DALHOUSIE UNIVERSITY

Term Project Report

Accessibility Door Usage and Associated Cost on Studley Campus

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Executive Summary

The purpose of this study is to quantify the cost of the usage of accessibility doors across Dalhousie University's Studley campus; the social cost takes into account the internal costs (cost of electricity and heating) incurred by Dalhousie University as well as the external cost that society incurs when CO2 is produced. The social cost is achieved by coupling the direct energy costs with the environmental externalities that are a result of the carbon dioxide (CO2) released through the production of energy that is required to open the accessibility doors. Furthermore, energy that is lost in the form of heat while the doors remain open is also taken into account when calculating the social cost of the usage of accessibility doors. This was achieved by recording the traffic (who utilized the accessibility button and who manually opened the door) of four doors found at the front entrance of four different buildings on the Studley Campus. The data was collected through passive observation and was collected at the same time of day across a span of 3 days.

The study reveals that Dalhousie creates 14.251 tons of CO2 per year due to the use of accessibility doors. Of the 14.251 tons produced, 1.158 tons of CO2 is produced by generating the required electricity to operate the doors. The remaining 13.293 tons of CO2 is generated by heat loss due to the doors remaining open for 20 seconds after the accessibility button has been pressed. Using Nicolas Stern's (2007) 2017 CO2 price the study reveals that the CO2 produced by Dalhousie University Studley Campus creates $1734.12 worth of external damages. The internal cost of operating the accessibility doors on Dalhousie Studley Campus was found to be $1799.85. Out of the $1799.85 required to operate the accessibility doors, $204.69 was the cost of the electricity to open the door, while the remaining $1595.16 was the cost of replacing the heat that was lost while the door was open. Combining the internal cost and the external damages together generates the social cost. The social cost of operating the accessibility doors on Dalhousie Study campus was found to be $5297.885.

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Background Information

1.1.1 Climate Change and Carbon Usage

Climate change is a complex phenomenon to define, however J. Hansen et al (2013), explains it as “an imposed change of planetary energy balance, increasing carbon dioxide (CO_2), from fossil fuel emissions, much of which will remain in the atmosphere for millennia" (p. 1). While the definition may be somewhat broad, it is because of the complexity of the subject. In 1992 more than 170 nations agreed that fossil fuel emissions needed to be decreased worldwide to avoid any dangerous human-induced climate change; present-day this agreement formulated in 1992 has not changed the fact that global emissions have in fact increased (Hansen et al, 2013). Previous studies strongly agree that humans are contributing to climate change and The Kyoto Protocol, an international treaty, provides targets for 37 industrialized countries to reduce emissions of the six main greenhouse gases, one of which being CO_2 (O’Neill, Seyfang, Whitmarsh, 2010).

A target to reduce global climatic warming by 2°C has been made and agreed upon. However, if emissions do not decrease drastically, preventing an increase in temperature of more than 2°C will be difficult to reach. In order to meet this target, social engagement is of utmost importance for allowing us to understand the effects humans have on the planet (O’Neill, Seyfang, &Whitmarsh, 2010).

1.1.2 Energy and Entropy - Electricity

Entropy itself is denoted as S and is represented by the SI units as J /k. K represents the absolute temperature in Calvin, while J represents joules of energy. This relationship is incredibly important to thermodynamics as it allows for the conversion between energy, entropy and electricity (Rothstein, 2013). Joules allows entropy to be converted into electricity since w=j/s, and the standard unit of electricity power is kW-h.

Being able to convert entropy into energy (J) and electricity energy (kW-h) allows for a monetary value to be added to entropy. This is because joules can be divided by the energy intensity of a fuel source (J/unit of mass) and then multiplied by the cost of the fuel source ($/unit of mass) to gain a dollar value. The same can be said about converting kW-h into a cost of electricity sold by the local utility supplier. These calculations are beneficial because it allows for monetary value to be placed on entropy.

With regards to the study, entropy plays a significant role in calculating the associated costs of using the accessibility doors. Therefore, it is important to understand how buildings are affected by entropy and how a lack of insulation can increase the use of energy, which in turn results in them buying more electricity (Gulbians, R. Khosrowpour, A. Taylor, J, E. 2016). Buildings are kept at specific temperatures to ensure that the occupants in the building are thermally comfortable. Investing in building improvements like insulated windows can help reduce the entropy loss (D’Oca, Corgrnati, Hong, et al 2015); this in turn can save the building owners money.

1.1.3 The Importance of Externalities

The purpose of this study is to provide a clear understanding of the energy required to operate an accessibility door. In terms of analysis and the application of critical thought, this research would prove to be quite superficial, as it does not explore the potential repercussions through said energy use. Environmental externalities in this context is an economic concept that encompasses the uncompensated environmental costs of fossil fuel use within the formal sector. An example of an environmental externality would be CO_2 produced through energy production, which increases greenhouse gases, which contributes to global warming. Externalities are not negative by nature, the presence of positive repercussions do exist, yet for this study, there will be a focus on the negative consumption externalities.

