Building Energy Audit of Studley Campus, Dalhousie University

Emily Colin	Environmental Science & Marine Biology
Thomas Harington	Sustainability & Sociology and Social Anthropology
Erik Nyhuus	Political Science & Sustainability
Bethany Scott	Biology & Environmental Studies
Jillian Vardy	Community Design & Sustainability

ENVS 3502 Final Report
April 17, 2015

Executive Summary

Energy consumption at Dalhousie University is a current issue that is in one way being addressed with the implementation of strictly LEED Certified buildings in the future. There are many benefits to LEED Certified buildings, which include not only economic and environmental improvements, but also aesthetic, cultural and social benefits as well. There are many aspects of the buildings that work to improve these benefits such as energy and water use, indoor environmental quality, infrastructure, and leisure/ study space quality (Retzlaff, 2009). Dalhousie University proudly supports LEED certified buildings and is on it's way to becoming a more sustainable campus. A prime example of Dalhousie's success is the Mona Campbell building on Dalhousie's Studley Campus, which is a LEED certified building and is widely recognized as the greenest building on campus. Currently, the building is closed in the evenings and on weekends (8am to 10pm Monday – Friday). If the Mona Campbell is the most sustainable building on campus, we want to discover why it is not used to its fullest potential by being closed on evenings and weekends. This project's analyzed energy consumption of buildings that are open on weekends across Dalhousie University's Studley Campus. This energy consumption research determined which buildings are likely consuming the most energy, and then indicated which buildings should be open on the weekends and which buildings should not. From this, our research then determined which buildings are suitable for weekend closure in comparison with the Mona Campbell Building. The satisfaction and potential use of the Mona Campbell building was supported through literature review and surveying of the population who would benefit from our research. Surveys were conducted to gather data on interest and awareness levels of the Mona Campbell's study space. From these findings we provide the University with structural data to potentially create a more sustainable option regarding weekend operations should action be taken to transform weekend operations. Our suggestion is that university building managers review our findings and discuss a potential weekend closure of a less energy efficient building. Our research suggests that there is potential to improve operational hours of certain buildings on campus between the Kenneth Rowe, Marion McCain, or the Goldberg Computer Science. We also suggest that there is room for further study to be conducted including more intricate analysis of building energy consumption sources to provide a more accurate definition of building comparisons.

Table of Contents

1.0 Introduction

1.1 Research Question

The main question we address with our research project is as follows:

"What are the benefits and barriers, based on energy savings and occupant satisfaction, of opening a LEED-Certified building on weekends to maximize study space and reduce energy consumption on Dalhousie's Studley campus?"

Furthermore, there are other questions we aimed to answer during our research, data collection, and analysis to gain a more holistic understanding of the issue:

- The Mona Campbell building is a LEED certified building and arguably the greenest building on campus; why is it not being used during weekends?
- What are the levels of energy consumption for buildings on Dalhousie University's Studley Campus?
- What are the current levels of energy consumption for the Mona Campbell in comparison to other buildings on Dalhousie University's Studley Campus?
- What are the costs associated with opening the Mona Campbell on weekends?
- Do students and staff want the Mona Campbell open on weekends?
- Will students use the Mona Campbell building if it is opened for use on weekends?

1.2 Scope

The scope for this research project was limited to the Studley Campus of Dalhousie University and included the Dalhousie student population, faculty members and support staff. We conducted a statistical analysis of the energy records in regards to energy cost and consumption for the Mona Campbell building and other buildings across Dalhousie University with a focus on Studley Campus. This comparison revealed the differences in energy consumption from building to building and highlights the benefits or barriers associated with opening the Mona Campbell on weekends. We conducted a survey of students, faculty and support staff members in the Killam Library, the Student Union building, and Risley Hall. The survey showed whether there is interest in extending the hours of operation of the Mona Campbell on evenings and weekends. We reviewed occupant satisfaction of other LEED

certified buildings, documented in articles, to review the benefits and barriers of LEED certified buildings according to the user population.

Our statistical analysis of energy consumption was based on information gathered from Rochelle Owen and the Embedded Efficiency Manager, Glen MacDougall. The data collection included a survey to be answered by students, support staff and faculty at Dalhousie University, which took five days to complete.

Our research methods were deductive, exploratory and potentially transformative. Our methods are deductive in that we hypothesized that the Mona Campbell building, or an alternative LEED certified building, would be energy efficient enough that it would be worth opening on weekends as an alternative to a less energy efficient building on the weekends. Our research was exploratory because we compared energy consumption of buildings on Studley Campus to discover if there is a building that consumes more energy that could be closed on the weekends in exchange with opening the Mona Campbell building. If our research is accepted our methods will become transformative in suggesting and achieving an increase in LEED certified building hours and a reduction in non-LEED certified/ less energy efficient building hours on Studley Campus at Dalhousie University. With the reduction of a building's hours that uses more energy than the Mona Campbell's, we will be reducing energy consumption on campus, promoting the use of a healthy study space, and causing higher economic savings through less energy. Through using quantitative and a priori research methods, we analyzed the gathered information and data to address our project's Studley Campus building sustainability issue.

2.0 Background

2.1 Rationale

Dalhousie University has been working towards becoming a greener, more sustainable university for a number of years. Sustainability "demands ways of living, working and being that enable all people of the world to lead healthy, fulfilling, and economically secure lives without destroying the environment and without endangering the future welfare of the people and the planet" (Johnston, Everard, Santillo, & Robèrt, 2007). If we wish to continue becoming a more sustainable campus, it is important that we make use of the buildings that are already considered energy efficient on campus, as well as continuing the mission of introducing additional energy efficient buildings. This research project conducted a study of each building's energy consumption on Studley Campus to determine which buildings save more energy and in

turn, save more money. We have looked into sustainable architecture as a whole, and then LEED certified buildings specifically. We have researched the economic benefits, occupant satisfaction, and energy savings and efficiency of other LEED certified buildings. To go along with occupant satisfaction we measured the interest and awareness of a Studley sample population to determine the existing interest in th ebuilding with arguably the most sustainable reputation: the Mona Campbell Building. Additionally, we have compared Dalhousie University with others schools that are striving for a more sustainable campus to see how other universities are reducing energy consumption, and how their use and benefits of LEED certified buildings can compare with ours. Based on the research gathered we conducted our project in such a way to improve the sustainability of Dalhousie University via energy efficiency on Studley campus regarding buildings of interest containing study space opened on weekends.

2.2 Background

Sustainable Architecture

Our research question focused on the idea of utilizing a LEED certified building for the benefit of both students and the university. The Mona Campbell building is a LEED certified building and arguably the most environmentally efficient in operation. The utilization of sustainable practices linked with the design and creativity in architecture has given rise to an assortment of buildings that beautify the urban landscape and reduce environmental impacts. In the book Ecological Design they accounted that the environmental crisis is a design crisis (Ryn & Cowan, 1996). The environmental crisis is a consequence of how things are constructed; from urban landscapes to greenspaces. There are six frameworks that are used when linking sustainability and architecture; technical, ecological, aesthetic, cultural, medical, and social (Farmer, 2013). Sustainable architecture and development have an enormous impact on the global scale as buildings “account for almost half of global energy consumption” (IPCC, 2007).

LEED Certified Buildings

The evaluation of efficiency and sustainability of ‘green’ buildings requires the use of many systems and tools. Worldwide it seems as though every county has come up with its own evaluation system. As such, not all evaluation systems are the same, depending on the country the system was developed in points will be allocated differently. For example, points allocated to water efficiency differ dramatically between the Green Building Council of Australia’s (GBCA) ranking system and the Leadership in Energy and Environmental Design (LEED) rating system. (Zuo & Zhao, 2014).

For the purpose of our research we concerned ourselves with the LEED certified rating system as it is the system that was used to rate our own Mona Campbell Building. The LEED system has four levels of certification, certified, silver, gold and platinum; of which the Mona Campbell Building is certified gold. The rank of a building is determined through the accumulation of points in certain categories such as energy, water, indoor environmental quality, sitting, infrastructure and pollution. (Retzlaff, 2009).

Economic Benefits to LEED

While environmental certifications can be accused of being marketing techniques and appealing to the "green community", there are indeed economic benefits that are clearly demonstrated across numerous studies. In the case of LEED certification, five different categories are examined: the sustainability of the site, the building's water efficiency, the energy and atmosphere, the materials and resources used, and the indoor environmental quality (Matisoff, Noonan, & Mazzolini, 2007).

Companies who have built LEED-certified buildings have found significant economic improvements in their buildings' maintenance costs. Herman Miller, a furniture manufacturer from the USA has reportedly saved $6 million over the course of a 7-year lease of a LEED-certified factory. Similarly, Castcon Stone Inc., a Pennsylvania-based construction company reduced their electricity use from 1,000,634 kWh to 675, 712 kWh in their new Silver-certified LEED factory. Another construction company McGraw-Hill has reported 10%-20% decrease in their operating expenses. Facilities that have profited from green economic benefits have installed lighting sensors, natural ventilation with operable windows, and an HVAC control system, among other devices (Ries, Bilec, Gokhan & Needy, 2007).

