

University of King's College Energy Audit:
A Study of the School of Journalism Computer Labs

Final Report
April 12, 2013

ENVS/SUST 3502: Campus as a Living Laboratory
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Executive Summary

In recent years, computer use has been steadily increasing, causing a significant increase in energy consumption by computers. One way to assist in reducing computer energy consumption is to employ proper power management, which involves strategies such as turning off computers when not in use and activating automatic settings so that they will enter low power modes after periods of inactivity. This research project evaluated the energy consumption of the computers in the three computer labs at the University of King's College School of Journalism, with the objective of determining strategies for reducing energy consumptions. The research involved a number of methods as follows: (1) interviews were conducted to gather information on current policies and procedures pertaining to computer power management in the labs; (2) the power management settings and watt usage for computer equipment was recorded in the three labs; and (3) the computer labs were observed twice for a twenty-four hour period, one on a Sunday and the other a Tuesday, to record the power status of the computers (off, sleep, etc.) and patterns of computer use. Based on these observations, it was calculated that in over the course of two academic terms (fall and winter), the estimated energy consumption of the computer labs is 4237 kWh. This energy consumption is also equivalent to 2424 kg of CO₂ or \$449.00. Different power management scenarios that would decrease the computer's energy consumption were simulated to estimate the amount of energy, money and greenhouses gases that could be saved with each power management strategy. It was found that the most energy efficient management settings would be to adjust computer brightness to the lowest setting and to turn computers off when not in use. However, barriers to turning off computers at night were identified in the interviews, and putting computers in computer sleep mode when not in use consumed only slightly more energy than turning computers off. Taking this into consideration, the following recommendations were made: lower automatic computer sleep time to 10 minutes on all computers, change the monitor brightness to the lowest possible setting on all computers, deactivate screen savers, and turn off computers at night if the identified barriers are ever able to be overcome. If the computers are set to sleep after 10 minutes and brightness reduced to the lowest possible setting, it was estimated that the University of King's College School of Journalism could save 2336 - 2448 kWh of energy, or \$247 – 259, over the course of two terms. In addition, it is recommended that power management strategies are written into a formal power management policy for the University of King's College School of Journalism computer labs.

1. Introduction

The University of King's College School of Journalism currently operates three computer labs, none of which has been subjected to a professional energy audit. The first objective of this research study was to quantify and calculate the current energy consumption of the University of King's College School of Journalism's Computer Labs. This was assessed in kilowatt-hours, and was also converted into energy costs and greenhouse gas emissions. The second objective was to generate potential alternative power management strategies, followed by an assessment of how these different strategies would affect energy consumption. The goal of the project was to present King's College with feasible scenarios to reduce energy consumption in the computer labs, thereby contributing to increased sustainability in the labs. The energy audit was meant to prompt a reevaluation of the Journalism School's computer lab policies and the implementation of improved power management techniques.

1.1. Rationale

1.1.1. Climate Change and Greenhouse Gas Emissions

There has been growing scientific consensus that a global transformation of the earth's climate is currently underway, due to the disproportionate amount of CO₂ gas being emitted into the atmosphere from human activities and the resulting intensification of the earth's greenhouse effect (IPCC, 2007). This increase in greenhouse gases more effectively traps solar radiation within the atmosphere, causing the mean global temperature to rise at a faster rate than it would naturally (IPCC, 2007). This sudden increase in mean temperature entails a host of other problems, as the earth is a connected system and one unbalanced aspect of its homeostasis will cause other parts to become out of sync as well (Solomon et al., 2007).

The International Panel on Climate Change (IPCC) has been a driving force in climate change research and predictions. Rising sea levels, ocean acidification due to the atmospheric deposition of carbon, more frequent extreme weather events, drought, and the melting of the polar ice caps are all symptoms of climate change that have been predicted by the IPCC in their *Fourth Assessment Report: The Physical Science Basis*, and are indeed becoming an expected reality in the world today. They have predicted that from 1990-2100 the global mean temperature could increase anywhere from 1.4°C to 5.8°C, with potentially irreversible effects on the planet's ecosystems and biogeochemical cycling, and more generally, the homeostasis of the diverse systems that allow the Earth to be a livable planet (Solomon et al., 2007).

Energy use in the form of electricity, which comes from electricity-generating power plants fueled by non-renewable fossil fuels, is a large overall contributor to greenhouse gas emissions and consequently to the global problem of climate change. In addition, as temperatures continue to rise due to climate change, energy consumption in climate sensitive areas is going to change corresponding to those warming temperatures, creating a positive feedback loop. In areas experiencing warmer temperatures, energy use in commercial buildings is expected to increase due to a greater desire for air conditioning, refrigeration, etc (Scott, 2007). This only heightens

the urgency of curbing the energy consumption now, in order to offset these expected future increases.

1.1.2. Increasing Energy Consumption from Commercial/Institutional Computer Usage

Energy consumed by household appliances such as office equipment and consumer electronics has been rapidly growing, and in the United States it accounts for almost 55% of the total energy consumption in commercial buildings (Solomon et al., 2007). From 2001 to 2006, the CO₂ emissions associated with commercial buildings grew at a rate of 3.0% per year (Solomon et al., 2007). In 2004, the CO₂ emissions from both electricity use and direct combustion were tallied at 8.6 Gt/yr (Solomon et al., 2007).

In Canada, energy consumption from offices has increased by 55% from 1990 – 2008 (Natural Resources Canada, 2011). Energy use from the commercial/institutional sector accounted for 13% of the total secondary energy usage in Canada in 2008. Out of all the types of energy consumption in the commercial/institutional sector, energy use from offices accounted for the highest portion at 35% (Natural Resources Canada, 2011). Various energy-saving measures can be introduced in offices, however, and especially in computers which are produced with adjustable power management settings. These include implementing more energy efficient settings in on and low-power modes, creating computer chips that reduce electricity use in low-power modes, and giving computer users reminders to turn equipment off before leaving the office (Solomon et al., 2007), (Marans, 2009).

1.1.3. Increasing Sustainability Initiatives on University Campuses

As large commercial institutions filled with computer labs, libraries, offices, and research labs, universities are major consumers of energy. However, universities have the potential to engender individuals who could be passionate about sustainability issues, through both formal and non-formal educational initiatives. In 2011, 284 campus energy conservation initiatives were announced on the online bulletin for the Association for the Advancement of Sustainability in Higher Education (AASHE). This was an increase of 28% from 2010, which only had 129 initiatives posted. The initiatives of 2011 included 97 solar installations, 34 energy overhauls, 21 wind initiatives, 19 renewable energy research centers, 17 campus energy competitions, 13 campus monitoring efforts, 12 renewable energy plans, and 9 geothermal projects (AASHE, 2011). The Massachusetts Institute of Technology saved 13 million kilowatt-hours after 1 year of initiating its Efficiency Forward Program, a campus-wide energy conservation and efficiency initiative and 24 million kilowatt-hours after 2 years (AASHE, 2011). The wide range of initiatives and the potential for savings in both energy and money is demonstrated by these American AASHE-supported post-secondary institutions, presenting us with a way forward for similar energy conservation initiatives at Canadian universities.

1.1.4. Energy Efficiency

This research project fits in with the larger context of impending climate change and campus energy-conservation initiatives in North America. Compared with large infrastructure changes, implementing energy conservation measures in electronics use procedures is relatively

easy, and is often called the low-hanging fruit of campus sustainability (Marans, 2009). Yet before energy conservation measures can be recommended or implemented, current energy consumption levels and use patterns must be evaluated (Vance, 2011).

It is important to outline the distinction between energy conservation and energy efficiency in this research. Energy efficiency applies to the implementation of new technologies that decrease energy consumption without necessarily changing the behaviour of the users of that technology (Lopes, 2012). Levels of energy consumption are a quantification of the behaviour of students and the use status of idle computers (Lopes, 2012). This study focused on energy conservation, rather than implementing new technology.

1.1.5. Energy Efficiency at the University of King's College

A previous analysis of computer energy policies and computer use at King's had not been conducted (personal communication with Alex Doyle, Feb. 1 2013). This project was the first assessment of the policies in place and of the actual levels of use in the computer labs over a 24-hour period. Recommendations of computer energy saving measures will be valuable new information in helping the University of King's College conserve energy, cutting greenhouse gas emissions and saving money on power bills. This study determined the current relationship between student use and computer status in order to provide recommendations for a new relationship, which would conserve energy relative to the current levels of computer energy consumption at King's.

The University of King's College is currently undergoing a student-led strategic planning initiative (University of King's College, 2013). Providing the Journalism Department and the University administration with recommendations for decreasing energy consumption at a time where the administration has an open and receptive attitude to student input increases the probability that the recommendations will be implemented.

A preliminary interview with Alex Doyle, head of Facilities Management at King's, indicated that there is a desire to increase energy efficiency and sustainability on campus (personal communication, Feb. 1 2013). He showed great interest in the possibility of an audit, and stated that he wants to decrease energy consumption on campus in order to decrease King's power bill as well as improve sustainability (personal communication, Feb. 1 2013). Thus at the level of Facilities Management, there was a desire for this research and an impetus to implement future recommendations.

The ultimate goal for this research was to trigger policy changes regarding computer use through the Journalism Department, which would in turn decrease the amount of energy consumed by computers on campus.

1.2. Research Problem and Questions

The current research study sought to assess energy consumption of the computers at the University of King's College School of Journalism and to provide recommendations based on

the observations collected to decrease the amount of energy consumed. The overarching research question was:

In the three computer labs at the University of King's College School of Journalism, what measures could be taken to reduce energy use by computers?

This research question was addressed by answering the following three specific questions:

1. Are there current policies in place pertaining to computer power management in the labs? If so, what are they?
2. In the labs, what are the current patterns of computer use and power management, and what is the energy consumption resulting from those patterns?
3. How would implementing or changing computer power management policies impact the amount of:
 - a. energy consumed?
 - b. money spent on energy for the computers?
 - c. greenhouse gas emissions produced by the energy used to power the computers?

1.3. Scope

This research was conducted in three computers labs in the Journalism School on the University of King's College campus. Observations will be taken in each lab every hour. The number of computers on/off/in hibernate/in sleep was recorded. Through interviews with staff and faculty of the Journalism School, basic information regarding computer use policies was collected.

The scope of the data collection was limited due to the time available to conduct research and the ability of researchers to be available for intensive data collection for more than a couple of days. The collected data would contain more validity if the collection and observation period was longer, but this was one of the limitations of the scope of this project. The average energy consumption and use levels for two days still provided baseline data that could be expanded on in future studies.

2. Background and Literature Review

2.1. Computer Energy Use and Power Management

In recent decades, the rapidly growing use of computers has resulted in a significant increase in aggregate energy consumption by computers. To illustrate, between 1988 and 2006, the total energy consumption by office computers in the United States tripled from 25 TWh to 75 TWh (Webber et al., 2006). A similar trend has occurred in Canada, where an increase in the use of computers and other office equipment in the commercial and institutional sectors as increased energy consumption by 75.5 PJ, which has led to an increase in related GHG emissions by 4.4

Mt (Natural Resources Canada, 2006). In 2006, the servers and data centers in the United States consumed approximately 1.5% of the country's total electricity consumption (EPA, 2007). Electricity use for data centres worldwide doubled between 2000 and 2005; as of 2005, electricity used for information technology equipment in data centers accounted for approximately 0.5% of the world's electricity consumption (Kooimey, 2008). Considering the use stage accounts for 55% of the total energy use in the life cycle of a computer (Masanet & Horvath, 2006), reductions in energy consumed by operating computers would make an important contribution to lowering their overall environmental footprint.

Even though the total energy use by computers has been rising, the energy consumption of individual computers has been declining. This is largely due to energy efficiency improvement efforts. One important element of making computers more energy efficient is what is known as power management. Power management involves strategies to reduce energy consumption of computers when they are not being actively used, such as by setting monitors and computers to automatically enter low power or 'sleep' modes when they have not been in use for a period of time (Walker, 2009). Power management originated as a way to prolong the battery life of laptop computers, and since has expanded to a wide variety of other electronic devices (Webber et al., 2006). The U.S. Environmental Protection Agency (EPA) launched the Energy Star certification program in 1992, which began to certify monitors, computers, printers, photocopiers, fax machines, scanners, and other devices that had power management features (Webber et al., 2006). Today, power management capabilities have become standard features in Windows and Macintosh operating devices (Walker, 2009).

Power management is important because computers consume significantly different amounts of energy in different power states. There are three main power states: on, low power, and off (Webber et al., 2006). While power levels in a particular state vary based on the particular model, Table 1 shows the average power level of computers and monitors in the U.S. (Kawamoto, Shimoda & Mizuno, 2004). Although the power levels from 2004 provided in this table are somewhat outdated and power consumption is likely lower today due to improvements in energy efficiency of computers, these were the most recent average figures (as opposed to figures based only on individual models) that could be found. They are displayed here to demonstrate the differences in energy consumption among different power states, rather than to be an accurate representation of current absolute consumption in each state. Evidently, computers and monitors consume significantly less power when in low power mode as compared to being on: 55% less for desktop computers, and 94% less for CRT monitors (Webber et al., 2006). An additional feature that some computers have is to go into 'hibernate', either automatically or manually (Webber et al., 2006). Hibernate mode consumes the same amount of energy as when a computer is turned off, but the user's current activities are saved so that they can be automatically revived when the computer is turned back on (Webber et al., 2006).

Table 1 Average power levels computers and monitors in the U.S. (Modified from Kawamoto, Shimoda, & Mizuno, 2004).

		On (W)	Low-power (W)	Off (W)
PC	Desktop	55	25	1.5
	Portable	15	3	2
Display	CRT	85	5	0.5
	LCD	15	1.5	0.5

The U.S Department of Energy recommends turning off monitors if not in use for twenty minutes or more, and turning off computer if not in use for two hours or more (2012). Dalhousie University recommends turning off computer monitors when not in use for 5 minutes and in general turning off monitors and computers when not in use as well as power bars (n.d). Despite the fact that it requires a surge of energy to turn on the equipment, this amount is less than leaving the equipment on for an extended period of time (U.S Department of Energy, 2012). Lack of clear information on when it is most energy efficient to turn off computers was reported as a barrier to individuals turning off computers by Kaplowitz et al (2012). It is also recommended that all office equipment be unplugged when not in use or be put on a power strip and turned off when equipment is not in use to avoid the draw of phantom power (energy which is drawn even when equipment is off) (U.S Department of Energy, 2012). Even though there may be an impact on computer life from being turned on and off on a regular basis, advances in technology have caused the majority of computers to become unaffected by this (U.S Department of Energy, 2012).

Considering the differences in energy consumption among different states, considerable energy savings can result from putting computers in low power states and/or powering them down when not in use. For institutions and companies that have hundreds to thousands of computers, this could add up to substantial savings in energy use and in the associated costs of energy (Masanet & Horvath, 2006). The EPA estimates that employing power management settings alone can save up to \$50 per computer on an annual basis (EPA, n.d., “Put your computers”). Despite the potential energy savings from power management strategies, these strategies are frequently not taken full advantage of. Both turning computers off and setting computers to enter low power states are important components of power management strategies that are often underused. A review of the literature on audits of office equipment found that turn off rates for personal computers ranged from 0% to 91% (Webber et al., 2006). Furthermore, according to Walker (2009), more than 90% of computer users in the U.S. do not use their automatic power savings settings to the fullest extent possible. A variety of studies in the literature have examined the potential of energy savings from power management strategies in more depth, several of which are outlined in the following paragraphs.

Through a series of calculations and analyses, a study by Masanet and Horvath (2006) examined various strategies to reduce the energy consumption of computers during their life cycle. They found that the top strategies were: turning off computers and monitors during non-use hours such as nights and weekends, which would save 24% of the energy in a computer’s lifecycle, and enabling all power management settings, which would save 21% of the energy in a computer’s lifecycle (that is, 21% if employed alone, and an additional 3% if employed in

addition to the former power-off strategy) (Masanet & Horvath, 2006). These strategies were second and third, after the top strategy of only purchasing LCD as opposed to CRT monitors.

In another study in the U.S., Webber et al. (2006) examined the after-hours power state of 1453 desktop computers and 1598 monitors at sixteen buildings (including offices, schools, universities, and medical buildings) in San Francisco, CA, Pittsburgh, PA, and Atlanta, GA. They found that an average of 60% of computers were left on, 4% were on low power states, and 36% were turned off, with the turn off rates varying between 5 to 67% in different buildings. For CRT monitors, 19% were left on (21% for LCD), 49% were in low power states (61% for LCD), and 32% were off (18% for LCD) (Webber et al., 2006). The study then compared energy consumption in the “as found” baseline scenario to three other scenarios, in which all computers in the study: 1) used power management strategies to successfully enter low power states, 2) were turned off during after-hours, and 3) both employed power management strategies and were turned off after hours (Webber et al., 2006). The energy savings are displayed in Table 2. The difference between the ‘as found’ scenario and the ‘power management and turn off’ scenario was an energy savings of a factor of 3.89 for desktop computers, 2.38 for CRT monitors, and 2.24 for LCD monitors (Webber et al., 2006). Evidently, employing power management settings and turning off computers and monitors when not in use can result in significant energy savings.

Table 2 Energy savings by employing power management strategies in Webber et al.’s 2006 study. (modified from Webber et al., 2006).

	Total energy use for devices in sample (MWh/year)			
	As found	100% successful PM	All turned off	All turned off & 100% successful PM
Desktop PC	486	280	144	125
CRT Monitor	329	167	152	138
LCD Monitor	13	7.4	6.2	5.8

Kawamoto, Shimoda & Mizuno (2004), in a similar study in Japan, estimated that 30% of a computer’s energy use is consumed while idling, while 40% is consumed during non-business hours. They estimated that simply decreasing the delay time before computers enter low power modes could reduce energy consumption during idling by 50%, and that using proper power management strategies during non-business hours could reduce energy consumption during that time period by 60% (Kawamoto, Shimoda & Mizuno, 2004). They found that fully using power management strategies and shortening power management delay times in all computers in Japan could together save 3.5 TWh annually, or the equivalent of 2% of the country’s commercial electricity consumption (Kawamoto, Shimoda & Mizuno, 2004). Additionally, their study emphasized the importance of shut down rates. They calculated that an office in the U.S. with fully activated power management settings would still consume more energy than an office in the Japan with no power management settings enabled, due a combination of the facts that Japan’s manual night-time shut-down rates are more than double those in the U.S., and also that Japan has a higher user of laptop as opposed to desktop computers.

