Policy and Behaviour: Exploring Energy Use by Computers in the Marion McCain Building

ENVS 3502: Environmental Problem Solving II
Karen Harper
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Jessica Bruce: BSc Biology
Bria Harvey: BSc Marine Biology
Caitlin Owens: BSc Environmental Science
Emily Rideout: BA International Development

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Introduction

In an era of increasing concern about environmental integrity and stability, all sectors of society including individuals, institutions, industry and government are re-examining their relationship with the environment. In recent years, Dalhousie University has attempted to reduce its environmental impact by increasing energy efficiency and reducing waste. However, these efforts have taken place in the absence of a guiding framework or strategy; the school does not have an environmental policy in place. As a result of this lack of direction, there are several issues to which no attention has been paid-one of which is energy consumption by computers in campus computer labs. We deemed it necessary to perform research which would begin to fill the void in data surrounding this issue.

Rationale

The world today is facing several global issues that threaten our way of life. Climate change is one issue, peak oil is another, growing population is yet another. All of these issues are impacted by or are the result of the over consumption and decrease in of fossil fuel sources. Our reliance on the combustion of fossil fuels has several negative consequences. Firstly, combustion produces several by-products that are detrimental to the environment. Carbon dioxide is a gas that collects in the upper atmosphere and is the major cause of climate change. Secondly, the extraction of fossil fuels is a highly invasive practice and requires the destruction of complex ecosystems. Finally, once the resource has been extracted it must be processed and then transported to a point of purchase. The primary concern with processing is the emissions produced by the energy intensive processes necessary to transform the crude oil into gasoline and other petroleum based products. The primary concern with transportation is the potential for oil spills which are ecologically and financially costly. Overall, the consumption of fossil fuels is fraught with cradle-to-grave implications for the environment and human society.

The environmental issues surrounding the use of fossil fuels have led to a general global increase in environmental awareness, education and action around the world. Post secondary institutions have been a sector in which a range of actions (or inaction) has been taken. This is evidenced by the signing of the 1990 Talloires Declaration by 350 university presidents in over 40 countries (University Leaders for a Sustainable Future 1990). With thousands of students, universities are large scale energy consumers and producers of waste, and therefore have an extraordinarily large environmental impact. Universities have many reasons to be concerned about energy consumption beyond the environmental damage caused by burning fossil fuels. As fuel costs continue to rise, the university must absorb these costs and may eventually have to raise tuition to mange the costs.

Universities are well positioned in society to create behavioural, structural and policy changes in order to reduce their impact on the environment. As David Orr (2004) points out "no institutions in modern society are better to catalyze the necessary transition to a sustainable world than universities. They have access to the leaders of tomorrow and the leaders of today. They have buying and investment power. They are widely respected. Consequentially, what they do matters to the wider public" (p.130). A quick Google search for ‘sustainability universities Canada’ reveals that dozens of Canadian Universities have created sustainability offices, hired sustainability coordinators or are becoming more environmentally conscientious. A deeper review of contemporary literature reveals that a great deal of research about energy consumption is being conducted at these institutions (Doukas, Rayale, Timberg & Yun 2004; Rewire 2007).

In recent years, Dalhousie University—a signatory to the Talloires Declaration—has made a strong commitment to becoming a sustainable campus. While a variety of environmental issues are being addressed, energy consumption is a key issue for the reasons stated above. Energy efficiency is so important in light of the fact that Dalhousie burns Bunker C fuel - an extremely "dirty" fossil fuel which produces higher than average green house gas emissions - to power its steam plant which produces heat for all three campuses (Dalhousie University 2006). In addition to the commitment made by the university administration, students have been extremely active in researching and addressing these issues directly or lobbying the administration to do so. In our initial explorations of the Dalhousie campus sustainability movement, we identified a gap in student knowledge surrounding the issue of overnight energy consumption by computers on campus. In undertaking this study, we hope to fill this gap in knowledge while contributing to the wider investigation into campus sustainability issues and institutional energy consumption and thereby further strengthen the sustainability movement at Dalhousie University.

Description of Research

Our research explores overnight energy consumption of computers in one Dalhousie computer lab, room 2019 in the Marion McCain building. Since there appeared to be a complete lack of information about the issue, we wanted to know if computers were in fact left on over night and if so why, and what could students do about it?

Objectives

Our research had three objectives. The first was to explore the issue of overnight energy consumption by computers in a Dalhousie computer lab. The second was to determine if there are any policies in place which dictate whether or not computers are left on overnight. And finally to make recommendations about ways in which it is possible to reduce the amount of energy consumed by computers overnight and in general at Dalhousie.

Setting

Dalhousie University is the largest post secondary institution in Nova Scotia with approximately 15,440 students (Dalhousie University 2007). Its three campuses (Studley, Sexton and Carelton) cover 79 acres, and has 71 planned use buildings and approximately 40 auxiliary buildings (Dalhousie University 2007).

Limitations & Delimitations

Limitations

There were a few limitations on the scope of our research. Time was a significant barrier for us as we only had 2.5 months to conduct our research. Furthermore, as full time students, our other academic obligations limited the amount of time we were able to devote to this project. Our time was further constrained by the fact that our research question evolved as we learned more about our topic, so that by the time we had settled on a concrete research question, we had even less time than we had initially. Nevertheless, this experience was beneficial to our research because it was exploratory in nature and required a starting point. In the grand scheme of things it hindered our scope and the overall degree of completion of the project.

Another limitation was our lack of technical expertise about computer hardware and software. As a result, out recommendations are not as specific (and therefore useful) as we would have liked. Instead we provided more general recommendations in the hopes that policy changes would rely on the in-depth knowledge of policy makers about computer technology.

Delimitations

Based on the time constraints mentioned above, it was necessary to limit the scope of our research while still providing a valuable contribution to the existing body of knowledge surrounding the issue. We chose examine after-hours energy consumption rather than day-time energy consumption for a number of reasons. We chose this time of day because it was simpler to study than the day-time; at night we knew no one was using the computers so there was uniform energy consumption whereas during the day there were periods of peak use as well as a variety of uses. We also chose after-hours because it was a time period in which policy changes could affect the greatest energy reductions with the least inconvenience to users. We chose to narrow our research further by studying only one campus building, the Marion McCain Arts and Social Sciences building. We chose this building because it had a large computer lab, had several lab attendants from whom we could collect data and because it was connected to the central computer system for the school (University Computing and Information Systems: UCIS). There are other computer labs on campus from which to choose as a sample. We excluded the Killam library Learning Commons computer lab from our study because it is operated independently of UCIS and is therefore not representative of campus-wide policies. Likewise, the Computer Science building is not connected to the UCIS system and furthermore, is open 24 hours a day which made recommendations for turning off computers for a period of several hours unfeasible.

We chose to focus on Studley campus (rather than Sexton or Carleton) because we are most familiar with this campus and it was a much more convenient location for research. However, we feel that this familiarity and convenience did not detract from the validity of our research as the McCain computer lab is representative of all UCIS operated labs on campus.

Another delimitation on our research was our choice of research methods; purposive sampling and face-to-face interviews. Because our primary research objective was to identify any policies pertaining to computers being left on/turned off after-hours, it was important to collect data from individuals who possessed the knowledge we were seeking, namely employees of the computer lab and of UCIS. For this reason, we chose to interview the Director of Academic Computing Services (ACS) for UCIS because he theoretically possessed the bulk of the knowledge we were seeking about policy. We chose to interview only the lab attendants who worked the closing shift in room 2019 because they were the most knowledgeable about after-hours conditions. Based on this criterion, the other two lab attendants who work during the day only were excluded from our study. We chose the interview format because we were asking questions that were specifically tailored to the interviewee, hence a survey format (usually designed to collect the same data from several individuals) would have been inappropriate for our research.

Definitions & Assumptions

Definitions

The following definitions require clarification for the purpose of our research.

Computer- includes a tower and a monitor

Figure A: Computer Tower

Tower- The portion of a computer that contains the main components such as a circuit board and hard drive.

Monitor- The portion of a computer which displays viewable images.

Figure B: Computer Monitor

After-hours- The segment of time when the computer lab is closed (ie: not open for use) and includes the hours from 10pm-8am on weekdays, 6pm-8am on weekends.

Assumptions

Our research contained some assumptions which should be clarified. We assumed that the computer lab was in fact not in use after-hours, and that the computer lab hours were the same as the building hours. We also assumed that the computers were left on 24 hours per day for 51 weeks which accounts for the computers being shut off for one week during Christmas holidays (Email from John Robertson, UCIS 2008). As discussed in our delimitations section, we are assuming that the study is confined to room 2019 in the Marion McCain building, and that our recommendations are applicable only to computer labs operated by UCIS (excludes the Killam library labs, Computer Science building, the GIS lab etc.). Likewise, we assumed that all data and recommendations are only applicable to the after-hours period of the day.