Similarly, residential buildings found their market value increased dramatically upon investing in the LEED certification. Studies conducted by G. Pivo and J. Fisher compare 336 green buildings to 1114 non-green buildings. According to their research, the sustainably constructed and operated buildings boast a 13.5% higher market value, along with 9.8% fewer utility expenses and 4.8% higher rent value (Popescu, Bienert, Schutzenhofer & Boazu, 2012).

Occupant Satisfaction

It is important to consider occupant satisfaction between LEED and non-LEED buildings because we want students to be satisfied with the spaces they have to work in, while still working our way towards a more sustainable and environmentally aware campus. In the article 'Occupant Satisfaction in LEED and non-LEED certified buildings' by Serigo Altomonte and Stefano Schiavon they discuss the different indoor environmental quality (IEQ) factors necessary to determine occupant satisfaction within commercial buildings, healthcare facilities,

laboratories, educational buildings and other facilities (2013). These factors include furniture layout, amount of privacy, cleanliness, air quality, thermal comfort, lighting, acoustic quality, which are described in Table 1 in Appendix B (Altomonte & Schiavon, 2013).

The Center for Built Environment (CBE) at the University of California used a method of surveying called 'cognitive interviewing'. This survey used a rating scale with 7 points from very satisfied (+3) to very dissatisfied (-3) with a neutral point in the middle (0). This survey questioned about the IEQ factors already mentioned above, as well as building characteristics such as year of construction or energy use. Initial results showed that occupant satisfaction was higher in LEED buildings because of air quality. The lower rated factors of LEED buildings were lighting and acoustics. The results of 10,129 responses on LEED buildings and 11,348 responses on non-LEED buildings are in Table 2 in Appendix B. The higher the occupant satisfaction for workspace, cleanliness, building maintenance, etc. in LEED buildings contributes to higher indoor environmental quality, which has been shown to reduce asthma, respiratory allergies, depression and stress (Altomonte & Schiavon, 2013). For students, this is particularly important because the stress university can have on a student can enhance or cause mental health to suffer. If we have buildings that help with health and promote better workspaces, why would we not make use of these to aid students in doing well in school while maintaining a healthy mental state. Additionally, if these buildings use less energy, while helping students, this is good for the university economically.

Energy Savings and Efficiency

There is little to no data available when it comes to the energy efficiency of LEED certified buildings. In 2008, a report was released by the US Green Building Council (USGBC), the creators of the LEED certification program, stating that "average LEED energy use [was] 25-30% better than the national average […]" (Turner & Frankel, 2008). This report received harsh criticism due to their sampling bias and statistical analyses. The data used in the report was only provided voluntarily by the building owners, which could have resulted in bias sampling. Furthermore, energy use intensity (EUI) was compared using the LEED median against the mean of all other construction. This as well as the exclusion of the 21 highest EUI ranking LEED buildings from the comparison is believed to have resulted in skewed data. (Scofield, 2009).

In truth, LEED buildings on average use 18-39% less energy per floor area than the comparable traditional buildings. Though, it is important to note that 28-35% of LEED buildings use more energy. (Newsham, 2009). This truth however does not mean that these buildings are unsustainable. It simply means that these particular buildings are using more energy. It is unknown how these buildings are being used and how often they are being used, it is also unstated what form of energy they are using. If they are using a sustainable form of energy such as solar power or wind power then there is little to no ecological footprint. Perhaps some

of these buildings are home to offices, which have higher energy requirements when compared to smaller businesses. Until such time as more data can be obtained and analyzed there will be no simple answers to the actual energy usage of LEED certified buildings.

Dalhousie in comparison with other Canadian University's Sustainability

There are many examples of universities that are working towards having a greener campus, meaning their institutions are consuming less energy and water. One example in particular is the University of Waterloo in Ontario. In a case study by Gregory Richardson and Jennifer Lynes they discussed their motivations and barriers of building and utilizing greener buildings on campus (2007). The increase in attendance in Canadian universities alone has increased 12 percent over the past decade, which means that universities are constantly required to accommodate for this enrolment increase (Lynes & Richardson, 2007). As enrolment increases, the energy and water consumption will inevitably increase. If the university is aware and committed to becoming a sustainable institution, the infrastructure to accommodate this population increase must be sustainable. Lynes and Richardson outline that one of the barriers to building more efficient buildings is the preconception that the initial costs of construction are higher, although often they can be equal to standard building initial costs (2007). There are far more motivations when it comes to financial savings, such as energy cost savings, and even the eventual savings from institutional image and reputation of having a greener campus (Lynes & Richardson, 2007). As well, it has been speculated that the institution can save money by having better work environments (Lynes & Richardson, 2007). When the work environment is more conducive to more employee productivity, there will be more work accomplished and less employee absenteeism, saving the institution money (Lynes & Richardson, 2007). The barriers of constructing greener buildings in the perception that it initials costs are higher, and also that there is a lack of leadership in promoting greener buildings within the institution. Once they are built they cost less money and promote a healthier, more productive workspace for both faculty and staff, as well as create a positive image for the institution.

Facility productivity in greener buildings increase by 25%, and it is evident that there is a positive correlation between the quality of the building and the performance of its employees Lower productivity can be linked to a poor indoor environmental quality, caused by lower air quality, and poorer ventilation and lighting (Ries, Bilec, Gokhan, & Needy, 2007). LEED buildings can assure happier working environments, and likely more productive employees. In the case of the Mona Campbell, it could very well be that it is a more inviting study space, based on its use of natural light and clean air.

3.0 Methods

This project used deductive techniques to assess the operation hours and energy use of Studley campus buildings based on comparative methods. The data that we compared was of building energy use measured an average kilowatt (kW) per hour per year value, which helped us in proposing potential changes for more sustainable building operations on weekends. We used exploratory research to gather specific qualitative and quantitative data of the buildings and the campus student body to propose a transformative outcome, from less to more sustainable, for student study areas that are open on the weekends. Of particular interest we compared the Mona Campbell building to other Studley buildings with similar study space availability that are open on weekends. We then measured awareness and interest based on student input via survey to support our proposition compared with background literature on the benefits of LEED-certified buildings and occupant satisfaction. This interest and background information was outlined with the potential to develop our research further with a transformative outcome on sustainable building operation hours and study space.

3.1 Literature Review

We gathered research information regarding sustainable architecture; LEED Certified buildings, their energy efficiency and economic qualities, Dalhousie campus sustainability, the Mona Campbell building characteristics as a LEED certified building, and comparable campus sustainability examples of other universities. Together these topics aim to develop further the benefits of LEED buildings and environmentally friendly architecture in support of extending the Mona Campbell building operational hours in attempt to improve campus sustainability, efficiency, and study space availability. Further research was conducted following data analysis and gathering survey information. This additional literature research is used to better understand our results and findings by comparing them to previous studies and information gathered in the past.

3.2 Building Energy Use Analysis of Studley Campus

3.2.1 Buildings

We assessed Studley building efficiency based on kilowatt (kW) per hour per year on average for five buildings. The buildings that we chose were those currently operational on weekends with available study space. These buildings could work as potential buildings to close should their energy use prove to be less efficient with less study space available than the Mona

Campbell, which is our building of interest. We chose the following buildings because they would be accurate comparisons with similar usages of study space for weekends and evenings:

- Computer Science
- Kenneth Rowe
- LSC
- McCain
- Mona Campbell*

*The Mona Campbell building is our building of interest that we will be comparing the other buildings energy use and study space to. The Mona Campbell is the building that we wish to see open and are therefore studying other buildings open on weekends relative to their energy use and hours of operation.

The building energy use data was provided to us by the campus' Embedded Efficiency Manager, Glen MacDougall. The quantitative data that we have regarding energy use ranges over a one-year time span and represents the energy consumption for each of the buildings above. This data was collected in the form of charts that represent kW usage per time (day and hour) during the 2014-2015 academic year up until the present time (September 2014-March 2015). Other building information gathered includes the hours of operation for each building and whether they are open or closed on the weekend (see appendix B). This data was collected from the Sustainability Director at Dalhousie, Rochelle Owen, in the form of a table listing building and hours per day of the week. Furthermore, we also compiled data on building study space capacity for comparisons of usefulness regarding the amount of space available for student use on weekends and evenings. The amount of study space is important when considering which buildings are similar to, but less energy efficient than the Mona Campbell building.

We analyzed Studley campus buildings in an attempt to better understand the motives behind operational hours of buildings that could contribute to study space on Studley campus. This is important, as we believe there is currently a demand for increased study space available to students, particularly on weekends. With specific interest in the Mona Campbell building comparisons and were made in the form of bar graphs in an attempt to project the energy saving benefits of operational hours for increased sustainability and efficiency as well as increased study space on campus.

3.2.2 Building Analysis

To evaluate our data we compared the Studley campus buildings energy consumption to the Mona Campbell building using bar graphs to create a visual display of the comparisons. These measures were compared using an average of kilowatt (kW) per hour per year to determine an accurate representation of the energy consumption. From this comparison, along with the comparison of relative abundance of study space compared to the Mona Campbell and the other buildings under analysis, we have proposed which building yields the most potential, to be replaced by the Mona Campbell on weekends.