A study by Roth (2004) states that computers left on at night, approximately 50% of computers in the non-residential sector, account for the majority annual energy consumption of desktop computers; only approximately 25% have power management settings activated. Power management settings were reported to be used to a greater extent, approximately 60%, for monitors (Roth, 2004). Research by Nisiforou et al (2012) at a large enterprise in Cyprus, asked office workers what they do with their computers at the end of the work day and 72% reported turning it off, while 12% said they logged out (computer left on), 11% reported turning off the screen, 3% reported putting it on sleep mode, and 2% reported leaving it on. This demonstrates that 28% of employees do not turn computers off at the end of the day, even though they are not used overnight. Similarly, an energy audit by Masoso and Grobler (2010) of six commercial buildings in Botswana and South Africa at night reported that some computers and other office equipment are left on overnight as well as over the weekend; this was the second largest consumer of energy, following the air conditioning systems. A differing result was recorded in a study of energy use behaviour in university science laboratories by Kaplowitz (2012); almost all participants stated that they turned off computers when not in use and 85% reported using automatic power settings on the computer to save energy.

Another relevant study conducted by Nedeyschi et al (2010), in collaboration with the University of California and Washinton, also discusses methods for reducing computer energy consumption utilizing power management techniques, like computer sleep during idle periods. By calculating the energy used during the periods of computer idling for a set number of computers, and then again is computer sleep mode as opposed to idle, a simple and effective comparison was made. The results from their idle vs. computer sleep (in which there is no work to process) test, obviously supported the notion of computer sleep as there is large potential energy savings. There was some subsequent concern that the constant switch from idle, to sleep, to in use, would cause a reduction in processing speed of the computers. Nedeyschi et al (2010) put those concerns to rest by determining that the reduction in speed, if any, would be negligible.

The studies above illustrate that there is considerable potential for improved energy savings from power management strategies. A variety of efforts can and have been employed to help realize these savings. Masanet and Horvath (2006) suggest that companies could undertake efforts such as implementing company-wide ‘switch-off’ campaigns, putting ‘switch-off’ reminder signs or stickers on computers, and educating employees about the potential energy savings and environmental benefits of using power management strategies. Larger scale initiatives have also proven useful.

While power management settings on monitors had become common by the end of the 1990s due to the EPA’s Energy Star program, it was estimated that only 56% of monitors had these settings activated in 2001 (EPA, 2012). As a result, the EPA launched a campaign in 2001 to have the sleep setting activated on one million monitors within a year, called the “Million Monitor Drive” (EPA, 2012). The campaign was highly successful, and within four year, approximately 660 million kWh of electricity had been saved as a result of 6.4 million monitors activating their sleep setting. The program took on a broader focus in 2008 to also target computers and other IT equipment, and is now referred to as the “Low CarbonIT” campaign. Through the efforts of these EPA campaigns, it is estimated that power management settings are now enabled in 95% of office monitors and 25% of office desktop computers, which results in an

annual saving of 10 billion kWh of energy and greenhouse gas emissions equal taking 15 million vehicles off the road (EPA, 2012).

Although encouraging the enablement of power management settings is a positive step, it is important that computers actually do enter lower power modes as they are set to do. In reality, some computers that do have their power management settings enabled still fail to enter low power modes (Webber et al., 2006). This occurs for a number of reasons. Some operating systems prevent computers from entering low power states (Webber et al., 2006). Networked computers can be particularly problematic, in that network activity, such as updates and virus scans, can keep computers awake (Webber et al., 2006). Furthermore, since some computers in low power states will fail to respond to network activity, and some companies will intentionally disable power management settings in order to maintain network presence (Webber et al., 2006).

Fortunately, solutions have been developed to deal with these problems (Walker, 2009). Software and network programs are now available that can activate power management settings in all computers in a network (Walker, 2009). These software programs can also ensure the computers in low power modes will still be able to receive network-wide updates including Windows and antivirus updates (EPA, n.d., "Implementation resources"). One example is the program NightWatchman Enterprise, which has been license on over 6 million computers globally, and has resulted in the saving of approximately 4.5 million tons of carbon dioxide emissions (EPA, n.d., "Implementation resources").

2.2. *Universities and Energy Consumption by Computers*

Universities have a large number of computers, and therefore a substantial amount of energy is consumed by computers at universities. It has been estimated that there are a total of 2 million computers at universities and colleges in North America, and if kept on all year long, these computers would consume approximately 950 MWh of electricity annually (Cabrera, & Zareipour, 2011). This energy consumption would produce 665,000 metric tons of carbon dioxide, or the equivalent of the emissions of 130,000 vehicles (Cabrera, & Zareipour, 2011). Therefore, it has been argued that significant energy savings and emissions reductions could be achieved by creating more effective computer power management strategies in higher education institutions (Cabrera, & Zareipour, 2011). These strategies may be fairly simple to employ given that the after-hours status of computers in labs is often controlled by one individual (Webber et al., 2006).

Important to take into consideration is not only the number of computers at universities, but also the usage rates of computers at universities. Webber et al. (2006) have suggested that computer labs at universities have a significant potential for energy savings since some university computer labs may have a larger number of unoccupied hours per day and per year in comparison to other buildings. The reality is that university facilities are highly used for approximately 34 weeks per year, but often have very low usage rates the other 18 weeks of the year (Spennemann, Atkinson, & Cornforth, 2007). Spennemann, Atkinson, & Cornforth (2007) have also argued that the idea that students should be able to have access to learning

environments, including computer facilities, 24/7, and the assumption that students would actually make use those facilities 24/7, may be somewhat misguided.

Several studies have examined usage of computers at universities. A study at the University of Calgary evaluated the use of three computer labs with a total of 64 desktop computers, finding clear seasonal patterns of computer use (Cabrera, & Zareipour, 2011). There were periods of low computer use during periods such as the beginning of semester, mid-semester breaks, and December break, with extremely low rates during the spring and summer terms; while, usage was not surprisingly highest during exam periods (Cabrera, & Zareipour, 2011). A similar study at the Charles Stuart University in New South Wales, Australia, similarly found marked variability in computer use that followed seasonal trends reflecting the progression of the academic year (Spennemann, Atkinson, & Cornforth, 2007). The study also found that 90% of computer usage occurs between Monday and Thursday, with Friday and the weekend having low usage rates, and that students use the computers during the day but in general do not make use of 24-hour computer facilities during the night (Spennemann, Atkinson, & Cornforth, 2007).

A number of studies have also calculated potential energy savings resulting from power management strategies in campus computer labs. The University of Calgary study mentioned above suggested the following three strategies: putting all computers in a deep sleep mode from midnight to 6 a.m., turning off half of the computers on weekends, and having a special power management schedule during the summer with significantly more computers in sleep mode and turned off (Cabrera, & Zareipour, 2011). The authors suggested that this would cut energy consumption in labs by half, thus savings 8 metric tons of carbon dioxide annually per lab, or a total of 495 metric tons for the university if employed in all labs (Cabrera, & Zareipour, 2011).

A study of computer energy usage was also conducted in the Marion McCain Rm 2019 computer lab at Dalhousie University by students in the “Campus as a Living Laboratory” class. It was estimated that \$2800 and 15.6 tonnes of carbon dioxide could be saved on an annual basis by turning the computers off after hours, and they recommended employing a centralized automatic shutdown and using Deepfreeze software in order to conduct network updates (Bruce et al., 2008).

Many higher education institutions are recognizing the considerable savings that can be realized through employing power management strategies in campus computer labs. On the AASHE website, the “Cool Campus! A How-To Guide for College and University Climate Action Planning” wiki contains a recommendation that campus computers enabled power management settings and shut off computers after-hours as an important component of a campus energy conservation strategy (AASHE, 2013).

Many campuses are taking efforts in this direction. For example, the Dalhousie University Sustainability Plan contains ‘Networked Power Management’ of computers as one of its key strategies (Dalhousie University Office of Sustainability, 2010). In the University of British Columbia’s Energy Policy for Classrooms and Offices, there are precise directions for the power management strategies to be employed, including that monitors and computers should be “set to enter sleep mode after 5 to 15 minutes of inactivity” and “standby or hibernate mode after

30 minutes of inactivity”, and “turned off when not in use” (UBC, n.d.). Campuses that have employed power management strategies are likely to see considerable savings as a result. For example, in the Yale University Facilities departments, computers had previously been left on all of the time for after-hours network updates. A power management strategy was employed in 2006, where users were asked to turn off their computers after use and software was employed to wake up the computers for network updates (EPA, n.d., “Success stories”). This has saved more than \$40 per computer annually, or \$4,700 for the 105 computers in the department. If this strategy were applied to all of Yale’s 10,000 computers, this could save \$400,000 per year (EPA, n.d., “Success stories”). At the University of New Hampshire, shutting down computers and unplugging other electronic equipment during the December break saved 92,000 kWh of electricity, which is enough electricity to power eight homes for a year and would have cost \$12,711 (UNH, 2006). The University of Ohio has saved 45% of its total computer energy use and 15,000 tons of carbon dioxide by shutting down computers that are not in use with computer management software (Sofer & Pottern, 2008). These represent just some of the many examples of initiatives in higher education institutes to employ computer power management strategies to achieve energy savings and reduce the associated greenhouse gas emissions.

2.3. *Sustainability at King’s*

There has been a fair amount of focus on sustainability at an institutional level at Dalhousie due to the presence of the Dalhousie University Office of Sustainability, but relatively little on King’s campus. Consequently, initiatives that aim to increase sustainability on King’s campus at the institutional level have been less than those initiated at Dalhousie.

There is currently a Sustainability Officer on campus who is elected by the King’s Student’s Union every year. The Sustainability Officer is the coordinator for Sustainability King’s, a group of students dedicated to organizing sustainability initiatives on campus (personal communication with Cate May Burton, King’s Sustainability Officer 2012, Feb. 15).

Actions that have been implemented by the group thus far include: starting a composting program in residence buildings (personal communication with Omri Haiven, VP External of the King’s Student’s Union, Feb. 17), getting rid of trays in the cafeteria which reduces the amount of food students take and the amount of food waste that is generated (personal communication with Omri Haiven, VP External of the King’s Student’s Union), introducing a reduced Via Rail train ticket from Halifax to Montreal for King’s students, which produces far less greenhouse gases than travelling by airplane (Walsh, 2012). The annual Green Shift Week encompasses events like the Dark and Dirty Challenge where students pledge to conserve electricity and water, and the Campus Climate Challenge, where students are challenged to engage in a number of energy-saving and waste-reduction actions over the course of two weeks, with the possibility of winning gift cards for local food (University of King’s College, 2013).

These actions are integral in their role of educating King’s students about energy conservation and sustainability, as changing traditional mindsets is an important step in changing people’s actions to ones that are more sustainable (Lopes, 2012). Implementing a composting

program and the reduced Via Rail train ticket show that student-led initiatives can introduce permanent processes that improve sustainability at King’s in the long-term.

3. Research Methods

This project investigated and audited energy use in the three computer labs in the University of King’s College School of Journalism. The computer labs are used for journalism classes, and they are also available for student use during non-class hours. They are available for any students to use during regular business hours, but are accessible to journalism students 24/7 with the use of a pass card. There are a total of 57 computers in the three labs (Table 3).

Table 3 Computer equipment in the three computer labs in the King’s School of Journalism.

Lab #	Equipment	Model Number	Number in Lab
Lab 1	Mac Computer	A1283	28
	Phillips Monitor	190 VW 9F B/27	28
Lab 2	Mac all-in-one	A1311	16
Lab 3 (Resource Room)	Mac all-in-one	A1224	13

An interview was conducted with the director of the School of Journalism to determine what power management policies are in place in the computer labs. Observations were made on (1) the power management settings of the computers, (2) the energy consumption of the computers in different states, and (3) computer usage in the labs. This data was used to estimate the current energy use in the labs over the course of two academic terms, and the calculate potential energy savings that could be realized by employing alternative power management scenarios.

3.1. Data Collection

3.1.1. Interviews with Journalism School Faculty and Staff

Interviews were conducted with relevant personnel on campus to determine whether there are any computer usage policies in place that mandates energy conservation measures. Interviewees included Kelly Toughill, Director of the King’s Journalism School, and Kate Ross, the computer lab technician for the Journalism School, whom Kelly recommended to us. Interviewees were recruited using an email invitation (Appendix 4).

The interview with Kelly Toughill was conducted in-person. The interview with Kate Ross was conducted over e-mail as she was too busy to meet in-person. The in-person interview with Kelly Toughill was semi-structured. An interview script was utilized; however, other questions that arose were asked in order to allow for new information to surface during the conversation and to obtain clarification where necessary. Interview questions were a mix of open-ended and single-response item questions (Appendix 5). The open-ended questions were used to allow for flexibility in the participant’s answers to explore the topics and allow for unexpected information to surface (Palys & Atchinson, 2008). Single-response item questions

were used where specific information was needed (Palys & Atchinson, 2008). The interview with Kate Ross over e-mail included the same questions; however, no additional questions were asked for clarification and the answers given were much shorter than the responses given in the in-person interview with Kelly Toughill.

3.1.2. Power Management Settings and Energy Consumption of Computer Equipment

The first stage of data collection involved conducting an initial assessment of the computer equipment in the labs to determine their current power management settings and energy consumption in various states. The methods for this study are informed by Webber et al (2006) that have analyzed computer power states via censuses as opposed to using sampling procedures. Furthermore, since our initial pilot test for this study revealed that different computers have their power management settings set differently, it was decided that it was important to collect data on each computer.

A map was created for each of the labs, and a number was assigned to each computer (i.e. 1 through 57). This was done to enable consistency among the researchers and to know which computer recorded data pertained to.

For each different computer equipment type and model, one computer was tested using a Watt-meter to evaluate the energy used in each power state: on, low-power display, sleep mode, and off. This data was recorded in Observation Table #1 (Appendix 1) and was used in estimating energy consumption in the labs. This was done as it has been recognized that power ratings for office equipment often differs from what is observed (Roth, 2004).

Each individual computer's power management settings found in the computer's 'Preferences' section were then recorded. The information recorded was as follows:

- Whether or not the computer's desktop and monitor are each set to automatically enter sleep mode
- The delay time before the desktop and monitor each enter automatic sleep mode
- Whether or not the computer's monitor is set to automatically enter screensaver mode
- The delay time before the monitor enters into screensaver mode
- The brightness of the monitor
- Whether or not the power management settings are adjustable by the user without an authorization password

This data was recorded in Observation Table #2 (Appendix 2) and was used to make suggestions in changes to power management in the labs.

3.1.3. Patterns of Computer Use and Power Status

The computer use and power status of the computers in the three labs was observed for a period of two days. Since computer use was predicted to vary between weekdays and weekends, one of the collection days was on a weekend and one was on a weekday. The days of observation were Sunday, March 10 and Tuesday, March 12, beginning at 12 a.m. and ending at

11 p.m. on each day. Each hour, on the hour, the status of each computer and monitor was recorded, in terms of whether it is in use, on but not in use, on sleep mode, or turned off.

The observer went through the list of the previously mapped and numbered computers numerically to ensure efficiency and routine. If a computer's monitor was black, the mouse was moved around to try to wake the computer up in order to determine if the computer was on sleep mode or off. The data was recorded in Observation Table #3 (Appendix 3). This observation table was developed based off of a similar table in another study that recorded whether computers and monitors were on, in low power mode, or off during after-hours (Webber et al., 2006). The data was used to provide an understanding of the patterns of use and patterns of power status in the computer labs, and to calculate potential reductions in energy use by changing power management practices.

3.2. *Data Analysis*

First, descriptive statistics were used to evaluate the data collected on power management settings using Observation Table #2 (using statistical methods outlined in Palys & Atchison, 2008). Percentages were calculated for the proportion of computers and monitors that were automatically set to enter sleep mode, monitors that were automatically set to enter screensaver mode, monitors set to full brightness, and computers with power management settings adjustable by the user. Additionally, the frequency, mode and range of the delay time for the computers and monitors to enter sleep mode and screensaver mode in each lab were calculated.

Second, using the data collected on computer use and power status in Observation Table #3, the percentage of computers and of monitors in each lab in each power status (in use, on, low power, off) was calculated for each hour over the two 24-hour observation periods. The data was graphed in order to provide a visual representation of the patterns of usage and power settings.

Third, the energy use in the computer labs over the course of two academic terms was estimated based on the energy consumption measurements and the observed patterns of computer use and power settings. The use and power status of each computer at the start of the hour was used to reflect the status for the entire hour. The number of computers or monitors in each state was multiplied by the measured energy consumption of the particular model in that power state. Since a range of energy consumption was measured for the computers that were on, both minimum and maximum energy consumption were calculated. The energy consumption of all of the computers and monitors in the labs was summed for both Sunday and Tuesday, to represent an estimate of energy consumption on a weekend day and a week day. The total energy consumption on Sunday was multiplied by two, and the total energy consumption on Tuesday was multiplied by five, with the sum representing an estimate of energy consumption over the course of a week. An academic term at King's is fifteen weeks long, including exam period but not including reading week (University of King's College, 2012). Therefore, the estimate of week-long energy consumption was multiplied by thirty to make an estimate of energy consumption over the course of the fall and winter academic terms. It was decided not to include the summer term, since computer usage patterns were assumed to be different during the summer

term. For this baseline scenario, normal brightness was used for all computers, since that was the setting observed on all of the computers during data collection (Figure 1, Results Section). Furthermore, when the all-in-one computers were in sleep, it was difficult to determine if the hard-drive or only the monitor were in sleep. Therefore, simplified assumptions were made that all computers in Lab 2 were in hard-drive sleep while all computers in Lab 3 were in monitor sleep, since this most closely represents the current automatic settings of the computers (Figure 1, Results Section).