Methods

In order to fully understand energy consumption by computers in the Marion McCain building at Dalhousie University, this study was exploratory in nature. As such, it was important to gain both qualitative and quantitative data. We gathered data through a literature review, face-to-face interviews, and by conducting an energy audit of the computer lab room 2019. By employing data triangulation, we hoped to increase the validity and reliability of the data. Palys and Atchison (2008) point out that "using various methods increases the reliability of a study by looking for the same information in multiple ways." (p. 61).

The literature review allowed us to look at previously conducted studies, identify deficiencies and obstacles, and apply them to the Dalhousie context in order to strengthen our study. The energy audit allowed us to obtain more concrete quantitative data regarding the amount of electricity being consumed in the labs as well as the amount of CO_2 emissions being released into the atmosphere by the computers. This information constituted our baseline data from which we were able to determine the potential financial, energy and CO_2 savings if the computers were turned off after-hours.

We acquired the qualitative elements of our data through face-to-face interviews with the four lab attendants who work the closing shift in room 2019. By interviewing this population, we were able to determine if there are any policies in place and if so, the nature of these policies as well as the degree of compliance with the policies. We also interviewed John Robertson, Director of Academic Computing Services for UCIS and Charles Walls, an instructor for Geographic Information Systems (GIS) and a manger of the GIS computer lab in order to gain a better understanding of the processes and operational procedures that are used in the McCain computer labs.

In order to ensure the accuracy of our data, we triangulated our findings, assessing it from different perspectives. The data regarding computer labs were obtained through interviews and by direct observation of the labs. The interviews with the lab attendants were preceded by a pilot test in order to see if we had made any unreasonable assumptions and if the structure and wording of the questions were appropriate for our research. By performing a pilot test, we were able to receive meaningful feedback about the style and choice of questions that we used, and the subjects we were interviewing were able to inform us if our questions were poorly worded, too broad, too complex or if there was some important aspect which we had unwittingly omitted.

We used purposive sampling inspired face-to-face interviews, which allowed us to clarify any questions the respondents may have had. This ensured the responses were based on accurate interpretations of the questions asked. If the questions were asked by the interviewees, our answers to them were neutral so we did not infer any bias towards any one type of response.

The information collected is relevant to the problem addressed because it allowed us to answer our secondary objective regarding the existence of policy. It also helped us understand why computers in different labs around campus followed different procedures (ie: Killam, Computer Science and GIS). Additionally, out data allowed us to discover ways in which we can promote behaviours and policies which would reduce the amount of energy being consumed by computers in the McCain.

The energy audit contained two stages, observation and calculation. For the first stage, we observed and recorded the number of computers and printers left. It was noted that all the monitors in this lab were Cathode Ray Tubes (CRT) and these monitors consume significant amounts of energy, while other labs on Studley campus use Liquid Crystal display (LCD) monitors which consume considerably less energy. The second stage of the energy audit consisted of entering this information into a formulaic electronic excel sheet obtained from an employee of Public Works and Government Services, Environmental Services branch (Myles Thompson). This tool allowed for the calculation of energy usage, CO_2 emissions, and cost savings for room 2019 and is useful for calculating the energy consumption and CO_2 emissions for other computer labs on campus. In attempt to compare our results for room 2019 to the rest of the labs in the McCain building, we conducted a second observational count for the rest of the computer labs in this building. This comparison allowed us to understand if room 2019 was representative of other UCIS-operated labs on campus.

Results

Energy Audit

The Marion McCain building on the Studley Campus of Dalhousie campus has multiple student computer labs. The largest and most frequently used student computer lab is room 2019 and houses 53 computers and 1 laser printer. All energy use and CO_2 calculations are conservative estimates based upon watt per item ratings of 67 watts for the tower that are P4, 3.2Ghz processors with 512Mb ram and 70 watts for a regular Cathode Ray Tube (CRT) monitor. An estimate of watts per item was obtained from a recent study on energy use with new personal computers from the University of Berkley (Roberson, J. *et al*, 2002 and personal interview with John Robertson). Presently, the 53 computers and 1 laser printer in room 2019 consume approximately 62,109 kWh/yr of energy. This current use of energy is based upon the finding that these computers are left on 24 hours a day, for 51 weeks or 358 days a year (the lab closes for one week over the Christmas holiday) (personal interview with John Robertson) .

We calculated the energy use, the financial cost and the amount of CO_2 emissions resulting from keeping the machines on over two different periods of time. Then, we forecasted results for these variables assuming all of the 52 CRT monitors were replaced with LCD monitors. One of the monitors in this room already has an LCD monitor. We felt this estimation was important because of the University's commitment to replacing all CRT monitors in this lab with LCD monitors throughout the months of May, June and July 2008 through the Evergreen Program (discussed in greater detail later in the Results section). The first time period we calculated was 24 hours a day, 358 days a year. The second time period was the after-hours period, which is Monday-Friday from 10pm-8am and Saturday-Sunday from 6pm-8am. Results for these variables are summarized in the below (Table 1.1).

Table 1.1 The table below lists the monetary expenditure and quantity of CO_2 that is emitted as a result of leaving the 53 computers and 1 printer on in room 2019 for 24 hours a day, 358 days a year as well as after hours. A forecasted list of values for LCD monitors is also included for these two time periods of 24 hours a day and after hours.

	24 hrs/358d CRT screens- currently	**After hours CRT screens – currently**	**24 hrs/358d LCD screens - forecast**	**After hours LCD screens - forecast**
Avoidable cost/year for Room 2019 ($)	6123.99	2854.82	4693.27	2179.02
Forecasted avoidable costs/year for all labs in McCain building ($)	13287.9	6194.41	10183.51	4728.06
Avoidable CO_2 tonnes per year for Room 2019	33.7	15.6	25.7	11.9
Forecasted avoidable CO_2 tonnes per year for all labs in McCain building	73	33.9	55.7	25.9

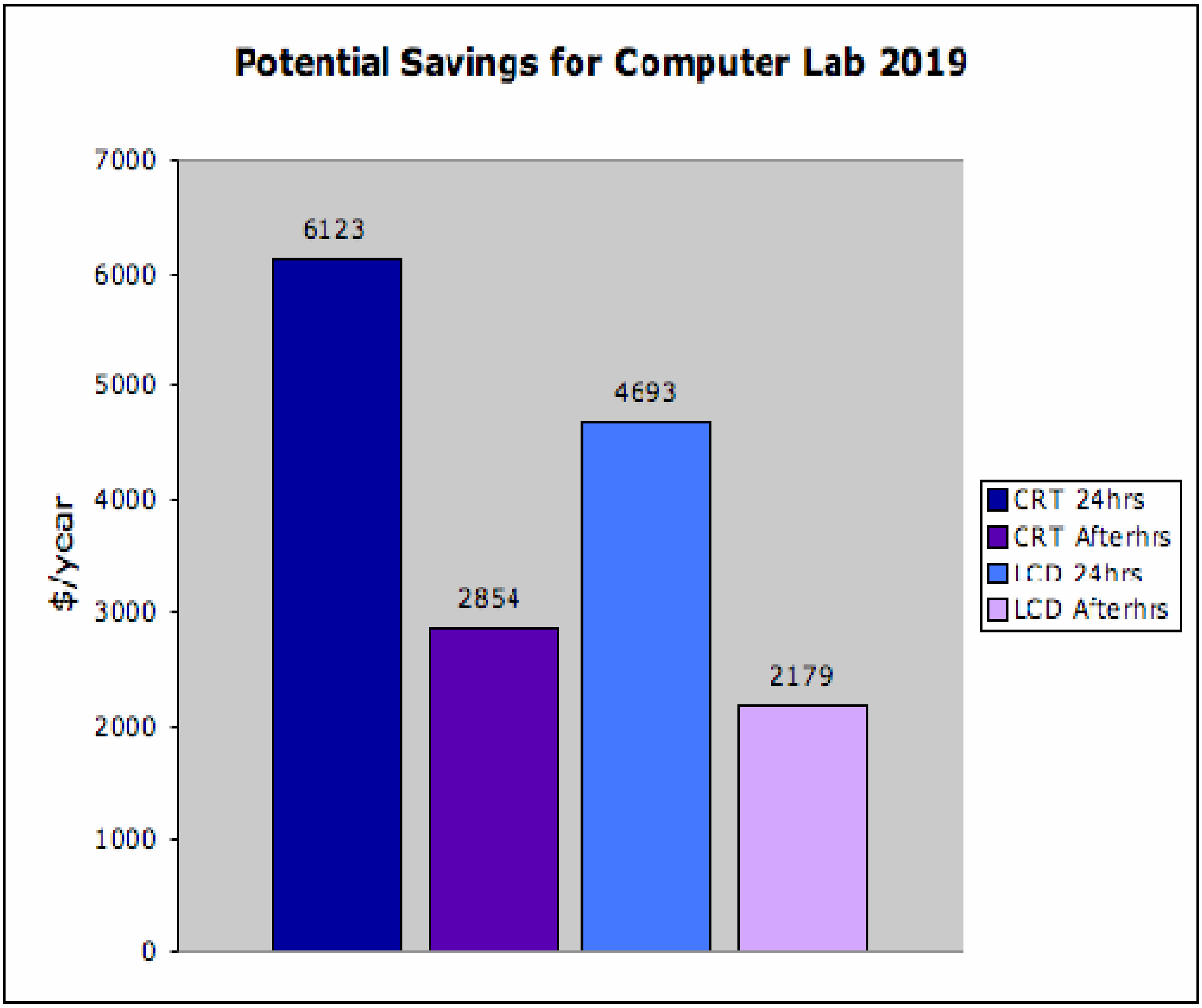

Fig. 1. The above graph depicts the differential cost savings of computer with CRT and LCD monitors over a 24 hour and after-hours period (358 days for one year). The numbers show that although LCD monitors will save the University roughly $2000 a year in electricity costs, another $2179 can be saved by turning off the new LCD monitors and towers after hours.

