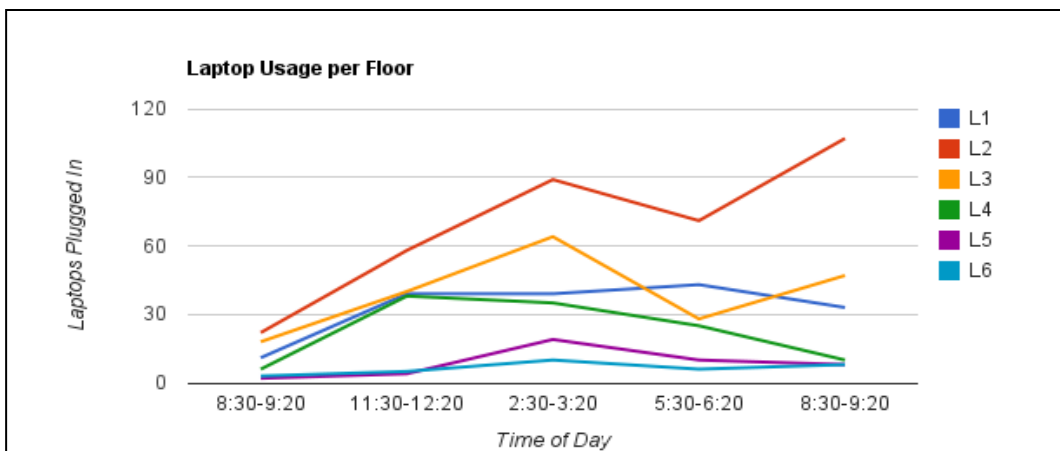
Student traffic in Mills Library follows a similar trend across all six floors, as shown in Figure 2. Traffic is lowest early in the morning (8:30 am to 9:20 am), then rises during the day, as more students arrive on campus. The number of students on each floor peaks in the middle of the day around 3:00 pm, and then declines later in the day, as classes end and students leave campus. The second, third, and fourth floors have the highest level of student traffic.

Figure 2. Students per floor by time of day (Mills Memorial Library).



Generally, the trend in laptop usage is similar to that of student traffic. The main differences are observed on the second and third floors, where laptop usage spikes at night (8:30 pm to 9:20 pm). One explanation for this trend is that a greater percentage of students who go to the library at night stay for an extended period of time. Unlike students who visit the library during the day, for an hour between classes, these students plan to work for multiple hours. Therefore, they are more likely to plug their laptops into available outlets.

Figure 3. Laptop usage per floor by time of day (Mills Memorial Library).



Suggestions to the Library Administration

By encouraging students to charge their personal computers only when necessary, the total energy use in Mills Memorial Library could be reduced. A campaign should target the second floor of the library, since this floor has both the most overall student usage, and the most laptop usage. Perhaps the library might consider encouraging students to plug in laptop computers only when they are being used or are low in battery. If this were done, the informational posters and other materials would be most effective if installed on the second floor. In addition, rooms L103 and L302 should also be targeted since they have the greatest proportion of students using laptops of all the rooms in the Mills library.

Conclusion

After surveying various rooms at designated times, our findings indicate that laptop usage and student traffic varies by room and floor in Mills Memorial Library. The floors with the fewest desktops available for use were more likely to attract students who wished to work on laptops. Predictably, student traffic and laptop usage follow a similar trend during the day. Notably, student traffic decreased during the evening, while laptop usage increased. Although these data were collected from within a limited window, results may help library administration to make decisions helping to reduce future energy usage within Mills.

2. Year-to-Year Analysis of Energy Consumption in Thode and Mills Libraries

Karina Armstrong, Arianne Flemming, Laura Walton and Jeff Wyngaarden

Introduction

This portion of the investigation provides information on energy use during select weeks of the year and shows the energy impact of students within the libraries. Such information may be useful in understanding the minimum amount of electrical energy needed to operate the campus libraries, and in examining ways to reduce energy consumption, and findings could lend support to new policies that might help to limit energy consumption and maximize the utility of the electricity that is consumed.

Methods

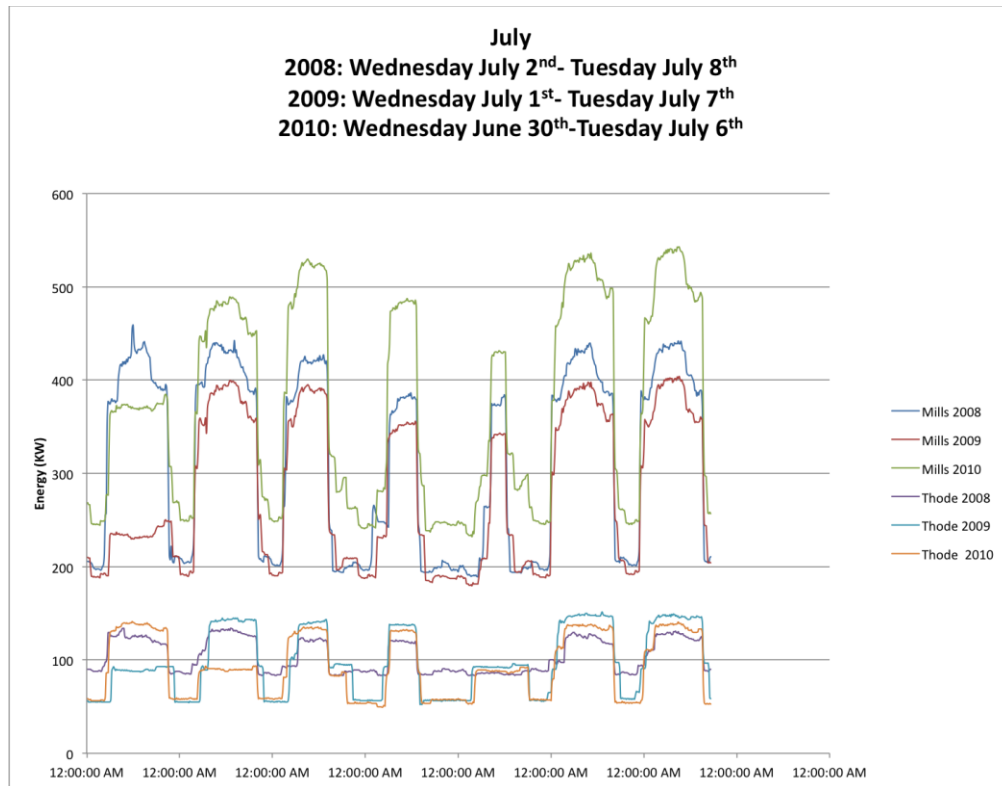
This study examined the trends in energy usage during specific weeks over the last two years. The weeks that were of particular interest were examined using electricity consumption data on Mills and Thode libraries from 2008 to 2011. These data were cross-referenced with statistics on the weather patterns and information on library renovations, programs, and equipment installations. The data were compiled into graphs to show the changes in energy usage in the same weeks from year to year, aligned by events such as reading week or days of the week (e.g. Wednesday July 2nd 2008 and Wednesday July 1st 2009), as shown in Figures 4 to 9.

Results

Mills: July 2008 and 2009

The energy trends in Mills were very similar between 2008 and 2009, without significant increases or decreases. Energy usage in Mills was slightly higher in 2008 than 2009; this was likely due to warmer temperatures and the need for more air conditioning as compared to the frigid summer of 2009 in which air conditioning was not needed at all other than for purposes of computer and system cooling. July 2009 was the coldest month of July since 1992. The lowest energy usage for both July 2008 and 2009 was on July 1st, when Mills library was closed for Canada Day.

Figure 4. Energy Usage in Mills and Thode, July 2008 to 2010.



Mills Baseline:

2008 - approximately 200 kW
 2009 - 195 kW
 2010 – approximately 250 kW

Thode Baseline:

2008 - approximately 90kW
 2009 - 60 kW
 2010 - 60 kW

Thode: July 2008 and 2009

A very steady trend of energy usage can be seen in Thode throughout all hours of the day, indicating perhaps lighting, computers and so forth were left on for the entire day and night without any kind of “kill switch” in place. This trend changed in 2009 when there are significant dips in kW energy usage in off times such as the middle of the night, creating a significantly lower baseline energy usage in Thode. Energy usage in Thode was particularly low on weekends in the summer, when it was closed, demonstrating that if the libraries are unlikely to be used it is beneficial from an energy expenditure perspective to close the facilities. Interestingly, the most energy usage in Thode was in July 2009; there was a lot of construction in Thode during this time, which would have likely caused the spike energy usage.