3.3 Survey Methods

3.3.1 Survey Population

The population from which we drew our samples was inclusive of Studley campus faculty, students and support staff within Studley Campus. We sampled the Studley campus student body to gather data from involved individuals who are familiar with the campus. This campus' input will be most valid in representing the interests of the Mona Campbell's operational hours. We conducted the surveys with individuals present in the Student Union Building, the Killam Library, and Risley Hall.

3.3.2 Probabilistic Multistage Cluster Survey

The quantitative data collected from the faculty, students and support staff was gathered as qualitative information of interest levels of the Mona Campbell building's operational hours via survey (see appendix A). The survey was probabilistic, multistage cluster and purposive as it is directed at Studley campus Dalhousie faculty, students and support staff. The survey was structured for a single, one option response to gather information that could be easily coded and quantified. The surveys were conducted in inclusive areas on campus to provide an unbiased sample. These areas included the Student Union Building, the Killam Library, and Risley Hall. The sample size was calculated using a 99% confidence level on a total student body of 18500 to predict a reliable sample size of 650 (see appendix A).

3.3.3 Survey Analysis:

We utilized the findings from the survey to support or reject our proposed replacement of the Mona Campbell. We compared awareness, support, and usage responses in the survey of faculty and staff to weigh the overall interest of the project (See appendix A). To quantify the findings we gave the responses numerical values (See appendix A), which were summed and weighted based on interest. This was done using an excel spreadsheet where each participant was given a row and columns represented the questions asked. To quantify the results there

were statistics drawn from the data within columns for each question. We also indicated the mean, median and mode of who took the survey, and the responses the participants gave to further explain the results (See appendix A for compressed survey data).

The survey indicates whether there is significant interest in opening the Mona Campbell building on weekends for study space. This determined whether there is social significance to support or reject the economic and environmental sustainability aspects of our proposition to open the Mona Campbell building on weekends.

3.4 Transition Analysis

We finally analysed building energy use, survey respondent interest and awareness, and background information on LEED-certified buildings together to propose the support of our hypothesis to open the Mona Campbell building on the weekends to increase the use of energy efficient buildings, which in turn acts to increase study space. The alternative, should our proposition have failed to be supported, would have been to propose alternatives to our hypothesis and choose either another efficient building or analyse whether Studley campus is already functioning at optimal efficiency levels.

3.5 Delimitations and Limitations

3.5.1 Delimitations

The delimitations of our study included the restriction of sampling the Studley campus buildings and faculty, students and support staff to create a more localized data set on a smaller scale to prevent redundancy in the comparisons. Furthermore, we restricted the buildings on Studley campus to only those who have study space and are already open on the weekends. These restrictions allowed for a more accurate representation of realistic possibilities and interests for sustainable building operation transformations.

The data regarding the energy use of each building was restricted to a year in order to achieve results that are realistic and not biased to a shorter period of time. This allows for a more accurate representation of energy use. More extensive data would limit error and bias.

We calculated our sample size as a function of the entire Dalhousie population rather than limiting it to a number for only Studley campus. This resulted in a larger sample size without compromising the accuracy and precision of the dataset.

We restricted our survey to a simplistic purposive single response structure in order to eliminate redundant information and restrict the findings to yes or no answers. We then used the responses equal to a numerical scale and finding the sum of each question asked. This quantified a response to each question to more easily explain the interest in the topic.

3.5.2 Limitations

A limitation of the project was the time frame for completion. The time frame restricted the attributes that could be compared regarding efficiency measures; more time could have allowed more specific characteristics of building consumption to be analysed for a more reliable and valid representation of building efficiency such as water consumption, monetary differences, surveys regarding specific building occupancy satisfaction.

3.6 Schedule, Deliverables and Communication Plan

The schedule revolved largely around surveying. The survey date and time was during the week of March 23- March 27, and was controlled according to Dalhousie regulations and permission to proceed on the premises. Surveying covered a time period of five days for 1.5 hours each day. Two group members were present at each survey date/location.

The comparative data analysis was conducted throughout the duration of the project period allotted inside of and outside of class time. All group members contributed to this analysis.

The deliverables of this project were expressed during the class Pecha Kucha presentations at the Grawood. This project aimed to influence those concerned with the efficiency and sustainability of Studley Campus. Our findings have been shared with the Sustainability Manager, Rochelle Owen, of Dalhousie University as she largely influenced and supported our project by providing guidance and data. Our findings have also been shared with the Embedded Efficiency Manager, Glen MacDougall, of Dalhousie University who also was a main contributor of data and guidance for our project. Furthermore, our project will be available to the public on the Dalhousie website under the 3502 course webpage upon completion of the course if the outcome is accepted.

4.0 Results

4.1 Survey Results

The survey process's ultimate goal was to quantify the interest and how informed the Studley Campus population was in the Mona Campbell Building should the building be proposed to be open on weekends (see Appendix A for table of compressed survey data). The

survey process established the majority of the participants to be students (611) where there was significantly less faculty (20) and support staff (19), which can be seen in figure 1 below.

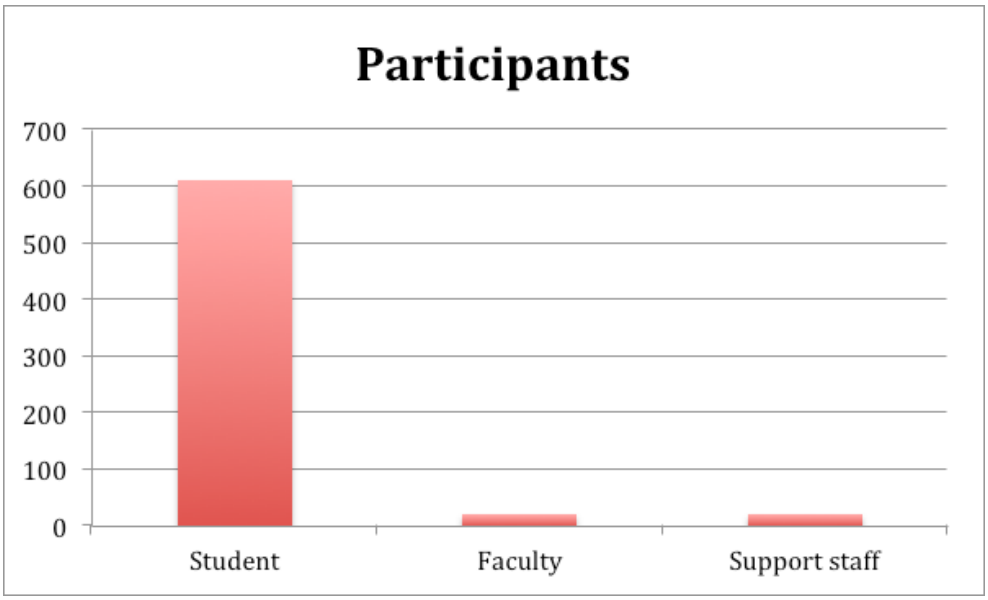


Figure 1. Participant data from the survey analysis when asked to indicate whether they were Dalhousie student (1), Faculty (2), Support staff (3).

Figure 2 below signifies the proportion of the sample population that had been to the Mona Campbell Building where 254 replied with yes and 396 replied with no.

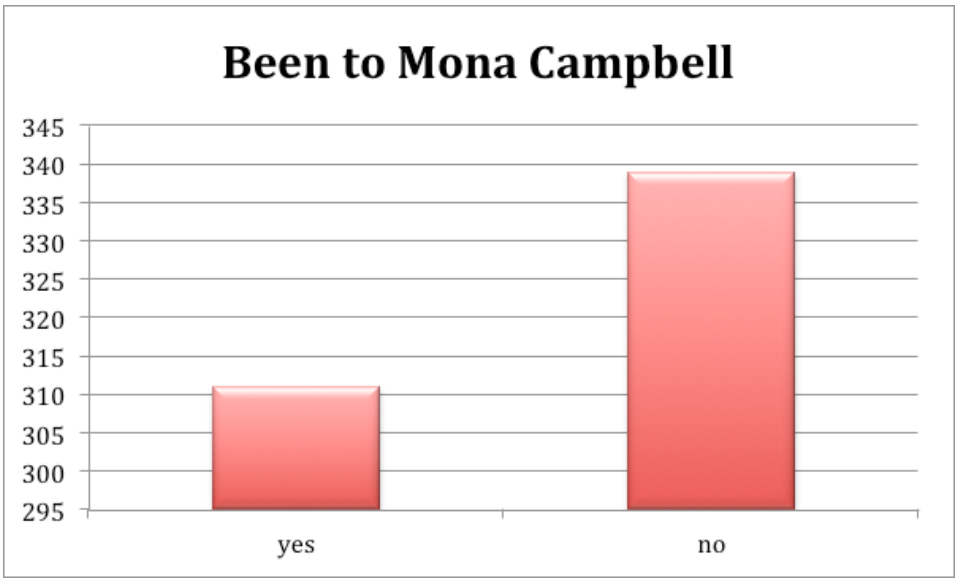


Figure 2. Participant data indicating whether they have ever been to the Mona Campbell building (yes or no)

Along with asking whether the population had been to the Mona Campbell building we quantified whether they were aware there was study space available in the building where 311 replied with yes the were aware of the study space and 339 replied with no they were not aware of the study space, as seen in figure 3.