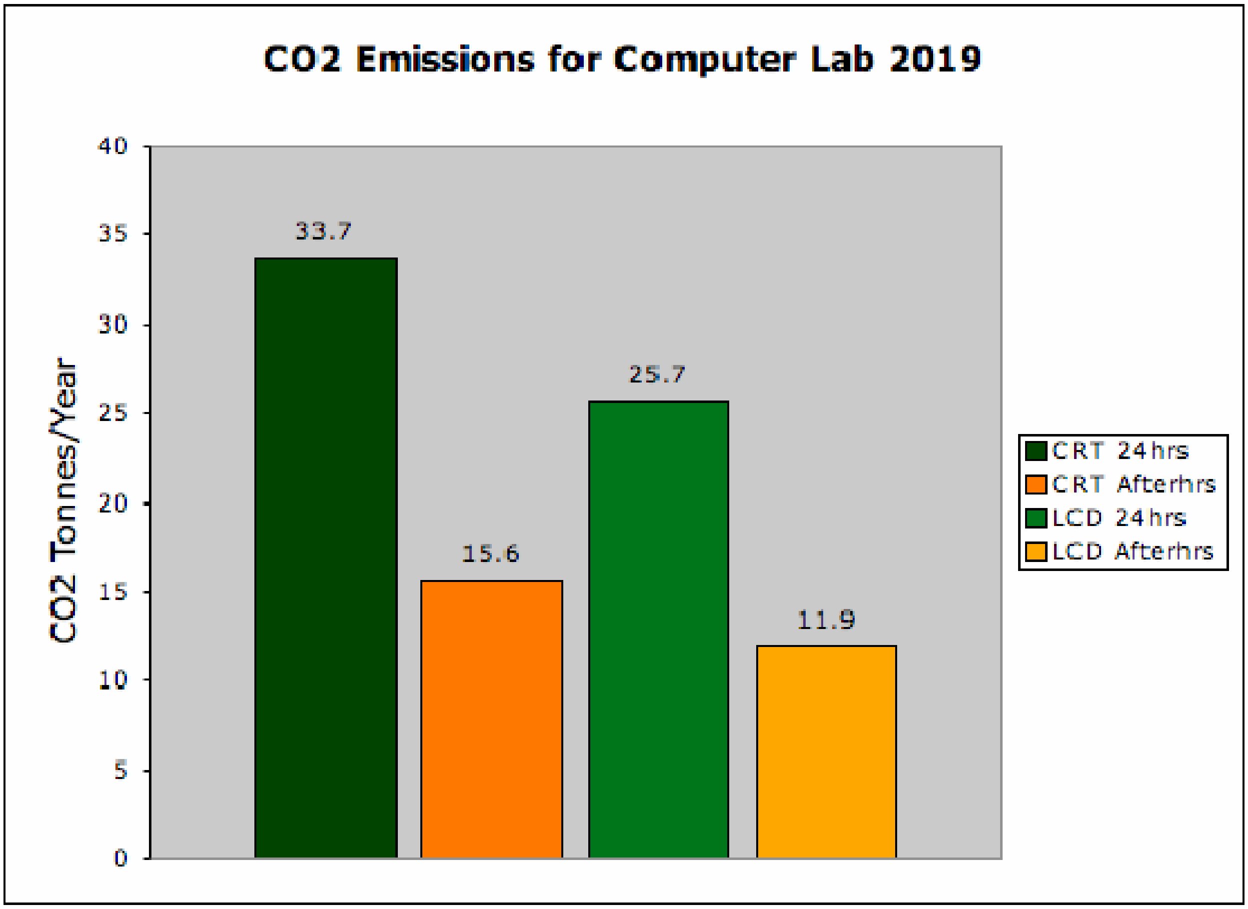

Fig 2. The above graph depicts the differential CO_2 emissions in tonnes of CRT and LCD monitors with computers and over a 24-hour period and after-hours period (358 days for one year). The numbers show that although LCD monitors will prevent about 8 tonnes of CO_2 from being emitted into the atmosphere from compared to the current CRT monitors, 11.9 tonnes of CO_2 can be accounted for by altering current behaviour and turning off the new LCD monitors and towers after hours.

As the above table and graph (Table 1.1, Fig.1) shows, currently, the 53 computers with 52 CRT monitors and 1 LCD monitor consume an avoidable electricity expenditure of each year of $ 2854.82 after hours. In other words, the University can save $2854.82 if these computers were turned of after hours as compared to leaving them running 24 hours a day. Even after UCIS replaces the 52 CRT monitors with LCD monitors, there is still a potential cost savings of

$2179.02. With new LCD monitors, the change in cost from the projected expense of $4693.27 to $2179.02 is a reduction of about 40% each year. On that same token, the second graph (Fig.2) shows a similar relationship with CO_2 emissions. Provided that each existing CRT monitor in room 2019 is replaced with a LCD monitor, 11.9 tonnes of CO2 and $2179.02 can be avoided for the after hours time interval each year compared to if these computers were left on 24 hours a day, 358 days a year.

Also noted in Table 1.1 is the extrapolation of these variables to the rest of the labs in the Marion McCain building. Assuming that these labs are under identical operating procedures, $4728.06 can be saved and 25.7 tonnes of CO_2 emissions can be prevented from release into the atmosphere each year from the activity of turning off the computers after-hours.

Interviews

Policy

From the interview with UCIS, it was determined that computers in labs are centrally controlled for maintenance and can be centrally turned off and on, although this function is not commonly used. Computers that are a connected to this central server, which includes most computer labs on campus excluding only a handful (the Killam learning commons, Computer Science, GIS), are to be left on at all times 24 hours a day, 358 days a year (labs are shut down for one week over the Christmas holidays). Computers (both monitor and tower) are required to be left on for maintenance and this maintenance can only be completed after the lab closes while the computers are idle. During the maintenance process, virus updates are enabled, which is not possible during the day because the updates are “locked down.” The maintenance process is automatic however and it begins at midnight for all labs and finishes at varying times depending on the amount of maintenance required by each computer. The time needed can vary form minutes to hours. Therefore, the rules in place for keeping computers on exist in order to maintain specific services. While there are no policies or guidelines to keep computers on, there are operational procedures in place which are the unspoken day to day procedures implicitly understood by UCIS staff.

UCIS maintains that these operational procedures are transmitted to lab attendants by informal but effective means of weekly meetings with superiors and verbal and email communication. If a computer is turned off by a student it is automatically disconnected from the central server and generally this is a minor problem that can be remedied by the lab attendant or another individual turning the computer back on. If computers were to be turned off overnight, UCIS thinks that the most effective method would be to use software which would automatically shut down all the computers connected to the UCIS central server.

It should be noted that UCIS claims that the monitors go into "deep sleep mode" when they are not in use; however, our observations from the energy audit indicate that the monitors go into screen saving mode only. Upon further research, we determined that deep sleep mode saves a significant amount of energy and that screen savers do not save any energy, and as a result we assumed the monitors are in screen saver mode when not in use for the energy audit (Harvard Green Campus Initiative, 2007).

Our interview with Charles Walls of GIS had slightly different results. Charles seemed to be unaware of any formal policy for turning off or on computers and is under the impression that this decision is up to individual lab administrators. The GIS lab places a great deal of importance in turning the computers off when they are not in use. After hours and even when they computers are not in use, Charles Walls and the lab instructors turn off the computers manually. The GIS lab is permitted by UCIS to operate as they se fit, in terms of turning off and on their computers. The GIS lab computers are exempt from the centralized maintenance that UCIS performs with most other labs on campus. Instead, GIS lab managers perform manual maintenance themselves if need be and the Deepfreeze software takes care of virus and other such software updates each time the computer is rebooted. Furthermore, our interview with Charles Walls from GIS determined that maintenance operations in his lab are comparable to the maintenance operations that UCIS performs with their centralized procedures.