Mills: July 2010

July 2010 was one of the hottest summers on record (37.9 degrees C in Hamilton on July 5th). Baseline energy usage of Mills increased approximately 50 kW/hour between July 2009 and July 2010 and the highest energy levels increased nearly 100 kW since July 2009. The combination of increased need for cooling and construction likely caused this increase. As in 2008 and 2009, there was significantly lower energy usage on July 1st Canada Day. The days of highest energy usage were on Thursdays, Fridays, Mondays and Tuesdays, with lower usage on weekends. Construction of the Lyons New Media Centre was also ongoing during this period.

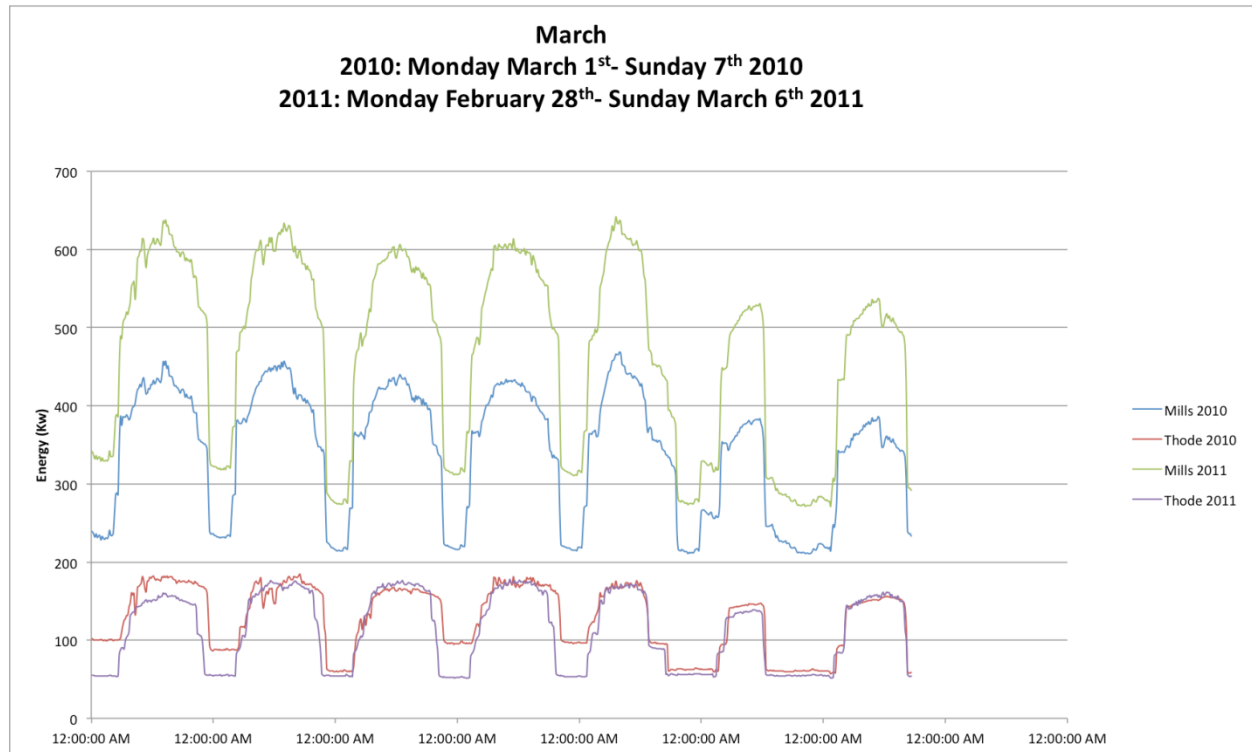
On July 1st 2009 and July 1st 2010, the energy usage was much lower than other days; again, this is likely due to Canada Day closing. In May 2010, the library began extensive renovations on the 4th floor of Mills, which were carried throughout the summer. In June 2010, compact shelving was moved from the first to fourth floor. Books were put into the mechanised shelves replacing the sheet music collection; it is likely that these shelves were used much more often after the move.

Furthermore, in the early summer of 2010, new mechanical equipment was installed, and new rooftop air-conditioning units were put in place, again providing reasons for the large increase in energy usage in 2010. As previously mentioned, 2010 was the hottest summer on record in Hamilton, thus the old and newly installed air-conditioning units would have been operating at a higher level than in the previous summer.

Thode: July 2010

Thode did not experience the same increases in energy usage as Mills. The energy usage in Thode was relatively constant for the entire week examined (apart from a decrease on Canada Day when library was closed, and lower usage on weekends when the library was closed).

Figure 5. Energy Usage in Mills and Thode, July 2008 to 2010.



Mills Baseline:

2010: 220kW

2011: 320kW

Thode Baseline:

2010: approximately 75kW

2011: 50kW

Mills: March 2010 and 2011

There was a significantly higher baseline (approximately 100 kW) in Mills from March 2010 to 2011. This would have been due to increased number of students in the library during the day, as well as the implementation of the new projects that occurred over the summer and were completed in September, such as the Lyons New Media Centre, which was put in place September 2010. Additional renovations were done over the summer. Within the centre there are 12 desktop computers; a video wall that is on all the time during operating hours; 10 digital signage machines; 8 people with working offices; a gaming room; and 2 edit suites. Also, within the Health Forum there is a large conference room with 4 major projectors, electric blinds and new lighting. Although all implementations are energy efficient options, the volume of additions likely caused this significant energy spike. New lights were also installed in lobby in February 2011 that may have contributed to the energy use increase.

Thode: March 2010 and 2011

Energy usage stayed relatively constant between 2010 and 2011, with no drastic increases or decreases. There is a slightly lower baseline in 2011. Installing effective kill-switches in place during off-use hours would be beneficial.