Fourth, five alternative power management scenarios were developed, and the energy consumption over two academic terms if these power management strategies were employed was calculated. The five alternative scenarios were as follows:

1. **Reduced brightness:** monitor brightness reduced to the power saving setting
2. **Computer sleep:** all computers in sleep when not in use (not just the monitors in sleep)
3. **Off:** all computers turned off when not in use
4. **Computer sleep and reduced brightness:** scenarios 1 and 2 combined
5. **Off and reduced brightness:** scenarios 1 and 3 combined

These alternative scenarios were developed based on areas that were observed to be potential areas for improvement in power management in the computer labs.

Finally, the current energy consumption and alternative scenario energy consumption were converted into energy costs and greenhouse gas emissions. Energy cost was based on a power rate of 10.59 cents per kWh, which is the base energy charge for general commercial buildings (NS Power, 2013a). Greenhouse gases emissions were based on a rate of 571.96 g/kWh CO₂eq., which is the rate of emissions from the Nova Scotia Power's Tufts Cover generating station which provides power to Dalhousie and therefore was also assumed to provide power to King's (NS Power, 2013b; Dalhousie University Office of Sustainability, 2012). The potential savings in energy consumption, energy cost, and greenhouse gas emissions under the alternative scenarios were determined by calculating the difference between the current scenario and each of the alternative scenarios.

3.3. *Reliability and Validity*

Reliability is defined as the degree to which repeated observations yields similar results (Palys & Atchinson, 2008). In terms of inter-rater reliability, which is reproduction of results among different observers (Palys & Atchinson, 2008), all researchers completed a pilot test of the observation charts and used the same map of computers as to ensure that observations were recorded the same way. Test-retest reliability refers to the degree to which similar results are reproduced on different occasions (Palys & Atchinson, 2008); due to the limited time available the observations were only recorded on one weekday and one weekend day. However, the observations done in the computer labs are easily repeatable and could be done at the King's School of Journalism again, or elsewhere, in order to assess the reliability of observations.

Catalytic validity refers to “the degree to which research moves those it studies to understand the world and the way it is shaped in order for them to transform it” (Lather, 1991, pg. 152). This study provides the University of King’s College School of Journalism with a better understanding of their current power management strategies, the usage patterns of the computer labs, and the potential for savings in energy and money, presented in various scenarios. The study then takes this information, combined with insights provided through interviews, and provides recommendations for the King’s School of Journalism. As such, the study allows for the better understanding of the situation and provides concrete steps for change by those individuals interviewed, both of whom are in charge of computer lab management at the University of King’s College School of Journalism.

3.4. *Delimitations and Limitations*

This study focused specifically on the three computer labs at the University of King’s College School of Journalism. It did not examine any other computer labs at King’s. It also did not examine other energy-consuming equipment in the labs, such as scanners or lights. Observations of computer use and status were only taken on two days during the winter term.

There were a number of limitations with this study. First, the energy consumption of each computer and monitor in each state was estimated using a Watt meter, but in reality the exact energy use of a computer is subject to variation based on the programs running at any one time. Since equipment to monitor the precise energy use over the course of a day was not available for this study, an estimate was used.

Second, the use and power status at the beginning of the hour was assumed to represent the state over the entire hour, which may not actually have been the case. However, it was not possible without special equipment to monitor the precise state of 57 computers at every point in time over a 24-hour period.

Third, measurements were only taken on two days of the year due to the time constraints of the study. In reality, computer usage may be highly variable on different days of the week, during different parts of the term, and between the fall and winter terms. Therefore, the extrapolation of the measurements from the two days to two academic terms only represents a very rough estimate of energy use in the computer labs over the course of an academic year. While this is exploratory research, a more in-depth future study could account for this limitation by making observations for an entire week, and during several weeks at different points throughout the academic term. Using equipment to monitor energy use rather than making in person observations would also make it easier to monitor the labs over longer periods of time.

This research is also limited by the short time span allotted to it, as well as the lack of any funding from King’s or external sources to implement recommendations.

4. Results

4.1. *Interviews: Power Management Practices and Policies in the Labs*

The interviews revealed that the computer labs are almost always open for students (all day and night) and that when the labs are open, the computers are generally left on. However, the labs are closed for Christmas holidays and some periods during the summer and during these times, the computers are turned off.

When asked why the computers are not turned off when not in use, the interviewees responded that computers need to be left running for use all day, that student projects are left open on computers, and that it would be an inconvenience to wait for computers to turn back on if turned off. It was reported that it would both be an inconvenience for individual students wanting to use the computers as well as for classes being taught in the labs to have to wait for computers to be turned back on.

As to turning computers off at night, there are two labs (labs two and three) which were reported to be used by students throughout the night as they are used by specific courses and they are used for specific student projects. Lab 1 is not used for specific classes and therefore not often used in the middle of the night; however, the computers cannot be turned off at night as the Final Cut editing software requires the internet to be off and they have yet to figure out how to turn off the computers without them automatically turning the internet on. Reportedly, it would be a hassle to go through and turn off the wireless internet when the computers are turned back on. It was reported that if the labs switch to a new editing program, such as Adobe Premiere, it may be possible turn the computers off. However, the computers undergo updates at night and the current system does not allow them to restart for this, which presents an additional challenge.

One interviewee also explained that computers are set to different settings depending on what they are used for and what courses are being taught; the automatic sleep time can be set to different times or disabled.

4.2. *Observations in the Labs*

4.2.1. *Energy Consumption of Computer Equipment*

The energy consumption varied among the different computer models in the three different labs (Table 4). Energy consumption was reduced substantially in the computers in Labs 2 and 3 by reducing the monitor's brightness to energy-saver mode; the computers in Lab 1 did not have this setting. There was almost no difference in energy consumption between computer equipment when off and when in sleep mode. However, there was a surge in energy consumption when turning the computers on and off (Table 5).

Table 4 Energy consumption in various power states for computer equipment in the three computer labs of the King’s School of Journalism. Measured using a watt meter. Minimum (min) and maximum (max) energy consumption are recorded since energy consumption was variable in some states. Lab 1 has Phillips monitors and Mac hard-drives, with no energy-saver brightness mode; Labs 2 and 3 have different models of Mac all-in-one computers (monitor and hard-disk combined) with an energy-saver brightness mode available.

		<u>Energy Consumption</u>			
		Min (W/hr)	Max (W/hr)	Min (W/hr)	Max (W/hr)
Lab 1	Off	Monitor		Mac (Normal Brightness)	
	On	0	0	2	2
	Sleep	24	24	15	25
Lab 2	Off	Mac (Normal Brightness)		Mac (Energy-Saver Brightness)	
	On	2	2	-	-
	Computer Sleep	84	90	42	46
	Monitor Sleep	2	3	-	-
	Screen Saver	38	42	-	-
Lab 3	Off	Mac (Normal Brightness)		Mac (Energy-Saver Brightness)	
	On	2	2	-	-
	Computer Sleep	50	52	38	38
	Monitor Sleep	2	3	-	-
	Screen Saver	24	26	-	-

Table 5 Energy consumption when turning on and off for computer equipment in the three computer labs of the King’s School of Journalism. Measured using a watt meter.

	<u>Turning On</u>		<u>Turning Off</u>	
	Energy consumption (W/hr)	Time (seconds)	Energy consumption (W/hr)	Time (seconds)
Lab 1	22 to 34	80	30	10
Lab 2	30 to 53	90	35	10
Lab 3	30 to 53	90	35	10

4.2.2. Power Management Settings of Computer Equipment

While all of the computer hard-drives in Lab 2 were set to automatically enter sleep, almost none of the computer hard-drives in Lab 1 and Lab 3 were (Figure 1). Almost all of the monitors in all three labs were set to automatically enter automatic sleep mode and screensaver mode. None of the computers had their monitors set to energy-saving brightness mode. Overall, the majority of the power management settings could not be adjusted by the user without a password.

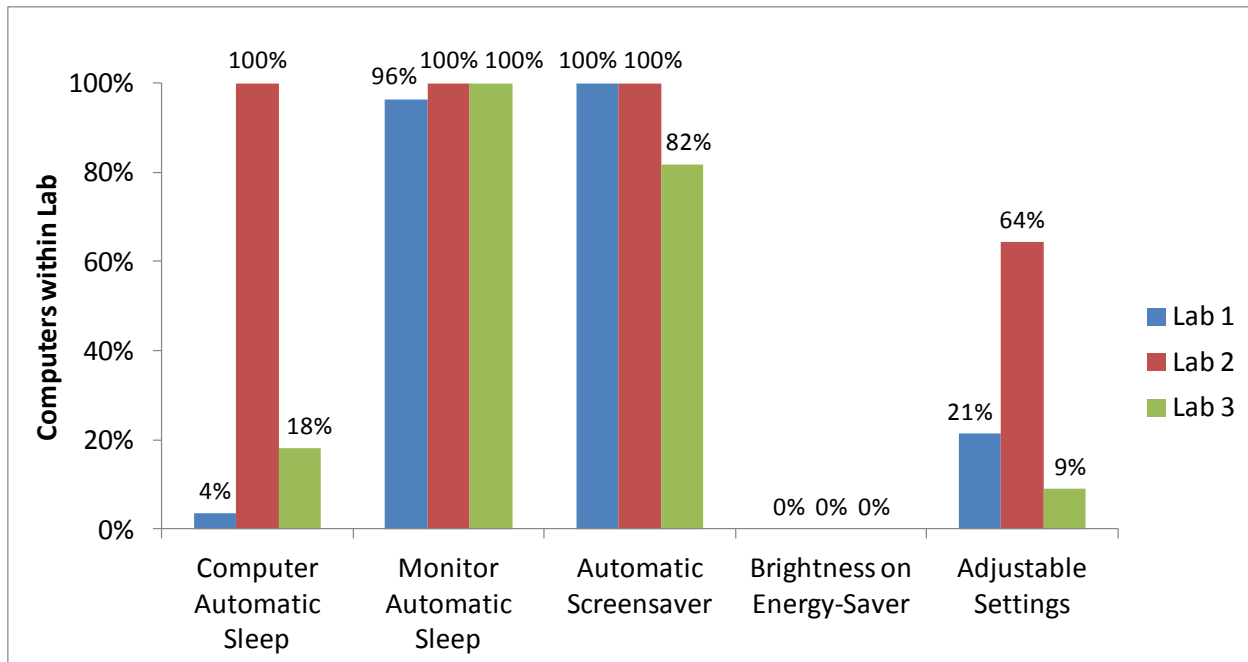


Figure 1 Percent of computer equipment with power management settings activated of the computers in the three computer labs at the King’s School of Journalism.

The time delay before computer hard-drives entered automatic sleep ranged from never to 60 minutes, with the mode being never in Lab 1 and Lab 3 and 10 minutes in Lab 2 (Figure 2; Appendix 6a). The time delay before monitors entered automatic sleep ranged from never to three hours, with the mode for all three labs being 10 minutes (Figure 3; Appendix 6b). The time delay before monitors entered automatic screensaver mode ranged from 10 minutes to 20 minutes, with the mode for all three labs being 20 minutes (Figure 4; Appendix 6c).

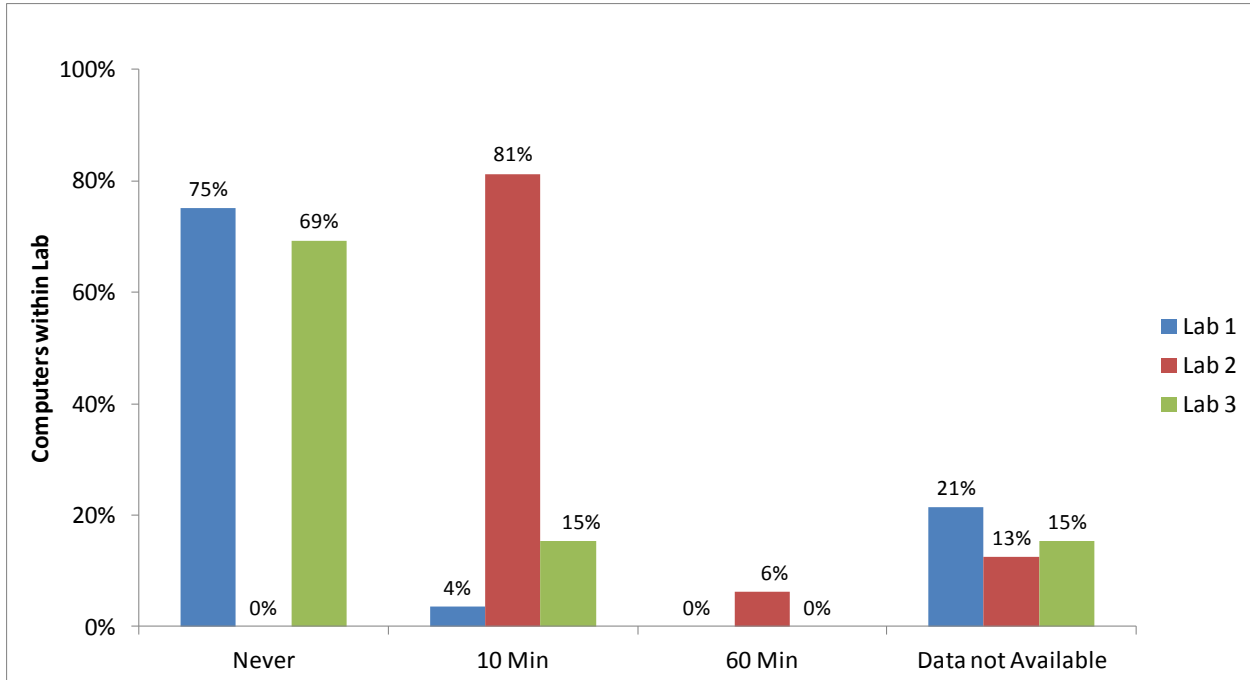


Figure 2 Frequencies of time delays before computers hard-drives enter automatic sleep in the three computer labs at the King’s School of Journalism.

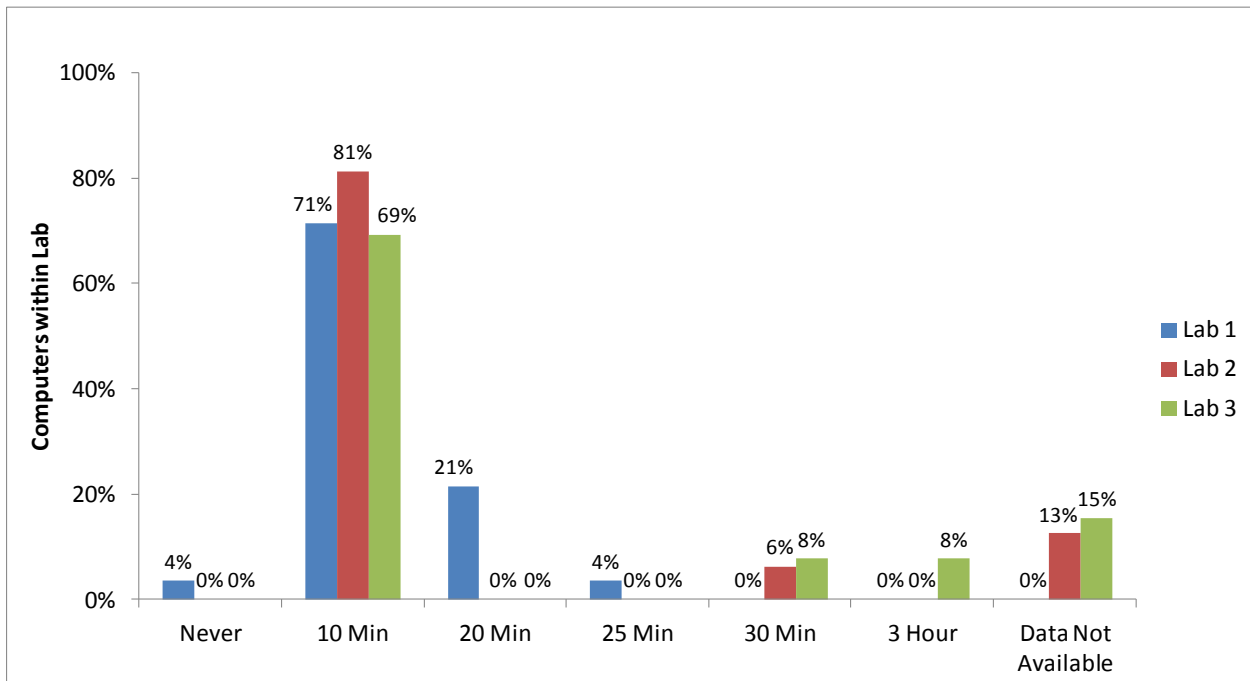


Figure 3 Frequencies of time delays before monitors enter automatic sleep in the three computer labs at the King’s School of Journalism.