Calculating externalities is a challenging task, considering that their impacts are not reflected in the cost of production or consumption. This study will not delve into finding accurate values of the cost of negative externalities. Rather, it is more realistic to explore the potential negative impacts as a means of giving a more accurate representation of the costs associated with the pressing of an accessibility button. In order to understand the value of negative impacts, natural capital must be calculated, specifically tangible factors (i.e., number of trees, fish population growth rates and etc...) as well as the intangible, such as ecosystem services. Only once a monetary value is set, will the study and its results have the ability to illustrate the significance behind the energy used to operate an accessibility door.

Currently, conservative "estimates show that global land use changes between 1997 and 2011 have resulted in a loss of ecosystem services of between $4.3 and $20.2 trillion/yr" (Costanza et al, 2014, p.157). This number does not have much value until a context is created where the overall value of ecosystem services is conservatively estimated to be "$124.8 trillion/yr – 2.7 times the original estimate. For comparison, global GDP was approximately 46.3 trillion/yr in 1997 and $75.2 trillion/yr in 2011 (in $2007)" (Costanza et al, 2014, p.156). These facts serve to put into perspective the costs that are not accounted for in the price of electricity and its production when examining the energy required to open an accessibility door.

1.1.4 Importance of Accessibility Door

Having campuses accessible to all individuals, who wish to pursue post-secondary schooling, is of great importance and reflected within some aspects of society. Thériault (2012) states that "at the federal level, …, it is recognized at least in principle that disability is a social creation and that government and other actors must strive to remove stigma and ensure inclusion" (p. 145). Thériault (2012) stresses that in order to create a society that is inclusive to individuals with disabilities, society must enhance the ability of said peoples, in order to ensure that they are able to pursue the same rights and opportunities as people without disabilities. The importance of the inclusion of people with disabilities can be found in legislature introduced within Canada. The Canadian Human Rights Commission (2013) codifies the protection of individuals from being discriminated by organizations. This includes the right to be treated equally and fairly.

These buttons are found on or around manual doors, allowing a manual door to open without the use of force, when the accessibility button is pressed. By having these doors equipped with said features, it ensures that people with physical disabilities are given equal opportunity to take part in Dalhousie's campus, which is of importance in a society which promotes the inclusion of all.

1.1.5 Cost associated with the use of the accessibility button

It has been found that the automatic door open button utilizes less power when compared to automatic sliding doors or swinging doors. Although, it still utilizes a significant amount of power to operate when pressed. The more frequently a machine is used, the increased likelihood that it will malfunction or fail. When people unnecessarily press the accessibility button it increases the chance of malfunction. Therefore, an increased frequency of maintenance and consequently having the aid unavailable to those who do require the assistance. Northern Kentucky University estimated that it costs two cents every time one of the buttons is used (Stearns, 2015). Although this value only considers the energy cost associated with the opening and closing of the door and does touch upon heat transportation. When a button is pressed, it stays open for approximately 20 seconds (Stearns, 2015). During this time, heat can escape depending on the season.

The escaped heat causes energy loss, and in turn an economic loss. This should be considered when the accessibility door is used. Generally, heat loss, from a door being open, would be classified as heat loss through an envelope. The general heat loss formula is shown below (Pegg, 2015):

$$Q = U * A * \Delta T \quad (1)$$

Therefore, the net area, the corresponding temperatures of air and the overall coefficient of heat transfer should be considered. An average area will be determined during the experiment to create a baseline. Two calculations will be completed to compare the corresponding heat loss, and difference, in between having the door open or keeping it shut. The overall energy lost from keeping the door open an extra energy 20 seconds can then be correlated to a monetary value to see how much energy and money is being wasted.

1.2 Project Objective

1.2.1 Statement

The broad idea of this project is to observe the small actions that are performed daily, that utilize energy, that in turn adds up to unnecessary costs for the energy and heat wasted. Dalhousie University Studley Campus is the focus of this study, looking at main buildings that are accessible through the automatic-open door buttons and how many people are using this button, and then calculating the associated costs. There will be no study of the behavior of the individuals pressing the accessibility button, however the study will look into future alternative options to the accessibility button.

1.2.2 Rationale

This research project will focus on an aspect of energy use that is often overlooked; the daily use and operation of the accessibility button. The data is collected by quantifying a sample of students and public on the Dalhousie Studley Campus. This project provides insight on a topic that is scarcely studied. These findings may help to foster a more energy efficient option for automatic doors all while still providing accessibility to individuals with disabilities. Using the collected data, the research project will be able to estimate the monetary costs that is exhausted annually by providing these accessibility buttons. This estimated cost is an important piece of data for Dalhousie to possess, in order for the school to recognize the amount of wasted energy, heat, and money.

1.2.3 Scope

This research project will employ a non-probabilistic approach by using passive sampling. Passive sampling is the process of recording the tendencies of the group being studied, while refraining from interacting with the individual. The research project will collect data from four locations on Studley Campus, at Dalhousie University, Nova Scotia that have been found to have high student traffic frequency. The sample frame of this research project includes the general population; all individuals who use the four main entrance doors chosen for this study. Using a quantitative analysis, the data collected will then be used to estimate the average amount of daily energy that is required to operate these accessibility doors.

