Green Clean, Laundry Machines

A study of Laundry Operations at the Dalplex

Photo by Ian Froese

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1.0 EXECUTIVE SUMMARY

The Dalplex is the primary fitness center for Dalhousie students as well as some community members; as such, the facility has a number of costs associated with it. This includes the cost of laundry operations in the Dalplex that are required to provide the rag and towel services for its members and to ensure the cleanliness of the varsity team uniforms. This study measured the type and quantity of laundry done at the Dalplex to determine the amount of detergent, water, and energy used by each washing machine in a single week, and to shed light on the environmental impact of these services. Using deductive techniques the project group was able to roughly calculate how much the Dalplex spends annually on its laundry operations, a grand total of $4314.81. Analysis of the data gathered from the study led to the conclusion that replacing the less efficient washing machine is not the most effective way to reduce costs, but rather a change in policy. It is recommended that the Dalplex create a policy requiring its employees to start a wash cycle only when the machine is at full capacity. The overall result will lead to the Dalplex reducing the amount energy, water and detergent consumed, the environmental impacts associated with the laundry operations, and a total savings of at least $1300 a year.

2.0 INTRODUCTION

2.1 Project Definition

Located on the Dalhousie Campus, the Dalplex is the primary fitness center for students and faculty members of Dalhousie University, and is also open to members of the HRM community. The Dalplex offers its members access to a wide variety of fitness options including free weights, fitness machines, an indoor pool, as well as a track. The Dalplex is also home to the majority of Dalhousie University's varsity sports teams, such as the Dalhousie volleyball and basketball teams. While most members tend to focus more on the fitness opportunities provided by the Dalplex, few pause to consider the work and resources that go into ensuring the Dalplex continues to run smoothly, and the impact these processes may be having on the environment. One such aspect that is rarely considered is the amount of laundry done each day to ensure that members have access to rags and towels for personal use and to clean equipment, as well as to provide clean uniforms for all the varsity sports teams that use the facilities.

This project therefore aims to measure the type and quantity of laundry done each day at the Dalplex to determine the amount of detergent, water, and energy used by the washing machines currently in place, and to shed light on the environmental impact of the laundry services provided to the members of the facility. From there, the data will be analyzed so that it may be used in future studies, or to suggest improvements that can be made to the Dalplex's current laundry operations in order to reduce their environmental impact.

2.2 Background and Literature Review

The two most commonly used types of washing machines in North America include top loaders and front loaders (Hustvedt et al., 2013). With a top loading washing machine, the laundry is put in a vertical tub where it is spun throughout the cycle. When it comes time to rinse, the tub is completely drained and filled up again with fresh water, using an average of 40 gallons of water per load of laundry (Hustvedt et al., 2013). This type of washer could originally hold more laundry and was much more convenient for users to load (Hustvedt et al., 2013). Front loading machines, on the other hand, are a more energy efficient option than the alternative top-loading style. The laundry is loaded into a horizontal tub that requires less water to do the same job; on average only 20-25 gallons of water are used per load of laundry (Hustvedt et al., 2013). Along with water consumption, washing machines also consume energy. The average washing machine has a minimum cycle temperature of 30°C on the cold setting, meaning that some electricity is required to heat the water regardless of the cycle (Pakula & Stamminger, 2014). In addition to this, energy is lost and wasted throughout the flow of the cycle (Masa et al., 2013). Detergent use is also an environmental concern. With the combination of thermal pollution and detergent residue in waste water, laundry processes can cause harm to wildlife as well as degradation of water quality and ecosystem functions (Saouter & White, 2002, and Masa et al., 2013).