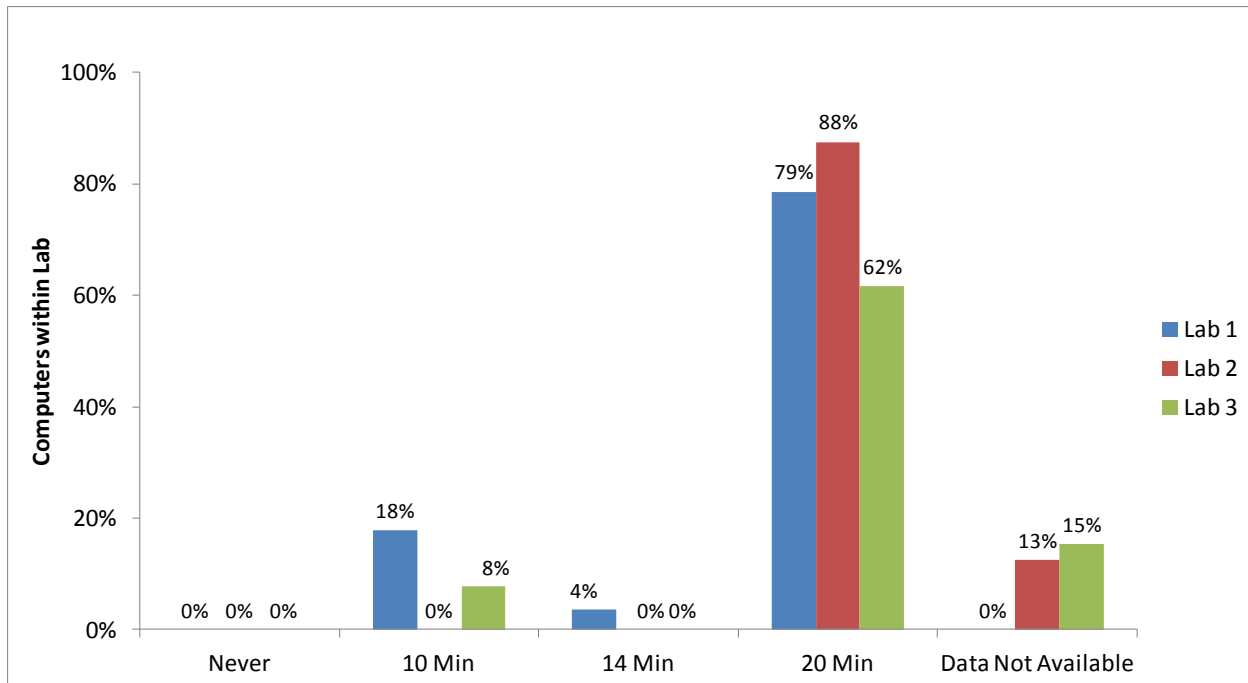


Figure 4 Frequencies of time delays before monitors enter automatic screensaver mode in the three computer labs at the King’s School of Journalism.

4.2.3. Patterns of Computer Use and Power Status

Although the computer labs are open 24-hours a day, seven days a week, there was minimal usage of the computer labs on the Sunday and during the night on both days (Table 6; Figure 5; Appendix 7). The highest periods of use were in Lab 1 during the late morning and early afternoon, and in Lab 2 during the late afternoon and early evening, part of which resulted from use during class time. When not in use, the majority of computers were either in sleep mode or off. However, some were on but not in use, and some were in screensaver mode. Furthermore, although many of the all-in-one computers in Lab 2 and 3 appeared to be in sleep mode, it was difficult to determine whether only the monitors were in sleep mode or if the hard-disks were also asleep. Since the majority of Lab 2 hard disks were set to automatically enter sleep mode while the majority of Lab 3 hard disks were not (Figure 1), in subsequent calculations it was assumed that observed sleep in Lab 2 computers meant hard disk sleep while observed sleep in Lab 3 meant monitor sleep only.

Table 6 Patterns of usage and power status of computer equipment in the three computer labs in the King’s School of Journalism as observed on Sunday, March 10 and Tuesday, March 12 from 0:00 to 22:00 every hour on the hour. Represented here as the average percent of computers in the lab in the power state over the 24-hour period. Number of Computers: Lab 1 = 28, Lab 2 = 16, Lab 3 = 13

	Lab 1 Computers		Lab 1 Monitors		Lab 2 All-in-One		Lab 3 All-in-One	
	Sunday	Tuesday	Sunday	Tuesday	Sunday	Tuesday	Sunday	Tuesday
Off	82%	43%	18%	26%	19%	0%	38%	37%
Sleep	10%	48%	75%	63%	74%	68%	50%	47%
Screensaver	N/A	N/A	4%	1%	0%	0%	6%	5%
On but not in Use	8%	1%	4%	1%	2%	12%	5%	4%
In Use	0%	8%	0%	8%	5%	18%	2%	7%

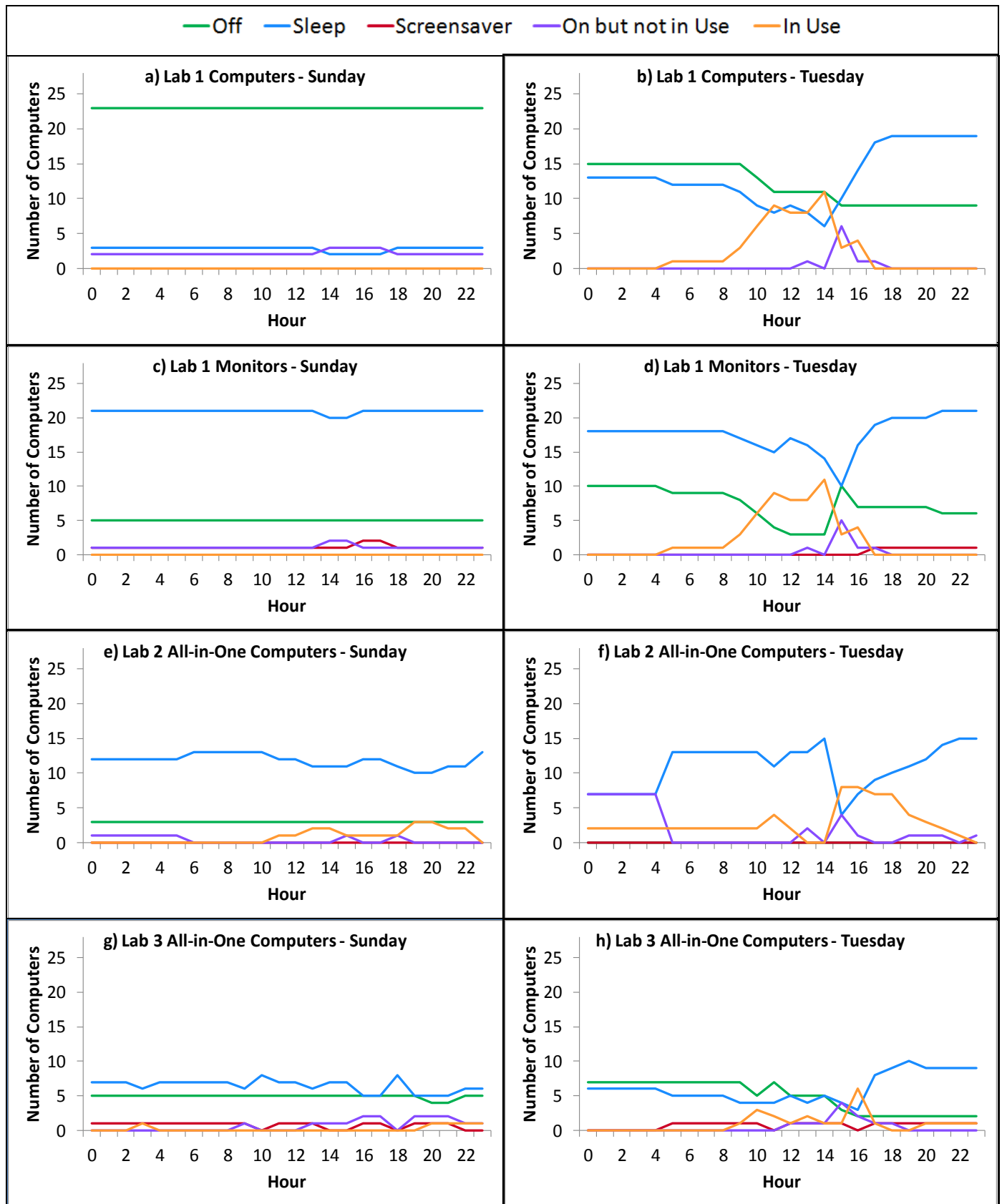


Figure 5 Patterns of usage and power status of computer equipment in the three computer labs in the King's School of Journalism as observed on Sunday, March 10 and Tuesday, March 12 from 0:00 to 22:00 every hour on the hour. Number of Computers: Lab 1 = 28, Lab 2 = 16, Lab 3 = 13

4.3. Calculations of Current Energy Consumption and Potential Savings

All of the alternative power management scenarios resulted in reduced energy consumption in comparison to the current situation (Figure 9; Appendix 8). It was estimated that employing one of these alternative scenarios could save anywhere between \$100 and \$280 over the course of two academic terms, representing between 22 and 62 % in energy consumption (Table 7). The scenario that resulted in the most savings was turning computers off when not in use and also reducing the brightness of the monitors to energy saving mode. However, the estimated savings were only slightly more than the scenario involving putting the computers in sleep mode when not in use and reducing the brightness of the monitors to energy saving mode. Furthermore, the computer “off” scenarios did not take into account the additional energy consumed by turning the computers on and off, which means that the difference in savings between “off” and “sleep” scenarios is likely even smaller than represented here.

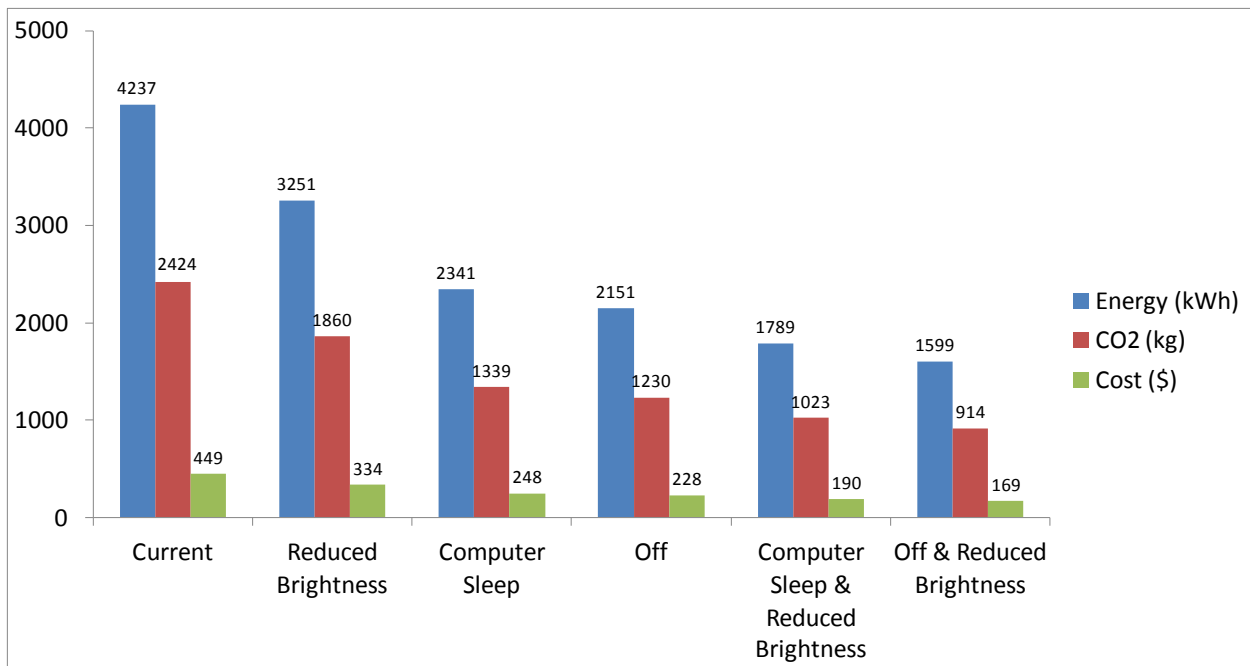


Figure 6 Estimates of energy consumption, carbon dioxide emissions, and energy costs over two academic terms (fall and winter) of the three computer labs in the King’s School of Journalism as they are currently and as they could be under five alternative power management scenarios. In cases where energy consumption in a particular state was represented by a range of values, the estimates displayed here are the maximum values.

Table 7 Savings in energy consumption, carbon dioxide emissions, and energy costs over two academic terms (fall and winter) of the three computer labs in the King’s School of Journalism under five alternative power management scenarios in comparison to the current situation. Savings are displayed as a range, based on the fact that energy consumption in some states varied over time when taking measurements.

<u>Alternative Scenarios</u>	<u>Savings in Comparison to Current Situation</u>			
	Energy (kWh)	C02 eq (kg)	Cost (\$)	Percent
1) Reduced Brightness	943 - 986	539 - 564	100 - 104	22 - 23 %
2) Computer Sleep	1814 - 1896	1038 - 1084	192 - 201	43 - 45 %
3) Off	1814 - 2087	1038 - 1194	192 - 221	43 - 49 %
4) Computer Sleep & Reduced Brightness	2336 - 2448	1336 - 1400	247 - 259	55 - 58 %
5) Off & Reduced Brightness	2336 - 2638	1336 - 1509	247 - 280	55 - 62 %

5. Discussion

The purpose of this research was to explore what measures could be taken to reduce energy consumption by computers in the three computer labs at the University of King’s College School of Journalism. The research set out to determine what current policies were in place pertaining to computer power managements in the labs, and the energy consumption of the labs resulting from current patterns of computer use and power management. Based on these findings, calculations were carried out to determine how implementing or changing power management strategies in the computer labs could reduce energy consumption, and consequently energy costs and greenhouse gas emissions in the labs.

After an in-depth analysis of the information obtained in the interview and the data collected on the three computer labs at The University of King’s College, the project’s research questions could be addressed. Both the interview and observations helped the project consider different ways to conserve energy use by computers.

5.1. Significant Findings of Research

During normal term months, the journalism students are granted 24/7 access to the labs. Computers in the labs did not have all the same settings, as some were used for teachers and others used for students running programs for long periods of time. In lab 2 and 3, the computers were left on to keep student work and updating systems running. Since some computers were on for different reasons, it was speculated that only Lab 1 could potentially be turned off during the night time, however this was not policy. In addition, if computers were off then either student or staff would need to start up the computer and programs prior to using them for work. This would prove to be time consuming or labour intensive to turn on and off computers.

A number of important findings related to the automatic power management settings were found. While the majority of all monitors were found to enter automatic sleep, almost all of the computers in two of the labs were not set to automatically enter sleep. This suggests that power management could be improved by ensuring that all computers, and not only the monitors, were

set to enter automatic sleep. Further, there were inconsistencies in terms of the delay times before automatically entering sleep mode, in that a number of computers had delay times much higher than the usual 10 minutes. This suggests that energy could be saved by making the delay time consistently at 10 minutes for all computers in the labs.

In measuring the energy consumption of the computers in various states, it was found that putting both monitors and computers in sleep mode significantly reduced energy consumption in comparison to when the computers were on. However, the difference in energy consumption between sleep mode and off was fairly insubstantial. This suggests that while turning computers off would allow for maximum energy savings, ensuring that all computers are all properly entering sleep mode when not in use would be a close second best if barriers exist that make it difficult to have all computers turned off when not in use. Additionally, it was found that reducing the brightness of the monitors would significantly reduce energy consumption. The energy-saver brightness setting was not perceived by the researchers to make images on the screen more difficult to see, and therefore reducing monitor brightness would be a simple way of reducing energy consumption.

Based on the observations, it was clear that there was a pattern of computer use in the labs. During the weekend, the usage of the labs was minimal when contrasted to a weekday. The weekend observations demonstrated that on average only 2-5% of computers are in use, while during the weekday on average 7-18% of computers were in use. In addition to the computers being used by students, some computers were left in different states (off, sleep, screensaver, and on but not in use) yielding various energy consumptions. With the data collected during the weekend and weekday, energy consumed, CO₂ released, and dollars spent could be estimated over two academic terms (fall and winter), using the maximum values. With the current patterns of computer use in the three computer labs, energy consumed for two academic terms would be equivalent to 4237 kWh. This energy is equivalent to 2424 kg CO₂ or \$449.00 dollars.

The analysis of the data made it clear that there could be an improvement in computer use status by implementing or changing policies at the University of King's College that would result in different values in the energy usage, funds spent, and greenhouse gas emissions fields. The project came up with a total of five different scenarios that, when calculated, could reduce values. Scenarios included: reduced brightness, computers on sleep, computers set off, computers on sleep and reduced brightness, and computers set off and reduced brightness. The scenario that could create the greatest changing in values was to turn all computers off when not in use and decreasing the brightness to the lowest possible setting. This scenario could result in a decrease of 2,638 kWh, and 1,510 kg of CO₂, and a savings of \$280.00. However, the savings were only slightly more than turning all computers to sleep mode when not in use and decreasing the brightness to the lowest possible setting.

It is clear that the analysis of the data collected demonstrates where the University of King's College is when considering energy consumption that leads to CO₂ emissions and money spent. One could say that the findings of the scenarios proposed could save the university money by reducing the energy consumed by the three labs. This could ultimately result in a decrease of CO₂ emitted, increasing the sustainability at the University of King's College.

5.2. *Consideration of Findings in Light of Previous Research*

The present study found that there is room for improvements in computer power management at the computer labs in the University of King's College School of Journalism. This finding is consistent with previous studies that have found that power savings settings are not being used to their full capacity in a large number of computers (Walker, 2009; Webber et al., 2006). In comparison to power management practices in some offices that were found to have night-time turn off rates as low as 0% and minimal use of sleep mode (Webber et al., 2006), the University of King's College School of Journalism labs clearly have better power management practices considering that a large portion of the computers are either in sleep or turned off when not in use. Still, this study found power management was not being used to the fullest extent possible, such as in the fact that most of the computers in two of the labs had monitor sleep but not computer sleep activated.

Furthermore, this study found that although the School of Journalism computer labs are open 24/7, usage during the night time and weekends is very minimal. This mirrors Spennemann, Atkinson & Cornforth's (2007) finding that in computer labs at the Australian post-secondary institution they were studying, the majority of computer usage occurred during the day from Monday to Friday. The fact that the computers tend not to be used 24/7 reinforces the importance of power management, since if computers are being unused for long periods of time it would not be sensible to keep them on.