Figure 6. Energy Usage, Reading Week, 2010 and 2011

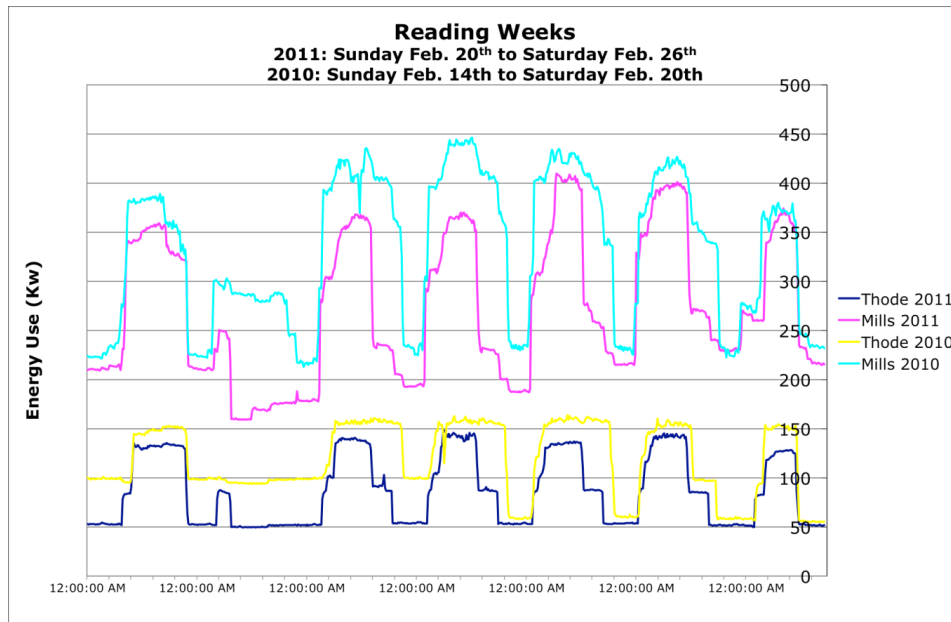


Figure 7. Energy Usage 2nd Week September 2009- 2010

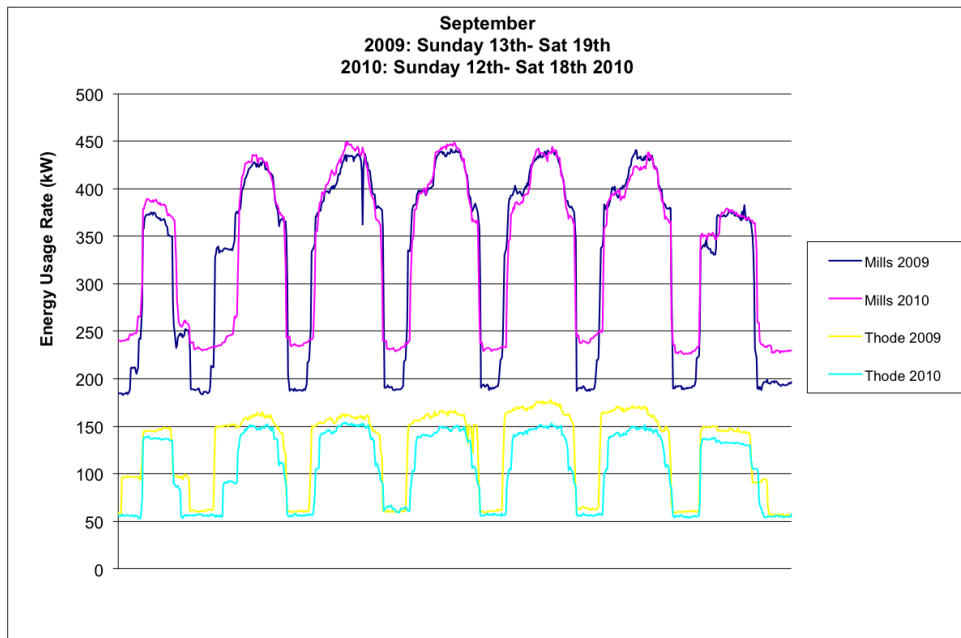


Figure 7. Energy Usage, 1st week November 2009 and 2010

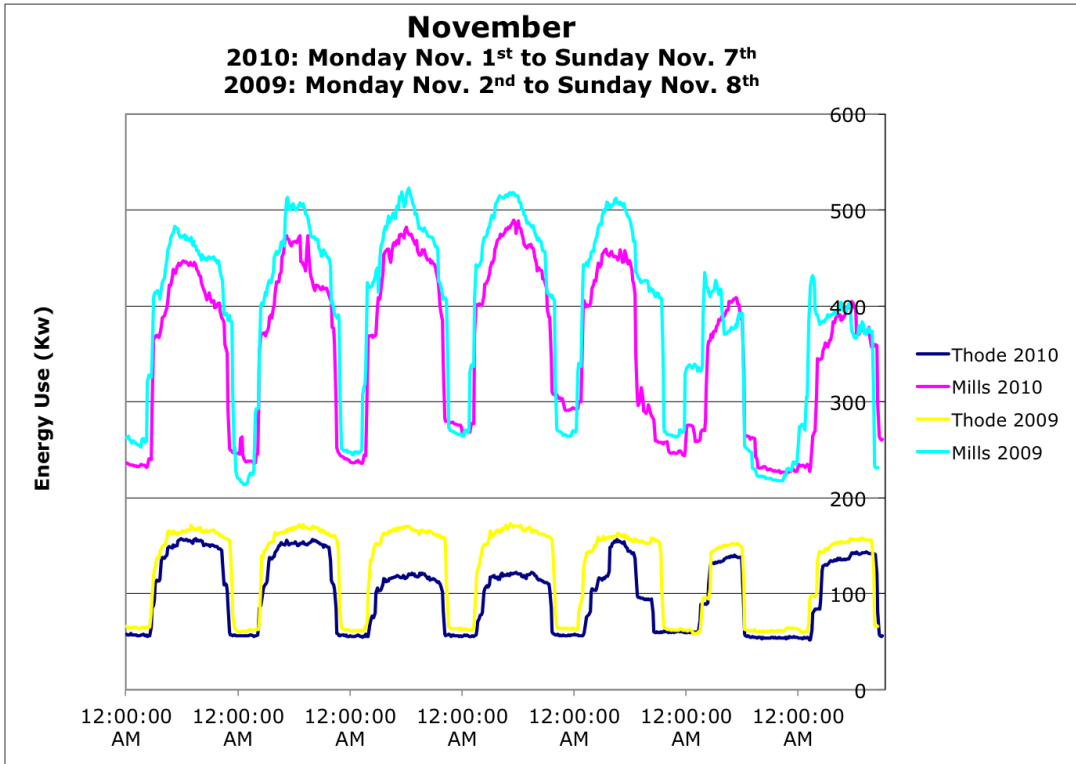


Figure 8. Energy Usage, 2nd Week of December, 2009-2010

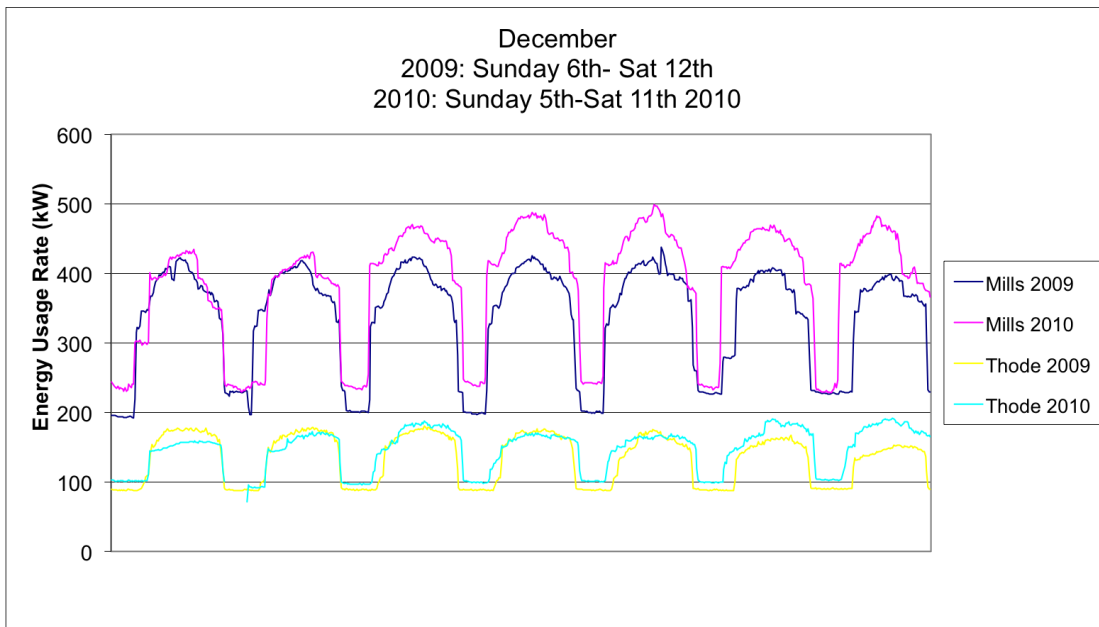
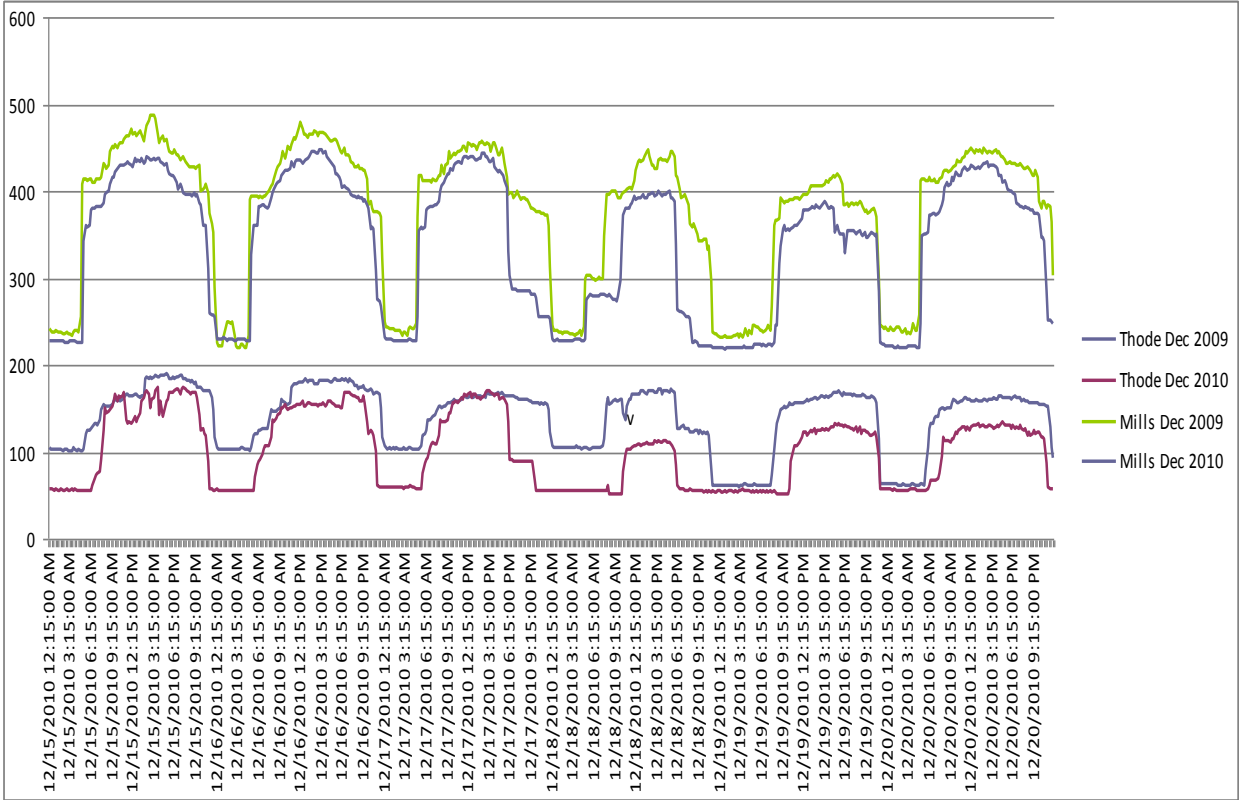