With the increasing awareness of global climate change, there has been a major push to address the excessive water, energy and detergent use of washing machines (Katayama & Sugihara, 2011). New styles of washing machines are being designed with the goal of decreasing the amount of water and energy used during each load. Efforts are also being made to create detergents that are less harmful

for the environment, in other words more "green", and that clean more efficiently (Hustvedt, 2011). A number of studies have done to assess different household washing machine efficiencies based on different temperatures and cycle times; some even set out to determine the variation of machine types and their efficiency in different regions of the world (Kim et al, 2015). A study done by Kim et al. in 2015 discovered that longer wash cycles with lower temperatures tend to have a better washing effectiveness while also significantly decreasing the amount of electricity used. Sabaliunas et al., 2006, confirmed those results, while also adding that there can be potential cost savings and CO2 emission reductions by decreasing temperature and choosing energy efficient labeled machines. Overall, most of the literature reviewed mentioned that the amount of energy, water and detergent used varies significantly between each washing machine model, creating the need for comparisons to be made to achieve accurate results. Although there was a large amount found on household style machines, there was inadequate data available on industrial practices.

2.3 Rationale

Dalhousie University is continuously working towards achieving greater sustainability around campus (Dalhousie University, 2016). Through the efforts of the Office of Sustainability, Dalhousie now has many green buildings, various programs addressing transportation, food, waste, and energy issues on campus, as well as volunteer opportunities for those who would like to get involved (Dalhousie University, 2016). There have been previous studies on Dalhousie laundry operations such as Washing Away Waste, a study conducted in 2013 with the goal of assessing the feasibility of implementing waste-reduction and scent-free policies in residential laundry operations throughout Dalhousie Campus (Hoffman, et al., 2013). This study addresses laundry in the residential context

and is similar to other studies that have been conducted in American universities, for example the University of California's Case Study: UCD Laundering Methods, or Penn State's investigation into laundry data in residence laundry machines, and their effort to enhance the sustainability of laundry operations in residence (Meddaugh, et al., n.d., Penn State News, 2004). However, when researching everything that has and is currently being done regarding sustainability on campus, it became apparent to our team that few studies have been done on laundry operations specifically at the Dalplex.

As previously mentioned, the Dalplex is the main fitness source for Dalhousie students, staff, and other community members. When thinking about the equipment, lighting, pool facility, showers, and various services offered to its members, one can only wonder how much energy is being used by the Dalplex, and how sustainably its current operations are. Of particular interest were the industrial washing machines used at the Dalplex to wash varsity team uniforms as well as towels and rags. The intent of this research project is to therefore assess these washing machines to identify any areas of improvement or alternatives that could help the laundry operations at the Dalplex become more efficient, environmentally friendly, or cost effective, in order to contribute to Dalhousie's sustainability efforts. Due to the limited studies on industrial washing machines, this project also aims to bring forth more relevant data that could be used in future studies.

3.0 RESEARCH METHODS

3.1 Description of Study Design

This project used deductive techniques to assess the water usage, energy efficiency, and laundry detergent usage of the washing machines at Dalplex. An initial exploration of the site showed that there are three different industrial-sized washing machines currently in use; from there, exploratory research was used to gather quantitative data from each washing machine to compare them to each other. The results were then used to determine the efficiency of each machine, which supported the proposal of alternative practices to reduce the Dalplex's environmental footprint, as well as potentially purchasing a more efficient washing machine.

Justification of Measurement Choices

The reasoning behind the use of a data table and observations to collect data as opposed to a survey or questionnaire is that they were the most effective means to obtain the raw data required for accurate results. The only way to get the specific data on the daily laundry operations at the Dalplex required for the study was to record the routines of the Dalplex employees. This method gave insight into the true quantitative values needed to create a cost-benefit analysis.

3.2 Procedure

3.2.1 Data Collection

The data collected on the laundry operations at Dalplex was obtained by way of a data collection table (Appendix A) filled out by members of building services at the Dalplex, who are in charge of the all the laundry in the building. The washing machines were numbered ahead of time, from 1 to 3, and corresponding booklets containing copies of the data table were placed on top of each machine, decreasing the likelihood of any confusion and ensured that data collection was as simple as possible for the employees.

Employees of the Dalplex recorded each load of laundry done for 1 week (March 11-17, 2016). The data table included specific information such as cycle setting (button 1, 2, 3, 4, 5, or 6), approximate size of laundry load (25%, 50%, 75% or 100% full), and laundry type (towels, uniforms, mixed, or other). After informing the employees of the project and its scope, they were asked to fill out the table to the best of their ability, and were also given contact information in case they had any questions regarding the study. Members of the project group also took turns observing the employees while doing laundry in order to become more familiar with laundry operations at the Dalplex, as well as ensure that the employees were properly filling out the data table.