1.3 Research Purpose

The purpose of this research project is to calculate and assign a cost to the usage of accessibility buttons that considers more than the direct energy cost paid by Dalhousie. Externalities associated with the production of said energy, as well as heat lost as a result of the doors being open for extended periods of time (a byproduct of the usage of accessibility doors) are factored into the cost. This social cost is then plugged into equations which will create a number that represents the social cost over the span of a year.

2. Research Methods

2.1 Design Sampling

The study began by gathering data on how many people used the accessibility button in relation to how many people opened doors manually on Dalhousie University Studley Campus, Halifax, Nova Scotia, Canada shown below in figure 2.1. Using passive observation, the study collected data from four locations on campus:

- Student Union Building
- Killam Memorial Library
- Kenneth C. Rowe Building
- Sir Charles Tupper Medical Building

Figure 2.1: Studley Campus inventory of accessibility doors

2.1.1 Justification

By using passive sampling, the group could surpass the complication of time and ethics related to data collection as the study did not require the need to speak to individuals about their actions. Data collection consisted of observing the actions of an individual without collecting any information that could be used to potentially identify said individual and compromise their anonymity. The study of button use and its associated costs is an important research topic to discuss as the calculations are intended to inform Dalhousie University of the amount of energy and money lost by the use of the accessibility button.

2.1.2 Procedures

The recording of observations was completed on the four building entrances, on three different days, within the same time range (1pm to 2pm). Once the data collection was completed, the group was then able to use quantitative analysis to create a cost analysis associated with the use of the accessibility button. Through the cost analysis, the monetary value was determined and attributed to the use of the doors and accessibility button. The analysis produced an estimated annual average of button pressing. This estimation was then used to consider the associated heat loss from the amount of time the doors are open due to the accessibility button as well as the energy associated with each button press.

2.2 Reliability and Validity

Collectively the decision to assume all individuals are physically capable and are all students at Dalhousie University was made to maximize the findings and ensure all data possible was collected surrounding the button pressing. Also, by only observing actions, any ethical concerns or applications have been rendered as a non-issue. This bypass provides the opportunity to simply observe actions without attaching an identity to the action being observed. This study also did not face any validity issues as the study is simply counting actions and calculating costs, which provides the study with many assumptions. The reliability of the study has been made on the assumption that defining a disability is complex and that it is simply too wicked of a problem to attempt to tackle in the collection of data and the time frame given.

2.3 Data Analysis

This study utilized descriptive statistics by finding the mean use of the accessibility button usage in relation to the amount of times entrance doors were opened. The data collected and averages calculated were then used to find the sum of energy used annually. A quantitative analysis will follow to create a cost analysis associated with the use of the accessibility button. The data that is obtained through passive sampling will then be analyzed to determine the monetary value that is attributed to the use of these doors. These numbers will consider the number of pushes and an average per year will then be found using assumptions per year from the conducted experiment. Furthermore, these final values will take into consideration the associated heat loss from the length of time the doors stay open.

2.4 Limitations and Delimitations

Certain limitations will be present in this study as the research methods that are being utilized, at their core, are superficial in certain aspects. Passive observation (the main research tool being utilized in the study) ignores all the potential qualitative data that could be gleamed from the study on people who use doors and accessibility buttons. Understanding personal reasoning behind each individual button press will not be possible with this method of data collection. As a result, the delimitations are greatly reduced when dealing with ethical issues, as there is no need to identify individuals in the study. Limitations to this study include: that only one campus (Studley) was analyzed; the time span of the study; the number of doors with accessibility buttons that where recorded; difference in seasonal temperature changes, and indoor temperatures during these seasons; the academic period that this information was recorded; and assumptions on area and heat transfer coefficients.

3. Results

The results from the three-day experiment is depicted below in Figure 3.1-3.4 for the Tupper Medical Building, Kenneth C. Rowe Management Building, Student Union Building and Killam Memorial Library respectively. Over the three-day experiment, Group 1 surveyed four buildings for one hour each from 1-2 pm. Over the total course of the experiment 2376 door usages were recorded. The Tupper Medical Building shown below in Figure 3.1. The highest percentage was seen on the Monday with a peak of 1.6%.