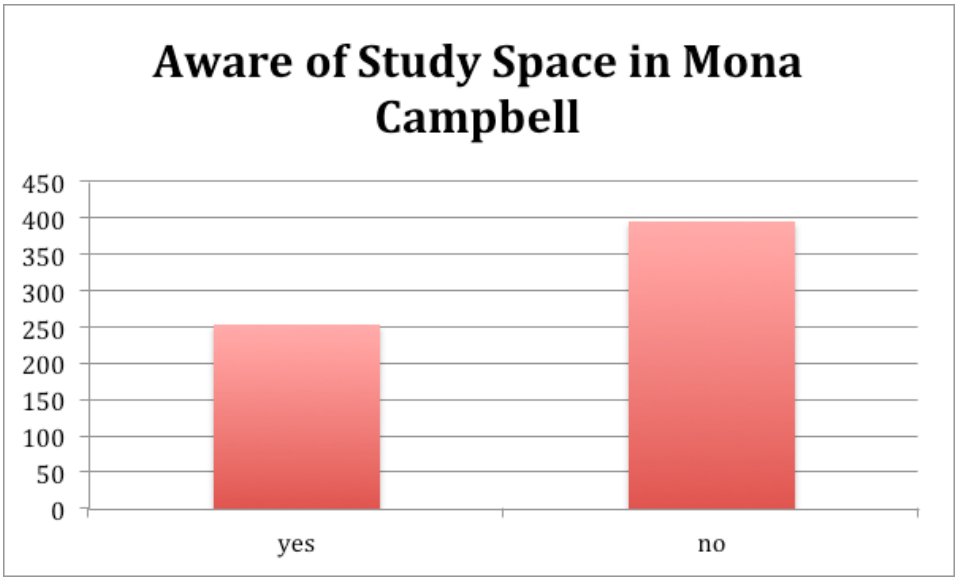


Figure 3. Participant data addressing whether they are aware that the Mona Campbell Building has study space (yes or no)

We questioned whether the awareness of study space reflected the use of the Mona Campbell Building's study space, where 175 responded with yes they have used the study space and 475 responded with no they have no used the study space which is represented in figure 4 below.

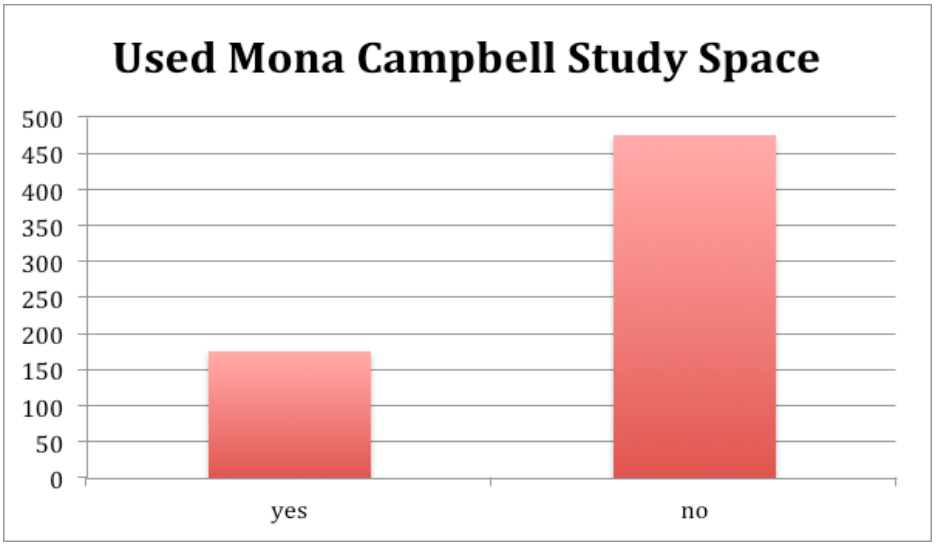


Figure 4. Participant data addressing whether they have used the Mona Campbell Building study space (yes or no)

Further examining the awareness of the population we questioned whether the participants were aware that the building was closed on weekends, as seen in figure 5, where 138 responded with yes they were aware of the Mona Campbell's weekend closure and 512 responded with no they were not aware.

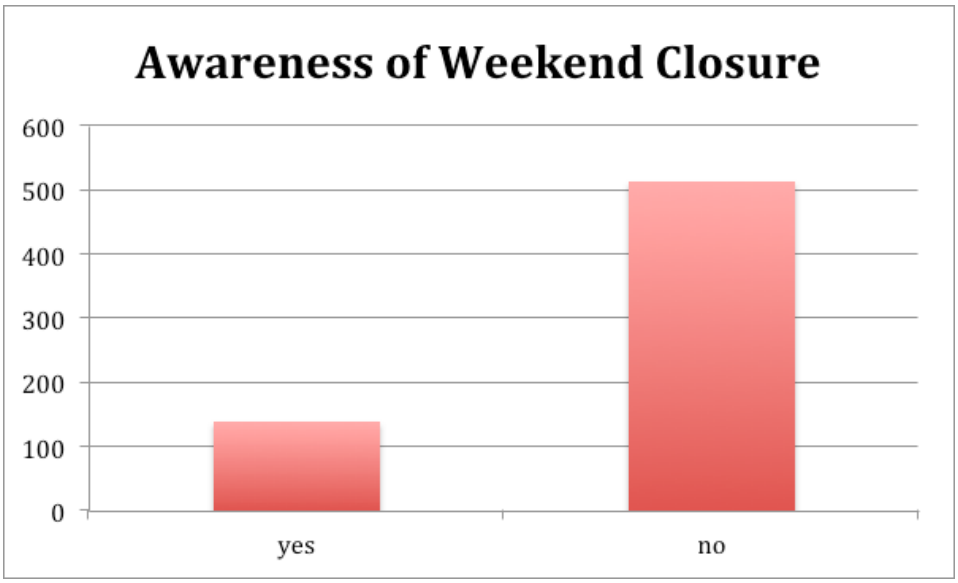


Figure 5. Participant data addressing the awareness of the Mona Campbell Building being closed on the weekends (yes or no)

After measuring awareness and current usage we asked whether they would be interested in using the Mona Campbell Building on weekends, to which 97 responded with they wouldn't use it, 186 responded with they were not likely to use it, 268 said they would use it sometimes and 99 said they would use it often. These data are gathered in figure 6.

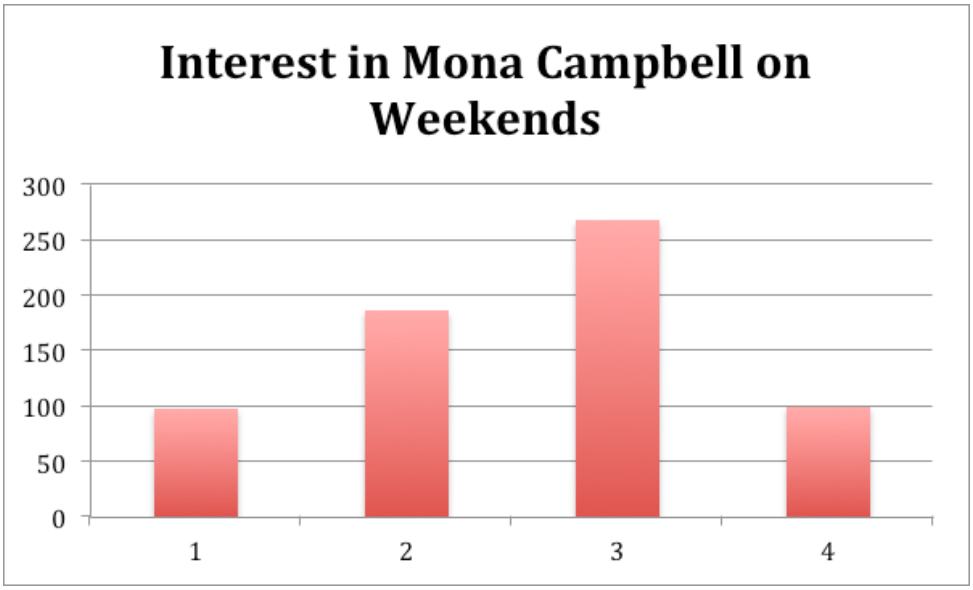


Figure 6. Participant data addressing the level of interest in the Mona Campbell Building being open on weekends (1=Wouldn't use it, 2= Not likely to use it, 3= Would use it sometimes, 4= Would use it often)

After measuring the interest in the building we looked at interest in study space exclusively where 120 responded with they wouldn't use the Mona Campbell's study space, 169 reponded with they were not likely to use it, 262 responded with they would use it sometimes, and 99 responded with they would use it exclusively for study space on weekends. These data can be seen in figure 7 below.