3.2.2 Data Analysis

Once the 3 binders were collected, all of the data from the tables was entered into an excel document. The data was then used to calculate the average number of loads per week, the average number of loads per day and the average load size for all 3 machines.

Energy, Water and Detergent Usage

In order to determine energy usage, the wattage (per hour) of each machine first had to be calculated. This was done by multiplying the volts by the amperes that were indicated on the back of each machine. Seeing as the average washing cycle is 45 minutes long, the wattage per hour was then multiplied by .75 of an hour and divided by 1000 in order to get the kW per 45 minute cycle.

As for water, the usage in gallons per cycle for each washing machine was obtained from the manufacturing company Wascomat.

There are 4 different chemicals used for all 3 machines that are automatically dispensed into the washing machine during a washing cycle. The exact amount of each chemical per cycle in millilitres was obtained from the supplier Dalcam Solutions, and was consistent for all 3 machines. Each amount was then totaled to determine the total chemical use per cycle.

The energy usage, water usage and detergent usage per cycle of the 3 different washing machines were then compared to assess their efficiency. This was done by calculating the daily, weekly, and annual energy, water, and detergent consumption of each washing machine at the Dalplex. The average number of loads for each machine per day was multiplied by the amount of energy, water and detergent used respectively per cycle to determine the daily usage of each machine. After that, the values were multiplied by 7 to determine the weekly usage, then by 365 for the annual usage based on the Dalplex laundry demands.

Energy, Water and Detergent Cost

A standard commercial energy charge of $0.08236 per kWh was determined from NS Power (NS Power and Emera Company, 2016). This standard charge was multiplied by .75 of an hour, and then by the energy usage per cycle of each machine to calculate the individual energy costs for 1 load of laundry.

Next a standard water rate of $0.976 per 220 gallons was determined from Halifax Water (Halifax, 2016). The water usage per cycle for each machine was then divided by 220 gallons and multiplied by $0.976 in order to calculate the water cost for 1 load of laundry.

Each of the 4 detergent chemicals is supplied to the Dalplex in a 20 Litre container. The price of each individual chemical container was provided by Dalcam Solutions. To find the price of each chemical for 1 load of laundry, the chemical usage per cycle was divided by 20 litres and multiplied by the price of the 20 L container. These 4 values were then added together to determine the total cost of detergent for 1 load of laundry, consistent with all 3 machines.

The average cost per cycle, as well as the daily, weekly, and annual costs for energy, water and detergent were then calculated using the same process as explained above.

Potential Savings

After realizing the rarity of loads that were done at full capacity and the cost of a single load of laundry, it was decided to assess the potential savings if all loads were only done when at

full capacity. Thus, the number of loads that could be saved was calculated along with the new number of loads per day and the average number of loads saved per day for all 3 machines.

The number of loads saved per day was then multiplied by the energy, water and detergent costs per cycle to calculate daily savings for each washing machine. Finally, the daily savings were multiplied by 7 and by 365 to get the amount of money the Dalplex could save weekly and annually in their laundry operations if each load were 100% full.

3.3 Reliability, Validity, and Trustworthiness

Reliability

This study proves to be reliable because it is easy to replicate, due to the fact that all that is needed to recreate the study is a similar data table, along with the agreement of the building services employees to participate. The study could also be conducted for any length of time, allowing for the possibility of infinite data. A study done by Kim et al. (2015) used a similar approach to collect data when investigating the electricity and water consumption of the washing machine operations in various countries, using quantitative data to show the potential environmental and economic impacts. The results of the study were also displayed in a similar fashion, in terms of CO2 emissions and monetary cost.

Validity

Although Newman et al. (2013) state how beneficial it is to use a mixed-methods approach when conducting research; they also discuss the importance of collecting quantitative data by means of a table. A table is used to "empirically determine the major concepts of the theory" (Newman et al., 2013). The data table used for the study provided this empirical information, and allowed for trustworthy results.