Figure 9. Energy Usage, 3rd Week of December, 2009 (Wednesday December 16th to Tuesday 21st), and 2010 (Wednesday December 15th to Monday 20th).



Results Summary

There are several significant trends in the data. Baseline energy consumption within both Mills and Thode (generally) increased from one year to the next. The most plausible explanation for this trend seems to be the installation of new equipment. However, overall consumption is on the decline as daytime usage appears to have decreased from one year to the next. In addition, consumption was dependant on outdoor temperature. Based on analysis of weather trends and energy usage rates it was discovered that temperature extremes result in significant increases in energy consumption in the library, while milder weather saw reductions in the energy used to control the library's climate. Clearly, this finding means that significant savings in energy and finances can be realized by minimizing the need to alter the interior climate of the libraries. In addition, from analysis of this data, it was observed that baseline usage, including equipment such as freezers and climate-control systems, contributes significantly to overall daytime and overnight energy usage rates. Results indicate that student usage is the most irregular factor contributing to energy usage and it accounts for much of the change that has

been observed over the last two years. The effect of closing the libraries is considerable; the energy savings realized by limiting the hours that the libraries are open is more significant than any other energy saving strategy. Renovations account for much of the energy consumption during the summer, when student usage is a smaller proportion of overall consumption.

Conclusion

While it may not be possible to reduce the baseline consumption significantly because of the need for climate control in the libraries, these findings support transitioning towards alternative or high-efficiency heating and cooling technologies. In addition, renovations and new equipment contribute considerably to the energy usage in the libraries; the establishment of the Lyons New Media Centre in Mills, and the Reactor Café in Thode, along with other changes in the equipment present in the libraries, led to significant increase in energy usage within both libraries. Reducing the amount of time that equipment is left on by implementing a “kill switch” program could save considerable amounts of energy; in addition, streamlining the computer update process could reduce baseline consumption by allowing computers to be turned off on some nights. Ideally, the energy usage rate in the libraries should be proportional to the number of occupants. The most efficient way to accomplish this has been limiting the hours of operation of the libraries to match student usage. By reducing hours during weekends and holidays McMaster’s libraries could increase the average utility per kilowatt hour and realize significant energy savings.

3. Technology Comparison

Jason Binder, Raman Kumar, Andrew McCormick, Jennifer Payne and Michelle Reid

Introduction and Methods

The goal of this component of the project was examine and evaluate alternatives (if any) to current technology in Mills and Thode.

The first step was to record the specific hardware within Mills and Thode according to their respective floors.¹ Once tabulated, energy usage per machine was calculated and then compared with leading competitors.

An assumed operating time of 8:00 am to 11:00 pm (15 hr) Monday through Thursday, 8:00 am to 6:00 pm (10 hr) Friday, 10:30 am to 6:00 pm (7.5 hr) Saturday, and 10:30 am to 11:00 pm (12.5hr) Sunday was used, for an accumulated weekly operating time of 45 hours. These numbers are based on the standard hours of operation of Mills and Thode, and give a close approximation of actual run times. Below is a report organized by technology type.

Photocopiers/Printers

a. Sharp Direct MX3501N – 10 units in Mills, 1 in Thode.

Max wattage: 1440W or 1.44 kW

Sleep wattage: 13W or 0.013 kW

Low power mode wattage: 185W or 0.185 kW²

Energy Usage Range (over one week):

a) Max Power

0.013 kW x 45h – 1.44 kW x 45h

0.585 kWh – 64.8 kWh

b) Low Power

¹ See attached excel documents (“Mills Inventory” and “Thode Inventory”). Note that some hardware may have been missed.

² Source: http://www.sharp.ca/pdf/br_MX3501N_pdf.pdf

0.013 kW x 45h – 0.185 kW x 45h

0.585 kWh – 8.325 kWh

Recommendation:

Low power mode will save approximately 225.9kWh per printer every month, which amounts to \$14.46 per machine, or \$159.03 for all 11 machines.³

Comparison:

The Sharp Direct MX3501N is one of the most energy efficient printer-photocopier machines in Sharp's colour lineup, outdone only by the Sharp Direct MX2300N in Low Power Mode by a meager 46.45 W.

b. Sharp Direct MX2300N – 1 unit in Mills.

Max wattage: 1440W or 1.44 kW

Sleep wattage: 13W or 0.013 kW

Low power mode wattage: 138.55W or 0.13855 kW⁴

Energy Usage Range (over one week):

a) Max Power

0.013 kW x 45h – 1.44 kW x 45h

0.585 kWh – 64.8 kWh

b) Low Power

0.013 kW x 45h – 0.13855 kW x 45h

0.585 kWh – 6.235 kWh

Recommendation:

Low power mode will save approximately 234.26kWh every month, which amounts to \$14.99.⁵

³ Based on a rate of 6.4 ¢/kWh.

Source: http://www.ieso.ca/imoweb/siteShared/regulated_prices.asp?sid=ic

⁴ Source: http://www.sharp.ca/pdf/br_MX2300N_pdf.pdf

Comparison:

The Sharp Direct MX2300N is the most energy efficient printer-photocopier machine in Sharp's colour lineup. 11 MX2300Ns will use approximately 22.99 kWh less than 11 MX3501Ns over the period of a week, and 91.96 kWh over a month, saving approximately \$5.89 per month.

Analysis:

It is not worth upgrading either machine at this time, as the MX2300N is the most energy efficient of Sharp's colour catalogue, and while the MX3501N uses slightly more energy this is only in Low Power Mode, replacing all 11 machines with the MX2300N is not recommended: the savings amount to \$5.89 per month, while a single MX2300N costs \$2499.00.⁶ Both the Sharp MX2300N and the MX3501N hold up well against comparable Xerox machines.⁷ While the Xerox ColorQube is more environmentally friendly, using solid ink rather than cartridge ink and toner, this in turn can use slightly more wattage, although the difference is minimal.⁸ The real issue is found in the price tag, as the ColorQube starts at a baseline \$19,799.⁹ Similarly the Sharp MX2300N and MX3501N are virtually the same as any comparable Canon all-in-one colour machines, except they do not have the added Low Power Mode feature.¹⁰ That said, it is highly recommended that the library take special care to ensure that all units are operating in Low Power Mode.

Microfilm Printers/Scanners

a. Canon Fileprint 300 - 1 unit in Mills, 2 unit in Thode.

Could not find energy specifications for this device.

⁵ Based on a rate of 6.4 ¢/kWh.

⁶ Source: <http://www.businessneedz.com/Sharp-MX-2300N-Color-Digital-Copier.html>

⁷ Source: <http://www.office.xerox.com/latest/856BR-01.PDF>

⁸ Source: <http://www.office.xerox.com/solid-ink/solid-ink-faq/enus.html>

⁹ Source: <http://www.office.xerox.com/multifunction-printer/color-multifunction/colorqube-9201-9202-9203/enus.html>

¹⁰ Source: http://www.canon.ca/inetCA/products?m=gp&pid=8398#_030

http://www.canon.ca/inetCA/products?m=gp&pid=3762#_030

http://www.canon.ca/inetCA/products?m=gp&pid=3754#_030

http://www.canon.ca/inetCA/products?m=gp&pid=3674#_030

b. Canon Fileprint 400 - 3 units in Mills.