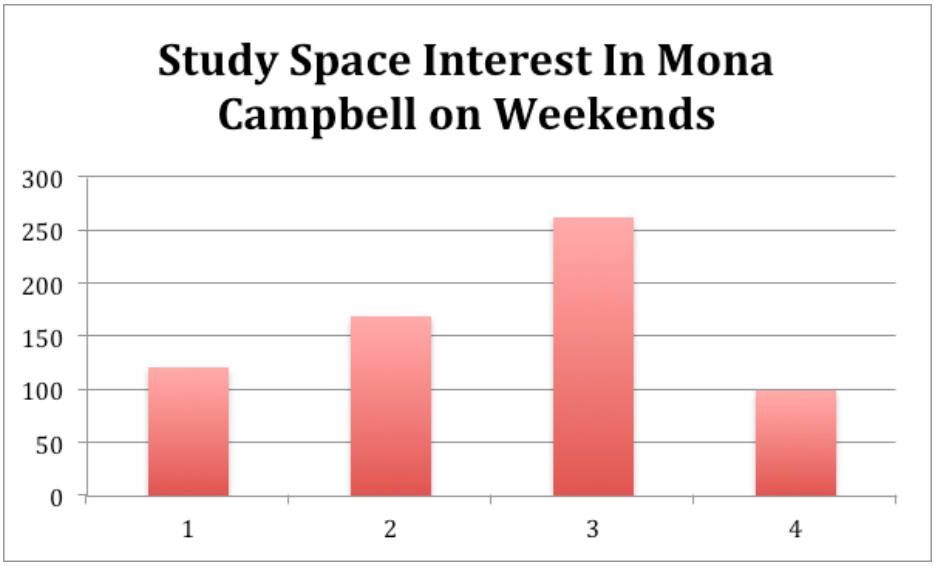


Figure 7. Participant data addressing the level of interest in the Mona Campbell Building study space if open on weekends (1= Wouldn't use it, 2= Not likely to use it, 3= Would use it sometimes, 4= Would use it exclusively for study space

4.2 Energy Comparison Results

The following figures 8 through 12 represent the comparisons of energy use measured in kilowatt per hour per year and are then expressed as an average of the year in question. These comparisons act as a guideline for the evaluation of the energy use of the Mona Campbell versus other potential study space areas that are open on weekends. These comparisons aid in proposing potential candidates for opening an additional building on weekends to supply Studley Campus with extra study space while using as little extra energy as possible.

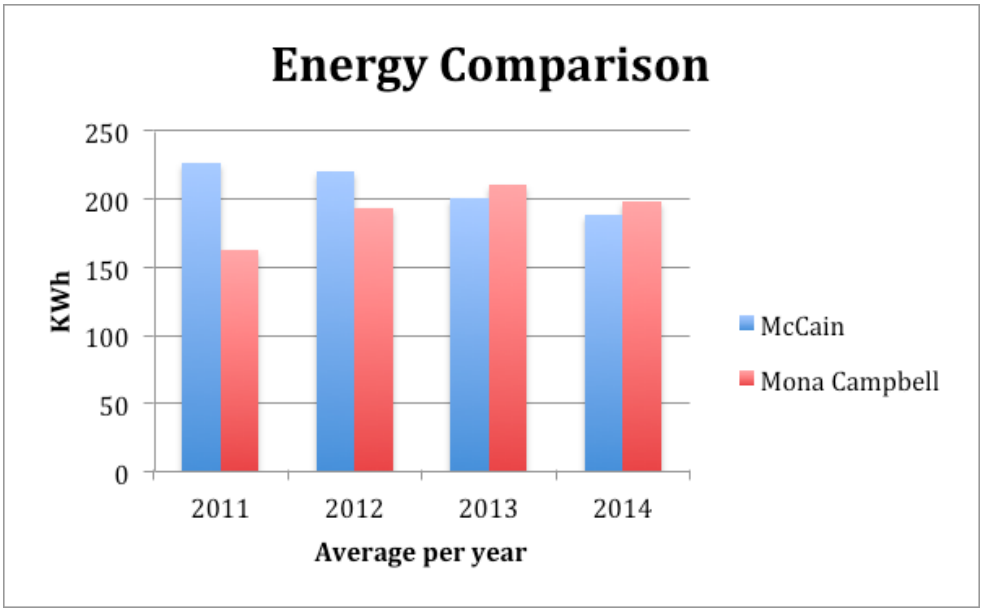


Figure 8. Energy usage comparison graph of the McCain versus the Mona Campbell Building on Studley Campus, Dalhousie University, where the energy is measured as an average kilowatt per hour per year.

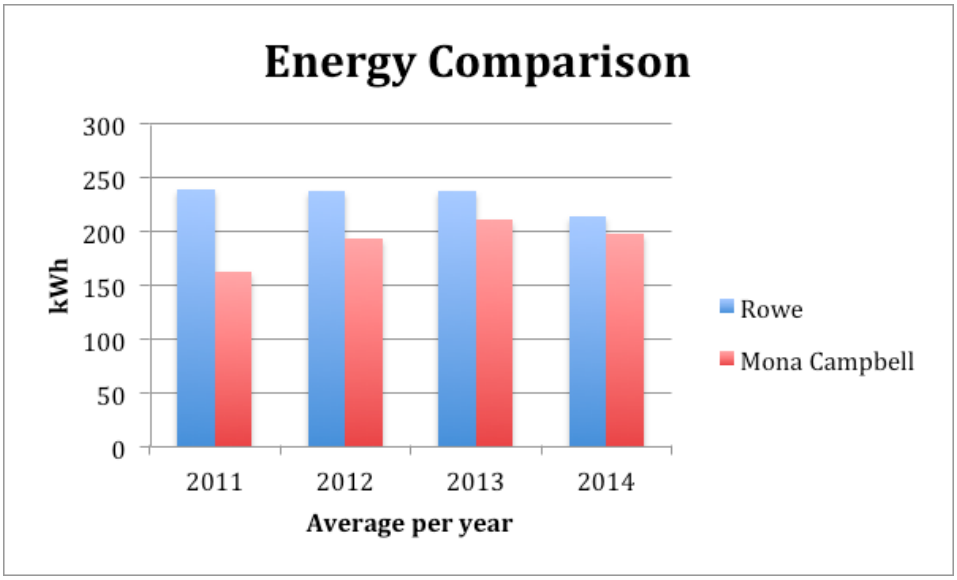


Figure 9. Energy usage comparison graph of the Kenneth Rowe Building versus the Mona Campbell Building on Studley Campus, Dalhousie University, where the energy is measured as an average kilowatt per hour per year.

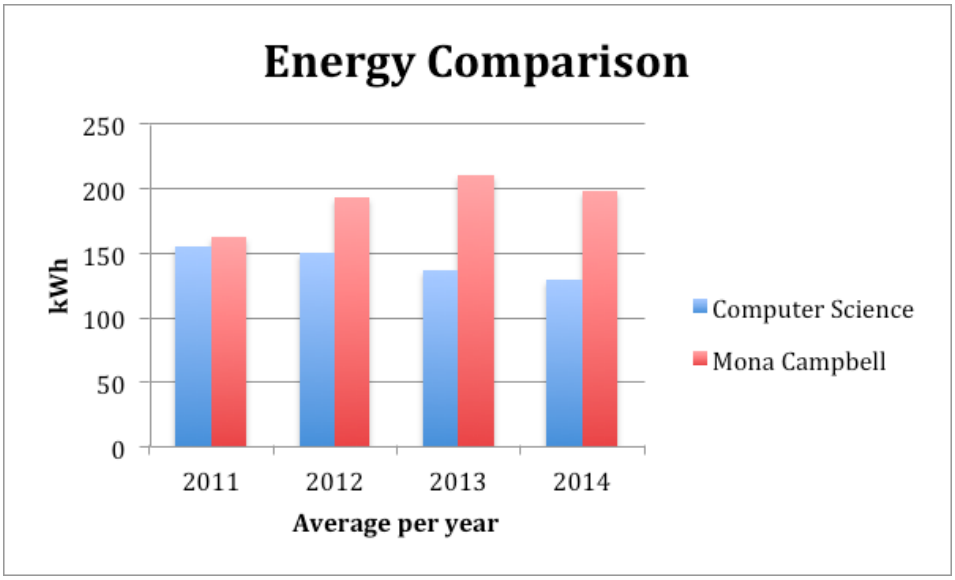


Figure 10. Energy usage comparison graph of the Goldberg Computer Science Building versus the Mona Campbell Building on Studley Campus, Dalhousie University, where the energy is measured as an average kilowatt per hour per year.