Based on the fact computer power management is not being used to its full capacity, it naturally follows that employing better power management in the University of King's College School of Journalism labs could result in savings in energy consumption, energy costs, and greenhouse gas emissions. Other studies have similarly found that significant savings can be found from improving power management in office settings (ex. Kawamoto, Shimoda & Mizuno, 2004; Masanet & Horvath, 2006) and in post-secondary institutions (ex. Bruce et al., 2008; Cabrera & Zareipour, 2011). Similar to Cabrera and Zareipour's (2011) study which found that improved power management could cut in half the energy consumption of computers in the University of Calgary's labs, the present study found that improved power management could cut the energy consumption in the King's labs by as much as 55 to 62%. This suggests the need to give serious consideration to improving power management in computer labs.

However, this study also found that a barrier to improving power management was concern that putting computers into sleep mode or turning them off would interfere with the functioning of programs running in the background. This concern is a common barrier to power management, as some companies disable power management settings to ensure that software, antivirus, and other updates can run properly (Webber et al., 2006). However, there are power management software programs available that can help address these problems, such as by waking computers in a network up for updates or ensuring that updates can still run when computers are in sleep mode (Walker, 2009). This suggests that there may be a need for greater awareness and implementation of these power management programs. In the case of the University of King's College School of Journalism labs, the editing programs may have special requirements, and research would be needed to determine which, if any, computer power

management program could enable the editing software to continue functioning while attaining the maximum possible reductions in energy consumption.

This study also found that there were behavioural barriers to improving power management in the School of Journalism labs. That is, it was assumed that professors or students would not be willing to arrive at class five minutes early to turn on computers to be ready when class started if computers were turned off at night. Previous researchers have suggested that behaviours relating to energy use offer significant potential for improving energy efficiency (Lopes, Atunes & Martins, 2012). Therefore, this research also supports the idea that improving energy efficiency could also be improved by changing certain behaviours and expectations, such as the expectation that computers will be already be on when students arrive at class.

5.3. *Implications of Research*

Considering that increasing use of computers is leading to increased energy consumption by computers (Natural Resources Canada, 2006), it is important to look for ways to reduce the energy being consumed by individual computers. Power management is one way that this can be done.

The present study has shown that significant savings in energy consumption, and consequently energy costs and greenhouse gas emissions, can be realized by employing better power management in the University of King's College School of Journalism computer labs. The potential savings of up to 1,510 kg of CO₂ emissions and \$280 over the course of two academic terms may seem fairly small on their own. However, if similar improvements to power management were made in all computer labs at post-secondary institutions in Halifax, in all computer labs at post-secondary institutions across Canada, in all institutions and companies that have computers in North America, and on every single computer across the globe, it is easy to imagine how large the potential savings could be.

Specifically related to campus sustainability, this research suggests that improving power management in computer labs at post-secondary institutions can be an effective component of an energy efficiency and energy reduction strategy. The improved practices that could be employed include turning all computers off when not in use and/or having all computers automatically enter sleep mode when not in use, reducing the brightness of monitors, and ensuring the delay times for entering automatic sleep mode are consistent and as low as possible for all computers. The University of King's College School of Journalism and other post-secondary institutions may also choose to incorporate power management strategies into formal computer lab policies and sustainability policies, in order to ensure that the strategies are consistently employed and adequately recognized as a contribution to sustainability.

This study also suggests the importance of conducting energy audits at King's and other post-secondary institutions. There was potential for significant savings based on this very small energy audit of the computer labs, and therefore it can be assumed that even more substantial energy savings could be realized from conducting a campus-wide energy audit. This study reaffirms that making improvements to campus sustainability can also be economically

advantageous, in this case due to the potential for reduced energy costs. Furthermore, in the process of conducting the energy audit on the computer, the researchers noticed that lights were left on in the labs and radiators were heating the labs at night and on the weekends when no one was in the labs. The observation that the computer labs has relatively little use during nights and weekends suggests there is potential for energy savings in the labs besides improved computer power management, such as by employing policies to have lights turned off when labs are empty and heating is reduced during periods of low usage. Future research and energy audits could help ensure that more of these potential savings could be realized.

Finally, the research suggests that there may be a need for improved awareness and education about energy consumption by computers and the potential for both cost savings and sustainability improvements employing better power management strategies. The interviews revealed a supposed behavioural barrier to improving power management, in that professors and students were expected to be resistant to coming to class a few minutes early to turn on computers. Perhaps greater awareness and emphasis on the importance of reduced energy consumption would make professors and students more open to changing their behaviours and would help remove this perceived barrier.

6. Conclusion

6.1. *Major Contributions of the Study*

The ultimate impact of this study is its potential to increase sustainability on the University of King's College campus. It provides evidence that there is a lack of knowledge at King's regarding the most effective employment of computer power management settings so that energy savings increase. There is a need at King's in general to better employ computer power management settings. This study only investigated the energy consumption of three computer labs, however if the recommendations were applied to other computer labs on campus there is potential for even greater energy savings.

It was also found that there are significant behavioural barriers to implementing computer power management settings to their fullest extent. From the interview with Kelly Toughill it was learned that professors are unwilling to take the extra time out of class at the beginning of class to wait for students to turn on their computers and for the editing programs to start, a process which would take 5-10 minutes. It was also found that relatively few students use the computer labs at night compared with daylight hours, indicating that the amount of computer labs left open at night could be decreased from all three to one or two. A barrier to computers being turned off at set times every night is that students may not have saved their work and that it would consequently be lost when computers automatically shut down.

Due to the data collected by this research as well as extrapolating the data for a number of proposed scenarios, this study is able to provide recommendations of varying levels of effort that will decrease the energy consumption of the computer labs in the Journalism school. By adjusting the power management settings on all of the computers, specifically decreasing brightness levels and implementing automatic computer after 10 minutes, a significant amount of

energy could be saved. This would consequently save money, allowing King's to redirect those funds to other areas. It would also decrease the overall amount of greenhouse gases emitted by campus operations, thus joining the global effort of decelerating the process of climate change.

If it is not feasible at this point in time to implement all of the recommendations, the information collected and the scenarios simulated will be available to guide any future energy saving efforts.

6.2. *Recommendations for Action*

Based on a review of the literature, interview results, a review of the settings available on the computers the University of King's College School of Journalism and their current use as well as energy use measurements in each state, the following recommendations are made:

- When possible, lower all the automatic computer sleep time for all computer sleep to 10 minutes. This is already the case in Lab 2; however, it would need to be implemented for labs one and three.
- Change brightness to the lowest possible setting on all computers; screens are still clearly visible.
- Deactivate the setting for automatic screen savers, as they are energy intensive.
- If there is change in editing software in Lab 1 which would allow computers to be turned off without interfering (see section 4.3 for details), the School of Journalism should explore the possibility to have the computers turn off at night turn computers off as this lab is not often used throughout the night. This would investigation into power management software that would allow the computers to automatically turn on in the night solely for updates.

If the first two recommendations (setting computers to sleep after 10 minutes and reducing brightness to the lowest possible setting) are implemented, the School of Journalism could save 2336 - 2448 kWh of energy, or \$247 – 259, over the course of two terms (Table 7).

Furthermore, it is recommended that these power management strategies are written into a formal power management policy for the University of King's College School of Journalism computer labs. This would help professors and students understand any changes that are being made, and would help ensure there is consistency in employing the improved power management settings to all computers within the labs. In order to maintain the settings specified in the written policy, such as a sleep mode delay time of 10 minutes, the School of Journalism staff may also want to disable the setting that allows users to adjust power management settings. Having the power management strategies as a written policy would also provide documented proof of King's efforts to work towards sustainability, and could in the future be incorporated into any campus-wide sustainability policies that may be developed.

6.3. *Recommendations for Further Research*

In the future, it would be greatly beneficial to conduct a comprehensive energy audit of all of Kings Campus. This computer lab audit merely skims the surface of the work that should be done. By auditing the residences, library, and additional Kings College buildings and retrofitting appropriately, it may be possible to implement strategies that would result in a significant saving of energy and money, and a reduction of greenhouse gas emissions. An overall audit would also help distinguish real barriers from perceived barriers. Once the barriers have become clearer, further retrofits and power management methods will become much easier to implement. The more in-depth the audit the better, but an overall lighting and heating / air conditioning audit would be the ideal place to start, seeing as those are some of the largest areas of energy consumption and thus could uncover the most effective retrofits. In addition, regularly scheduled maintenance checkups on their larger technical equipment (ex: hot water heater, air-conditioning system) are crucial, even if there isn't anything noticeably wrong. Many facets of these technologies can become altered and go unnoticed, for example the economizer on an air conditioning system may be left open, which won't stop it from doing its job, but it "can add as much as 50 percent to a building's annual heating costs" (Responsible Energy, 2010).

For the computer labs specifically, research should be conducted regarding the potential of employing power management software and connecting all the journalism computers to one central network, thus allowing them all to be shut off at the same time from one location and automatically woken up for updates when necessary. As of now, there are some barriers (whether real or perceived is still unclear) negating certain energy reduction and power management options from being applied, one being the need to keep the computers on all night for certain editing software to remain operational. Kelly Toughill, Director of the Kings Journalism School, stated that should Kings obtain the new Adobe Premier editing software, the computers may be able to be shut down at night. Research into this and other software options could facilitate easier and more efficient power management in the labs.

There are also behavioural barriers in the way of implementing the recommendations. These include students not saving their work and being at risk of losing it if computers were turned off automatically at certain times, and professors and students not wanting to come to class a few minutes early to turn on the computers so that they would be ready for when class begins. Research could look to better understand these behavioural barriers and methods to potentially overcome them. This could include assessing professors' and students' current awareness about energy consumption of computers to determine if raising awareness about the benefits of energy savings would assist in overcoming these barriers.

While conducting observations in the labs, it was observed that lights were left and the heat radiators were going when no one was in the labs. A full energy audit of other energy consuming appliances within the labs would enable an assessment of what other energy savings improvements could be made in the labs. This could include researching the feasibility of installing programmable thermostats and the effectiveness of putting up signs reminding students to turn off the lights.

7. Acknowledgements

The research team would like to thank Kelly Toughill, Director of the Journalism School, for allowing us to conduct this study in the computer labs and for providing us with an interview. This research project would like to thank Kate Ross, the Journalism School Lab Technician, for providing us with information regarding the computer use policies and power management settings. We would also like to thank Nick Hatt, the Dean of Residences at the University of King's College, for providing us with initial guidance and direction for this study, as well as for coordinating with Patrol staff to let us in to the computer labs after hours. Thank you to Rochelle Owens for providing us with background knowledge regarding King's and energy audits, to Tarah Wright for giving us advice, and finally to Lauri Lidstone, the mentor for this project who provided invaluable guidance for this project and a listening ear every step of the way.

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9. Appendices

Appendix 1: Observation Table #1 – Energy Consumption in Different States

Equipment Type & Model	Energy Consumption (W)			
	On	Low –Power Display	Sleep Mode	Off

Appendix 2: Observation Table #2 – Power Management Settings

Equipment #	Computer automatic sleep (y/n)	Computer sleep # of minutes	Monitor automatic sleep (y/n)	Monitor sleep # of minutes	Automatic screensaver (y/n)	Screensaver # of minutes	Monitor brightness	Adjustable settings (y/n)

Note: For y/n, 1=yes, 0 = no

Appendix 3: Observation Table #3 – Computer and Monitor Use and Power Status

Observer(s):		Date:					
Time:		Occupancy:					
Computer or Monitor	Equipment #	In use	On but not in use	Screensaver (for monitors)	Off	Sleep	Hibernate (MAC N/A)

Appendix 4: Interview Invitation

Hi Kelly,

I spoke with you briefly today about an interview regarding the Journalism School's computer lab policies and operations. The class we are conducting this audit for is ENVS/SUST 3502, "Campus as a Living Laboratory". The course description can be found here: <http://registrar.dal.ca/calendar/class.php?subj=ENVS&num=3502>

Interviewing you or Kate Ross would be a part of our research methods, in order to determine what procedures are currently in place regarding computer use. There are 5 people total in this group, but 1 or 2 would be conducting this interview. I've attached the questions to this email for you to look over. The interview itself will only take about 10 minutes, as the questions are quite technical in nature.

Let me know if this sounds okay, and if you have any availability in the week or two following reading week to meet.

Thank you very much for your time and help!
Anna Bishop

Appendix 5: Interview Questions

1. How many hours a day are the computer labs accessible to students (and staff)?
 - a. How many days a week?
 - b. How many weeks of the year?
2. Are there ever times when the computer labs are **not** open to students (and staff)?
3. Is there a centralized way to control the computers?
 - a. Do you use any software to time computer start ups/shut downs/hibernation? (ex. centralized power management software)
 - b. If not, would it be possible?
4. What happens to computers when This research project are not in use?
 - a. Are computers set to sleep (or low power mode) after a certain amount of time of inuse or at a certain time of day
 - b. If yes, when? (after what interval of time or what time of day?)
 - c. If they are not set to power down, why not?
 - d. Could they be?
 1. If not, why not?
5. Are computers ever turned off?
 - a. If so, when? How often?
 - b. When are they turned back on?
 - c. If they are never turn off, why not?
6. Would it be feasible to turn off the computers at night?
 - a. If yes, would staff be able to turn them off at the end of the day?
 1. If yes, how do you think that could be implemented?
 2. If not, why not?
 - b. Is there a program that could do this automatically?
 - c. Are there any obstacles you foresee to turning computers off at night? (virus scans, system updates)
 - d. If it would not feasible, why not?
 - e. If some computers are required to be left on all the time, could others be turned off?
7. Are there any written and/or unwritten policies regarding computer power status that we just talked about?
8. What happens with the computers when the residences are closed?
 - a. Are computers turned off for Christmas break?
 1. If not, why not?
 2. Could they be?
 - b. Are computers turned off for the summer?
 1. If not, why not?
 2. Could they be?
9. Are there are any policies in place about turning on and off the lights in the computer labs?
10. Is there anything else you can think of that would assist us in researching the energy use and policies of the computer labs at kings?
11. Is there anyone else that you could recommend us to speak to that might have insights into this project?

Appendix 6: Aggregate Data – Delay Times for Automatic Power Management Settings

Time delays before entering automatic sleep and screensaver modes for computer equipment in the three computers labs at the King’s School of Journalism. Number of Computers: Lab 1 = 28, Lab 2 = 16, Lab 3 = 13

A) Automatic Computer Hard-disk Sleep Mode

	Never	10 Min	60 Min	Data not Available
Lab 1	21	1	0	6
Lab 2	0	13	1	2
Lab 3	9	2	0	2

B) Automatic Monitor Sleep Mode

	Never	10 Min	20 Min	25 Min	30 Min	3 Hour	Data Not Available
Lab 1	1	20	6	1	0	0	0
Lab 2	0	13	0	0	1	0	2
Lab 3	0	9	0	0	1	1	2

C) Automatic Screensaver Mode

	Never	10 Min	14 Min	20 Min	Data Not Available
Lab 1	0	5	1	22	0
Lab 2	0	0	0	14	2
Lab 3	0	1	0	8	2

Appendix 7: Aggregate Data – Patterns of Computers Usage and Power Status

Aggregate raw observed data: Patterns of usage and power status of computer equipment in the three computer labs in the King’s School of Journalism as observed on Sunday, March 10 and Tuesday, March 12 from 0:00 to 22:00 every hour on the hour. All data represents the **percent of computers in the lab** in that particular state. Number of Computers: Lab 1 = 28, Lab 2 = 16, Lab 3 = 13

A) Lab 1 Computers, Sunday

Hour	Off	Sleep	Screensaver	On but not in Use	In Use
0	82	11	N/A	7	0
1	82	11	N/A	7	0
2	82	11	N/A	7	0
3	82	11	N/A	7	0
4	82	11	N/A	7	0
5	82	11	N/A	7	0
6	82	11	N/A	7	0
7	82	11	N/A	7	0
8	82	11	N/A	7	0
9	82	11	N/A	7	0
10	82	11	N/A	7	0
11	82	11	N/A	7	0
12	82	11	N/A	7	0
13	82	11	N/A	7	0
14	82	7	N/A	11	0
15	82	7	N/A	11	0
16	82	7	N/A	11	0
17	82	7	N/A	11	0
18	82	11	N/A	7	0
19	82	11	N/A	7	0
20	82	11	N/A	7	0
21	82	11	N/A	7	0
22	82	11	N/A	7	0
23	82	11	N/A	7	0
Average	82	10	N/A	8	0

B) Lab 1 Computers, Tuesday

Hour	Off	Sleep	Screensaver	On but not in Use	In Use
0	54	46	N/A	0	0
1	54	46	N/A	0	0
2	54	46	N/A	0	0
3	54	46	N/A	0	0
4	54	46	N/A	0	0
5	54	43	N/A	0	4
6	54	43	N/A	0	4
7	54	43	N/A	0	4
8	54	43	N/A	0	4
9	54	39	N/A	0	11
10	46	32	N/A	0	21
11	39	29	N/A	0	32
12	39	32	N/A	0	29
13	39	29	N/A	4	29
14	39	21	N/A	0	39
15	32	36	N/A	21	11
16	32	50	N/A	4	14
17	32	64	N/A	4	0
18	32	68	N/A	0	0
19	32	68	N/A	0	0
20	32	68	N/A	0	0
21	32	68	N/A	0	0
22	32	68	N/A	0	0
23	32	68	N/A	0	0
Average	43	48	N/A	1	8

C) Lab 1 Monitors, Sunday

Hour	Off	Sleep	Screensaver	On but not in Use	In Use
0	18	75	4	4	0
1	18	75	4	4	0
2	18	75	4	4	0
3	18	75	4	4	0
4	18	75	4	4	0
5	18	75	4	4	0
6	18	75	4	4	0
7	18	75	4	4	0
8	18	75	4	4	0
9	18	75	4	4	0
10	18	75	4	4	0
11	18	75	4	4	0
12	18	75	4	4	0
13	18	75	4	4	0
14	18	71	4	7	0
15	18	71	4	7	0
16	18	75	7	4	0
17	18	75	7	4	0
18	18	75	4	4	0
19	18	75	4	4	0
20	18	75	4	4	0
21	18	75	4	4	0
22	18	75	4	4	0
23	18	75	4	4	0
Average	18	75	4	4	0