Power Usage: 380W¹¹

Recommendations:

Since the Canon Fileprint 400 uses such little energy – approximately 17.1kWh over a week’s duration – there are few cost-effective alternatives. With such low energy use, all 3 units cost roughly \$3.28 per week in total, and \$13.13 per month.

By comparison, the Fileprint 250, which uses 170W,¹² uses approximately 7.65kWh over a week. 3 units of the Fileprint 250 would therefore cost roughly \$0.49 per week, and \$5.88 per month, a difference of \$7.25 per month.¹³

Analysis:

Due to a lack of pricing information for the various printers, it is difficult to make accurate conclusions. However, the prices of toner cartridges, while not energy related, certainly can have a monetary impact. A Canon Fileprint 400 toner cartridge costs \$199.97, while the Fileprint 300 cartridges cost \$45.97 each. The Fileprint 250 falls in the middle, with cartridges priced at \$107.97.¹⁴

Televisions

a. LG Flatron SP4200K - 2 units in Mills

Max wattage: 40W or 0.040 kW

¹¹ Source: <http://www.donnegan.com/video/ms400.pdf>

¹² Source: <http://www.donnegan.com/video/ms400.pdf>

Based on a rate of 6.4 ¢/kWh.

¹³ Based on a rate of 6.4 ¢/kWh.

¹⁴ Sources:

<http://www.cannoninkjet.com/mallsitecgi/search.php?limit=compatibility&show=CanonFileprint400&uid=c19beb4e7273bec27ced4dffdd47ae02>

<http://www.cannoninkjet.com/cartridges.CanonFilePrint300.html>

<http://www.cannoninkjet.com/mallsitecgi/search.php?limit=compatibility&show=CanonFilePrint250&uid=1d8fd7ebb9dd9604f282e950232f20d3>

Sleep wattage: 1W or 0.001 kW

Energy Usage Range (over one week):

0.040 kW x 45h

1.8 kWh¹⁵

b. Samsung LM46C - 4 units in Mills

Could not find energy specifications for this device.

c. LG 32LH30 - 2 units in Mills

Wattage: 192W¹⁶

Energy Usage Range (over one week):

0.192kW x 45h

8.64kW

d. JVC P'Art - 3 units in Mills

Could not find energy specifications for this device.

Recommendations and Analysis:

The televisions that are used in Mills and Thode Libraries vary substantially in energy consumption and price, depending on the number of units ordered as well as other factors. Therefore it is recommended that purchasing decisions be based upon energy usage. The most energy efficient televisions currently on the market are those in the Sharp Aquous line. LCD televisions generally consume the least amount of power, with this brand costing an average of \$13/year to run, depending on the screen size.

¹⁵Source: http://www.lg.com/ca_en/computer-products/monitors/LG-lcd-monitor-W2353V-PF.jsp

¹⁶Source: http://www.lg.com/ca_en/tv-audio-video/tv/LG-lcd-tv-32LH30.jsp

Compared to some televisions currently being used by this could save upwards of \$15.75/year per television set.

Computers

a. Optiplex GX520 – 17 units in Mills, 3 in Thode.

Max wattage: 130.55W or 0.131 kW

Sleep wattage: same as low power wattage.

Low power wattage: 1.24W or 0.0124 kW

Energy Usage Range (over one week):

a) Max Power

$0.00124 \text{ kW} \times 45\text{h} - 0.131 \text{ kW} \times 45\text{h}$

0.0558 kWh – 5.895 kWh

b) Low power mode

$0.00124 \text{ kW} \times 45\text{h}$

0.0558 kWh

Recommendation:

Lower power mode will save approximately 466.36 kWh every month, which amounts to \$29.40 in savings in total.

Comparison:

The Mac Mini is the most energy efficient CPU available. Comparing maximum power consumption, it would save 327 kWh for 20 machines per month, or \$20.92.

b. Optiplex GX620 – 90 units in Mills, 27 units in Thode.

Max wattage: 125W or 0.125 kW

Sleep wattage: 1.20W or 0.0012 kW

Low power mode wattage: 1.20W or 0.0012 kW

Energy Usage Range (over one week):

a) Max Power

$0.0012 \text{ kW} \times 45\text{h} - 0.125 \text{ kW} \times 45\text{h}$

0.054 - 5.63

b) Low Power

$0.0012 \text{ kW} \times 45\text{h}$

0.054 kWh

Recommendation:

Low power mode will save approximately 2609.73 kWh every month for the 117 machines, which amounts to \$167.02 per month.

Comparison:

117 Mac minis would save 1792.6 kWh per month or \$114.73 per month.

c. Other Windows-based computers - 15 in Mills

Note: Mills library has several other computer types with similar energy consumption rates. These types include the Dell Precision T1500, HP Compaq DC7900, LG, and IBM 300GL. For the sake of simplicity, this category will average the maximum and low power consumption for these computers.

a) Max power

$0.00124 \text{ kW} \times 45\text{h} - 0.125 \text{ kW} \times 45\text{h}$

0.0558 kWh - 5.625 kWh

b) Low power mode

$0.00124 \text{ kW} \times 45\text{h}$

0.0558 kWh

Recommendation:

Lower power mode will save approximately 334.15 kWh every month, which amounts to \$21.39.

Comparison:

15 Mac Minis instead of these computers would save 230 kWh or \$14.69 per month.

Analysis:

The most effective means of increasing efficiency would be to operate the computers in low power mode, but switching to a higher power mode when needed. The Mac Mini could be considered in the future as an upgrade to the current computers. Since the energy savings are not substantial, there is not a pressing need to upgrade. However, considering the age of computers like the GX520, it would be reasonable for the university to upgrade within the next two years. That would be an ideal opportunity for McMaster's libraries to invest in more efficient computers.

d. 13-inch MacBook (2008 model) – 27 units in Mills

Energy Star certification, EPEAT (Electronic Product Environmental Assessment Tool) Gold Rating.

Data could not be found for idle/max wattage, but the 2008 model runs on a 45-Watt hour lithium-polymer battery, with a 60 Watt Magsafe power adapter. When considering 2010 models, it should be noted that MacBook model MC516 uses 39% less energy and has a 20% carbon footprint than the original MacBook.¹⁷ Also, the 2010 model has a power adaptor that uses 83% less power than the previous generation MacBook when plugged in to an outlet but not connected to the computer (no-load usage).¹⁸

Regardless of model type, it is important to consider the settings for the machine in question. Screen brightness has a large impact on power usage. For the 2010 model functioning at 100V, an idle machine with the screen turned off uses 5.1W versus 10.5 W for a screen at full brightness. This two-fold difference holds true for machines drawing 115 V and 230 V, noting that power consumption

¹⁷ MacBook Environmental Report, May 2010: <http://www.apple.com/environment/reports/>

¹⁸ MacBook Environmental Report, May 2010: <http://www.apple.com/environment/reports/>

doubles when the screen is set to full brightness. Therefore, care should be taken to set screens to 50% brightness, which optimizes battery life and balances energy consumption with clear visibility.

e. iMac 8.1

24 inch, 2.8 GHz, 2008 Model – 6 units in Mills, 12 Units in Thode

- Max continuous power: 280 W

20 inch, 2.66 GHz, 2008 Model – 55 units in Mills, 8 Units in Thode

- Max continuous power: 200 W

As both models do not function at maximum continuous power for the 45 hours/week assumption, it is not feasible to calculate the energy difference between the two models.

Considering the 2009 iMac model data:¹⁹

| Power Consumption | Idle | CPU Max |
|--------------------------|-------------|----------------|
| 24-inch 2.93 GHz | 116.4 W | 192.2 W |
| 20-inch 2.66 GHz | 60.7 W | 108.9 W |

Energy Usage Range (over one week)

a) 24-inch 2.93 GHz

$$0.1164 \text{ kW} \times 45\text{h} - 0.1922 \text{ kW} \times 45\text{h}$$

5.238 kWh – 8.649 kWh

b) 20-inch 2.66 GHz

$$0.0607 \text{ kW} \times 45\text{h} - 0.1089 \text{ kW} \times 45\text{h}$$

2.7315 kWh – 4.9005 kWh

The 20-inch model therefore uses 52% of the power that the 24-inch model uses when idle, compared to 57% at the maximum power. Based on prices at the time of purchase, the 20-inch 2008

¹⁹ Source: <http://support.apple.com/kb/HT3559>

model cost \$1499, whereas the 24-inch 2008 model cost \$1799.²⁰ When considering price and power usage, the 20-inch model appears to be more economical. However, considerations should be made as to whether the extra processing power of the 24-inch screen makes it a worthwhile purchase. Regardless of the chosen model, screen brightness settings should be considered to limit energy consumption per machine. Also, factory settings should be changed to set 'screen sleep' and 'screen idle' modes to auto-start after a shorter time period, as a number of computers surveyed had sleep-mode instigating after 15 minutes. This would reduce the overall energy consumption of computers while they are not in use.

f. MacPro 10.5.8 2.8 GHz – 15 units in Lyons New Media Centre, Mills

Based on the 2008 Mac Pro data, 8-core 2.8 GHz.