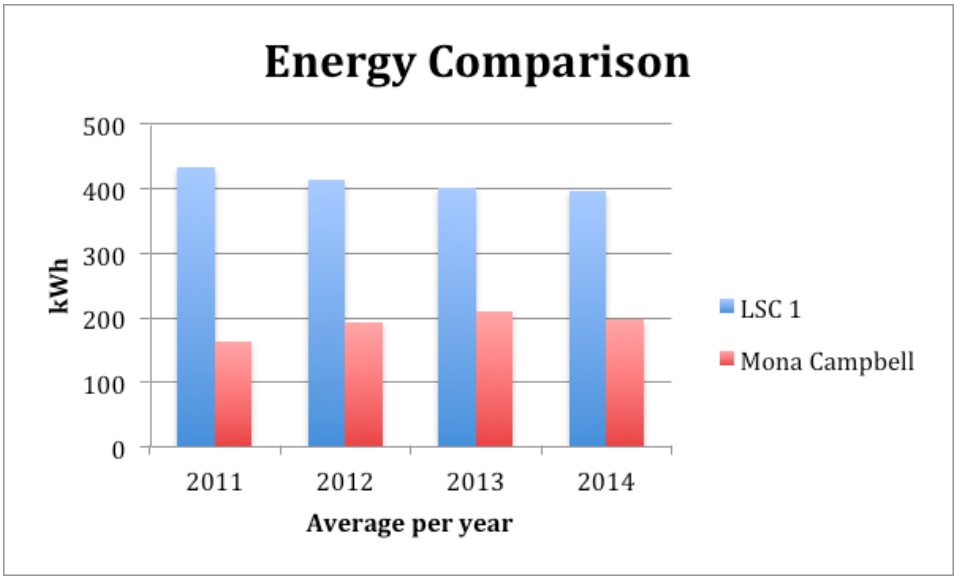


Figure 11. Energy usage comparison graph of the Life Sciences Center (tower 1) versus the Mona Campbell Building on Studley Campus, Dalhousie University, where the energy is measured as an average kilowatt per hour per year.

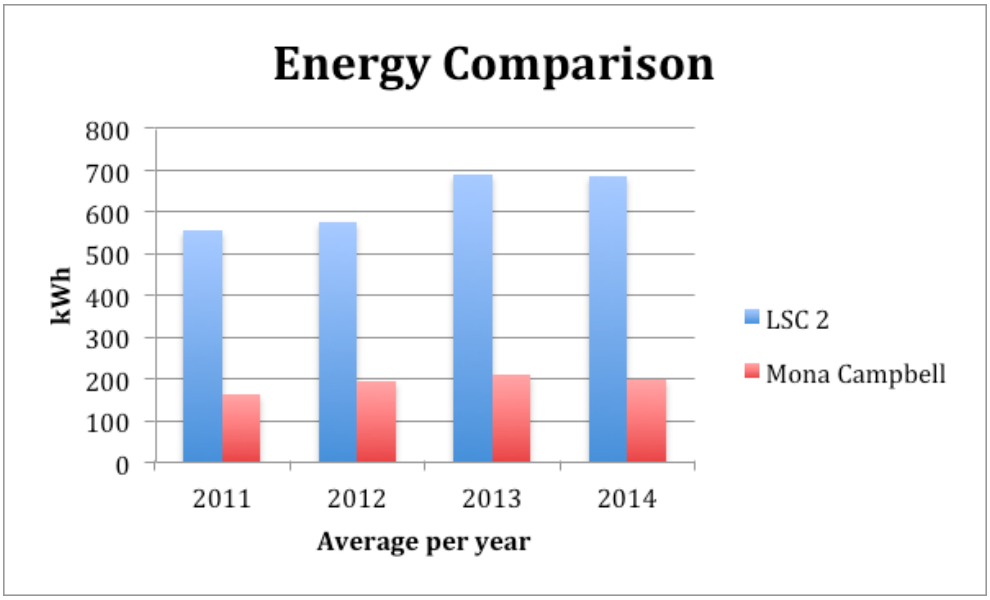


Figure 12. Energy usage comparison graph of the Life Sciences Center (tower 2) versus the Mona Campbell Building on Studley Campus, Dalhousie University, where the energy is measured as an average kilowatt per hour per year.

5.0 Discussion

5.1 Survey Analysis

Our survey was a means to discover how the student and staff population of Dalhousie University felt about our research project involving the Mona Campbell building's operational hours, specifically as a study space. For the survey we used a sample size of 650 people that were chosen at random. The survey was carried out over 5 days throughout the Studley Campus at Dalhousie University. The locations we used consisted of Risley Hall, The Killam Library and The Student Union building. Of our sample size 611 were students, 20 faculty and 19 were support staff. These numbers allowed for an accurate analysis of the population of Dalhousie University where the main population of our concern was the student's interest and usage of the Mona Campbell building. The first question for the survey addressed who they were at Dalhousie University, be it student, faculty or support staff. We primarily were looking to have more students than faculty and support staff as this research looked at the benefits for Studley campus but also for the students regarding study space on weekends. The second and third questions focused on whether the population had attended the Mona Campbell buildings and measured their awareness pertaining to study spaces within the building. This was to find out how much of the student population knew about the Mona Campbell building. If they had been inside and if they were aware of the possible study spaces available. The findings to these questions were as follows; 396 students had not been to the Mona Campbell building, which was over half of the sample size. Question three showed more promise of indicating awareness with 311 knowing about the study spaces but still 339 not knowing. From these two questions we were able to determine that the majority of our sample size were uneducated on the Mona Campbell building and its available study spaces. The fourth and fifth questions looked at use of the study space, along with asking if students knew that the building was not open to the general student body on weekends. Although our initial findings show a lack of use and knowledge of the building we start to see a change within these responses. Overwhelmingly, 475 individuals surveyed had not used the Mona Campbell's study facilities and 512 were not aware it was even closed on weekends. This strongly supports our early theories of students not knowing about the study spaces in one of Dalhousie's most sustainable buildings, and furthermore it established that the population was unaware it was closed on weekends. The last two questions focused on the actual use of the building and if they would use the study rooms or just the building in general. The majority of individuals who took the survey (268) would use the building on weekends while 99 would have used it often. This confirms our initial hypothesis that if more students knew about the building and its facilities they would then want to use it. The final question, number seven, showed us that 262 respondents would again use it if it was available and 99 would use it as their primary study space. This gave us over 50%

of our sample size and confirmed our suggestion that LEED-buildings that focus on open, green and bright spaces make better study spaces, as determined from the interest in the LEED-certified Mona Campbell building. As highlighted in the literature review, the higher the occupant satisfaction for workspace, cleanliness and building maintenance in a LEED building can contribute to higher indoor environmental quality. This has been shown to reduce asthma, respiratory allergies, depression and stress (Altomonte & Schiavon, 2013). This all contributes to a better learning atmosphere for the student and a better work environment for the faculty and support staff.

We state that the survey is an important addition to the energy efficiency data that we collected and compared of Studley campus buildings. The survey would give the student body, as well as faculty and support staff, a voice in the issue that is study space availability, specifically in sustainable LEED-certified buildings. We realise that if the majority of the sample size were not in favour of opening the building we would have an issue with conflict-of-interest where our groups ideal is not supported by the general population. With the results showing that the sample size was in favour of opening the building and using its facilities on weekends, this solidifies our findings with the energy efficiency figures. The survey also considered the advantages that LEED buildings posses; their build and design take into account much more than just the layout, focusing on workplaces, open designs, air-flow, light, and green spaces. The studies outlined in the background show an overwhelming increase in cognitive functions and ability when students are exposed to these elements.

5.2 Building Energy Analysis

Our research results from analyzing the energy use of buildings on Studley Campus, provided by Glen MacDougall, proved to be surprising in various ways. We compared the average yearly kWh usage of the Mona Campbell to the Kenneth Rowe, the Goldberg Computer Science, the McCain Arts and Social Sciences building, and the Life Sciences Centre. This data provided kilowatt per hour (kWh) recordings every 15 minutes per hour, per day, per year. So the graphs in Figures 1-7 are based on 15-minute average for the entire year. Additionally, emailing with Glen MacDougall provided insight to the fluctuations we noticed in energy consumption.

The comparison of the Mona Campbell and the McCain proved to be quite surprising, as the Mona Campbell starts off using less energy on a yearly average of kWh, and then gradually this shifts and the McCain begins using more energy. After thorough discussion with Glen MacDougall, he brought light on the reasoning for this. There is a data centre in the Mona Campbell, which is a large contribution of the power usage in the building. As the data centre grows, the power usage grows. To cut back on energy expenditures, MacDougall and his team determined that they could turn an entire cool system off which decreased the kW to mean by almost 50 kW in November 2014. As a result of the cooling system being turned off,

unfortunately the building's humidity was extremely low, so two 37.5 kW humidifiers were installed. These humidifiers cycle on and off, based on readings.

Another large contribution of power from the Mona Campbell is heating. The Mona Campbell is heated through heat pumps, which are electrically powered. The McCain is heated by both heat pumps and steam. Steam is the main heat source for the building, and there are heat pumps on the 3rd floor, which are electrically powered. So, one can assume that the energy consumption for the building would be higher if it is fully heated by electrical heat pumps, although if the age of the building and the only slight difference of electricity used by each building are taken into account, the Mona Campbell is still very sustainable energy-wise. The building is built to maintain the heat within the building, and would not allow much heat to escape unless a door is opened. Whereas the McCain is using just under the same amount of energy and is only being heated electrically on the 3rd floor (out of 4 floors). This means more cost is going towards the building being heated by steam on the 1st, 2nd and 4th floor. The Mona Campbell does not have the additionally cost. Another reason for the dip in energy use for the McCain in 2014 was a malfunction of an entire air handler. According to Glen MacDougall, the air handler was shut down for almost an entire year for maintenance, which would have had a large impact on energy consumption.