Environmental Concerns and the Evergreen Program

It is important to Charles Walls to turn off the computers in his lab for environmental reasons, but outside of environmental reasons, he indicated that he would turn them off regardless. Financial gain is not a motivating factor for Charles Walls because the GIS lab does not reap the financial benefits resulting from reduced energy consumption by computers. Furthermore, UCIS also does not benefit financially because they are not in any way responsible for the electricity bills on campus (Facilities Management is responsible for absorbing the costs associated with energy consumption on campus). Despite this lack of financial savings, Charles Walls feels that turning off computers regularly has saved the GIS lab money on maintenance and hardware replacement.

UCIS made an interesting point which was that the heat generated by computers should be explored if energy conservation is to be addressed. Apparently, the electricity required to air condition computer labs in order to ensure the computers do not overheat is considerable. UCIS also pointed out that the vast quantity of computers in the world is a large concern for the environment. Ultimately, the cost of running these machines will dictate actions taken by UCIS. UCIS maintains that after guaranteeing a high quality of service to students, energy efficiency is a priority and is at the forefront of their decision making process when considering hardware and software upgrades and changes to services. It should be noted that automatic updates in this lab are vital because of this lab is heavily used compared to other labs on campus especially the GIS lab that is secured by a coded door to which only GIS/Earth Science students have access.

We would like to acknowledge some commendable and significant actions that UCIS is contributing to campus sustainability. Firstly, UCIS says that the heat generated by computers and subsequent need for cooling systems is constantly under review in attempt to reduce the heat that is produced. An over-arching initiative encompassing these efforts and more is the Evergreen Program. This program operates in cycles and has been carried out in 2002, 2005 and 2008, and consists of computer upgrades in all labs on campus. The old hardware is recycled as much as possible on campus; less frequented labs receive older hardware. UCIS doess and will continue to make efforts to consider energy efficiency and heat production when purchasing new hardware. Another aspect of the Evergreen program involves disposal of units; UCIS is working towards the refurbishment and redistribution of old units within the Halifax community. One of the most significant actions UCIS is taking related to this research study is the full-scale replacement of all CRT monitors with LCD monitors. The GIS lab replaced all their CRT monitors with LCD monitors in 2006. LCD monitors consume about half the amount of energy that CRT monitors do, resulting in both a reduction in CO2 emission, wattage use and provides financial savings (Appendix A, Fig. 1 and 2).

Lab attendants

Although the actual administration of the lab attendant interviews seemed successful, we noticed some discrepancies in the lab attendant's responses upon analyzing the results. Most significantly, between the male and female lab attendant's responses pertaining to why they leave the computers on at all times. Both the females recalled that the Academic Computing Services (ACS) training manual states that it is part of their job to keep the computers on at all times but the males did not remember how they were told this, just that they were aware that keeping computers on at all times was a part of their duties.

We found it encouraging that all of the lab attendants were fairly enthusiastic about improving campus sustainability by turning off computers after hours. One lab attendant has often wondered why they were not off in the first place. When questioned about how important it was to them to turn off computer and for what reasons, most placed saving energy above saving money, protecting hardware and safety. However, one lab attendant did place protecting hardware above all else. This lab attendant was under the impression that turning the computers off and on frequently poses undue stress on the hardware. This is not actually the case, as evidenced by lower hardware replacement costs in the GIS lab and literature indicating that computers can withstand frequent shutting down and starting up operations (Harvard Green Campus Initiative, 2007). All four of the lab attendants were unclear about the reasons behind keeping the computers on, but they each perform their duties to keep them on 100% of the time.

DISCUSSION

The purpose of this research was to explore energy use by computers in the Marion McCain Building room 2019 on Dalhousie Studley Campus. On the whole, our results lead us to conclude that both money and energy is wasted unnecessarily during the after-hours period, at which point the lab is closed and the computers are not in use. These results have prompted us to make recommendations regarding computer use during this time period in order to reduce energy consumption, electricity costs and promote behavioral changes that foster sustainability on Dalhousie campus. Furthermore, it is our hope that the suggestions we provide will inspire and lead others to explore this research subject in greater detail and in varying campus circumstances for expanded applicability.

Strengths & Weaknesses

Strengths

Our research has several strengths. Firstly, we were able to bring attention to the issue of energy consumption by computers based on our exploratory research which may encourage further research in this area. We were also able to contribute our findings to the body of student knowledge surrounding campus sustainability issues and thereby strengthen the greening the campus movement. Another strong point within our study was the validity of our research and recommendations. Our recommendations are valid because they come straight from the people who work closely with these types of hardware and software in these types of computer labs. They are also derived from an audit that was originally designed by the Federal Government and therefore is credible and the best tool for the task.

Weaknesses

Later, in the research compilation stage, we noticed that there were some gaps in our research. Some things that would have been helpful to our research and recommendations include the following: knowing more about the computer programming, software and hardware; having access to a computer expert/consultant; and actually being able to look at the ACS training manual. While our current recommendations are valid and consistent with our results, it nevertheless would have aided our recommendations if we had been able to explore the software options available and if there are any programs which are relevant to the Dalhousie context. By knowing more about this aspect of computers we think that our recommendations could have been more concrete and creditable. As we are not experts in computer software or programming we cannot confidently tell UCIS what software will or will not work in their labs.

We also found that there was a significant discrepancy between John Robertson's answers to our interview and our observations. He said computers in room 2019 go into deep sleep mode during periods of inactivity, but our observations noted that they only go into screen saving mode. Deep sleep mode uses significantly less energy than the screensaver mode. We question our observation because what appeared to be screen saver mode to us may have actually been deep sleep mode; our lack of technical expertise is lacking in this regard. When we conducted our audit we assumed the monitors were in screensaver mode after-hours, therefore based this fact, our data may be erroneous. A helpful tactic would to have consulted with someone of John Robertson's technical expertise to help us identify the correct mode. We also think that it would have been valuable to get someone of Mr. Robertson's expertise to review our initial recommendations after which we could have refined them so they were realistic and based on sound data.

Implications and Recommendations

The implications of our research lead us to make several recommendations to UCIS. First and forest, our primary recommendation for UCIS is the revision of their current operational procedures concerning automatic maintenance at midnight of each night. We propose that these operational procedures be revised such that computers can be turned off during the after-hours period without disrupting computer services to students when the labs are open. We suggest that UCIS primarily use the Deepfreeze software (which is currently installed on their computers) more to their advantage to help achieve this goal. Deepfreeze software is designed to target four main markets, one of which is Universities (Faronics Corporation, 2008). The many helpful features of Deepfreeze can enable UCIS to maintain a level of service that is acceptable to the student body, which the GIS lab demonstrates.

In addition to Deepfreeze, we also suggest that UCIS explore new software programs that allow for central automatic or central manual shutdown and start up once maintenance and updates are complete. Central automatic shutdown refers to the act of having automated software shut down all the computers in all the labs operated by UCIS from a central location or server. Central manual shutdown refers to the act of having a UCIS employee shut down all the computers in all the labs operated by UCIS from a central location or server.

In the meantime, we suggest that UCIS find some way that the computers could be off for up to five or six days a week and updated only once or twice a week using their current maintenance procedure. Such adaptations to the operational procedure would require that either a lab attendant or UCIS turn the computers off at night either manually or centrally. Although this is not currently being instituted, it would be in the interest UCIS and facilities management (who pay for energy used) to look into software programs that would enable them to do these things automatically. Furthermore, we also recommend that UCIS regularly evaluate their systems so they not only fulfill the status quo but go a step beyond and realize a new higher standard of operations.

Our research also proposed some other recommendations which were behavioural in nature rather than policy based. It was suggested by the lab attendants that there is a distinct reduction in computer use between 8pm and 10pm when the lab closes. The lab attendants suggested that the computers could be turned off during this period by students once they have finished using a computer. Encouraging this individual action taken by students accomplishes three things: reduction in the cost of energy and CO2 emissions, strengthening of student education about computer energy consumption, and a shift in student behavior. Visual prompts and verbal reminders by the lab attendants can assist in achieving these goals. Involving students directly in turning computers off cultivates empowering and positive behaviours in students by making them feel as though they are contributing to campus sustainability. The more that students are educated on reducing energy consumption and are encouraged to turn off computers once they are done with the machine, this simple action can become habitual. Moreover, these behaviours will likely spread from the 2019 lab to other labs on campus and at home.

When considering our recommendations, it is important to bear in mind that UCIS provides a service to the general student body. Therefore, if we could show that the majority of the student body is in favour of a more sustainable computer service, then concrete recommendations could be made on the basis of the kind of service that students prefer or demand. Determining the extent of student preferences for sustainable types of computing service is a topic that needs to be studied further. Nevertheless, it would be an excellent opportunity to encourage a behavioural change could only benefit the campus sustainability movement that Dalhousie has recently begun to support.