D) Lab 1 Monitors, Tuesday

Hour	Off	Sleep	Screensaver	On but not in Use	In Use
0	36	64	0	0	0
1	36	64	0	0	0
2	36	64	0	0	0
3	36	64	0	0	0
4	36	64	0	0	0
5	32	64	0	0	4
6	32	64	0	0	4
7	32	64	0	0	4
8	32	64	0	0	4
9	29	61	0	0	11
10	21	57	0	0	21
11	14	54	0	0	32
12	11	61	0	0	29
13	11	57	0	4	29
14	11	50	0	0	39
15	36	36	0	18	11
16	25	57	0	4	14
17	25	68	4	4	0
18	25	71	4	0	0
19	25	71	4	0	0
20	25	71	4	0	0
21	21	75	4	0	0
22	21	75	4	0	0
23	21	75	4	0	0
Average	26	63	1	1	8

E) Lab 2 All-in-one computers, Sunday

Hour	Off	Sleep	Screensaver	On but not in Use	In Use
0	19	75	0	6	0
1	19	75	0	6	0
2	19	75	0	6	0
3	19	75	0	6	0
4	19	75	0	6	0
5	19	75	0	6	0
6	19	81	0	0	0
7	19	81	0	0	0
8	19	81	0	0	0
9	19	81	0	0	0
10	19	81	0	0	0
11	19	75	0	0	6
12	19	75	0	0	6
13	19	69	0	0	13
14	19	69	0	0	13
15	19	69	0	6	6
16	19	75	0	0	6
17	19	75	0	0	6
18	19	69	0	6	6
19	19	63	0	0	19
20	19	63	0	0	19
21	19	69	0	0	13
22	19	69	0	0	13
23	19	81	0	0	0
Average	19	74	0	2	5

F) Lab 2 All-in-one computers, Tuesday

Hour	Off	Sleep	Screensaver	On but not in Use	In Use
0	0	44	0	44	13
1	0	44	0	44	13
2	0	44	0	44	13
3	0	44	0	44	13
4	0	44	0	44	13
5	0	81	0	0	13
6	0	81	0	0	13
7	0	81	0	0	13
8	0	81	0	0	13
9	0	81	0	0	13
10	0	81	0	0	13
11	0	69	0	0	25
12	0	81	0	0	13
13	0	81	0	13	0
14	0	94	0	0	0
15	0	25	0	25	50
16	0	44	0	6	50
17	0	56	0	0	44
18	0	63	0	0	44
19	0	69	0	6	25
20	0	75	0	6	19
21	0	88	0	6	13
22	0	94	0	0	6
23	0	94	0	6	0
Average	0	68	0	12	18

G) Lab 3 All-in-one Computers, Sunday

Hour	Off	Sleep	Screensaver	On but not in Use	In Use
0	38	54	8	0	0
1	38	54	8	0	0
2	38	54	8	0	0
3	38	46	8	0	8
4	38	54	8	0	0
5	38	54	8	0	0
6	38	54	8	0	0
7	38	54	8	0	0
8	38	54	8	0	0
9	38	46	8	8	0
10	38	62	0	0	0
11	38	54	8	0	0
12	38	54	8	0	0
13	38	46	8	8	0
14	38	54	0	8	0
15	38	54	0	8	0
16	38	38	8	15	0
17	38	38	8	15	0
18	38	62	0	0	0
19	38	38	8	15	0
20	31	38	8	15	8
21	31	38	8	15	8
22	38	46	0	8	8
23	38	46	0	8	8
Average	38	50	6	5	2

H) Lab 3 All-in-one Computers, Tuesday

Hour	Off	Sleep	Screensaver	On but not in Use	In Use
0	54	46	0	0	0
1	54	46	0	0	0
2	54	46	0	0	0
3	54	46	0	0	0
4	54	46	0	0	0
5	54	38	8	0	0
6	54	38	8	0	0
7	54	38	8	0	0
8	54	38	8	0	0
9	54	31	8	0	8
10	38	31	8	0	23
11	54	31	0	0	15
12	38	38	8	8	8
13	38	31	8	8	15
14	38	38	8	8	8
15	23	31	8	31	8
16	15	23	0	15	46
17	15	62	8	8	8
18	15	69	8	8	0
19	15	77	8	0	0
20	15	69	8	0	8
21	15	69	8	0	8
22	15	69	8	0	8
23	15	69	8	0	8
Average	37	47	5	4	7

Appendix 8: Energy Consumption Calculations Under Current Situation and Alternative Power Management Scenarios

Calculations estimating energy consumption, energy costs, and carbon dioxide emissions over two academic terms (fall and winter) of the three computer labs in the King’s School of Journalism as they are currently and as they could be under five alternative power management scenarios. Calculations are based on extrapolating usage and power state patterns observed on a Sunday and a Tuesday to two academic terms. Since energy consumption in some states was measured as a range of values, both minimum and maximum estimates of consumption are displayed. Number of Computers: Lab 1 = 28, Lab 2 = 16, Lab 3 = 13. Academic term = 15 weeks; Academic term = two academic terms (fall and winter). CO₂ eq. = greenhouse gas emissions measured in carbon dioxide equivalent. Cost of electricity = \$0.1059/kWh. CO₂ eq = 0.57196 kg/kWh CO₂ eq.

Baseline Scenario: Current Situation

	Sunday (kWh)	Tuesday (kWh)	Week (kWh)	Term (kWh)	Per Academic Year		
					kWh	Cost (\$)	CO ₂ eq (kg)
Minimum							
Lab 1 Computers	2.0	2.2	15.0	224.9	449.9	47.6	257.3
Lab 1 Monitors	1.2	1.7	11.0	165.2	330.5	35.0	189.0
Lab 2	3.1	10.1	56.6	849.4	1698.8	179.9	971.7
Lab 3	6.1	6.4	44.2	663.0	1326.1	140.4	758.5
Total	12.4	20.4	126.8	1902.6	3805.2	403.0	2176.4
Maximum							
Lab 1 Computers	2.6	3.2	21.0	315.3	630.6	66.8	360.7
Lab 1 Monitors	1.2	1.7	11.0	165.2	330.5	35.0	189.0
Lab 2	3.5	11.0	62.3	933.9	1867.9	197.8	1068.3
Lab 3	6.5	6.8	46.9	704.1	1408.1	149.1	805.4
Total	13.8	22.7	141.2	2118.6	4237.1	448.7	2423.5

Scenario 1: Reduced brightness – monitor brightness reduced to the power saving setting

	Sunday (kWh)	Tuesday (kWh)	Week (kWh)	Term (kWh)	Per Academic Year		
					kWh	Cost (\$)	CO2 eq (kg)
Minimum							
Lab 1 Computers	2.0	2.2	15.0	224.9	449.9	47.6	257.3
Lab 1 Monitors	1.2	1.7	11.0	165.2	330.5	35.0	189.0
Lab 2	1.9	5.3	30.3	455.0	910.1	96.4	520.5
Lab 3	5.4	5.6	39.1	585.8	1171.7	124.1	670.2
Total	10.6	14.8	95.4	1431.0	2862.1	303.1	1637.0
Maximum							
Lab 1 Computers	2.6	3.2	21.0	315.3	630.6	66.8	360.7
Lab 1 Monitors	1.2	1.7	11.0	165.2	330.5	35.0	189.0
Lab 2	2.3	6.0	34.7	520.8	1041.5	110.3	595.7
Lab 3	5.8	6.0	41.6	624.3	1248.6	132.2	714.1
Total	12.0	16.9	108.4	1625.6	3251.3	344.3	1859.6

Scenario 2: Computer sleep – all computers in sleep when not in use (not just the monitors in sleep)

	Sunday (kWh)	Tuesday (kWh)	Week (kWh)	Term (kWh)	Per Academic Year		
					kWh	Cost (\$)	CO2 eq (kg)
Minimum							
Lab 1 Computers	1.3	2.1	13.1	195.9	391.7	41.5	244.1
Lab 1 Monitors	0.0	1.3	6.7	100.8	201.6	21.3	115.3
Lab 2	2.4	6.3	36.5	546.8	1093.7	115.8	625.5
Lab 3	0.9	1.7	10.1	151.9	303.8	32.2	173.8
Total	4.6	11.4	66.4	995.4	1990.9	210.8	1138.7
Maximum							
Lab 1 Computers	2.0	3.0	18.8	282.7	565.4	59.9	323.4
Lab 1 Monitors	0.0	1.3	6.7	100.8	201.6	21.3	115.3
Lab 2	2.8	7.0	40.9	612.9	1225.8	129.8	701.1
Lab 3	1.1	1.9	11.6	174.2	348.5	36.9	199.3
Total	5.9	13.2	78.0	1170.6	2341.3	247.9	1339.1

Scenario 3: Off – all computers turned off when not in use

	Sunday (kWh)	Tuesday (kWh)	Week (kWh)	Term (kWh)	Per Academic Year		
					kWh	Cost (\$)	C02 eq (kg)
Minimum							
Lab 1 Computers	1.3	2.1	13.1	195.9	391.7	41.5	224.1
Lab 1 Monitors	0.0	1.3	6.7	100.8	201.6	21.3	115.3
Lab 2	2.4	6.3	36.5	546.8	1093.7	115.8	625.5
Lab 3	0.9	1.7	10.1	151.9	303.8	32.2	173.8
Total	4.6	11.4	66.4	995.4	1990.9	210.8	1138.7
Maximum							
Lab 1 Computers	1.3	2.6	15.9	237.9	475.7	50.4	272.1
Lab 1 Monitors	0.0	1.3	6.7	100.8	201.6	21.3	115.3
Lab 2	2.5	6.7	38.7	581.0	1162.1	123.1	664.7
Lab 3	0.9	1.7	10.4	155.5	311.0	32.9	177.9
Total	4.7	12.4	71.7	1075.2	2150.5	227.7	1230.0

Scenario 4: Computer sleep and reduced brightness – scenarios 1 and 2 combined

	Sunday (kWh)	Tuesday (kWh)	Week (kWh)	Term (kWh)	Per Academic Year		
					kWh	Cost (\$)	C02 eq (kg)
Minimum							
Lab 1 Computers	1.3	2.1	13.1	195.9	391.7	41.5	224.1
Lab 1 Monitors	0.0	1.3	6.7	100.8	201.6	21.3	115.3
Lab 2	1.6	3.5	20.5	307.4	614.9	65.1	351.7
Lab 3	0.8	1.4	8.7	130.3	260.6	27.6	149.1
Total	3.7	8.3	49.0	734.4	1468.9	155.6	840.1
Maximum							
Lab 1 Computers	2.0	3.0	18.8	282.7	565.4	59.9	323.4
Lab 1 Monitors	0.0	1.3	6.7	100.8	201.6	21.3	115.3
Lab 2	1.9	4.1	24.1	362.1	724.2	76.7	414.2
Lab 3	1.0	1.6	9.9	149.0	298.1	31.6	170.5
Total	4.9	9.9	59.6	894.6	1789.3	189.5	1023.4

Scenario 5: Off and reduced brightness – scenarios 1 and 3 combined

	Sunday (kWh)	Tuesday (kWh)	Week (kWh)	Term (kWh)	Per Academic Year		
					kWh	Cost (\$)	C02 eq (kg)
Minimum							
Lab 1 Computers	1.3	2.1	13.1	195.9	391.7	41.5	224.1
Lab 1 Monitors	0	1.3	6.7	100.8	201.6	21.3	115.3
Lab 2	1.6	3.5	20.5	307.4	614.9	65.1	351.7
Lab 3	0.8	1.4	8.7	130.3	260.6	27.6	149.1
Total	3.7	8.3	49.0	734.4	1468.9	155.6	840.1
Maximum							
Lab 1 Computers	1.3	2.6	15.9	237.9	475.7	50.4	272.1
Lab 1 Monitors	0	1.3	6.7	100.8	201.6	21.3	115.3
Lab 2	1.6	3.7	22.0	330.2	660.5	69.9	377.8
Lab 3	0.8	1.4	8.7	130.3	260.6	27.6	149.1
Total	3.8	9.1	53.3	799.2	1598.5	169.3	914.3

Appendix 9: Project Proposal

**University of King's College Energy Audit:
*A Study of the School of Journalism Computer Labs***

Research Proposal
February 22nd, 2013

ENVS 3502: Campus as a Living Laboratory
Ms. Tarah Wright
Mentor: Ms. Lauri Lidstone

Written by:
Anna Bishop, Brittany Maguire, Calvin Gleason, Chris Fallis, Tiffany Vass

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1. Project Definition

1.1. *Research Problem and Question*

This research will assess the daily level of energy consumption of the computers at the University of King's College, and provide recommendations based on the observations collected to decrease the amount of energy consumed.

Research Question:

In the 6 computer labs at The University of King's College (Library, Journalism School, Alexandra Hall Residence, and Radio Room), what measures could be taken to conserve energy use by computers?

1. Are there current policies in place pertaining to computer use status in the labs? If so, what are they?;
2. What are the current patterns of computer use in the lab, and the energy use resulting from those patterns?;
3. How would implementing or changing computer use status policies impact the amount of:
 - a) energy used?;
 - b) the total amount of spent on energy for the computers?;
 - c) the greenhouse gas emissions produced by the computers?

1.2. *Rationale*

There has been growing scientific consensus that a global transformation of the earth's climate is currently underway, due to the disproportionate amount of CO₂ gas being emitted into the atmosphere from human activities and the resulting intensification of our earth's greenhouse effect. This increase in greenhouse gases more effectively traps solar radiation within the atmosphere, causing the mean global temperature to rise at a faster rate than it would naturally. This sudden increase in mean temperature entails a host of other problems, as the earth is a connected system and one unbalanced aspect of its homeostasis will cause other parts to become out of sync as well (Solomon et al., 2007).

The International Panel on Climate Change (IPCC) has been a driving force in climate change research and predictions. Rising sea levels, ocean acidification due to the atmospheric deposition of carbon, more frequent extreme weather events, drought, and the melting of the polar ice caps are all symptoms of climate change that have been predicted by the IPCC in their *Fourth Assessment Report: The Physical Science Basis*, and are indeed becoming an expected reality in our world today. They have predicted that from 1990-2100 the global mean temperature could increase anywhere from 1.4°C to 5.8°C, with potentially irreversible effects on our planet's ecosystems and biogeochemical cycling, and more generally, the homeostasis of the diverse systems that allow our Earth to be a livable planet (Solomon et al., 2007).

Energy use in the form of electricity, which comes from electricity-generating power plants fueled by non-renewable fossil fuels, is a large overall contributor to greenhouse gas emissions and consequently to the global problem of climate change. In addition, as temperatures continue to rise due to climate change, energy consumption in climate sensitive areas is going to change corresponding to those warming temperatures, creating a positive feedback loop. In areas

experiencing warmer temperatures, energy use in commercial buildings is expected to increase due to a greater desire for air conditioning, refrigeration, etc (Scott, 2007). This only heightens the urgency of curbing our energy consumption now, in order to offset these expected future increases.

Energy consumed by household appliances such as office equipment and consumer electronics has been rapidly growing, and in the United States it accounts for almost 55% of the total energy consumption in commercial buildings (Solomon et al., 2007). From 2001 to 2006, the CO₂ emissions associated with commercial buildings grew at a rate of 3.0% per year (Solomon et al., 2007). In 2004, the CO₂ emissions from both electricity use and direct combustion were tallied at 8.6 Gt/yr (Solomon et al., 2007). Various energy-saving measures can be implemented, such as introducing energy efficiency settings in on and low-power modes, creating computer chips that reduce electricity use in low-power modes, and giving computer users frequent reminders to turn equipment off before leaving the office (Solomon et al., 2007), (Marans, 2009).

As large commercial institutions filled with computer labs, libraries, offices, and research labs, universities are major consumers of energy. However, universities also have the unique quality of being filled with highly skilled, educated academics who are passionate about sustainability issues. In 2011, 284 campus energy conservation initiatives were announced on the online bulletin for the Association for the Advancement of Sustainability in Higher Education (AASHE). This was an increase of 28% from 2010, which only had 129 initiatives posted.

The initiatives of 2011 included 97 solar installations, 34 energy overhauls, 21 wind initiatives, 19 renewable energy research centers, 17 campus energy competitions, 13 campus monitoring efforts, 12 renewable energy plans, and 9 geothermal projects (AASHE, 2011). The Massachusetts Institute of Technology saved 13 million kilowatt-hours after 1 year of initiating its Efficiency Forward Program, a campus-wide energy conservation and efficiency initiative and 24 million kilowatt-hours after 2 years (AASHE, 2011). The wide range of initiatives and the potential for savings in both energy and money is demonstrated by these American AASHE-supported post-secondary institutions, presenting us with a way forward for similar energy conservation initiatives at Canadian universities.

This research project fits in with the larger context of impending climate change and campus energy-conservation initiatives in North America. It will determine the amount of electricity being consumed by 3 computer labs in the Journalism School at the University of King's College. Observations will be recorded every hour over a two-day time span of the amount of computers being used, and the use statuses of all computers (on/off/hibernate/sleep). Compared with large infrastructure changes, implementing energy conservation measures in electronics use procedures is relatively easy, and is often called the low-hanging fruit of campus sustainability (Marans, 2009). Yet before energy conservation measures can be recommended or implemented, current energy consumption levels and use patterns must be evaluated (Vance, 2011).

Interviews will also be conducted with the relevant personnel on campus to determine whether there is a current computer usage policy in place that mandates energy conservation measures. Interviewees will include Kelly Toughill, Director of the King's Journalism School, and Kate Ross, the computer lab technician for the Journalism School.

The stakeholders in this study include the students who use the computers, the Journalism School staff and faculty, and Nick Hatt, Dean of Residence.