Max power: 318 W or 0.318 kW

Idle power: 155 W or 0.155 kW

Power Usage Range (over one week)

0.155 kW x 45h – 0.318 kW x 45h

6.975 kWh – 14.31 kWh

Analysis:

Energy usage for these computers is 2-3 times higher than the iMacs when running at maximum power, but it is understood that the higher processing power is required for the energy-intensive media work done in Lyons. Considering a rate of 6.4 ¢/kWh, costs for running these machines during a 45 hour week would range from \$26.78 - \$54.95 per month, depending on the processing power required for the projects.

Recommendation:

If the computers are left on idle when the Lyons New Media Centre is closed (for the other 123 hours per week), they will cost an additional \$219.63 per month. Therefore, it is recommended that the computers be turned off during the night hours.

²⁰ Source: http://www.macspeedzone.com/html/hubs/specs/archive/08/imac_april.shtml

f. MacBook Pro 13-inch – 12 units in Lyons New Media Centre, Mills

Meets Energy Star 5.0 Requirements, Gold Rating EPEAT

Calculations based on 2010 MacBook models MC374, MC375²¹

Power Consumption for 13-inch MacBook Pro

| Mode | 100V | 115V | 230V |
|--------------------------|--------------|--------------|--------------|
| Power adapter, no-load | 0.18W | 0.19W | 0.24W |
| Off | 0.31W | 0.31W | 0.37W |
| Sleep | 1.19W | 1.19W | 1.30W |
| Idle—Display off / on | 6.6W / 12.5W | 6.6W / 12.5W | 6.8W / 13.2W |
| Power adapter efficiency | 88.3% | 88.2% | 87.7% |

22

Recommendations:

The cost difference between leaving the laptops in sleep mode versus idle mode is nearly negligible. When not in use, it is still advisable to leave the laptops fully charged either off or in sleep mode to avoid unnecessary energy draw to power standby mode. Monitor brightness should also be adjusted to 50% to reduce power consumption and prolong battery life.

Miscellaneous

a. 3M Library Systems Selfcheck System 6420 Selfcheck - 3 units in Mills

Could not find energy specifications for this device.

Recommendations and Analysis:

The cost of this self checkout machine is \$24 154.99²³, therefore it is recommended that an in-depth analysis, including daily usage and energy consumption specifications information, be undertaken in order to determine the efficacy and potential benefit/cost of these machines.

²¹ MacBook Pro 13-inch Environmental Report, April 2010: <http://www.apple.com/environment/reports/>

²² MacBook Pro 13-inch Environmental Report, April 2010: <http://www.apple.com/environment/reports/>

²³Source: <http://www.demco.com/goto?blk100882>

b. Simplex Digital Clock - 20 units in Mills, 7 units in Thode

Could not find energy specifications for this device.

c. Hitachi Projector CP X328 - 1 unit in Mills

Wattage: 240W

Cost: \$7 495²⁴

Energy Usage Range (over one week):

0.24kW x 45h

10.8kWh

Recommendations and Analysis:

The cost of running this projector full time is \$35.94/year, however it is unlikely for a projector to be on at all times. In comparison to other projectors, even energy efficient models, the efficiency of this particular model is substantial, other ecologically friendly projectors boast 300 watts for lamp consumption. There are, however, several cheaper alternatives that have similar wattage.²⁵

d. VCR/DVD JVC HRXVC1U - 3 units in Mills

Wattage: 192W²⁶

Energy User Range (over one week):

0.192 x 45h

8.64kWh

Recommendations and Analysis:

²⁴Source: <http://www.aboutprojectors.com/Hitachi-CP-X328-projector.html>

²⁵Source: <http://www.panasonic.com/business/projectors/ecology.asp>

²⁶Source: <http://www.jvc.ca/en/consumer/archived-product-detail.asp?model=HR-XVC1U>

The power consumption of VCR/DVD combination units is quite variable, however Energy Star approved models are highly recommended, which can use as little as one quarter of the electricity compared to standard models, including phantom load usage²⁷.

e. Hand Dryer World Order Ltd. 'No Touch' Model NT126 - 4 units in Mills

Wattage: 2000W²⁸

Energy User Range (over one week):

2kW x 45h

90 kWh

f. Coman Hand Dryer - A5 2637 - 3 units in Thode

Could not find energy specifications for this device.

Recommendations and Analysis:

It is difficult to compare the energy efficiency and actual performance of various hand dryers, however it is recommended that the libraries gradually shift towards high speed versus warm air dryers. High speed dryers use up to 80% less energy than standard warm air models and additionally help prevent the spread of potentially harmful bacteria²⁹.

g. Haws Drinking Fountain - 3 units in Mills

Could not find energy specifications for this device.

h. Elkay Drinking Fountain - 1 unit in Mills

²⁷Source:

http://www.energystar.gov/index.cfm?fuseaction=_FIND_A_PRODUCT.showProductGroup&pgw_code=HA

²⁸Source: <http://www.restaurantequipment.net/new/World-Dryer-NT126-WH-Surface-Mount-Hand-Dryer~WOR-NT126-WH.html>

²⁹<http://www.energyrefuge.com/archives/eco-friendly-hand-dryers.htm>

Could not find energy specifications for this device.

Recommendations and Analysis:

Since the power consumption for both drinking fountains was not able to be determined, recommendations must be based upon other ecologically friendly factors. Halsey Taylor offers a line of environmentally friendly fountains that claim to harbour more than a 50% greater energy efficiency, a 40% reduction in water usage, and an 8% reduction in refrigerant compared to standard models. Price ranges for these models are roughly equivalent to standard models.³⁰

Monitors

Recommendations and Analysis:

The majority of non-Apple monitors in use in the Mills and Thode libraries, the Dell E193FP and E196FP, are moderately efficient, fitting the Energy Star criteria³¹ of 2 W or less during standby mode, 1 W or less when off, and on criteria based on screen size and number of megapixels. Assuming operation for 45 hours per week in normal mode, the 90 Dell E193FP monitors use roughly 8000 kWh hours per year, costing \$513 annually. The 47 Dell E196FP monitors use roughly 3700 kWh hours per year, costing \$239 annually.

Nonetheless, there are certainly more efficient options on the market. For example, the Philips 150S7 uses a stunning 12.8 W in normal operation, in comparison to the Dell E193FP's 34 W or the Dell E196FP's 38 W. A 137 monitor suite of this Philips model would use roughly 4100 kWh per year, as opposed to about 12 000 W for the 137 Dell monitors currently in Mills and Thode. A suite of such monitors (Philips 150S7) would have a yearly operating cost of \$262 in contrast with the Dell's \$750. However, this Philips monitor is considerably more expensive than either Dell, costing roughly double (\$240³² in comparison to the Dell's \$125³³). It is evident that the energy savings (about \$488) do not come close to outweighing the additional cost of these monitors (an additional \$15 755).

³⁰Source: <http://www.allfountains.net/green.html>

³¹Source: http://www.energystar.gov/index.cfm?c=monitors.pr_crit_monitors

³²Source: <http://science.howstuffworks.com/environmental/green-tech/sustainable/5-energy-efficient-computer-monitors2.htm>

³³Source: <http://www.amazon.com/E193FP-Black-Panel-Color-Monitor/dp/B0012MIND6>

Another manufacturer, eMachines E17T6W produces a monitor with a normal operating use of 25 W.³⁴ Replacing 137 Dell monitors with this model would result in annual savings of 3700 W (using 8000 kWh in comparison to 11 700 kWh) or \$239, costing \$513 as opposed to \$752 for the Dell suite on an annual basis. However, like the Philips model, such monitors are slightly more expensive, costing \$140 per unit in comparison to the Dells' \$125; for a suite of 137, such monitors would be \$2055 more. With annual power savings of only \$239, it would take almost nine years of use to make these two options equal in cost.