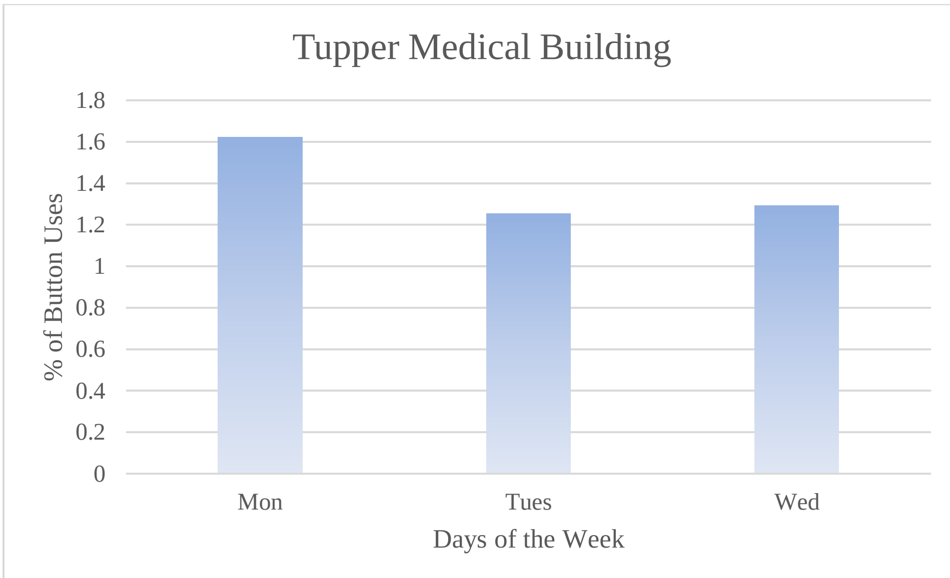

Figure 3.1: % of Accessibility Button uses for the Tupper Medical Building for the respective days from 1-2pm

The results for the Kenneth C. Rowe Management Building are shown in Figure 3.2. The average button use for the building was calculated to be 5.5%. The building had little deviation between its maximum of 5.6% and its minimum of 5.4%.

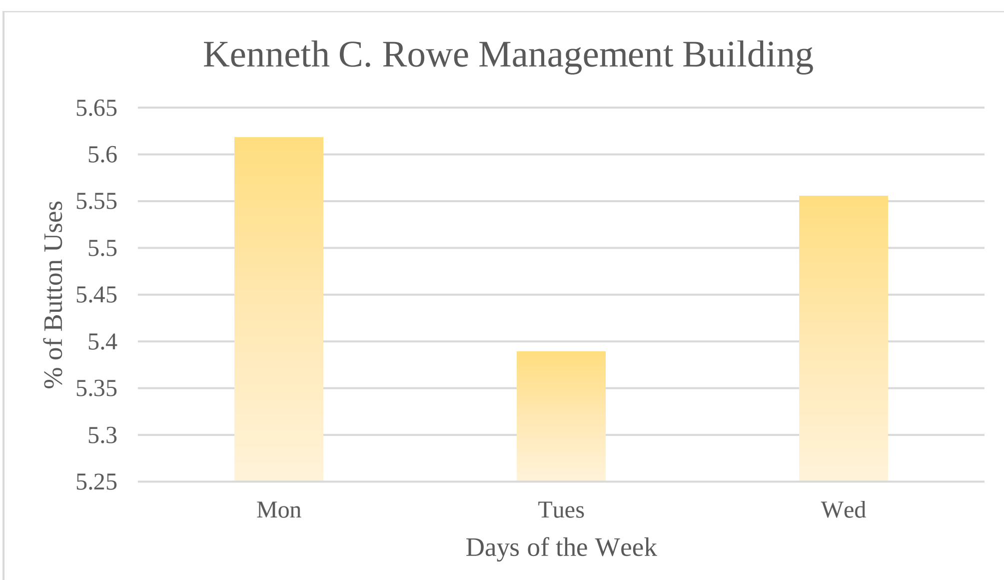

Figure 3.2: % of Accessibility Button uses for the Kenneth C. Rowe Management Building for the respective days from 1-2pm

The results for the Student Union Building can be seen below in Figure 3.3. The average button use for this building was calculated to be 1.9%. The lowest percentage for the whole experiment was on Tuesday and was found to be 0.87%.

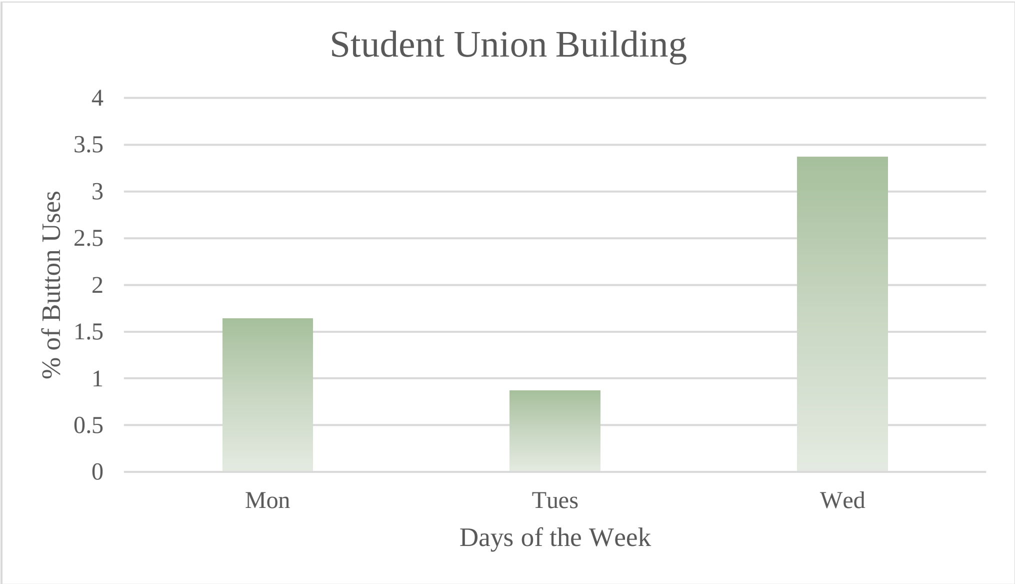

Figure 3.3: % of Accessibility Button uses for the Student Union Building for the respective days from 1-2pm

The results for the experiment on the Killam Memorial Library are depicted below in Figure 3.4. The Library found to have the highest percentage of accessibility button use for the experiment with an average of 14.3%.