We also learned that UCIS participates in the Evergreen program which occurs every three years and is slated to occur this year from May to July. Through this program, UCIS upgrades hardware and shuffles older hardware into less frequently used labs. This year, the program will replace the current CRT monitors with new LCD monitors in the McCain building. While we recognize that the Evergreen program is a valuable contribution to the campus sustainability movement because it promotes energy efficiency, however, it is not enough in and of itself. The Evergreen program only addresses hardware upgrades and not systems or user and behaviour efficiencies and therefore addresses only a portion of the larger picture. If UCIS were to take a more active role in addressing the Evergreen program's shortcomings, then this may merit further praise.

If UCIS were to implement any combination of these recommendations they would be able to not only reduce Dalhousie's ecological footprint but also create savings that could indirectly benefit the students to whom they serve.

Further Recommendations

While our research was not exhaustive, we hope that we have been able to shed some light on the issue of energy consumption by computers at Dalhousie. Due to the limitations and delimitations imposed upon this research, there were a number of topics that we were not able to research but which should be investigated in order to further contribute to and advance the campus sustainability movement at Dalhousie University. We recommend that further research be undertaken to investigate the following issues: Energy consumption by computers in the Killam library. The Killam library operates independently from UCIS but contains two of the largest and most high traffic computer labs on campus which consume a significant amount of energy.

Further research should be conducted to better understand the procedures for disposing of hardware. While in general energy efficiency in computers is improving, the number of computers in the world is on the rise. A typical monitor contains three to nine pounds of lead, circuit boards contain beryllium, cadmium, flame retardants to name a few of the harmful contents of computer hardware (Crede 1995). Many electronics are sent to developing countries with lax environmental regulations and subsequently the toxins contained in computer hardware are released into the natural environment. As a signatory to the Talloires Declaration, Dalhousie University has an obligation to deal with hardware wastes in an appropriate manner. Currently, it is not known how Dalhousie deals with its electronic wastes.

Another issue that requires investigation is the heating, ventilation and air conditioning (HVAC) systems serving campus computer labs. During the course of our research, we learned that computers consume energy in two ways: Through direct energy consumption of the unit and through the heat produced by computers. When several computers are grouped in one room (as in a computer lab) a great deal of heat is produced and requires that the room be ventilated. HVAC systems consume a great deal of energy themselves.

Conclusion

After researching energy consumption by computers in the computer lab 2019 in the McCain building, we were able to make recommendations at both the policy and behavioural level which would reduce the amount of energy consumed by computers connected to the UCIS system. Examples of recommendations include a revision of the UCIS operational procedures which require daily over-night maintenance and encouraging students to turn off computers after peak hours. We were also able to provide a baseline study for future research by students, faculty or UCIS as apart of the recommended annual evaluation of their systems. Reducing energy consumption at Dalhousie University is vital for several reasons; for financial savings, to reduce the amount of CO_2 released into the atmosphere as a result of burning Bunker C fuel and finally because the global phenomenon of climate change and peak oil demand it.

Appendix A

Interviews

Interview Questions for Lab Attendants

Computer lab room number: 2019

Interview #1

1. Listed below are various motivations for turning off computers over night. Please rank the them based on importance, with 1 being the most important
   a. Saving energy
   b. Saving money
   c. Protecting hardware
   d. Other: please elaborate____

Saving energy, saving money, protecting hardware

2. Do you turn off computers at the end of your shift? Yes[ ] No [x]
   a. If yes what is the single most important reason you do so?
      i. Policy
      ii. Personal conviction
      iii. other
   b. If no, what is the single most important reason you do not do so?
      i. Policy – no policy, no mention of anything
      ii. Personal conviction
      iii. Other

3. Are you aware of any policies, either formal or informal, pertaining to turning off computers at the end of your shift?
   a. If no,
      i. If policy said you had to turn off computers would you comply? Yes [x] No [ ]
   b. If yes, what is the policy? If anything, if the computer is broken you can shut it off. Up to the lab attendant. If computer is off during peak lab time, lab attendant must turn it on.

   c. If yes, does the policy pertain to
      i. Monitors
      ii. Towers
      iii. Both

d. If yes, how were these policies transmitted to you?
    i. Letter [ ]
    ii. Written document [ ]
    iii. Training manual [ ]
    iv. Oral Formal/informal [ ]
    v. Orientation [ ]
    vi. Other [ ]

e. If there are policies in place, how often do you fulfill them?
    vii. 0-25% [ ]
    viii. 26-50% [ ]
    ix. 51-75% [ ]
    x. 76-100% [ ]
    xi. If no, what is the single most important reason you do not?

4. Are you aware of any policies pertaining to leaving computers on at the end of your shift?
    a. If no,
        i. If policy said you had leave computers on would you comply?
        Yes [ ] No [ ]

    b. If yes, does the policy pertain to
        i. Monitors
        ii. Towers
        iii. Both – during peak time of day

    c. If yes, how were these policies transmitted to you?
        i. Letter [ ]
        ii. Written document [ ]
        iii. Training manual [x] mostly pertains to print credits, must stand up every 20 minutes to make sure all computers are in working condition
        iv. Oral Formal/informal [ ]
        v. Orientation [ ]
        vi. Other [ ] – noone really said to turn them on at peak time, but one of their duties is to make sure that all computers are working, which was stated in the training manual. So, if there are any problems, they are rebooted or Scott is told.

    d. If there are policies in place do you fulfill them?
        i. 0-25% [ ]
        ii. 26-50% [ ]
        iii. 51-75% [ ]
        iv. 76-100% [x]
        v. If no, what is the single most important reason you do not?

5. Some individuals think that turning off computers is an individual responsibility, other think it is the establishments responsibility, which perception do you share if either? Individual [ ] Establishment [x]
    a. If you do not share either perception, what is your perception?

6. What do you think would make turning off computers occur more regularly when the lab closes?
   -cost

   -students complaining

7. If turning off comp were an individual responsibility, do you have any suggestions about how we can get people to turn off computers more often?

-reminder on wallpaper

-posters

8. To your knowledge, do individual lab users ever turn off computers?
   Yes[ ] No[x]

    a. If yes, has this ever created any issues?
        i. With you
        ii. With your supervisor
        iii. With hardware (Programs, maintenance etc)
        iv. Other

9. Is there anything else that you would like to add?
   -laser printers go on energy saving mode after an hour of being left idle.

   -very interested in helping us to ensure that computers are turned off at night!

Interview #2

1.Listed below are various motivations for turning off computers over night. Please rank them based on importance, with 1 being the most important

a. Saving energy 2
b. Saving money 3
c. Protecting hardware 1
d. Other: please elaborate: safety 4

2. Do you turn off computers at the end of your shift? Yes[ ] No [x]

a. If yes what is the single most important reason you do so?
    i. Policy
    ii. Personal conviction
    iii. other

b. If no, what is the single most important reason you do not do so?
    i. Policy x
    ii. Personal conviction
    iii. Other

3. Are you aware of any policies, either formal or informal, pertaining to turning off computers at the end of your shift?
    a. If no,
        i. If policy said you had to turn off computers would you comply? Yes [x] No [ ]
    b. If yes, what is the policy?

    c. If yes, does the policy pertain to
        i. Monitors
        ii. Towers
        iii. Both

    d. If yes, how were these policies transmitted to you?
        i. Letter [ ]
        ii. Written document [ ]
        iii. Training manual [ ]
        iv. Oral Formal/informal [ ]
        v. Orientation [ ]
        vi. Other [ ]
    e. If there are policies in place, how often do you fulfill them?
        i. 0-25% [ ]
        ii. 26-50% [ ]
        iii. 51-75% [ ]
        iv. 76-100% [ ]
        v. If no, what is the single most important reason you do not?

4. Are you aware of any policies pertaining to leaving computers on at the end of your shift?
    a. If no,
        i. If policy said you had leave computers on would you comply?
        Yes [x] No [ ]

    b. If yes, does the policy pertain to

i. Monitors
ii. Towers
iii. Both

c. If yes, how were these policies transmitted to you?
   i. Letter [ ]
   ii. Written document [ ]
   iii. Training manual [ ]
   iv. Oral Formal/informal [ ]
   v. Orientation [ ]
   vi. Other [ ]
d. If there are policies in place do you fulfill them?
   i. 0-25% [ ]
   ii. 26-50% [ ]
   iii. 51-75% [ ]
   iv. 76-100% [ ]
   v. If no, what is the single most important reason you do not?

5. Some individuals think that turning off computers is an individual responsibility, other think it is the establishments responsibility, which perception do you share if either? Individual [x] Establishment [ ]
   a. If you do not share either perception, what is your perception?

6. What do you think would make turning off computers occur more regularly when the lab closes?
   -lab attendants can check at the end of their shift to turn off the computers.

7. If turning off comp were an individual responsibility, do you have any suggestions about how we can get people to turn off computers more often?