Looking at newer Dell monitors, a replacement for the current monitors, the IN1920, uses only 19 W in normal operation, as opposed to 34 and 38 W for the current models in use. The IN1920 monitors would use roughly 6100 kWh of power annually, costing \$390; replacing all current Dell monitors with this monitor would save \$362 or 5600 kWh (cutting monitor energy use by 48%). These monitors cost \$110; the cost of replacement of all 137 monitors (roughly \$15 000) must be weighed against the possible electricity savings.

Rather than replacing hardware, energy could be saved by putting a sleep timer on the monitors, having them go into standby mode when not in use. If the current monitors were left on standby (in contrast with a normal on performance) for even one-tenth of the time, this would result in savings of \$113, roughly 15% of the cost of power for the monitors.

a. **Dell E196FP**³⁵ – 60 units in Mills, 30 in Thode

Size³⁶: 19 inches

Normal Wattage: 38.1 W

Standby³⁷: < 2W

Switch Off: <1 W

b. **Dell E193FP**³⁸ – 47 units in Mills

ENERGY STAR compliant

Size: 19 inches

³⁴ Source: <http://www.emachines.com/products/products.html?prod=E17T6W>

³⁵ Source: <http://support.dell.com/support/edocs/monitors/e196fp/en/about.htm>

³⁶ Note that all monitor sizes indicated are diagonal values.

³⁷ Standby is termed by some manufacturers as “sleep”, “active off” or “power saving” mode.

³⁸ Source : <http://support.dell.com/support/edocs/monitors/e193fp/En/specs.htm>

Maximum: 45 W

Normal: 34 W

Standby: ≤ 1 W

Switch off: ≤ 1 W

c. **Samsung Syncmaster 753DF** – 1 unit in Mills

ENERGY STAR Compliant in 2001

Size: 17 inches

Maximum: 90 W

Normal: 75 W

Standby³⁹: 55 W, 15 W, 3 W

Switch off: ≤ 1 W

d. **NEC Accusync LCD5V⁴⁰** – 3 units in Mills

Size: 15 inches

Maximum: 22 W

e. **HP L1906⁴¹** – 1 unit in Mills

Size: 19 inches

Maximum: 37 W

Normal: 33 W

Standby: 2 W

Conclusion

In conclusion, inventory of Mills and Thode libraries has revealed the variety of different electronics available for student use. When considering the feasibility of replacing older units with newer technology, it is important to consider both the upfront investment in machinery as well as the

³⁹ This monitor has three types of standby mode.

⁴⁰ Source: <http://www.retrevo.com/d/ds/progress?doc=cbba9e563fd8b31b8bd79c878763fd74&rk=0.613584206206724>

No additional information on this monitor could be found.

⁴¹ Source: <http://h10010.www1.hp.com/wwpc/ca/en/sm/WF06b/12142134-12142136-12142136-12142136-12142138-12240170-67918421.html>

long-term savings incurred by updating to more energy efficient devices. We have determined that a sizeable amount energy and thus money can be saved if current devices are monitored to ensure that they are operating at the optimal conditions for power conservation. These measures may require automated shut-off timers, idle mode settings, or monitoring brightness. By optimizing the current technology in the library inventory to perform more efficiently, operating costs can be lowered until sufficient funds are available to invest in newer devices.

4. Mills' Computers: Potential Energy and Monetary Savings

Meghan Dertinger, Kirab Hahn, Caroline Kasee and Shobinee Sarma,

Introduction

This section of the Service Learning Project evaluated NightWatchman software, examined the energy use of McMaster's computers using plug-meters, and surveyed the use of Facebook In on library computers.

NightWatchman Software Analysis

Introduction

All background statistics and research on the NightWatchman project were taken from McMaster's Sustainability Office's January 2011 "NightWatchman Project Update." The software NightWatchman is a potential addition to McMaster's library system. Already installed in McMaster's Health Sciences library, it is projected that the system will save McMaster \$45/seat/year, while a return on the initial program investment will be achieved in only three months. The program accepts security updates, minimizes the window of opportunity for virus infiltration, automatically powers down PCs according to a centrally controlled schedule, ensures PCs enter low power states during idle periods, and provides an accurate and detailed reporting of current and future financial, energy, and CO₂ savings. Furthermore, the software has already been purchased by Facility Services – it simply needs library approval to be installed on computers in the libraries.

Method

Given that the one-time cost of NightWatchman and Wake Up software is \$16.50/seat, and given that anticipated savings in the Health Sciences Library is \$45.00/seat/year, the anticipated cost savings with the software installed on all of Mills' computers – not including the 61 iMacs in the Mills' Learning Commons – was calculated.

Table 1. Anticipated Yearly Cost Savings in Mills with NightWatchman

| Computer Model | Total | 1 st Floor | 2 nd Floor | 3 rd Floor | 4 th Floor | 5 th Floor | 6 th Floor | Yearly Savings (\$45 / seat) |
|---------------------------------------|-------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|---------------------------------|
| Dell Optiplex GX520 | 17 | 12 | 1 | 1 | | 2 | 1 | \$765 |
| IBM Personal Computer 300GL | 1 | 1 | | | | | | \$45 |
| LG eSkynet | 3 | 1 | 2 | | | | | \$135 |
| Dell Optiplex GX620 | 90 | | 86 | 4 | | | | \$4050 |
| HP Compaq DC7900 Small Form Factor | 8 | | 8 | | | | | \$360 |
| Mac Pro 10.5.8 | 15 | | | | 15 | | | \$675 |
| Dell Precision T1500 | 3 | | | | | | 3 | \$135 |
| Total Number of Computers | | | | | | | | 137 |
| Total Savings (\$45 / seat / year) | | | | | | | | \$6165 |

Analysis

It is important to take into account the price of the software when projecting Mills' yearly savings. The program costs \$16.50, and there are 137 computers, costing a total of \$2260.50. With an anticipated yearly savings of \$6165 and a total software cost of \$2260.50, the library will save \$3904.50 in its first year. Given that NightWatchman costs \$16.50/seat, **Mills will save \$3904.50 in its first year** when considering the price of the software. And after its first year, **Mills will save \$6165 per year.**

Conclusion

Four hundred NightWatchman licenses have already been purchased by Facility Services. Furthermore, Facility Services has, to date, funded the necessary annual \$2 per seat in updates and support. As long as the licenses are in use and the software is saving the library money and energy, it can be expected that Facility Services' funding for NightWatchman will continue. The library is currently interested in the project, but is seeking more specific information about NightWatchman's ability to allow updates in the middle of the night. It is recommended that future research involve more detailed data regarding the operations and mechanics of the NightWatchman program so that the software can be given installation approval from the library. Given the anticipated \$6165 in energy

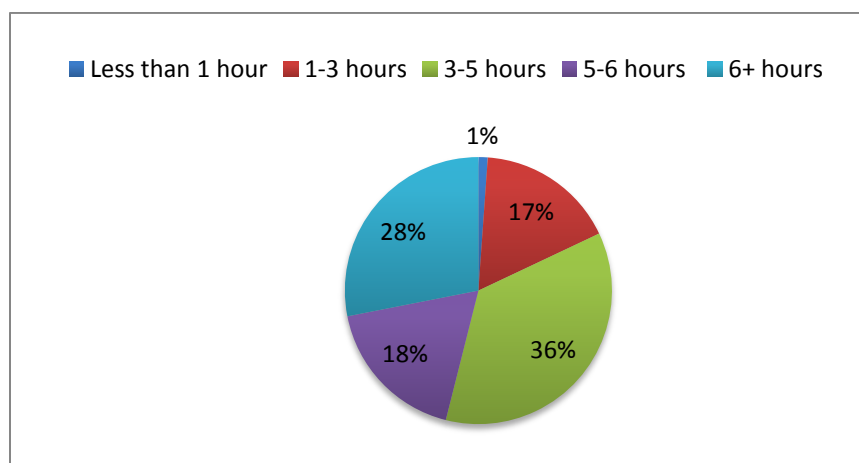
savings per year, there is no question that NightWatchman is a worthwhile and important step in McMaster's financial and environmental sustainability.

Facebook Usage in McMaster Libraries

Introduction and Method

In order to examine the role that Facebook plays in library energy usage, a survey was conducted of 90 Arts and Science undergraduate students, ages 18 to 23, asking series of questions to determine the amount of time spend on Facebook in McMaster libraries. Out of these students, 23, or 25% were male, while 67 or 74% were female. Reported hours of general internet use for this population is displayed below (Figure 10).