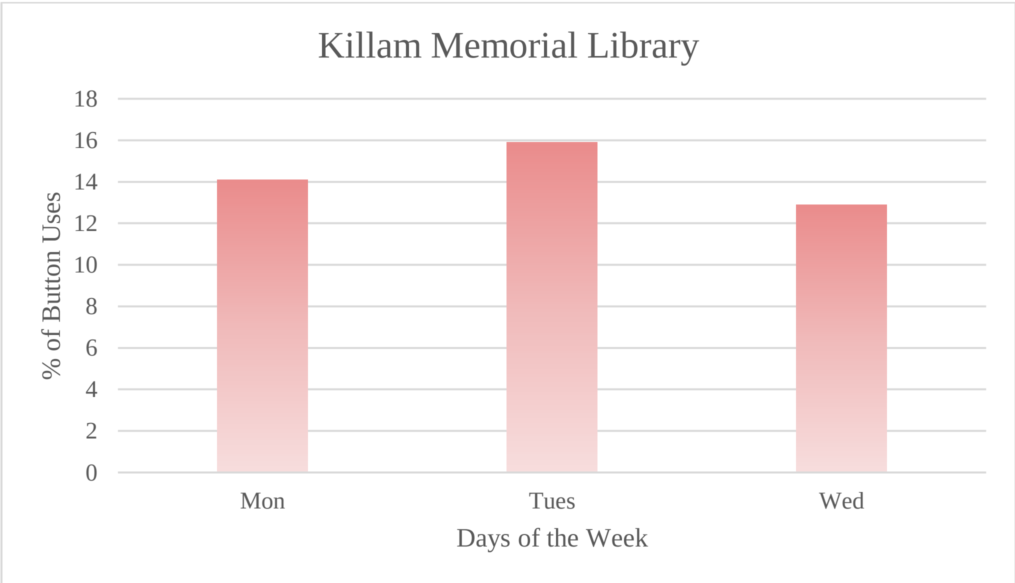

Figure 3.4: % of Accessibility Button uses for the Killam Memorial Library for the respective days from 1-2pm

The average of the four buildings for each day was then taken and is shown below in Figure 3.5. The usage rate of the accessibility button ranged from 5.75% on Monday to 5.86% on Tuesday.

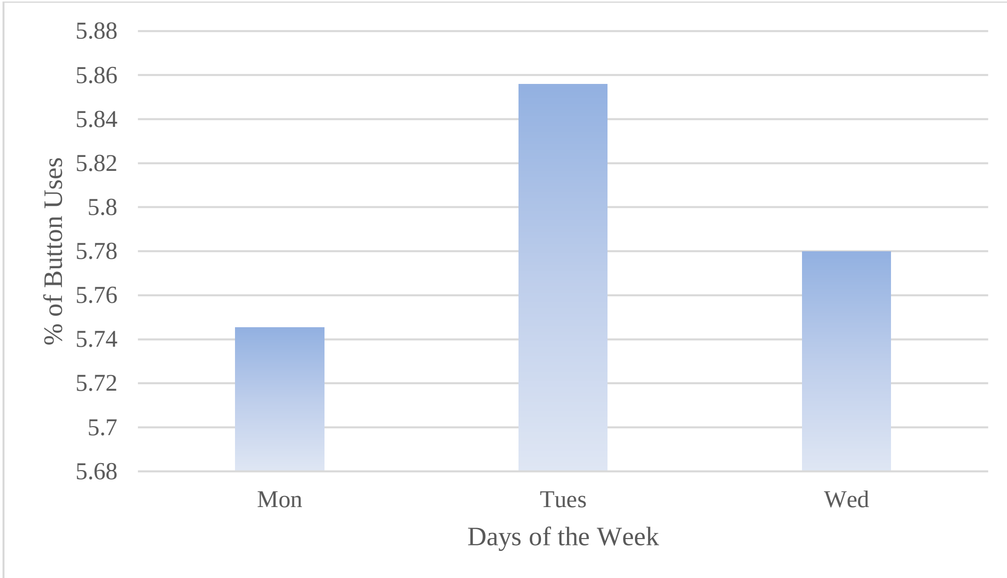

Figure 3.5: The average % of accessibility button uses for the four buildings for the respective days from 1-2pm

The results from the experiment, averaged for the four buildings, is depicted below in Table 3.1. The four buildings, Tupper Medical Building, Student Union Building, Killam Memorial Library and the Kenneth C. Rowe Management Building, were all surveyed from 1-2 pm on March 20th, 21st and 22nd.