A previous analysis of computer energy policies and computer use at King's has not been conducted (personal communication with Alex Doyle, Feb. 1 2013). This project will be the first assessment of the policies in place and of the actual levels of use in the computer labs over a 24-hour period. Recommendations of computer energy saving measures will be valuable new information in helping the University of King's College conserve energy, cutting greenhouse gas emissions and saving money on power bills.

It is important to outline the distinction between energy conservation and energy efficiency in this research. Energy efficiency applies to the implementation of new technologies that decrease energy consumption without necessarily changing the behaviour of the users of that technology (Lopes, 2012). This study will focus on energy conservation through changing the use patterns of students and the use status of unused computers, rather than through implementing new technology. Levels of energy consumption are a quantification of the behaviour of students and the use status of idle computers (Lopes, 2012). Consequently, this study will determine the current relationship between student use and computer status in order to provide recommendations for a new relationship, which would conserve energy relative to the current levels of computer energy consumption at King's.

The University of King's College is currently undergoing a student-led strategic planning initiative (University of King's College, 2013). Providing Facilities Management and the University administration with recommendations for decreasing energy consumption at a time where the administration has an open and receptive attitude to student input increases the probability that our recommendations will be implemented.

A preliminary interview with Alex Doyle, head of Facilities Management at King's, indicated that there is a desire to increase energy efficiency and sustainability on campus (personal communication, Feb. 1 2013). He showed great interest in the possibility of an audit, and stated that he wants to decrease energy consumption on campus in order to decrease King's power bill as well as improve sustainability (personal communication, Feb. 1 2013). Thus at the level of Facilities Management, there is a desire for this research and an impetus to implement future recommendations.

Facilities Management, in conjunction with the Bursar's office, completed a basic lighting audit on campus in 2011 (personal communication with Rochelle Owen, Feb. 12). However, adequate records of this audit or any other previous efforts on energy conservation and sustainability conducted at an institutional level could not be obtained. This was due largely to various miscommunications and misunderstandings between us and Facilities Management, the Dean of Residence, the Bursar's Office, and The Office of Sustainability at Dalhousie.

Due to the lack of adequate records of past lighting audits, our scope was narrowed to consumption from computer use. This was done in order to circumvent any possibility of conducting redundant research, which would not be as useful or valuable as conducting primary research on a new component of energy consumption on campus. Our ultimate goal for this research is to trigger policy changes regarding computer use through Facilities Management, which would in turn decrease the amount of energy consumed by computers on campus.

A preliminary assessment of the 3 Journalism School computer labs between 12am-4am showed that the computers are left on all night, with few to no students using them in those time periods. That was the initial impetus for this study, as the observed computer energy consumption seemed to be excessive and unnecessary for those time periods and student use levels. Exploring the energy consumption associated with leaving the computers on all night

compared to turning them off and on during certain periods of low use was the original question that prompted the full development of this study.

1.3. Scope

This research will be conducted in three computers labs in the Journalism School on the University of King's College campus. Observations will be taken in each lab every hour. The number of computers on/off/in hibernate/in sleep will be recorded, as well as the amount of students in the lab using the computers.

The process of data collection will occur for 2 days. The average level of computer use during those two days is contingent on the placing of that week within the larger context of the whole term. It could be a busy assignment time for students, and thus our data could be disproportionately high compared to the rest of the term, or it could be a lull period, thus making the collected data disproportionately low compared to the rest of the term.

The scope of the data collection is limited due to the time available to conduct research and the ability of researchers to be available for intensive data collection for more than a couple of days. The collected data would contain more validity if the collection and observation period was longer, but this is one of the limitations of the scope of this project. The average energy consumption and use levels for two days will still provide baseline data that can be extrapolated for further use.

Through interviews with staff and faculty of the Journalism School, basic information regarding computer use policies during the summer, reading week, and Christmas break will be collected.

2. Background and Literature Review

2.1. Computer Energy Use and Power Management

In recent decades, the rapidly growing use of computers has resulted in a significant increase in aggregate energy consumption by computers. To illustrate, between 1988 and 2006, the total energy consumption by office computers in the United States tripled from 25 TWh to 75 TWh (Webber et al., 2006). A similar trend has occurred in Canada, where an increase in the use of computers and other office equipment in the commercial and institutional sectors as increased energy consumption by 75.5 PJ, which has led to an increase in related GHG emissions by 4.4 Mt (Natural Resources Canada, 2006). In 2006, the servers and data centers in the United States consumed approximately 1.5 percent of the country's total electricity consumption (EPA, 2007). Considering the use stage accounts for 55% of the total energy use in the life cycle of a computer (Masanet & Horvath, 2006), reductions in energy consumed by operating computers would make an important contribution to lowering their overall environmental footprint.

Even though the total energy use by computers has been rising, the energy consumption of individual computers has been declining. This is largely due to energy efficiency improvement efforts. One important element of making computers more energy efficient is what is known as power management. Power management involves strategies to reduce energy consumption of

computers when they are not being actively used, such as by setting monitors and computers to automatically enter low power or ‘sleep’ modes when they have not been in use for a period of time (Walker, 2009). Power management originated as a way to prolong the battery life of laptop computers, and since has expanded to a wide variety of other electronic devices (Webber et al., 2006). The U.S. Environmental Protection Agency (EPA) launched the Energy Star certification program in 1992, which began to certify monitors, computers, printers, photocopiers, fax machines, scanners, and other devices that had power management features (Webber et al., 2006). Today, power management capabilities have become standard features in Windows and Macintosh operating devices (Walker, 2009).

Power management is important because computers consume significantly different amounts of energy in different power states. There are three main power states: on, low power, and off (Webber et al., 2006). While power levels in a particular state vary based on the particular model, Table 1 shows the average power level of computers and monitors in the U.S. (Kawamoto, Shimoda & Mizuno, 2004). Evidently, computers and monitors consume significantly less power when in low power mode as compared to being on: 55% less for desktop computers, and 94% less for CRT monitors (Webber et al., 2006). An additional feature that some computers have is to go into ‘hibernate’, either automatically or manually (Webber et al., 2006). Hibernate mode consumes the same amount of energy as when a computer is turned off, but the user’s current activities are saved so that they can be automatically revived when the computer is turned back on (Webber et al., 2006).

The U.S Department of Energy recommends turning off monitors if not in use for twenty minutes or more, and turning off computer if not in use for two hours or more (2012). Dalhousie University recommends turning off computer monitors when not in use for 5 minutes and in general turning off monitors and computers when not in use as well as power bars (n.d). Despite the fact that it requires a surge of energy to turn on the equipment, this amount is less than leaving the equipment on for an extended period of time (U.S Department of Energy, 2012). It is also recommended that all office equipment be unplugged when not in use or be put on a power strip and turned off when equipment is not in use to avoid the draw of phantom power (energy which is drawn even when equipment is off) (U.S Department of Energy, 2012). Even though there may be an impact on computer life from being turned on and off on a regular basis, advances in technology have caused the majority of computers to become unaffected by this (U.S Department of Energy, 2012).

Table 1 Average power levels computers and monitors in the U.S. (Modified from Kawamoto, Shimoda, & Mizuno, 2004).

		On (W)	Low-power (W)	Off (W)
PC	Desktop	55	25	1.5
	Portable	15	3	2
Display	CRT	85	5	0.5
	LCD	15	1.5	0.5

Considering the differences in energy consumption among different states, considerable energy savings can result from putting computers in low power states and/or powering them down when not in use. For institutions and companies that have hundreds to thousands of computers, this could add up to substantial savings in energy use and in the associated costs of

energy (Masanet & Horvath, 2006). The EPA estimates that employing power management settings alone can save up to \$50 per computer on an annual basis (EPA, n.d., “Put your computers”). Despite the potential energy savings from power management strategies, these strategies are frequently not taken full advantage of. Both turning computers off and setting computers to enter low power states are important components of power management strategies that are often underused. A review of the literature on audits of office equipment found that turn off rates for personal computers ranged from 0% to 91% (Webber et al., 2006). Furthermore, according to Walker (2009), more than 90% of computers in the U.S. do not use their automatic power savings settings to the fullest extent possible. A variety of studies in the literature have examined the potential of energy savings from power management strategies in more depth, three of which are outlined in the following paragraphs.

Through a series of calculations and analyses, a study by Masanet and Horvath (2006) examined various strategies to reduce the energy consumption of computers during their life cycle. They found that the top strategies were: turning off computers and monitors during non-use hours such as nights and weekends, which would save 24% of the energy in a computer’s lifecycle, and enabling all power management settings, which would save 21% of the energy in a computer’s lifecycle (that is, 21% if employed alone, and an additional 3% if employed in addition to the former power-off strategy) (Masanet & Horvath, 2006). These strategies were second and third, after the top strategy of only purchasing LCD as opposed to CRT monitors.

In another study in the U.S., Webber et al. (2006) examined the after-hours power state of 1453 desktop computers and 1598 monitors at sixteen buildings (including offices, schools, universities, and medical buildings) in San Francisco, CA, Pittsburgh, PA, and Atlanta, GA.

They found that an average of 60% of computers were left on, 4% were on low power states, and 36% were turned off, with the turn off rates varying between 5 to 67% in different buildings.

For CRT monitors, 19% were left on (21% for LCD), 49% were in low power states (61% for LCD), and 32% were off (18% for LCD). The study then compared energy consumption in the “as found” baseline scenario to three other scenarios, in which all computers in the study: 1) used power management strategies to successfully enter low power states, 2) were turned off during after-hours, and 3) both employed power management strategies and were turned off after hours.

The energy savings are displayed in Table 2. The difference between the ‘as found’ scenario and the ‘power management and turn off’ scenario was an energy savings of a factor of 3.89 for desktop computers, 2.38 for CRT monitors, and 2.24 for LCD monitors (Webber et al., 2006).

Evidently, employing power management settings and turning off computers and monitors when not in use can result in significant energy savings.

Table 2 Energy savings by employing power management strategies in Webber et al.’s 2006 study. (modified from Webber et al., 2006).

	Total energy use for devices in sample (MWh/year)			
	As found	100% successful PM	All turned off	All turned off & 100% successful PM
Desktop PC	486	280	144	125
CRT Monitor	329	167	152	138
LCD Monitor	13	7.4	6.2	5.8

Kawamoto, Shimoda & Mizuno (2004), in a similar study in Japan, estimated that 30% of a computer's energy use is consumed while idling, while 40% is consumed during non-business hours. They estimated that simply decreasing the delay time before computers enter low power modes could reduce energy consumption during idling by 50%, and that using proper power management strategies during non-business hours could reduce energy consumption during that time period by 60% (Kawamoto, Shimoda & Mizuno, 2004). They found that fully using power management strategies and shortening power management delay times in all computers in Japan could together save 3.5 TWh annually, or the equivalent of 2% of the country's commercial electricity consumption (Kawamoto, Shimoda & Mizuno, 2004). Additionally, their study emphasized the importance of shut down rates. They calculated that an office in the U.S. with fully activated power management settings would still consume more energy than an office in the Japan with no power management settings enabled, due a combination of the facts that Japan's manual night-time shut-down rates are more than double those in the U.S., and also that Japan has a higher user of laptop as opposed to desktop computers.

The studies above illustrate that there is considerable potential for improved energy savings from power management strategies. A variety of efforts can and have been employed to help realize these savings. Masanet and Horvath (2006) suggest that companies could undertake efforts such as implementing company-wide 'switch-off' campaigns, putting 'switch-off' reminder signs or stickers on computers, and educating employees about the potential energy savings and environmental benefits of using power management strategies. Larger scale initiatives have also proven useful.

While power management settings on monitors had become common by the end of the 1990s due to the EPA's Energy Star program, it was estimated that only 56% of monitors had these settings activated in 2001 (EPA, 2012). As a result, the EPA launched a campaign in 2001 to have the sleep setting activated on one million monitors within a year, called the "Million Monitor Drive" (EPA, 2012). The campaign was highly successful, and within four year, approximately 660 million kWh of electricity had been saved as a result of 6.4 million monitors activating their sleep setting. The program took on a broader focus in 2008 to also target computers and other IT equipment, and is now referred to as the "Low CarbonIT" campaign. Through the efforts of these EPA campaigns, it is estimated that power management settings are now enabled in 95% of office monitors and 25% of office desktop computers, which results in an annual saving of 10 billion kWh of energy and greenhouse gas emissions equal taking 15 million vehicles off the road (EPA, 2012).

Although encouraging the enablement of power management settings is a positive step, it is important that computers actually do enter lower power modes as they are set to do. In reality, some computers that do have their power management settings enabled still fail to enter low power modes (Webber et al., 2006). This occurs for a number of reasons. Some operating systems prevent computers from entering low power states (Webber et al., 2006). Networked computers can be particularly problematic, in that network activity, such as updates and virus scans, can keep computers awake (Webber et al., 2006). Furthermore, since some computers in low power states will fail to respond to network activity, and some companies will intentionally disable power management settings in order to maintain network presence (Webber et al., 2006).

Fortunately, solutions have been developed to deal with these problems (Walker, 2009). Software and network programs are now available that can activate power management settings in all computers in a network (Walker, 2009). These software programs can also ensure the computers in low power modes will still be able to receive network-wide updates including

Windows and antivirus updates (EPA, n.d., “Implementation resources”). One example is the program NightWatchman Enterprise, which has been license on over 6 million computers globally, and has resulted in the saving of approximately 4.5 million tons of carbon dioxide emissions (EPA, n.d., “Implementation resources”).

2.2. *Universities and Energy Consumption by Computers*

Universities have a large number of computers, and therefore a substantial amount of energy is consumed by computers at universities. It has been estimated that there are a total of 2 million computers at universities and colleges in North America, and if kept on all year long, these computers would consume approximately 950 MWh of electricity annually (Cabrera, & Zareipour, 2011). This energy consumption would produce 665,000 metric tons of carbon dioxide, or the equivalent of the emissions of 130,000 vehicles (Cabrera, & Zareipour, 2011). Therefore, it has been argued that significant energy savings and emissions reductions could be achieved by creating more effective computer power management strategies in higher education institutions (Cabrera, & Zareipour, 2011). These strategies may be fairly simple to employ given that the after-hours status of computers in labs is often controlled by one individual (Webber et al., 2006).

Important to take into consideration is not only the number of computers at universities, but also the usage rates of computers at universities. Webber et al. (2006) have suggested that computer labs at universities have a significant potential for energy savings since some university computer labs may have a larger number of unoccupied hours per day and per year in comparison to other buildings. The reality is that university facilities are highly used for approximately 34 weeks per year, but often have very low usage rates the other 18 weeks of the year (Spennemann, Atkinson, & Cornforth, 2007). Spennemann, Atkinson, & Cornforth (2007) have also argued that the idea that students should be able to have access to learning environments, including computer facilities, 24/7, and the assumption that students would actually make use those facilities 24/7, may be somewhat misguided.

Several studies have examined usage of computers at universities. A study at the University of Calgary evaluated the use of three computer labs with a total of 64 desktop computers, finding clear seasonal patterns of computer use (Cabrera, & Zareipour, 2011). There were periods of low computer use during periods such as the beginning of semester, mid-semester breaks, and December break, with extremely low rates during the spring and summer terms; while, usage was not surprisingly highest during exam periods (Cabrera, & Zareipour, 2011). A similar study at the Charles Stuart University in New South Wales, Australia, similarly found marked variability in computer use that followed seasonal trends reflecting the progression of the academic year (Spennemann, Atkinson, & Cornforth, 2007). The study also found that 90% of computer usage occurs between Monday and Thursday, with Friday and the weekend having low usage rates, and that students use the computers during the day but in general do not make use of 24-hour computer facilities during the night (Spennemann, Atkinson, & Cornforth, 2007).

A number of studies have also calculated potential energy savings resulting from power management strategies in campus computer labs. The University of Calgary study mentioned above suggested the following three strategies: putting all computers in a deep sleep mode from midnight to 6 a.m., turning off half of the computers on weekends, and having a special power

management schedule during the summer with significantly more computers in sleep mode and turned off (Cabrera, & Zareipour, 2011). The authors suggested that this would cut energy consumption in labs by half, thus savings 8 metric tons of carbon dioxide annually per lab, or a total of 495 metric tons for the university if employed in all labs (Cabrera, & Zareipour, 2011).

A study of computer energy usage was also conducted in the Marion McCain Rm 2019 computer lab at Dalhousie University by students in the “Campus as a Living Laboratory” class. It was estimated that \$2800 and 15.6 tonnes of carbon dioxide could be saved on an annual basis by turning the computers off after hours, and they recommended employing a centralized automatic shutdown and using Deepfreeze software in order to conduct network updates (Bruce et al., 2008).

Many higher education institutions are recognizing the considerable savings that can be realized through employing power management strategies in campus computer labs. On the AASHE website, the “Cool Campus! A How-To Guide for College and University Climate Action Planning” wiki contains a recommendation that campus computers enabled power management settings and shut off computers after-hours as an important component of a campus energy conservation strategy (AASHE, 2013).

Many campuses are taking efforts in this direction. For example, the Dalhousie University Sustainability Plan contains ‘Networked Power Management’ of computers as one of its key strategies (Dalhousie University Office of Sustainability, 2010). In the University of British Columbia’s Energy Policy for Classrooms and Offices, there are precise directions for the power management strategies to be employed, including that monitors and computers should be “set to enter sleep mode after 5 to 15 minutes of inactivity” and “standby or hibernate mode after 30 minutes of inactivity”, and “turned off when not in use” (UBC, n.d.). Campuses that have employed power management strategies are likely to see considerable savings as a result. For example, in the Yale University Facilities departments, computers had previously been left on all of the time for after-hours network updates. A power management strategy was employed in 2006, where users were asked to turn off their computers after use and software was employed to wake up the computers for network updates (EPA, n.d., “Success stories”). This has saved more than \$40 per computer annually, or \$4,700 for the 105 computers in the department. If this strategy were applied to all of Yale’s 10,000 computers, this could save \$400,000 per year (EPA, n.d., “Success stories”). At the University of New Hampshire, shutting down computers and unplugging other electronic equipment during the December break saved 92,000 kWh of electricity, which is enough electricity to power eight homes for a year and would have cost \$12,711 (UNH, 2006). The University of Ohio has saved 45% of its total computer energy use and 15,000 tons of carbon dioxide by shutting down computers that are not in use with computer management software (Sofer & Pottern, 2008). These represent just some of the many examples of initiatives in higher education institutes to employ computer power management strategies to achieve energy savings and reduce the associated greenhouse gas emissions.