The Goldberg Computer Science comparison to the Mona Campbell was quite surprising, because it used quite a lot less energy than the Mona Campbell. After speaking with Glen MacDougall on this matter, he clarified why this could be. The Computer Science building was built in 1999, and has both heat pumps and steam. Due to the age of the building, the heat pumps are quite ineffective and a large amount of steam must compensate for the heat the heat pumps do not provide. So even though there is minimal energy usage, this is compensated by the vast amount of steam used. The McCain's energy use is higher than the Computer Science building's because it relies on their heat pump more than the Computer Science building.

The Kenneth Rowe used more energy than the Mona Campbell, but not by a great amount. Similar to the Computer Science building, the Rowe is heated by steam and heat pumps. Although, it's energy consumption is higher than the Mona Campbell's. This must mean that the Rowe relies more on their heat pumps than on steam, and also the building is quite large.

We compared the Mona Campbell to the Life Sciences Centre (LSC), which is broken into two towers when recording energy, just to see how drastic the energy consumption in the LSC is. One tower used over 400 kWh on average every 15 minutes. The second tower used over 600 kWh every 15 minutes.

The energy efficiency department is working on a project to developing alarms for each building on kilowatts. These alarms will radar kWh usage, and also take into account weather, holidays, weekdays vs. weekends, and semesters (September to April) vs. non-semesters (May to August).

6.0 Conclusion

Recommendations

While it would be difficult to re-organize university weekend operations, the findings we have discovered should at least spark some sort of conversation regarding the buildings the school chooses to keep open. Different buildings are depended on for different scholastic functions, and while weekend availability is an important element of school operations, we feel like there is still room for improvement.

We had originally intended to suggest closing one of the buildings that use more energy on a daily basis during weekends and instead open the Mona Campbell. However, we did not have the time to research how these buildings are used over the course of the weekend. Therefore we would have been outspoken by making a solid recommendation, and we would likely interfere with university management.

We spoke to Dalhousie's embedded efficiency manager Glen MacDougall. He suggested that the Computer Science building – despite not using much energy – uses a lot of steam to heat itself. Having been built in 1999, the heat pumps are fairly inefficient. The Mona Campbell could be a worthy replacement, but there may be weekend operations occurring in the Computer Science building that would be unable to operate in the Mona Campbell. We took these possible barricades into consideration.

Nonetheless, we recommend that the university building managers review our findings and discuss a potential weekend closure that the Mona Campbell's opening could replace for the sake of preserving energy. Our research described the economic and social profits of LEED buildings, and we hope that Dalhousie management notes these potential benefits.

Further Studies

We recommend that further research built off of the data and findings we have compiled would be beneficial to creating a more sustainable Studley campus regarding building energy use. Such research may include more intricate analysis of internal building energy use sources (heating/cooling/water consumption), and more occupant satisfaction research conducted for each building to measure social, academic, and health interests of specific buildings. We feel these additional findings would further support the transformation of Studley Campus sustainability.

7.0 Acknowledgements

Acknowledgements

As a group we would like to fully acknowledge and thank the following people for their contributions and guidance with our research project. First, our professor Dr. Tarah Wright for supplying us with the background knowledge, tools, and resources to make this research project possible. We would next like to acknowledge our mentor Nathan Ayer for all of his guidance and input to propel our research in the right direction. Dr. Rochelle Owen of Dalhousie University for her input on our area of study as well as for supplying us with building data and further resources. Glen MacDougall, Dalhousie's Efficiency Manager, for supplying us with the building energy use data as well as the tools to analyse it. Finally, we thank everyone who participated in our survey to make that part of our research possible.

8.0 References

Altomonte, S., & Schiavon, S. (2013). Occupant satisfaction in LEED and non-LEED certified buildings. *Building & Environment*, 6866-76. doi:10.1016/j.buildenv.2013.06.008

Altomonte, S., Rutherford, P., & Wilson, R. (2014). Mapping the Way Forward: Education for Sustainability in Architecture and Urban Design. *Corporate Social Responsibility and Environmental Management*, 21(3), 143-154.

Bilec, M.M., Gokhan, N.M., Needy, K.L. & Ries, R. The economic benefits of green buildings: A comprehensive case study. *Eng. Econ*. 2006, 51, 259–295, DOI:10.1080/00137910600865469.

Cowan, S. & Van der Ryn, S. (2013). Ecological design. *Island Press*.

Driza, P and Park, N. (2013). Actual energy and water performance in LEED-certified educational building. *Sustainability: The Journal of Record*, 6(4), 227-232. doi: 10.1089/sus.2013.9850

Farmer, G. (2013). Re-contextualising design: Three ways of practising sustainable architecture. Arq : *Architectural Research Quarterly*, 17(2), 106-119. doi:http://dx.doi.org/10.1017/S1359135513000468

Frankel, M & Turner, C. (2008). Energy Performance of LEED for New Construction Buildings. *Final Report, New Buildings Institute*, White Salmon, WA. Retrieved from: http://www.usgbc.org/Docs/Archive/General/Docs3930.pdf

Hubka, David M. (2009). LEED 2009 and existing buildings. *PM Engineer*, 15(7), 10 11,13-14. Retrieved from:http://ezproxy.library.dal.ca/login?url=http://search.proquest.com/docview/203588608?accountid=10406doi: 10.1177/0739456X09340578

Johnston, P., Everard, M., Santillo, D., & Robèrt, K. H. (2007). Reclaiming the definition of sustainability. *Environmental science and pollution research international*, 14(1), 60-66.

Lukman, R., & Glavič, P. (2007). What are the key elements of a sustainable university?. *Clean Technologies and Environmental Policy*, 9(2), 103-114.

Lützkendorf, T., & Lorenz, D. (2005). Sustainable property investment: valuing sustainable buildings through property performance assessment. *Building Research & Information*, 33(3), 212-234.

Lynes, J. K., & Richardson, G. (2007). Institutional motivations and barriers to the construction of green buildings on campus: A case study of the University of Waterloo, Ontario. *International Journal Of Sustainability In Higher Education*,8(3), 339-354.

Matisoff, D.C., Noonan, D.S., & Mazzolini, A.M. (2014). Performance or Marketing Benefits? The Case of LEED Certification. *Environmental Science & Technology*, 48(3), 2001-2007. DOI: 10.1021/es4042447.

Mitchell, R. (2013). New report highlights financial value of green buildings. *Civil Engineering/Siviele Ingenieurswese,* 21(4), 74-75. Retrieved from http://ezproxy.library.dal.ca/login?url=http://search.proquest.com/docview/1427002684?accountid=10406

M., Santillo, D., & Robèrt, K. H. (2007). Reclaiming the definition of sustainability. *Environmental science and pollution research international*, 14(1), 60-66.

Newsham, G. R., Mancini, S., & Birt, B. J. (2009). Do LEED-certified buildings save energy? yes, but.. *Energy and Buildings*, 41(8), 897-905.doi:http://dx.doi.org/10.1016/j.enbuild.2009.03.014

Nicolow, J. (2010). Greening the campus. *Environmental Design & Construction,* 13(7), 28-32.

Popescu, D., Bienert, S., Schutzenhofer, C., & Boazu, R. (2011). Impacts of energy efficiency measures on the economic value of buildings. *Applied Energ*y. 89(1), 454-463. DOI:10.1016/j.apenergy.2011.08.015

Retzlaff, R. C. (2009). The use of LEED in planning and development regulation. An exploratory analysis. *Journal of Planning Education and Research*. 29(1), 67-77.

Schiavon, S., & Altomonte, S. (2014). Influence of factors unrelated to environmental quality on occupant satisfaction in LEED and non-LEED certified buildings. *Building & Environment*, 77148-159. doi:10.1016/j.buildenv.2014.03.028

Scofield, J. H. (2009). Do LEED-certified buildings save energy? Not really… *Energy and Buildings.* 41(12), 1386-1390. doi: 10.1016/j.enbuild.2009/08.006

Sharp, L. (2009). Higher education: the quest for the sustainable campus.*Sustainability: Science, Practice, & Policy*, 5(1), 1-8.