Table 3.1:Experiment results from the four buildings for the respective days

Day of the Week	Accessibility button used	Door opened manually	Total
Monday	29	717	746
Tuesday	21	659	680
Wednesday	39	911	950

3.1 Heat Loss

The parameters for the calculation are listed below in Table 3.2. The daily average temperatures for the Monday, Tuesday and Wednesday were found to be 3°C, 6°C and 8°C, respectively (AccuWeather, 2017). The area of the door was found to be 80 in by 36 in (Assa Abloy, n.d.) The overall coefficient of heat transfer for air was found to be 21 for free convective air (Pegg, 2015). The general heat loss could then be quantified through an envelope of air by the following equation:

$$Q = U * A * \Delta T \tag{1}$$

First, the heat for each of the days was quantified in watts (W). This unit was then converted by multiplying the average time of the door being open, 20 seconds, and converting to kW-h using a constant of 1J to 2.77E-7 kW-h. This was able to be done as 1W = 1 J/s. These results were then plotted below in Figure 3.6.

Table 3.2: Parameters used to quantify the heat loss through a door

Parameter	**Symbol**	**Value**	**Unit**
Inside Temperature	Ti	25	^oC
Outside Temperature, Monday	$T_{O,M}$	3	^oC
Outside Temperature, Tuesday	$T_{O,T}$	6	^oC
Outside Temperature, Wednesday	$T_{O,W}$	8	^oC
Width of the Door	W_{door}	36	in
Height of the Door	H_{door}	80	in
Coefficient of Heat Transfer for Air	U_{air}	21	W/m^2-K
Time of the Door Being Open	t	20	s

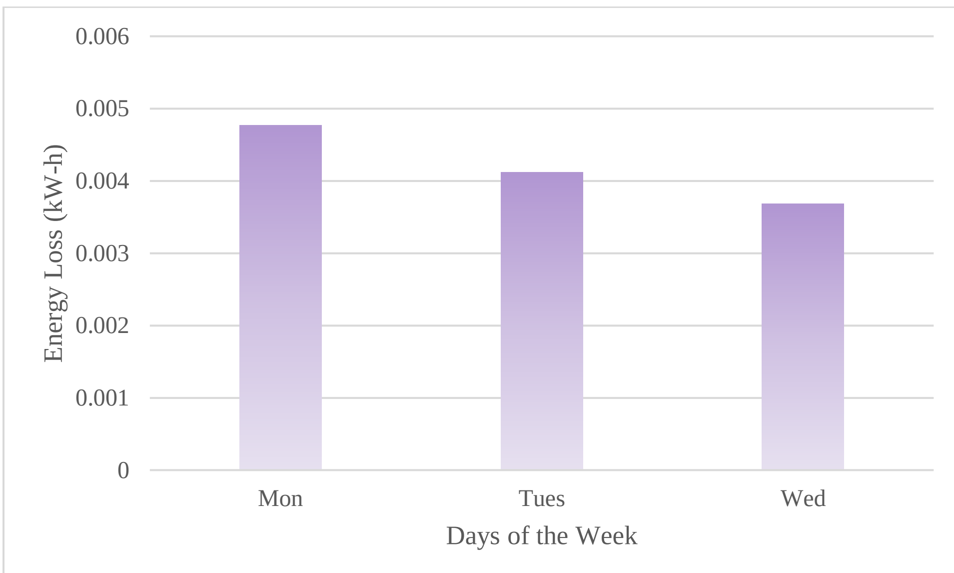

Figure 3.6: Energy lost (kW-h) from the four buildings from the three day experiment

4. Economics

The internal price of operating all 28 exterior accessibility doors and 6 interior accessibility doors was calculated by taking the total time the motors of the doors (300 W) and changing it into kW-h, assuming the door's motor worked for 20 seconds per button push (Assa Abloy, n.d). This number was then multiplied by the average amount of times the accessibility button was pushed daily. This was followed by multiplying it by the number of days in the year (365), to gain the amount of kW-h used per year to operate the accessibility doors.

The amount of kW-h used per year was multiplied by a percentage which represents Nova Scotia's power make up by energy source (Nova Scotia Power, 2017). Biofuel and imported energy make up the remaining 5% of energy not included in calculations; it was decided not to include them due to the challenges and uncertainty of determining the amount of CO_2 produced by biofuels and imported energy. It was assumed that Dalhousie was running on 60% of its total load. This means that Dalhousie buys its electricity at 11.7cents/kW-h (Nova Scotia Power, 2017). Using 11.7cents/kW-h as the cost of electricity, the cost was then multiplied by the amount of kW-h produced per generating source. This was completed to find the internal price that Dalhousie pays per energy generating source, which is shown in Table 4.1 below.

Table 4.1: Internal price ($/utility) of using the 300W accessibility button

Electricity Make-Up	%	Internal Price ($)
Coal	63	135.073
Gas	10	21.44
Hydro	9	19.306
Wind	13	27.872
Total	95	204.691

Table 4.2 shows the external cost of producing the required amount of kW-h of energy to operate the accessibility buttons. The external cost was calculated by taking the kW-h produced per generating source, and dividing it by energy intensity in kW-h per gCO_2 (IPPC 2017). This number was converted to tons of CO_2, which was then multiplied by $120/ton, as this is the recommended price of CO_2 in 2017 (Stern. N, et al. 2007). These values multiplied together represent the results of the external cost per energy source.