Figure 10. Hours of General Internet Use Among Respondents



All of the respondents were students in the Arts and Science Program, a factor that contributes to sample bias. Furthermore, there was a response bias as well, since students who spend less time online are probably less likely to complete an online survey. In addition, some students did not answer all questions. Self-reporting of habits measures students' perceptions of their habits, which may be skewed. The key results of this survey are reported below.

Results

When respondents were asked if they used computers at Mills, Thode or Innis libraries, 88 respondents answered this question, and 46 reported that they did not use campus computers, while 42

responded that they did. Out of the respondents that reported using library computers, most (76%) reported using them for less than an hour, as shown in Figure 11. Furthermore, when asked how much of this time was spent on Facebook, most (73%) reported using Facebook for less than 10 minutes, as shown in Figure 12.

Figure 11. “If you use library computers, on average how many hours a day do you use them?”

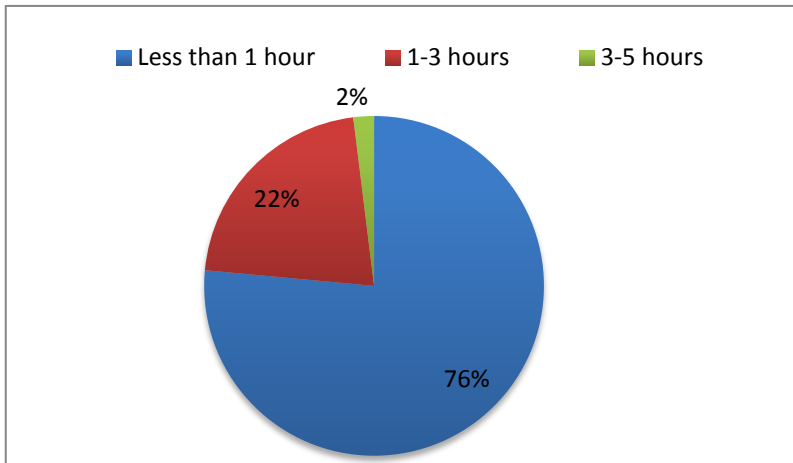
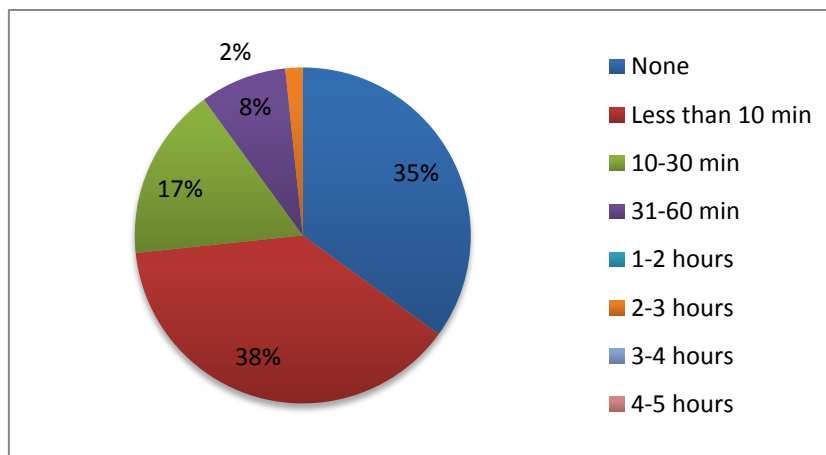


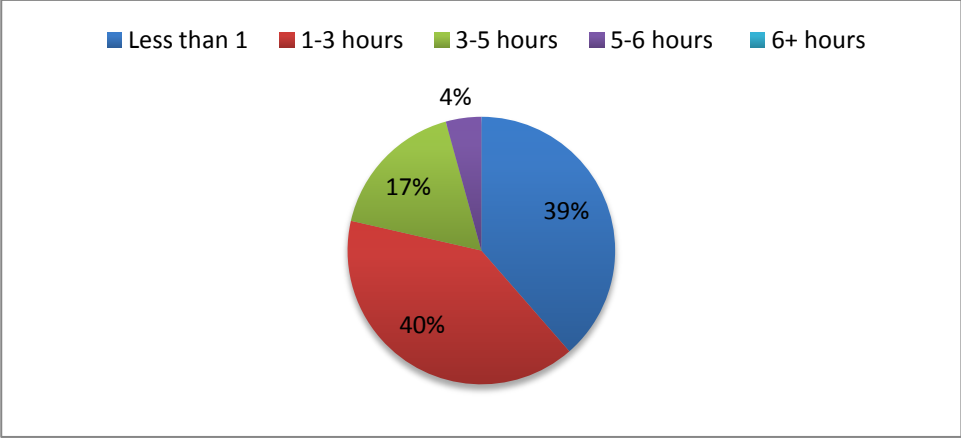
Figure 12. “How much of your time on the library computers is spent on Facebook?”



Laptop usage and Facebook in McMaster libraries was also examined in this survey. When students were asked if they used their laptops in Mills, Thode or Innis, 70 responded that they did,

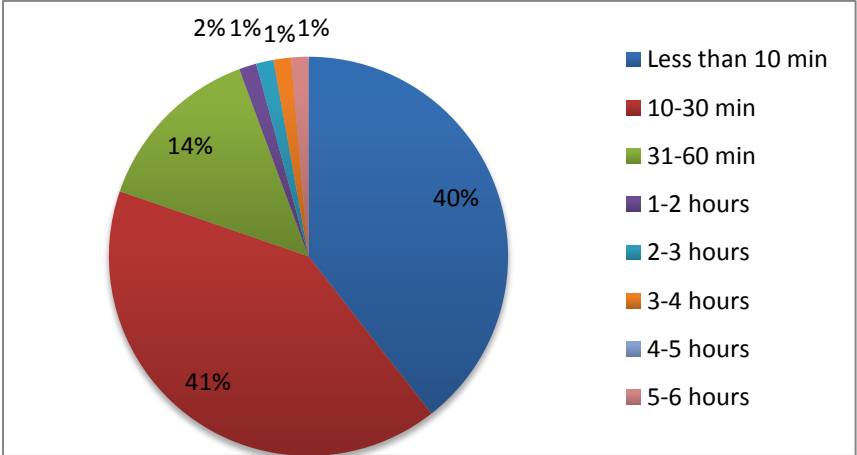
while 19 reported that they did not. When asked how many hours they used their laptops in McMaster libraries, 40% of respondents said 1 to 3 hours, while 4 % reported 5 to 6 hours (Figure 13).

Figure 13. “On average how many hours a day do you use your laptops in the library?”



Finally, when respondents were asked to estimate how much of their library laptop time was spent on Facebook, 41% responded 10 to 30 minutes, while 1% reported Facebook usage times of 2 to 3 hours, 3 to 4 hours, and 5 to 6 hours, respectively (Figure 14).

Figure 14. “How much of the library laptop time is spent on Facebook?”



Analysis

From this survey, it seems as though the majority of students use their laptops at McMaster libraries and for longer periods of time than they use the library computers. However, it was determined that the majority of Facebook users on their laptops only used it for 10 to 30 minutes, a relatively negligible time. This may mean that Facebook does not in fact interfere with student productivity, or it could simply be a function of the sample bias (i.e. only 90 respondents, all Arts and Science students).

Conclusions

Ultimately, greater investigation into Facebook usage among undergraduate students at McMaster will need to be done to determine more conclusively if Facebook usage on library computers and laptops interferes with the productivity of students, thus contributing to increased energy consumption. However, the results of this survey do indicate that energy conservation efforts should focus on student laptop use, rather than library computers, as the majority of students use these when in McMaster libraries. Although how students use their personal computers may be difficult to monitor, first further investigation and then awareness campaigns connecting Facebook use and total energy use will be the first steps in reducing this specific form of energy consumption on campus.

Conclusion

Overall, the present investigation sought to examine the use of energy in McMaster libraries. This work has revealed a number of ways in which it may be possible for McMaster libraries to reduce energy consumption or make it more efficient, namely through updating existing technology and the continuous monitoring of alternatives, the implementation of kill-switch programs, the installation of NightWatchman software, the careful selection of library hours based on student use, and the implementation of educational campaigns. In addition, it has presented data on energy usage by location, time of day, and year, and summarized such trends, which may be of use in future library decision-making.