-don't forget to shut down icon on desktop

8. To your knowledge, do individual lab users ever turn off computers?
   Yes[ ] No[x]

   a. If yes, has this ever created any issues?
      i. With you
      ii. With your supervisor
      iii. With hardware (Programs, maintenance etc)
      iv. Other

9. Is there anything else that you would like to add?

-computers should be turned off overnight.

-students should have access to computers somewhere on campus for 24hrs.

-all computers on campus should have the same software, except for specialized software such as the GIS lab or the tupper labs

Interview #3 & #4

1.Listed below are various motivations for turning off computers over night. Please rank the them based on importance, with 1 being the most important

e. Saving energy **3 1**
f. Saving money **2 3**
g. Protecting hardware **1 2**

2. Do you turn off computers at the end of your shift? Yes[ ] No [X X]
   a. If yes what is the single most important reason you do so?
      i. Policy
      ii. Personal conviction
      iii. Other
   b. If no, what is the single most important reason you do not do so?
      i. Policy [X X]
      ii. Personal conviction
      iii. Other

3. Are you aware of any policies, either formal or informal, pertaining to turning off computers at the end of your shift?
   a. If no, [X X]
      i. If policy said you had to turn off computers would you comply? Yes [X X] No [ ]

4. Are you aware of any policies pertaining to leaving computers on at the end of your shift?
   a. If no,
      i. If policy said you had leave computers on would you comply?
      Yes [ ] No [ ]

   b. If yes, what is the policy?
   →Do not turn computers off at the end of "our" shift because the ACS training manual says that computers must be left on at all times and you only log off, not shut down. Also if you see a computer off you should turn it on.

   c. If yes, does the policy pertain to
      i. Monitors
      ii. Towers

iii. Both [X X]

d. If yes, how were these policies transmitted to you?
   i. Written document [ ]
   ii. Training manual [X X]
   iii. Oral informal [ ]
   iv. Orientation (oral formal) [ ]
   v. Other [ ]
e. If there are policies in place do you fulfill them?
   i. 0-25% [ ]
   ii. 26-50% [ ]
   iii. 51-75% [ ]
   iv. 76-100% [X X]
   v. If no, what is the single most important reason you do not?

5. Some individuals think that turning off computers is an individual responsibility, other think it is the establishments responsibility, which perception do you share if either? Individual [X] Establishment [X X]

6. What do you think would make turning off computers occur more regularly when the lab closes?

→Telling the lab attendants to turn off the computers at the end of their shift.

7. If turning off computers were an individual responsibility, do you have any suggestions about how we can get people to turn off computers more often?

→Devise a rule that says after a certain time, like 7:30pm, any student in a McCain computer lab needs to turn off their computer when they are finished on it.

→ Putting up signs by the computers and around the computer labs saying turn off computers either when you're finished on them or after a certain time of day.

8. To your knowledge, do individual lab users ever turn off computers?
   Yes[X X] No[ ]

   a. If yes, has this ever created any issues?
      i. With you **[X X] because we have to turn them back on.**
      ii. With your supervisor
      iii. With hardware (Programs, maintenance etc) **[X X] if they are shut down improperly.**
      iv. Other

9. Is there anything else that you would like to add?
   → The computer labs should update their equipment to newer energy efficient models.

   → See if you can turn off computer by one main computer in the building or even one main computer in the computer lab.

   → Turning computers on/off during the day wastes more energy so they should be left on when the lab is open.

   → Change the ACS rules so that it is mandatory for all computers to be shut off when the

lab closes.

   → The computers in the computer labs should be turned off when the lab closes to save

energy and be more ecologically friendly.

GIS Interview: Charlie Walls

Q1: Is the GIS lab different from the UCIS in terms of policies regarding turning off computers/printers overnight.

Yes, they think that turning off computers is an important aspect of running a lab; also there is no automatic update program in the GIS lab… He thought that it was overrated anyway especially when they have Deepfreeze software installed in their computers.

Not aware of any formal policy, Thought it was up to individual lab administrators.

Deepfreeze: every time a computer is shutdown this processes resets the computers does an automatic update an then refreezes it, its also a safeguard against viruses.

Q2: How so? Are the policies of GIS computers independent of UCIS policies?

Yes, they don't bothjer them, they don't mind that GIS does its own thing

Q3: Is the GIS lab connected to the UCIS system in terms of centralized maintenance, etc?

No

Q4: Who performs maintenance and is it manual or centralized? How long does it take per computer?

Software

- GIS problem
- Tom and Charlie deal with it
- Takes minutes/machine
- Use Ghost(software) image

Hardware

- dido
-
- pack the computer up and take it to hardware services

Q5: Do you think this maintenance is comparable to UCIS operations with respect to maintenance?

They are pretty much the same, and managed the same way. Same OS both run office, difference is UCIS runs automatic updates where as GIS doesn't.

Q6: Are the procedures that you do with your computers feasible for other UCIS computers on campus?

Yes by using a simple "TOOL"

- Sticker that says turn off computer when finished
- Someone to remind people to comply "bad guy" to get the point across.

Q7: It is commonly understood that energy consumption creates GHG emission, how important is it to GIS to reduce energy consumption via computer policies in terms of decreasing GHG emissions? Scale of 1-5 with 5 being = very important

4→5 GIS would do it anyway

- computers are power hungry
- ERTH student are also well aware of envs impacts.

Q8: Does the GIS lab partake in any energy savings measures with respect to computers? For cost savings or other reasons?

Not really, they replace there CRT monitors with LCD monitor in 2006

Q9: Is the GIS lab a beneficiary of financial saving resulting from reduced energy consumption?

No they are not

- They do however feel that they save money on maintenance. By turning off there computers ware and tear on the hardware seems to be reduced.

Q10: Do you or your colleagues turn off computers when the lab closes? What are the hours of the GIS lab?

Yes, myself lab instructors and Tom turn off computer when student leave then on at noght but als we turn them off when we seen they have left them on during the day. It a routine and we also continuously encourage the student to turn there own computers off when they have completed they work

Hours

7am – 11pm

7pm on Fri/Sat

Q11. Is there anything else that you would like to contribute or add?

Use sticker reminder

On screen shutdown button

Visibility of policy (to clear up any misperceptions)

Think that the was they run the GIS lab is feasible for all other labs on campus

- Lab supervisors (computer specialist/professionals) could do update every couple of weeks /every month
- Could use “LISTSERV” to communicate with other Lab Managers concerning different problems or concerns, discuss Ghost and Deepfreeze

UCIS Interview: John Robertson

1. Can you please explain the difference between UCIS and ACS?

ACS is a subset of UCIS (which is campus wide)

UCIS has 3 departments ACS, Network and systems, (data centers), Admin computing (banner syst) dal online,

ACS is a mix of services directed at 5 stakeholder s: students ,faculty, researchers, staff, alumni.

How services are delivered: comp labs (27/28 labs across 3 campuses), desktop support (faculty and staff), help desk, hardware services, pcpc, ILO, training course for non-credit (fee), specialists (stats support, web data, support).

2. Are computers in labs centrally controlled?

-For maintenance? Yes [x] No [ ]

-For turning off/on? Yes [x] No [ ]

3. Are there any policies in place pertaining to turning off lab computers over night?
Yes [   ] No [x]

- If yes, what is the policy?

- If yes, does the policy pertain to
    - Monitors
    - Towers
    - Both
- If yes, is the policy campus wide? Or is it limited to specific areas or labs? Which areas?

- If yes, how were these policies transmitted to your staff including lab attendants?
    - Please check all that apply
        - Training manual [ ]
        - Oral (formal-orientation) [ ]
        - Oral (informal- conversation) [ ]
        - Email [ ]
        - Other [ ]

- The last set of questions asked about turning off computers, are you aware of any policies pertaining to leaving lab computers on over night?
  Yes [x] No [ ]
  Computers must be left on for maintenance,
  Every building has different hours, security staff necessary (for ppl and hardware)
  Operational process (as opposed to policy or guideline: operation dictates that comps need to be on to do maintenance (labs have to be closed other wise maintenance will mess with user service)
  Computers are "locked down" during the day: no virus updates. Over night, maintenance needs to open up system and reset defaults, get virus updates. Maintenance is automatic, no humans
  Window of maintenance: time varies, minutes to hours. Maintenance begins at midnight for all labs and finishes whenever, depending on the amount of maintenance required by each computer

    - If yes, does the policy pertain to

        - Monitors -no, they go into sleep mode when not in use, power saving settings are in operation (during the day too)
        - Towers- yes, because if you disrupt power then you disrupt the connection
        - Both

    - If yes, how were these policies transmitted to your staff including lab attendants?
      Lab manager mostly informed by UCIS, managers then inform attendants
        - Please check all that apply
            - Training manual [ ]
            - Oral (formal-orientation) [ ]
            - Oral (informal- conversation) [ ]
            - Email [ ]
            - Other [x] weekly meeting with superiors and followed up with verbal and email communication

- Does turning off computers overnight interfere with maintenance or any other aspect of UCIS operations? Yes [x] No [ ]
    - If yes, what is the nature of the interference?