Table 4.2: External Price ($/utility) of using the 300W accessibility button

Electricity Make-Up	%	Tones of CO_2 /Year	External Price ($)
Coal	63	1.0069	120.828
Gas	10	0.1442	17.304
Hydro	9	0.0042	0.504
Wind	13	0.0027	0.324
Total	95	1.158	138.96

To generate the social cost, external cost was added to the internal cost. The total was found to be $343.651, which represents the cost that both Dalhousie and society pay for the use of accessibility buttons on doors; this is shown in Table 4.3 below.

Table 4.3: Internal, External and Social Price ($/utility) of using the 300W accessibility button

Electricity Make-Up	Internal Price ($)	External Price ($)	Social Price ($)
Coal	135.073	120.828	255.901
Gas	21.44	17.304	38.744
Hydro	19.306	0.504	19.81
Wind	27.872	0.324	28.196
Total	204.691	138.96	343.651

The total energy lost was calculated from the heat loss, Q, that was calculated originally as previously mentioned. Assumption of one calendar year, with the door operating for 12 hours a day were used for the calculations. It can be noted that during the summer months, usage may decrease as student population declines. Although, the percentage of decreased activity could not be quantified due to the time limitation of the study. Dalhousie's facilities team supplied the group with the locations and numbers of all the accessibility doors in Figure 2.1 with 28 of these being exterior doors that could lose energy from varying temperatures. The total energy lost, 0.26 GJ, was found for the 28 exterior doors on Studley Campus can be seen below in Table 4.4.

Table 4.4: Heat loss cost associated with opening the accessibility door

Heat loss	Energy Lost (J)	Internal Price ($)	Tones of CO_2/year	External Price ($)	Social Price ($)
Natural Gas	264 332 188.8	3359.074	13.293	1595.16	4954.234

5. Discussion

These findings emphasize that, what may seem to be an insignificant action such as pressing the accessibility button, in actuality, can add up to be a significant cost of energy. The results show that on average, the accessibility button is pressed only 5.8% of the time while doors are being used; roughly 94% of the time the door is opened manually. Though this research did not consider the reason an individual chose to use the accessibility button, it is apparent that there is a benefit or reason that an individual uses the accessibility button. The increase caused by this perceived benefit, of use of the accessibility button, increases energy costs and the amount carbon being released into the environment.

In this study, the Tupper Medical Building saw the lowest percentage of accessibility button usage, followed by the Student Union Building, the Kenneth C. Rowe Management Building, and lastly the Killam Memorial Library (Figure 3.1-3.4). The Killam Memorial Library saw the most significant usage of the accessibility button with its lowest usage at roughly 13% (Figure 3.4). Whereas the highest usage from the other three buildings were approximately 5.6% recorded at Kenneth C. Rowe Management Building (Figure 3.2). The age of the buildings may come in to play when trying to interpret these results.

As engineers design more sophisticated structures, lighter materials are used which is made evident by Berge (2009). Berge states that since societies have evolved to understand that their resources are limited, people are finding ways to build more efficient buildings with less. The buildings with the lowest button pushes tended to be newer buildings compared to a building such as the Killam Memorial Library. These newer buildings may have lighter doors or better mechanics that allow them to open smoother, which may account for such drastic differences in percentages of button pushes. The Killam Memorial Library is also notoriously known to students for having large heavy doors inside the structure. This could, to some degree, be related to the reason people are more likely to press the accessibility button for assistance at Killam Memorial Library.

Human Resources and Skills Development Canada (HRSDC) (2011) states that the overall disability rate in Canada is 14.3%. This average, with regards to overall disability in Canada, would be assumed to be reflected in the study on the average percentage of times that the accessibility button was pressed. However, our study produced much lower results of individuals pressing the button than HRSDC had identified as the percentage of population that has a disability. This could be attributed to the fact that the HRSDC study accounted for a broad understanding of disabilities, which included more than just physical disabilities, as well as not specifically identifying the number of individuals with a disability who attend a post-secondary institution. Another potential cause for this is that this study, which was performed at Dalhousie University, may have seen lower results than what would be assumed from HRSDC data due to campus accessibility. Even though these doors are accessible, other aspects of the campus may deter those who are physically disabled from attending Dalhousie University, and therefore lower the expected results.

The main objective of this study was to express the social costs associated with using the accessibility button. By providing context on the social costs of the accessibility button this study can help facilitate more studies in a field that has little research. Further research in this field could be used to help educate, as well as lower the social costs that are experienced by the unnecessary use of energy.