Trustworthiness

This study is trustworthy seeing as the evidence accumulated through the information from the data table supports the original hypothesis, proving its dependability, credibility, and confirmability. The use of observation allowed for the data collection to be supervised, minimizing human error and further legitimizing the results.

3.4 Delimitations and Limitations

Delimitations

There were numerous delimitations associated with the study, the first being the restriction of the Dalplex as the sole source of data instead of using multiple locations, such as Sexton campus gym. This narrowed the scope of the study and made it difficult to compare the Dalplex's laundry operations to other gyms or recreation centers in terms of sustainable practice. However, despite not being able to use comparative analysis, the study still provides insight on opportunities for improvement at the Dalplex.

Another delimitation is the reliance on members outside the project group to record data. Although this was not expected to be a major issue, seeing as the employees in charge of recording the data were highly educated and able, it is still a concern worth mentioning due to possibility of unknown personal error. Such errors could have resulted in false data sets, which would have negatively impacted the results of the study. In an attempt to minimize this problem, as well as to be more engaged in the data collection process, members of the project group sat in to monitor the data collection during the first two days of the week-long study period.

Limitations

Limitations associated with the study included time constraints, data availability, the Hawthorne effect, the seasonal sporting schedule and, as stated in delimitations as well, staff inaccuracy during data recording.

The length of the study was severely constrained, allowing for only one week to collect the necessary data. This restriction could have potentially impacted the study by limiting the collection of the necessary amount of data required to create accurate results. Despite the small time period given to complete the study, the week's worth of data collected was sufficient to provide an accurate representation of the laundry operations done at the facility.

Data availability is a common concern for research projects, as it is always uncertain whether or not information on the subject will be available. This was an issue at the beginning of the study when it was required to contact the washing machine company. The project group

hoped to obtain the specifications of the washing machines regarding energy consumption, but it soon became apparent that this information was unavailable. The project group overcame this obstacle by personally calculating the energy consumption of each washing machine using the data available on the back of the machines themselves.

The Hawthorne effect, also known as the observer effect, is used to describe individuals altering their behaviour when under observation, a possible risk seeing as the employees of the Dalplex were observed doing laundry and recording data for the first two days of the study. Upon being observed, it is possible that the employees increased the size of each load in an attempt to appear more environmentally conscious, which could have altered the results of the study. To counteract this possibility, observation was only conducted for two out of the seven days of the study, minimizing contact with the employees.

The seasonal sporting schedule also played a role in limiting the study, as the amount and type of laundry done at the Dalplex changes with the seasons due to the inclusion of varsity team uniforms. This could have been an issue when generalizing the annual results of the study, seeing as only one time period was actually observed. A solution used to address this problem was the randomization of the week of laundry operations observed at the Dalplex.

4.0 RESULTS

4.1 Data Collection

A total of 51 loads of laundry were done at the Dalplex over the week observed (Figure 1). Machine 1 was used far more than the other two, with almost half the loads done in this machine alone (Figure 1). Machine 3, on the other hand, was only used 9 times over the entire week (Figure 1). A total average of 7 loads of laundry were done per day between the 3 machines, as seen in Figure 1. Machine 1 was responsible for about 4 of these daily loads, machine 2 was responsible for about 2 loads, and machine 3 only about 1 load (Figure 1).