Zhao, Z., & Zuo, J. (2014). Green Building research-current status and future agenda: A review. *Renewable and Sustainable Energy Reviews*, 30, 271-281. doi: 10.1016j.rser.2013.10.021

Appendix A

Survey for student population

A. Please indicate if you are:
1. Dalhousie Student
2. Faculty
3. Support Staff

B. Have you ever been in the Mona Campbell Building?
1. Yes
2. No

C. Are you aware that the Mona Campbell Building has study space?
1. Yes
2. No

D. Have you ever used the Mona Campbell Building study space?
1. Yes
2. No

E. Are you aware that the Mona Campbell Building is not open on weekends?
1. Yes
2. No

F. How likely would you be to used the Mona Campbell Building should the building be open on weekends?
1. Wouldn't use it
2. Not likely to use it
3. Would use it sometimes
4. Would use it often

G. How likely would you be to use the Mona Campbell Building study space should the building be open on weekends?
1. Wouldn't use it
2. Not likely to use it
3. Would use it sometimes
4. Would use it exclusively for study space

Sample Size

Using: http://www.surveysystem.com/sscalc.htm
Confidence Interval 5%
At a confidence level of 99%
From: http://www.dal.ca/about-dal/dal-at-a-glance.html
Total Students Enrolled at Dalhousie University 18 500
Sample Size: 643
Round up to 650 for accuracy

Compressed survey data totals and values used in excel to create graphs

Question	*Response*	*Total Participants*
Q1	1	611
	2	20
	3	19
Q2	1	254
	0	396
Q3	1	311
	0	339
Q4	1	175
	0	475
Q5	1	138
	0	512
Q6	1	97
	2	186
	3	268
	4	99
Q7	1	120
	2	169
	3	262
	4	99

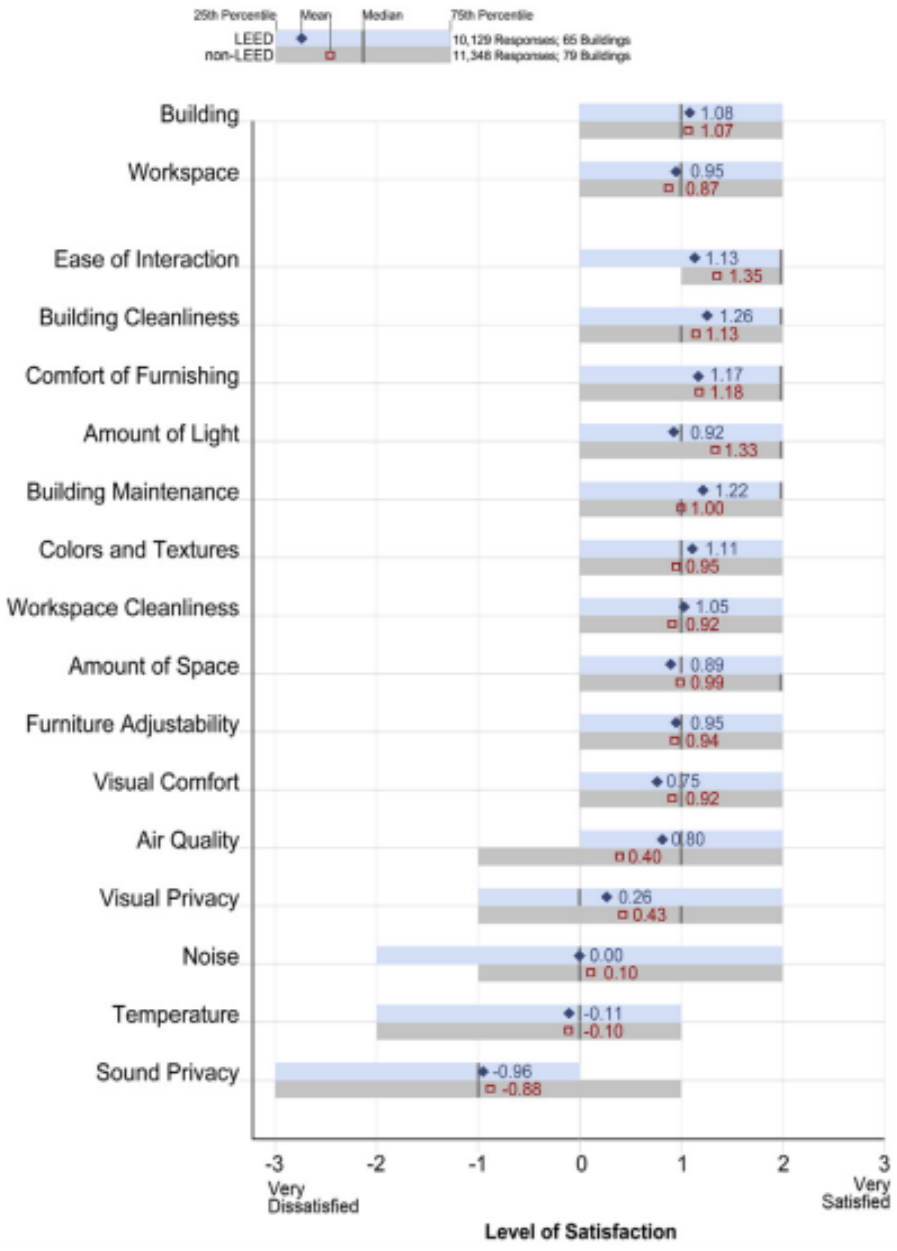
Appendix B

Occupant Satisfaction Factors

Categories included in the CBE occupant indoor environmental quality survey.

Office layout	Amount of space available for individual work and storage
	Level of visual privacy
	Ease of interaction with co-workers
Office furnishings	Comfort of office furnishings (chair, desk, computer, equipment, etc.)
	Ability to adjust furniture to meet your needs
	Colors and textures of flooring, furniture and surface finishes
Thermal comfort	Temperature in your workspace
Air quality	Air quality in your workspace (i.e. stuffy/stale air, air cleanliness, odors)
Lighting	Amount of light in your workspace
	Visual comfort of the lighting (e.g., glare, reflections, contrast)
Acoustic quality	Noise level in your workspace
	Sound privacy in your workspace (ability to have conversations without neighbors overhearing and vice versa)
Cleanliness and maintenance	General cleanliness of the overall building
	General maintenance of the building
General comments	Your personal workspace
	Building overall

Occupant Satisfaction Results



Building Operational Hours

BUILDING SCHEDULES

2014-2015

BUILDING	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
Arts Centre	0800 - 2400	0800 - 2400	0800 - 2400	0800 - 2400	0800 - 2400	0800 - 2400	0800 - 2400
Campbell Building	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	CLOSED	CLOSED
Chase Building	0730 - 1800	0730 - 1800	0730 - 1800	0730 - 1800	0730 - 1800	CLOSED	CLOSED
Chemistry/Macdonald	0800 - 1730	0800 - 1730	0800 - 1730	0800 - 1730	0800 - 1730	CLOSED	CLOSED
Central Services	0630 - 1700	0630 - 1700	0630 - 1700	0630 - 1700	0630 - 1700	CLOSED	CLOSED
Computer Science	0700 - 1700	0700 - 1700	0700 - 1700	0700 - 1700	0700 - 1700	1000 - 1800	1000 - 1800
Dental Complex	0645 - 2200	0645 - 2200	0645 - 2200	0645 - 2200	0645 - 2200	1000 - 1800	1200 - 2000
Dunn Building	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 21:30	CLOSED	CLOSED
Hicks Building	0700 - 1800	0700 - 1800	0700 - 1800	0700 - 1800	0700 - 1800	CLOSED	CLOSED
Killam Atrium	0730 - 2400	0730 - 2400	0730 - 2400	0730 - 2400	0730 - 2400	0800 - 2400	0800 - 2400
Killam Library	0800 - 2100	0800 - 2100	0800 - 2100	0800 - 2100	0800 - 1800	1000 - 1800	1000 - 1800
Law Library	0800 - 1600	0800 - 1600	0800 - 1600	0800 - 1600	0800 - 1600	CLOSED	CLOSED
Law Building	0800 - 1630	0800 - 1630	0800 - 1630	0800 - 1630	0800 - 1630	CLOSED	CLOSED
Lemarchant Place*	0700 - 2000	0700 - 2000	0700 - 2000	0700 - 2000	0700 - 1900	0900 - 1700	1030 -1700
Life Sciences Centre	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	0800 - 2200	0800 - 2200
LSRI	0800 - 1700	0800 - 1700	0800 - 1700	0800 - 1700	0800 - 1700	CLOSED	CLOSED
McCain	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	0800 - 2200	0800 - 2200
Rowe	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	0800 - 2200	0800 - 2200
Sexton Campus BA	1800 - 2400	1800 - 2400	1800 - 2400	1800 - 2400	1800 - 2400	0800 - 2400	0800 - 2400
SOSB	0800 - 1700	0800 - 1700	0800 - 1700	0800 - 1700	0800 - 1700	CLOSED	CLOSED
Tupper Building BA*	1800 - 2300	1800 - 2300	1800 - 2300	1800 - 2300	1800 - 2300	0800 - 2300	0800 - 2300
University Club	0600 - CALL	0600 - CALL	0600 - CALL	0600 - CALL	0600 - CALL	CALL	CALL
ANYTIME OUTSIDE OF THE POSTED HOURS - A SERVICE REQUESTS IS REQUIRED FOR ADDITONAL BA							
ACADEMIC KILLAM LIB	0800 - 2400	0800 - 2400	0800 - 2400	0800 - 2400	0800 - 2400	1000 - 2400	1000 - 2400
ACADEMIC LAW LIB	0800 - 2245	0800 - 2245	0800 - 2245	0800 - 2000	0800 - 1630	1200 - 1800	1200 - 2245
ACADEMIC LAW BLDG	0800 - 2300	0800 - 2300	0800 - 2300	0800 - 2000	0800 - 1800	1200 - 1800	1200 - 2300
ACADEMIC HICKS	OPEN 0700	CLOSE 1800	OR 1/2 HOUR	AFTER LAST	CLASS	CLOSED	CLOSED
ACADEMIC COMP SCI	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	0700 - 2200	1000 - 1800	1000 - 1800
*Lemarchant Place Holiday Hours are - 11:30 - 15:30							
*Tupper building guard required after 19:00							