2.3. *Sustainability at King’s*

There has been a fair amount of focus on sustainability at an institutional level at Dalhousie due to the presence of the Dalhousie University Office of Sustainability, but relatively little on King’s campus. Consequently, initiatives that aim to increase sustainability on King’s campus at the institutional level have been less than those initiated at Dalhousie.

There is currently a Sustainability Officer on campus who is elected by the King’s Student’s Union every year. The Sustainability Officer is the coordinator for Sustainability King’s, a group of students dedicated to organizing sustainability initiatives on campus (personal communication with Cate May Burton, King’s Sustainability Officer 2012, Feb. 15).

Actions that have been implemented by the group thus far include: starting a composting program in residence buildings (personal communication with Omri Haiven, VP External of the King’s Student’s Union, Feb. 17), getting rid of trays in the cafeteria which reduces the amount of food students take and the amount of food waste that is generated (personal communication with Omri Haiven, VP External of the King’s Student’s Union), introducing a reduced Via Rail train ticket from Halifax to Montreal for King’s students, which produces far less greenhouse gases than travelling by airplane (Walsh, 2012). The annual Green Shift Week encompasses events like the Dark and Dirty Challenge where students pledge to conserve electricity and water, and the Campus Climate Challenge, where students are challenged to engage in a number of energy-saving and waste-reduction actions over the course of two weeks, with the possibility of winning gift cards for local food (University of King’s College, 2013).

These actions are integral in their role of educating King’s students about energy conservation and sustainability, as changing traditional mindsets is an important step in changing people’s actions to ones that are more sustainable (Lopes, 2012). Implementing a composting program and the reduced Via Rail train ticket show that student-led initiatives can introduce permanent processes that improve sustainability at King’s in the long-term.

3. Research Methods

3.1. Description of King’s Computer Labs

The three King’s Journalism computer labs will be examined. The computer labs are used for journalism classes, and they are also available for student use during non-class hours. They are available for any students to use during regular business hours, but are accessible to journalism students 24/7 with the use of a pass card. Lab One is composed of 28 Mac computers, which have Philips monitors. Lab Two is composed of 16 all-in-one Mac computers. The Resource Room contains 13 all-in-one Mac computers. Therefore, at total of 57 computers will be included in the study. Tables 3 to 5 provide information from the manufacturer’s websites on the energy consumptions of these computer models in different power states. (Note: In the tables, “Max” is defined as the maximum possible power draw based on the computer’s power supply rating, and “Idle” reflects the power used with only Finder open, using the default power management settings.)

Table 3. Energy Use of Equipment in Computer Lab One

Equipment	Model Number			
Monitor: Philips*	190 VW 9F B/27	ON: < 35W	Sleep: < 1W	Off: <1W**
Computer: Apple***	A1283	Max: 110W	Idle:14W	Off: *****

*(Philips, 2008)

**Philips recommends the monitor be turned off when it is not in use for a long time (Philips, 2008)

***(Apple Inc., 2013)

**** Information not available

Table 4. Energy Use of Equipment in Computer Lab Two

Equipment	Model Number			
Computer: Apple*	A1311	Max:114W	Idle: 85W	Off: **

*(Apple Inc., 2013)

** Information not available

Table 5. Energy Use of Equipment in the School of Journalism Resource Room

Equipment	Model Number			
Computer: Apple*	A1224	Max: 170W	Idle:135W	Off: **

*(Apple Inc., 2013)

** Information not available

3.2. Data Collection

3.2.1. Initial Assessment of Computer Labs

The first stage of data collection will involve conducting an initial assessment of the computers in the labs, including information on their energy use and current power management settings. Since there are only a total of 57 computers in the three labs, a census of the computers can be conducted. Previous similar studies that have analyzed computer power states have also conducted censuses as opposed to using sampling procedures (ex. Webber et al., 2006).

Furthermore, since a pilot test revealed that different computers have their power management settings set differently, it will be important to collect data on each computer.

A map will be created for each of the labs, and a number will be assigned to each computer (i.e. 1 through 57). The model number of each computer will be recorded. The computer and monitor models are typed on a sticker located on casing. This is usually found on the bottom or the back of the device. When collecting observations, each individual researcher will be able to simply reference the computer number without needing to re-specify the model number. This will also enabling consistency among the researchers.

For each different model, one computer will be tested using a Watt-meter to evaluate the energy used in each power state: on, low power, hibernate (if applicable) and off. This data will be used when calculating energy use. The measurements will enable a confirmation of the energy use specifications provided by the manufacturers, and will also fill in information about energy consumption in some power states that were not provided by the manufacturers. This data will be recorded in Observation Table #1 (see Appendix 1).

Each computer's power management settings will then be evaluated. Each computer model has a power management section in preferences. Although the exact settings vary by models, the information included in preferences may include:

- Whether or not the computer's desktop and monitor are each set to automatic sleep
- The delay time before the desktop and monitor each enter automatic sleep
- Whether or not the computer's monitor is set to automatically enter screensaver mode
- The delay time before the monitor enters into screensaver mode

- Whether or not the computer is set to be woken up for network access
- Whether or not the hard disk is enabled to enter sleep mode

The data on these settings will be recorded for each computer using Observation Table #2 (see Appendix 2).

Additional information to be collected includes whether or not computers are able to be turned off without automatically powering up again, whether or not the user is able to adjust power management settings without an authorization password, and whether or not the computer is plugged into a power strip. This information on how the computers' power management settings are programmed is important for identifying potential areas of energy savings. For example, the data may lead to a recommendation to reduce the delay time before computers enter sleep mode, which studies have shown to reduce overall energy consumptions (Kawamoto, Shimoda & Mizuno, 2004).

3.2.2. Computer Use and Power Status Assessment

The computer use and power status of the computers in the three labs will be observed for a period of two days. Since computer use will likely vary between weekdays and weekends, one of the collection days will be on a weekday and one will be on a weekend. The days of observation will be Sunday, March 10 and Tuesday, March 12, beginning at 12 a.m. and ending at 11 p.m. on each day. Each hour, on the hour, the status of each computer and monitor will be recorded, in terms of whether it is in use, on but not in use, on sleep mode, on hibernate mode (if applicable) or turned off.

It will be assumed that the use and power status of each computer at the start of the hour reflects the status for the entire hour. The observer will go through the list of the previously mapped and numbered computers numerically to ensure efficiency and routine. If a computer's monitor is black, the mouse will be moved around to try to wake the computer up in order to determine if the computer is on sleep mode or off. The data will be recorded in Observation Table #3 (see Appendix 3). This observation table was developed based off of a similar table in another study that recorded whether computers and monitors were on, in low power mode, or off during after-hours (Webber et al., 2006). The data will be used to provide an understanding of the patterns of use and patterns of power status in the computer labs.

3.2.3. Interviews with Journalism School Faculty and Staff

Interviews will be conducted with the relevant personnel on campus to determine whether there is a current computer usage policy in place that mandates energy conservation measures. Interviewees will include Kelly Toughill, Director of the King's Journalism School, and Kate Ross, the computer lab technician for the Journalism School, whom Kelly recommended to us. (See Appendix 4 for interview invitation.)

Interviews conducted will be semi-structured. Interview scripts will be utilized; however, other questions that arise may be asked in order to allow for new information to surface during the conversation. Interview questions are a mix of open-ended questions in order to allow for flexibility in participants' answers and a greater depth of the interview and of single-response item questions where specific information is required (Palys & Atchinson, 2008). (See Appendix 5 for interview questions.)

3.3. *Data Analysis*

First, descriptive statistics will be used to evaluate the data collected on power management settings using Observation Table #2 (using statistical methods outlined in Palys & Atchison, 2008). The percentage of computers and monitors that are automatically set to enter sleep mode, that are able to be powered off, that have adjustable settings, and that have other power saving settings enabled will be calculated. The mean, mode and range of the delay time for the computers and monitors to enter sleep mode will be calculated. This will serve as a basis for making any potential recommendations.

Second, using the data collected on computer use and power status using Observation Table #3, the percentage of computers and of monitors in each power status (in use, on, low power, hibernation, off) will be calculated for each hour over the 48-hour observation period. The data will then be graph using two stacked bar graphs (one for computers and one for monitors), showing the percentage in each status (y-axis) against time (x-axis). This will provide a visual representation of the data, and will be used to determine patterns and pick out periods of high and low use.

Third, the potential energy savings by changing the power management strategy in the computers labs will be calculated. First, a baseline scenario of energy use will be established, representing the current consumption of energy in the computer labs. The data collected in Observation Table #1 on the energy consumed by each model in each power state and the data collected in Observation Table #3 on the number of hours each computer and monitor is in each state will be used to estimate the amount of energy consumed by the computers in an average week. The data collected on the Sunday will be used for Sunday and Saturday, and the data collected on Tuesday will be used for Monday through Friday.

Based on the information obtained from the interview on whether or not the lab is open during the summer, the estimate over the course of the week will be extrapolated to estimate the amount of energy consumed by the labs over the course of the year during the times it is open.

Once the baseline scenario has been established, recommendations will be made based on the observations and the interview on a new computer power management strategy to reduce energy consumption in the labs. For example, a recommendation could be made to turn off all computers at night and on the weekend.

The amount of energy that would be consumed under this scenario will then be calculated. From this, the potential energy savings over the course of a year will be calculated.

The potential savings will be represented in three ways: 1) kilowatt hours (kWh); 2) dollar value, based on a power rate of 10.59 cents per kWh, which is the base energy charge for general commercial buildings (NS Power, 2013a); and 3) greenhouse gases, based on a rate of 571.96 g/kWh CO₂eq., which is the rate of emissions from the Nova Scotia Power's Tufts Cover generating station which provides power to Dalhousie and therefore is also assumed to provide power to King's (NS Power, 2013b; Dalhousie University Office of Sustainability, 2012).

3.4. *Delimitations and Limitations*

This study will focus specifically on the three computer labs at the King's University School of Journalism. It will not examine other computer labs at King's. It will also not examine other energy-consuming equipment in the labs, such as scanners or lights. Observations of computer use and status will only be taken on two days during the winter term.

There are a number of limitations with this study. First, the energy consumption of each computer and monitor in each state is being estimated using a Watt meter, but in reality the exact energy use of a computer will vary based on the programs running at any one time. Since equipment to monitor the precise energy use over the course of a day is not available for this study, an estimate is being used.

Second, the use and power status at the beginning of the hour is being assumed to represent the state over the entire hour, which may not actually be the case. However, it is not possible without equipment to monitor precise state of 57 computers at every point in time over a 24-hour period.

Third, measurements are only being taken on two days of the year due to the time constraints of the study. In reality, computer usage may be highly variable on different days of the week and throughout the year. In particular, measurements are not being taken during the summer and on holidays. Therefore, the extrapolation of the measurements from the two days will only represent a very rough estimate of energy use in the computer labs over the course of a year.

This research is also limited by the short time span allotted to it, as well as the lack of any funding from King's or external sources to implement recommendations.

4. Schedule, Deliverables, and Communications Plan

A schedule of expected dates to complete the research tasks has been prepared and is included in Appendix 6.

The preliminary deliverables for this project will be the class report to be posted on the Environmental Science Department website and the Pecha Kucha presentation to share the findings with the students and instructors of the class.

Additionally, a summary reported will be produced of the research project that highlights the policy recommendations for increasing energy conservation in computer usage at King's. A meeting will be scheduled with Alex Doyle, the Head of Facilities Management at King's, and/or Kelly Toughill, Director of the King's Journalism School, as appropriate, to present them with the summary report. In this meeting, the research methodology, results, and recommendations will be discussed in a concise and thorough manner. Any questions about the research will be answered, and assistance will be offered if needed to implement the recommendations fully.

If Mr. Doyle or Ms. Toughill recommend a meeting with other members of the administration at King's, such as an employee of the Bursar's Office, the summary report will also be presented to them.

The success of the project will be evaluated based on the ability to computer the specified observations, to make recommendations to reduce energy consumption in the computer labs if appropriate, and to communicate any recommendations to the management and staff at King's who would have the capacity to implement those recommendations.

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6. Appendices

Appendix 1: Observation Table #1 – Energy Consumption in Different States

Model	Energy Consumption (W)			
	On	Low Power	Hibernate	Off

Appendix 2: Observation Table #2 – Power Management Settings

#	Computer automatic sleep (y/n)	Computer sleep # of minutes	Monitor automatic sleep (y/n)	Monitor sleep # of minutes	Automatic screensaver (y/n)	Screensaver # of minutes	Power off enabled (y/n)	Adjustable settings (y/n)	Wake up for network access (y/n)	Hard disk sleep (y/n)	Power strip (y/n)

Note: For y/n, 1=yes, 0 = no

Appendix 3: Observation Table #3 – Computer and Monitor Use and Power Status

Observer(s):		Date:					
Time:		Occupancy:					
Computer or Monitor	Equipment #	In use	On but not in use	Screensaver (for monitors)	Off	Sleep	Hibernate (MAC N/A)

Appendix 4: Interview Invitation

Hi Kelly,

I spoke with you briefly today about an interview regarding the Journalism School's computer lab policies and operations. The class we are conducting this audit for is ENVS/SUST 3502, "Campus as a Living Laboratory". The course description can be found here: <http://registrar.dal.ca/calendar/class.php?subj=ENVS&num=3502>

Interviewing you or Kate Ross would be a part of our research methods, in order to determine what procedures are currently in place regarding computer use. There are 5 people total in this group, but 1 or 2 would be conducting this interview. I've attached the questions to this email for you to look over. The interview itself will only take about 10 minutes, as the questions are quite technical in nature.

Let me know if this sounds okay, and if you have any availability in the week or two following reading week to meet.

Thank you very much for your time and help!
Anna Bishop

Appendix 5: Interview Questions

12. How many hours a day are the computer labs accessible to students (and staff)?
 - a. How many days a week?
 - b. How many weeks of the year?
13. Are there ever times when the computer labs are **not** open to students (and staff)?
14. Is there a centralized way to control the computers?
 - a. Do you use any software to time computer start ups/shut downs/hibernation? (ex. centralized power management software)
 - b. If not, would it be possible?
15. What happens to computers when they are not in use?
 - a. Are computers set to sleep (or low power mode) after a certain amount of time of inuse or at a certain time of day
 - b. If yes, when? (after what interval of time or what time of day?)
 - c. If they are not set to power down, why not?
 - d. Could they be?
 1. If not, why not?
16. Are computers ever turned off?
 - a. If so, when? How often?
 - b. When are they turned back on?
 - c. If they are never turn off, why not?
17. Would it be feasible to turn off the computers at night?
 - a. If yes, would staff be able to turn them off at the end of the day?
 1. If yes, how do you think that could be implemented?
 2. If not, why not?
 - b. Is there a program that could do this automatically?
 - c. Are there any obstacles you foresee to turning computers off at night? (virus scans, system updates)
 - d. If it would not feasible, why not?
 - e. If some computers are required to be left on all the time, could others be turned off?
18. Are there any written and/or unwritten policies regarding computer power status that we just talked about?
19. What happens with the computers when the residences are closed?
 - a. Are computers turned off for Christmas break?
 1. If not, why not?
 2. Could they be?
 - b. Are computers turned off for the summer?
 1. If not, why not?
 2. Could they be?
20. Are there are any policies in place about turning on and off the lights in the computer labs?
21. Is there anything else you can think of that would assist us in researching the energy use and policies of the computer labs at kings?
22. Is there anyone else that you could recommend us to speak to that might have insights into this project?

Appendix 6: Schedules

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
24	25	26	27	28	1	2
3	4	5	6 Initial Lab Data Collection Time TBD	7	8	9
10 Lab Observations 12AM-12PM	11 Lab Observations 12AM-12PM	12	13	14	15	16
Interviews –Times TBD						
17	18	18	20	21	22	23
Data Analysis						
24	25	26	27	28	29	30
Writing of Final Report/ Making of Presentation						
31 Presentation Slides Due	1 Practice Presentation	2 Pecha Kucha Presentations	3	4	5	6
Writing of Final Report						
7	8	9	10	11	12 Report and Peer Evaluation	13
Editing of Final Report						

Sunday, March 10th, 2013		Tuesday, March 12th, 2013	
Time	Observer	Time	Observer
12:00 AM	Brittany	12:00 AM	Anna
1:00 AM	Brittany	1:00 AM	Anna
2:00 AM	Brittany	2:00 AM	Anna
3:00 AM	Brittany	3:00 AM	Anna
4:00 AM	Brittany	4:00 AM	Anna
5:00 AM	Tiffany	5:00 AM	Calvin
6:00 AM	Tiffany	6:00 AM	Calvin
7:00 AM	Tiffany	7:00 AM	Calvin
8:00 AM	Tiffany	8:00 AM	Calvin
9:00 AM	Tiffany	9:00 AM	Calvin
10:00 AM	Chris	10:00 AM	Brittany
11:00 AM	Chris	11:00 AM	Brittany
12:00 PM	Chris	12:00 PM	Brittany
1:00 PM	Chris	1:00 PM	Brittany
2:00 PM	Chris	2:00 PM	Brittany
3:00 PM	Calvin	3:00 PM	Tiffany
4:00 PM	Calvin	4:00 PM	Tiffany
5:00 PM	Calvin	5:00 PM	Tiffany
6:00 PM	Calvin	6:00 PM	Tiffany
7:00 PM	Calvin	7:00 PM	Tiffany
8:00 PM	Anna	8:00 PM	Chris
9:00 PM	Anna	9:00 PM	Chris
10:00 PM	Anna	10:00 PM	Chris
11:00 PM	Anna	11:00 PM	Chris