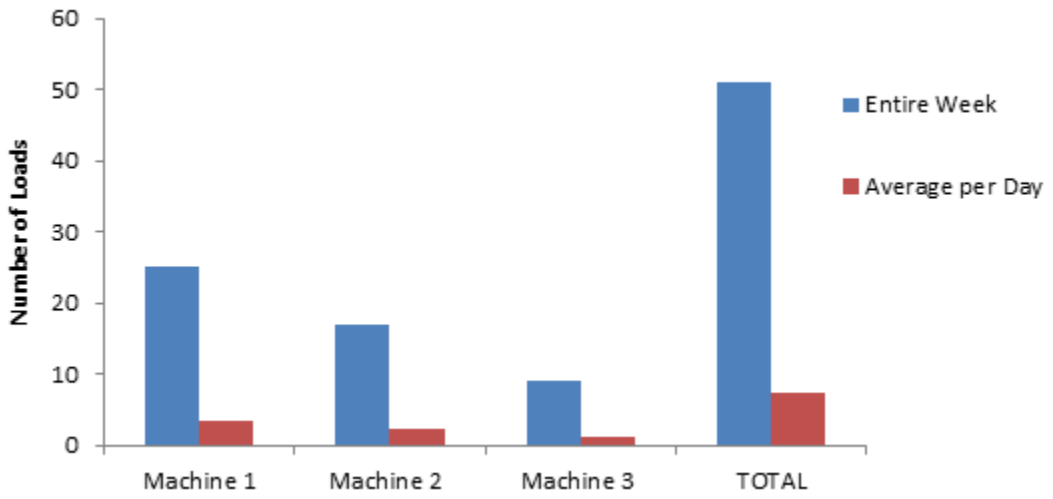

Figure 1 Average number of laundry loads done in machine 1, machine 2 and machine 3 per day and during the entire week of data collection.

As shown in Figure 2, the majority of loads done over the week were less than 100% full. Between all 3 washing machines, the average load size was only 69%, with machine 1 having the highest average of 72% full, and machine 2 having the lowest with an average of 66% full (Figure 2).

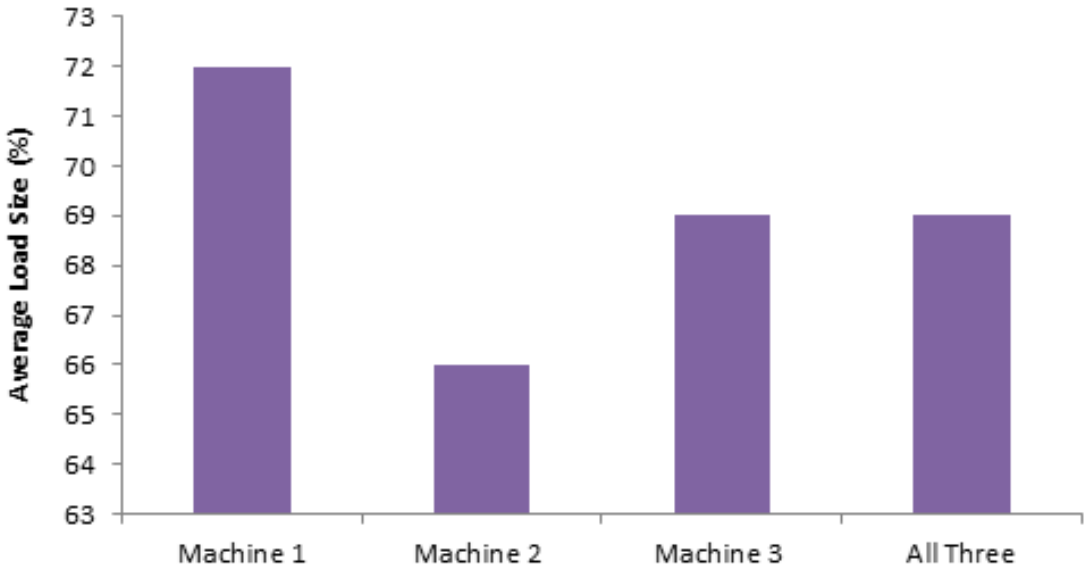

Figure 2 Average load sizes (%) of laundry done in the Dalplex in machine 1, machine 2 and machine 3 and of all three during the week of data collection.

4.2 Energy, Water and Detergent Usage

In terms of energy efficiency, machine 3 consumes the most energy (1.09 kW) for 1 load of laundry, and machine 2 consumes the least (0.78 kW) (Figure 3). For water efficiency, machine 3 also has the highest consumption of 100 gallons per cycle as shown in Figure 4. Machine 1 uses the least amount of water (80 gallons) and machine 2 uses a medial amount of 90 gallons per cycle (Figure 4). As seen in Figure 5, the total amount of detergent use per cycle for all 3 machines was determined to be

0.275 litres.