6. Conclusion

This study reveals the implications of small actions (and their summation) in a broader context and the consequences of such actions. In observing the number of times accessibility buttons are pressed on the main, external doors of the Studley campus, it was possible to quantify the internal cost, external cost, and social costs of using the accessibility doors. Based on the findings of the four chosen locations, the amount of energy that was required for the 28 exterior accessibility doors and the 6 interior accessibility doors on campus to be used year-round, for 12 hours per day was found. This resulted in the study determining that through the electricity spent in the opening of the door and the associated heat loss, the economic cost of accessibility doors on campus is $5,297.89 per annum. Through the use of electricity and corresponding heat loss, it was discovered that 14.451 tons of CO_2 are produced annually. These findings are quite significant, as the maximum percentage of people using the accessibility button entering the building was found to be 16%. This demonstrates that even a small portion of the population at Dalhousie, when using the accessibility button for a variety of reasons, results in a large and excessive use of energy and the subsequent production of CO_2. Identification through this study of both the economic cost associated with the use of the accessibility button, and the corresponding CO_2 produced allows for the potential reflection for students on campus that used the accessibility door, whom do not require such physical assistance. Although the implementation of accessibility buttons is necessary to have at institutions, the data collected and analyzed for this study purposes do not factor in that amount of energy that is used by someone who requires the assistance of the accessibility button. This overarching analysis, however, does provide insight for future implementation of potentially more energy efficient accessible doors that will not produce such a large social cost. Further development of this study would result in more accurate and insightful findings as a significant amount of assumptions were used due to significant limitations to the study. This study however does provide significant findings alone as there is a major literature gap on information regarding the energy and cost associated with the use of the accessibly button.

7. Acknowledgements

This study would not have been possible without guidance and direction from Professor Dr. C. Greene, and his continuous support and curiosity in regards to the chosen topic. Criticism and corresponding navigation was adequately given thanks to Buky, the Teaching Mentor assigned to assess the progress of this study. Lastly, a thank you to Nicola Embelton-Lake from Dalhousie's Facilities Management, who went above and beyond in providing this study with essential information in regards to identification of all the accessibility doors on campus.

Extension of this study's regards and appreciation goes to all those who contributed to the success of the findings and analysis of this work.

References

Abdollahi, A. Mollahassani-pour, M. Rashidinejas, M. (2016). *Appraisal of eco-friendly Preventive Maintenance scheduling strategy impacts on GHG emissions mitigation in smart grids*. Journal of Cleaner production 143 page 212-223. http://dx.doi.org/10.1016/j.jclepro.2016.12.127

AccuWeather. (2017, March). *Halifax, Canada Local Weather*. Retrieved from https://www.accuweather.com/en/ca/halifax/b3p/march-weather/49538

Assa Abloy. (N.D) *Swing Door Besam SW200i ™.* Retrieved from Assa Abloy entrance systems: AB/TDS.SW200i.CAN-USA-EN-1.0/1411

Berge, B. (2009). *The ecology of building materials.* New York, NY: Routledge

Canadian Human Rights Commission. (2013). Equality. Retrieved from: http://www.chrcccdp.gc.ca/eng/content/equality

Corgnati, S, P. D'Oca, S. Hong, T. Taylo-Lange, S ,C. Yan, D. (2015*) Advances in research and application of energy related occupant behavior in building*. Energy and Building. 116. Page 694-702

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S. J., Kubiszewski, I., ... & Turner, R. K. (2014). Changes in the global value of ecosystem services. Global Environmental Change, 26, 152-158.

Gulbians, R. Khosrowpour, A. Taylor, J, E. (2016) *Occupants workstation level energy-use prediction in commercial building: Developing and assessing a new method to enable targeted energy efficiency program*. Energy and Building 127 page 1133-1145 http://dx.doi.org/10.1016/j.enbuild.2016.05.071

Hansen, J., Kharecha, P., Sata, M., Masson-Delmotte, V., Ackerman, F., Beerling, D. J., . . . Zachos, J. C. (2013, December 3). Assessing "dangerous climate change": required reduction of carbon emissions to protect young people, future generations and nature. *PLOS*. doi: http://dx.doi.org/10.1371/journal.pone.0081648

Human Resources and Skills Development Canada. (2011). *Disability in Canada: a 2006 profile.* Retrieved from http://deslibris.ca.ezproxy.library.dal.ca/ID/228949

Intergovernmental Panel on Climate Change. (2007). *Energy supply. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Nova Scotia Power. (2017). *Larger General Tariff.* Retrieved from http://www.nspower.ca/en/home/about-us/electricity-rates-and-regulations/rates/large-general-tariff.aspx

Nova Scotia Power. (2017). *Where is your energy coming from? Year to Date*. Retrieved from http://www.nspower.ca/en/home/about-us/todayspower.aspx#

O'Neill, S., Seyfang, G., & Whitmarsh, L., (2011). Public engagement with carbon and climate change. (N. Adger, K. Brown, & D. Conway, Eds.) *Global environmental cange*, *21*(1), 56-65.

Pegg, M. H. (2015). *Transport Phenomena.* Halifax: Dalhousie University.

Rothstein, J, P. (2013) *Thermodynamics reference handbook*. University of Massachusetts. Retrieved from http://www.ecs.umass.edu/mie/faculty/rothstein/230pdf/fe_t hermodynamics_reference_handbook1.pdf

Stearns, A. (2015). Unnecessary Use of Automatic Door Openers: How much Energy is Wasted? Santa Cruz, CA: Recycle Nation

Stern, N. H., & Great Britain. (2007). *The economics of climate change: The Stern review*. Cambridge, UK: Cambridge University Press.

Thériault, L. (2012). About Canada: disability rights. *Canadian Review of Social Policy*, (68), 145-147. Retrieved from http://ezproxy.library.dal.ca/login?url=http://search.proquest.com.ezproxy.library.dal.ca/docview/1370183827?accountid=10406