  Power disruption disrupts the connection, not insurmountable, but is annoying (mostly just inconvenient for users because they have to wait for computer to reboot or have to find a lab attendant)

    - How often does this type of interference occur?
        - Daily [ ]
        - Weekly [ ]
        - Monthly [ ]
        - Once every 3 months [ ]
        - Once every 6 months [ ]
        - Once per year [ ]
        - Other unknown, record kept by UCIS by essentially unmonitored because it is primarily a ground level inconvenience and doesn't affect UCI service provision

- To the best of your knowledge, why aren't computers in labs turned off over night?

Computers required to be on for daily maintenance

- In your opinion, who should be responsible for turning off computers over night: (in an ideal world)

    - Individual users [ ]
    - Lab attendants [ ]
    - ACS supervisor (Scott McKenzie) [ ]

- UCIS/ACS [ ]
- Other [x] It should be automatic because it would be would be more effective. Technology is improving and will probably allow for this type of control.

- Is UCIS a beneficiary of any financial savings resulting from reduced energy consumption by computers? Yes [ ] No [x] The university pays the energy bills and receives savings

  If Yes, can you please expand on the process by which these savings are transmitted?

- Do you have any suggestions about how to make it simpler to turn off computers?
  - For example, a single desktop icon that shuts down the whole computer? Some comps have this feature

    Automate the process

- Can you please explain the process by which UCIS policies are reviewed and changed?

Impetus to change can come from student, government, faculty, executive.
Management team especially the executive oversee writing of policy, but the executive director has final word
A bulletin is released and is posted on the website, Letter from executive director released
The onus is on the Managers to make sure people below him know about the new policy (via email or conversation).
Procedure/Guidelines (thou should rather than thou shalt) undergoes a similar process (ex: staff on cells phones while driving

- It is commonly understood that energy consumption creates GHG emissions. On a scale of 1-5 with 5 being the most important, how important is it to UCIS to reduce emissions created by computers and printers?

  - 2   3   *4*   5

Services are the first priority, then doing it within the constraints of energy savings.
Energy consumption in computers has *always* been a concern, but now the issue is the increase in the number of computers in world.
Information technology has always been self-viewed as a green industry (compared to steel industry for example)
Heat generated by computers requires air conditioning…more of a concern for GHG's than actual power consumption by unit…often this factor is not considered
Economic bottom line the primary motivator
Try to centralize servers so air conditioning can also be centralized

- Explain evergreen:
  2 cycles completed (02, 05, 08)
  The intent is to replace all computers with new ones
  -Trickle down of hardware (old hardware moved to less-used labs),
  UCIS look at the green aspect when buying new hardware in terms of energy and heat consumption
  Also starting to look at the disposal of old units
  "re-deployment" ie: refurbishment and redistributed within community *look into this more** (through a leasing company; deal not signed yet)
  Plan to replace CRT's with flat screens (CRT's are HOT)
  Industry ISO standards relating to power consumption are improving, hoping for automated powering down of units
  Printers: replaced with updated laser printers

- Under the Evergreen project, are there any plans to upgrade the computers in labs in the McCain building? Yes [x] No [ ] all labs being upgraded
  - If yes, what upgrades are being considered?
    See above
    Asses services, restructuring rooms, laptop rooms

  - When would these changes be implemented?
    May-July '08 for replacing all comp. Upgrades occur every 3 years, but this interval may change as tech changes (ie: may be longer between upgrades)

  - If no, why are they not being considered for upgrades?

- Is there anything you would like to add?

For auxiliary labs in the McCain: laptops were bad decisions: easy to steal so lab has to be locked unless it is specifically booked (Dean's decision)
Common-pool labs, central booking system (ie anyone can book room for classes) available for all building hours (not auxiliary lab)
Try to survey faculty and students about services but low student response, even went through DSU (mention in report)

Try to do the right things within constraints (service is the priority)

Recognize economic element, consciously trying to reduce heat, on going effort.

"Green" considerations are a priority and are at the forefront of decision making processes.

MISC INFO

Learning commons controlled by library, and one lab on the other 2 campuses is the same.

Mr.Power thinks about power consumption

Industry ISO standards relating to power consumption are improving, hoping for automated powering down of units

Appendix B

Energy Audit

(See attached colour coded sheets)

Appendix C

Photos

Marion McCain Arts and Social Sciences Building

Caitlin Owens, 2008

Computer Lab 2019

Caitlin Owens, 2008

Computer With CRT Monitor in Room 2019

Caitlin Owens, 2008

Appendix D

Letter of Introduction/ Consent Forms

Thank You Card

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Image Sources

Figure A (computer tower): http://www.supportregion.com/images/tower.jpg

Figure B (computer monitor): http://www.sz-wholesale.com/uploadFiles/all-in-one%20LCD%20computer_753.jpg

Assumptions:

Number of hours out of office:	6348		(16h x 5 days) + 48h weekend) x 46 Weeks
Cost of electricity:	$ 0.099		Nova Scotia ($0.0986), NB ($0.0723), PEI ($0.084), NL (0.06102) - source Hogan, W.A. (2007). Sustainable Energy Study. Part I: Utility Power Rates, Present Power Usage & Possible Opportunities to Reduce Electrical Energy. Public Works and Government Services Canada - Atlantic Region. 27 pp.
Emission factor used:	).5418 Kg CO2 / KWh		This is the national average, according to Federal House in Order (FHIO) figures (See:)

Item	Mode	Watt/Item	Source
Reg Computer Tower	On	67	Assumes Intel Pentium 4 with reference to Roberson, Judy A. et. Al. Energy Use and Power Levels in New Monitors and Personal Computers. July 2002. University of Berkeley. p. 21 (http://enduse.lbl.gov/Info/LBNL-48581.pdf)
	Low	11	"Deep Sleep" mode would be 1 Watt relative to off with reference to Roberson, Judy A. et. Al. Energy Use and Power Levels in New Monitors and Personal Computers. July 2002. University of Berkeley. (http://enduse.lbl.gov/Info/LBNL-48581.pdf)
Monitor, "Regular" (CRT)	On	70	Assumes roughly 17" monitors with 140 square inches display, with reference to Roberson, Judy A. et. Al. Energy Use and Power Levels in New Monitors and Personal Computers. July 2002. University of Berkeley. p. 15-17 (http://enduse.lbl.gov/Info/LBNL-48581.pdf)
	Low	7	"average deep sleep power for CRTs was 7W" see Roberson, Judy A. et. Al. Energy Use and Power Levels in New Monitors and Personal Computers. July 2002. University of Berkeley. (http://enduse.lbl.gov/Info/LBNL-48581.pdf)
Monitor, "Flat Screen" (LCD)	On	37	Assumes 17" monitors with 148.5 square inches (13.5 x 11) display, with reference to Roberson, Judy A. et. Al. Energy Use and Power Levels in New Monitors and Personal Computers. July 2002. University of Berkeley. p. 15-17 (http://enduse.lbl.gov/Info/LBNL-48581.pdf)
	Low	2	"average deep sleep power for LCDs was 2W",. See Roberson, Judy A. et. Al. Energy Use and Power Levels in New Monitors and Personal Computers. July 2002. University of Berkeley. (http://enduse.lbl.gov/Info/LBNL-48581.pdf)
Laser Printers, Individual	On	40	Based on list of 441 networked EC printers in the NCR, looked at 9 of the most common Hewlett Packard Laserjet models (4050, 4100, 4200, 4 Plus, Color 4550, Color 4600, 4000, 5/5m/5n, 5000) collectively accounting for 289 EC printers in the NCR. Taking into account the number and Idle Power consumption of each of these 9 printer types, the "average printer" consumes 40 Watts. Numbers for Idle Power consumption came from "Product Specifications" listed at http://h20000.www2.hp.com/bizsupport/TechSupport/Product.jsp?prodTypeId=18972&prodCatId=236252&locale=en_US&taskId=101&contentGroup=NT_CT_Specifications&docIndexId=178991
	Low	21	Based on list of 441 networked EC printers in the NCR, looked at 9 of the most common Hewlett Packard Laserjet models (4050, 4100, 4200, 4 Plus, Color 4550, Color 4600, 4000, 5/5m/5n, 5000) collectively accounting for 289 EC printers in the NCR. Taking into account the number and PowerSave mode electricity consumption of each of these 9 printer types, the "average printer" consumes 21 Watts when in PowerSave mode. Numbers for PowerSave mode electricity consumption came from "Product Specifications" at: http://h20000.www2.hp.com/bizsupport/TechSupport/Product.jsp?prodTypeId=18972&prodCatId=236252&locale=en_US&taskId=101&contentGroup=NT_CT_Specifications&docIndexId=178991

Marion McCain Equipment Energy Audit Data Sheet- Rm 2019- CRT 24hr/365 days

Surveyor	ssica Bruce	Date of Survey:	13-Mar-08
Building:	Marion McCain Building		
Room:	2019		