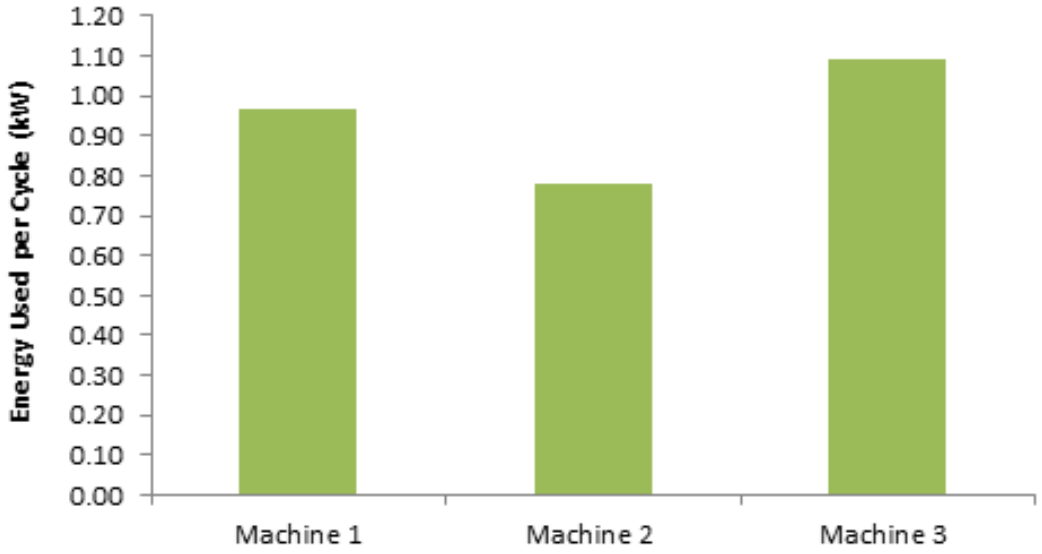

Figure 3 Amount of energy used in kilowatts per cycle for machine 1, machine 2 and machine 3 in the Dalplex.

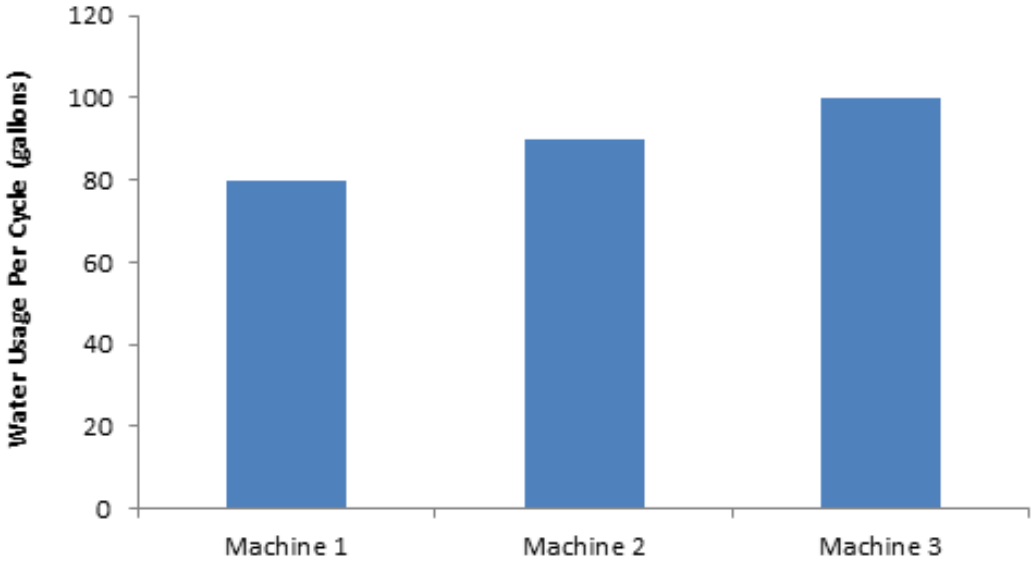

Figure 4 Amount of water used in gallons per cycle for machine 1, machine 2 and machine 3 in the Dalplex.

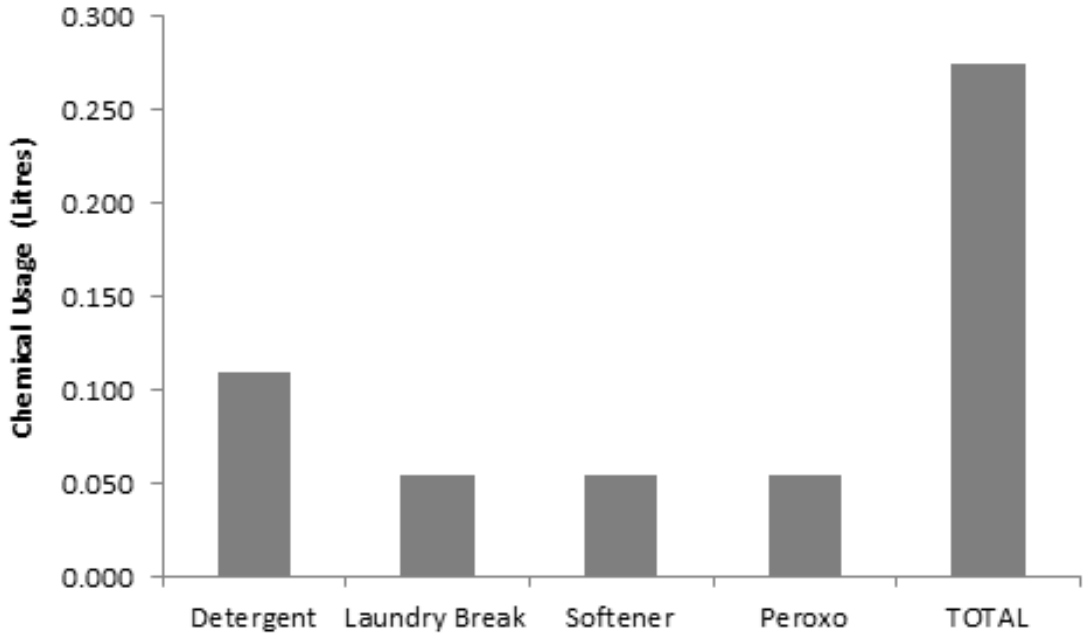

Figure 5 Amount of individual chemical usage and total usage in litres per cycle for all 3 machines in the Dalplex.

4.3 Energy, Water and Detergent Cost

The total average cost for 1 load of laundry at the Dalplex is $1.66, which includes the cost of energy, water and detergent (Figure 6). Individually, energy costs an average of $0.06 per cycle, water costs an average of $0.40 per cycle, and detergent costs $1.20 per cycle (Figure 6).