ASSUMPTIONS ARE IN BLUE

SURVEY DATA GOES IN YELLOW

Assumed Dollars per kWh =	$ 0.099	
Assumed Number of Hours On "Avoidably" / Year =	8568	(24h x 7 days) x 51 Weeks (assuming a week off during Christmas break)
Assumed kg of Co2 per kWh =	0.5418	
Assumed Watts / Item left on =		(See W / Item Column)
Number of workstations audited =	53	
of workstations with similar policy (53+45) in Marion McCain building (hypothetically) =	115	

(See "Sources" tab for rationales)

Equipment Item	Status	Watts/ Item	Number of Items Counted in Survey	%	Watts	kWh/yr	Avoidable Cost/Yr	Avoidable Cost/Yr throughout the McCain building if this sample represented standard equipment policy and behavior	Avoidable CO2 (tonnes)/Yr	Avoidable CO2/Yr (tonnes) throughout the McCain building if this sample represented standard behavior and policy
Reg Computer Tower	Total		53	100%						
	On	67	53	100%	3551.0	30425.0	$2,999.90	$6,509.22	16.5	35.8
	Off			0%						
Monitor, "Regular" (CRT)			#	%	Watts					
	Total		52	100%						
	On	70	52	100%	3640.0	31187.5	$3,075.09	$6,672.36	16.9	36.7
	Off			0%						
	Low	7		0%	0.0	0.0	$0.00	0	0.0	0
Monitor, "Flat Screen" (LCD)			#	%	Watts					
	Total		1	100%						
	On	37	1	100%	37.0	317.0	$31.26	$67.82	0.2	0.4
	Off			0%						
	Low	2		0%	0.0	0.0	$0.00	0	0.0	0
Laser Printers			#	%	Watts					
	Total		1	100%						
	On	40		0%	0.0	0.0	$0.00	0	0.0	0
	Off			0%						
	Low	21	1	100%	21.0	179.9	$17.74	$38.49	0.1	0.2
	TOTALS:				7,249.0	62,109.4	$6,123.99	$13,287.90	33.7	73.0
		Avg. Watt			**136.8**					

Marion McCain Equipment Energy Audit Data Sheet-Rm 2019- LCD 24 hr/365 days forecast

Surveyor: ssica Bruce | Date of Survey: 13-Mar-08
Building: Marion McCain
Room: 2019

ASSUMPTIONS ARE

SURVEY DATA GOES

Assumed Dollars per kWh = $ 0.099
Assumed Number of Hours On "Avoidably" / Year = 8568 (24h x 7 days) x 51 Weeks
Assumed kg of Co2 per kWh = 0.5418
Assumed Watts / Item left on = (See W / Item Column)
Number of Employees Audited = 53
of workstations with similar policy (53+45) in Marion McCain building (hypothetically) = 115

(See "Sources" tab for rationales)

(When you change the n
yellow **boxes, the number**

Equipment Item	Status	Watts/ Item	Number of Items Counted in Survey	%	Watts	kWh/yr	Avoidable Cost/Yr	Avoidable Cost/Yr throughout the McCain building if this sample represented standard equipment policy and behavior	Avoidable CO2 (tonnes)/Yr	(to M s st
Reg Computer Tower	Total		53	100%						
	On	67	53	100%	3551.0	30425.0	$3,012.07	$6,535.63	16.5	
	Off			0%						
Monitor, "Regular" (CRT)			#	%	Watts					
	Total		0	NA						
	On	70		NA	0.0	0.0	$0.00	0	0.0	
	Off			NA						
	Low	7		NA	0.0	0.0	$0.00	0	0.0	
Monitor, "Flat Screen" (LCD)			#	%	Watts					
	Total		53	100%						
	On	37	53	100%	1961.0	16801.8	$1,663.38	$3,609.23	9.1	
	Off			0%						
	Low	2		0%	0.0	0.0	$0.00	0	0.0	
Laser Printers			#	%	Watts					
	Total		1	100%						
	On	40		0%	0.0	0.0	$0.00	0	0.0	
	Off			0%						
	Low	21	1	100%	21.0	179.9	$17.81	$38.65	0.1	
	Off	0		NA	0.0					
	TOTALS:				5,533.0	47,406.7	$4,693.27	$10,183.51	25.7	
		Avg. Watts / Workstation:			104.4					

Marion McCain Equipment Energy Audit Data Sheet - Rm 2019 - CRT After hours/365days

Surveyor: ssica Bruce | Date of Survey: 13-Mar-08

Building: Marion McCain

Room: 2019

ASSUMPTIONS ARE IN BLUE

SURVEY DATA GOES IN YELLOW

Assumed Dollars per kWh = $ 0.099

Assumed Number of Hours On "Avoidably" / Year = 3978 (10h x 5 days) + 28h weekend) x 51 Weeks

Assumed kg of Co2 per kWh = 0.5418

Assumed Watts / Item left on = (See W / Item Column)

Number of Workstations Audited = 53

of workstations with similar policy (53+45) in Marion McCain building (hypothetically) = 115

(See "Sources" tab for rationales)

Equipment Item	Status	Watts/ Item	Number of Items Counted in Survey	%	Watts	kWh/yr	Avoidable Cost/Yr	Avoidable Cost/Yr throughout the McCain building if this sample represented standard equipment policy and behavior	Avoidable CO2 (tonnes)/Yr	Avoidable CO2/Yr (tonnes) throughout the McCain building if this sample represented standard behavior and policy
Reg Computer Tower	Total		53	100%						
	On	67	53	100%	3551.0	14125.9	$1,398.46	$3,034.40	7.7	16.6
	Off			0%						
Monitor, "Regular" (CRT)			#	%	Watts					
	Total		52	100%						
	On	70	52	100%	3640.0	14479.9	$1,433.51	$3,110.45	7.8	17.0
	Off		0	0%						
	Low	7		0%	0.0	0.0	$0.00	0	0.0	0
Monitor, "Flat Screen" (LCD)			#	%	Watts					
	Total		1	100%						
	On	37	1	100%	37.0	147.2	$14.57	$31.62	0.1	0.2
	Off		0	0%						
	Low	0	0	0%	0.0	0.0	$0.00	0	0.0	0
Laser Printers			#	%	Watts					
	Total		1	100%						
	On	40		0%	0.0	0.0	$0.00	0	0.0	0
	Off			0%						
	Low	21	1	100%	21.0	83.5	$8.27	$17.94	0.0	0.1
	TOTALS:				7,249.0	28,836.5	$2,854.82	$6,194.41	15.6	33.9
		Avg. Watts / Workstation:			136.8					

Office Equipment Energy Audit Data Sheet - Rm 2019 -LCD After hours/ 365 days forecast

Surveyor:	ssica Bruce	Date of Survey:	13-Mar-08
Building:	Marion McCain		
Room:	2019		

ASSUMPTIONS ARE IN BLUE

SURVEY DATA GOES IN YELLOW

Assumed Dollars per kWh =	$ 0.099	
Assumed Number of Hours On "Avoidably" / Year =	3978	(10h x5 days) + 28h weekend x 51 weeks
Assumed kg of Co2 per kWh =	0.5418	
Assumed Watts / Item left on =		(See W / Item Column)
Number of Employees Audited =	53	
of workstations with similar policy (53+45) in Marion McCain building (hypothetically) =	115	

(See "Sources" tab for rationales)

Equipment Item	Status	Watts/ Item	Number of Items Counted in Survey	%	Watts	kWh/yr	Avoidable Cost/Yr	Avoidable Cost/Yr throughout the McCain building if this sample represented standard equipment policy and behavior	Avoidable CO2 (tonnes)/Yr	Avoidable CO2/Yr (tonnes) throughout the McCain building if this sample represented standard behavior and policy
Reg Computer Tower	Total		53	100%						
	On	67	53	100%	3551.0	14125.9	$1,398.46	$3,034.40	7.7	16.6
	Off			0%						
Monitor, "Regular" (CRT)			#	%	Watts					
	Total		0	NA						
	On	70		NA	0.0	0.0	$0.00	0	0.0	0
	Off			NA						
	Low	7		NA	0.0	0.0	$0.00	0	0.0	0
Monitor, "Flat Screen" (LCD)			#	%	Watts					
	Total		53	100%						
	On	37	53	100%	1961.0	7800.9	$772.28	$1,675.71	4.2	9.2
	Off			0%						
	Low	2		0%	0.0	0.0	$0.00	0	0.0	0
Laser Printers			#	%	Watts					
	Total		1	100%						
	On	40		0%	0.0	0.0	$0.00	0	0.0	0
	Off			0%						
	Low	21	1	100%	21.0	83.5	$8.27	$17.94	0.0	0.1
	Off	0		NA	0.0					
	TOTALS:				5,533.0	22,010.3	$2,179.02	$4,728.06	11.9	25.9
		Avg. Watts / Employee:			104.4					