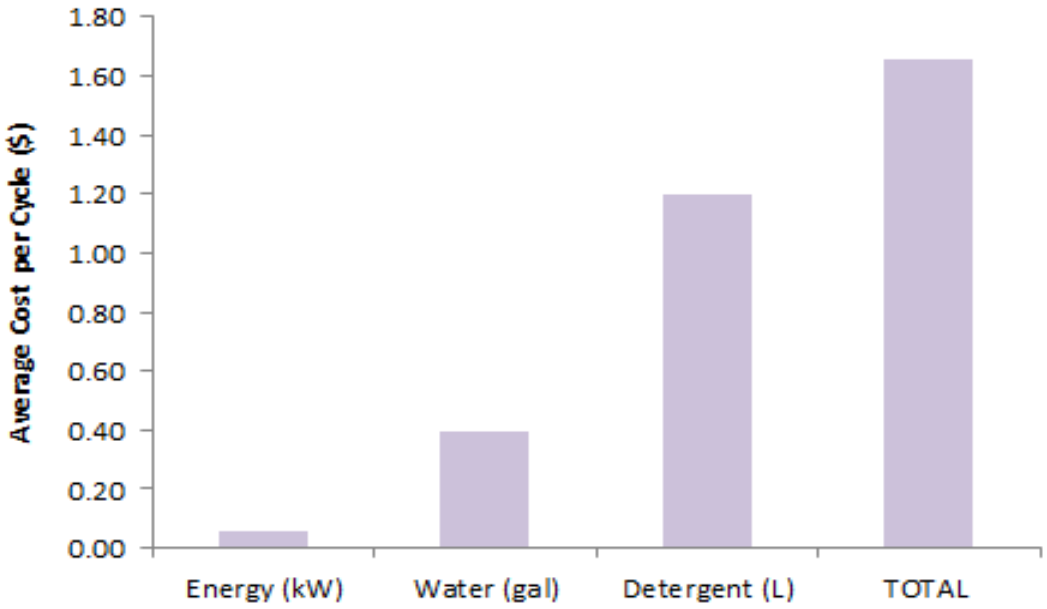

Figure 6 Average cost in dollars per cycle for energy (kW), water (gal), detergent (L) and total for the 3 washing machines at the Dalplex.

The daily, weekly and annual amount spent on energy, water and detergent was also calculated, with the assumption that the data collected represents an average week for laundry operations at the Dalplex. The annual cost of each category was of particular interest and is illustrated in Figure 7. In 1 year Dalhousie University spends roughly $4314.81 on laundry operations at the Dalplex. A significant amount of this total, about $3200.00, is due to detergent alone as shown in Figure 7. Water use is also a large contributor, costing just over $1000 a year, while energy accounts for only about $100 (Figure 7).

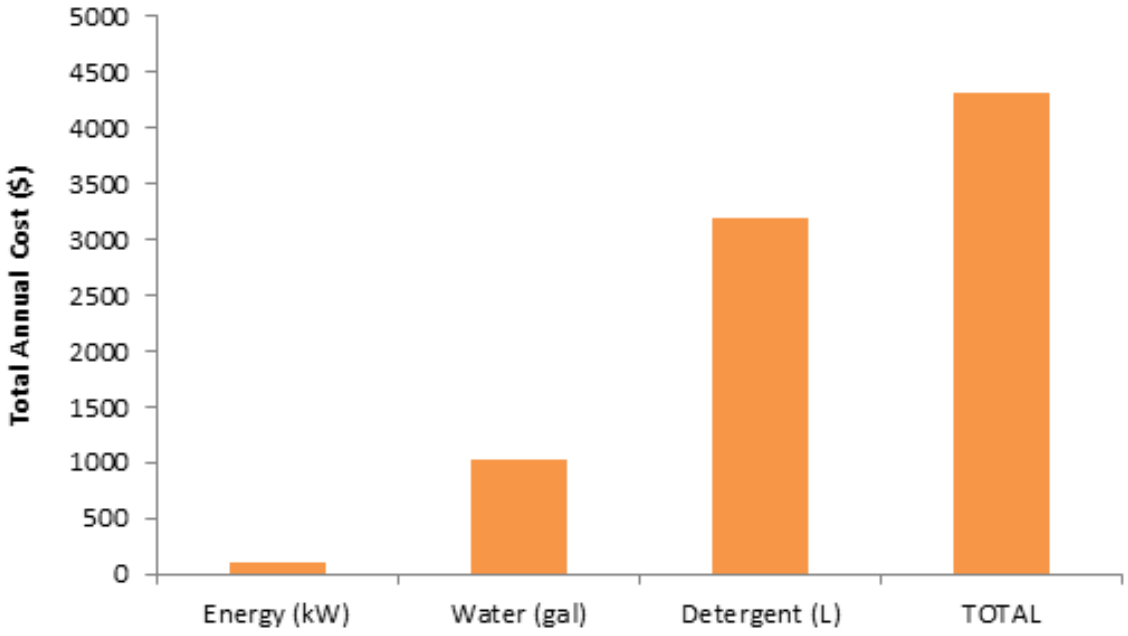

Figure 7 Total annual costs in dollars of energy (kW), water (gal), detergent (L) and the total of all 3 for all washing machines in the Dalplex.

4.4 Potential Savings

If all loads were done at 100% capacity, Dalhousie would save approximately $1331 each year, as shown in Figure 8. As detergent costs the most per year (Figure 8), reducing detergent consumption could save a total of roughly $971 per year (Figure 8). Water savings would add up to just over $250 a year, and energy savings around $100 a year (Figure 8).

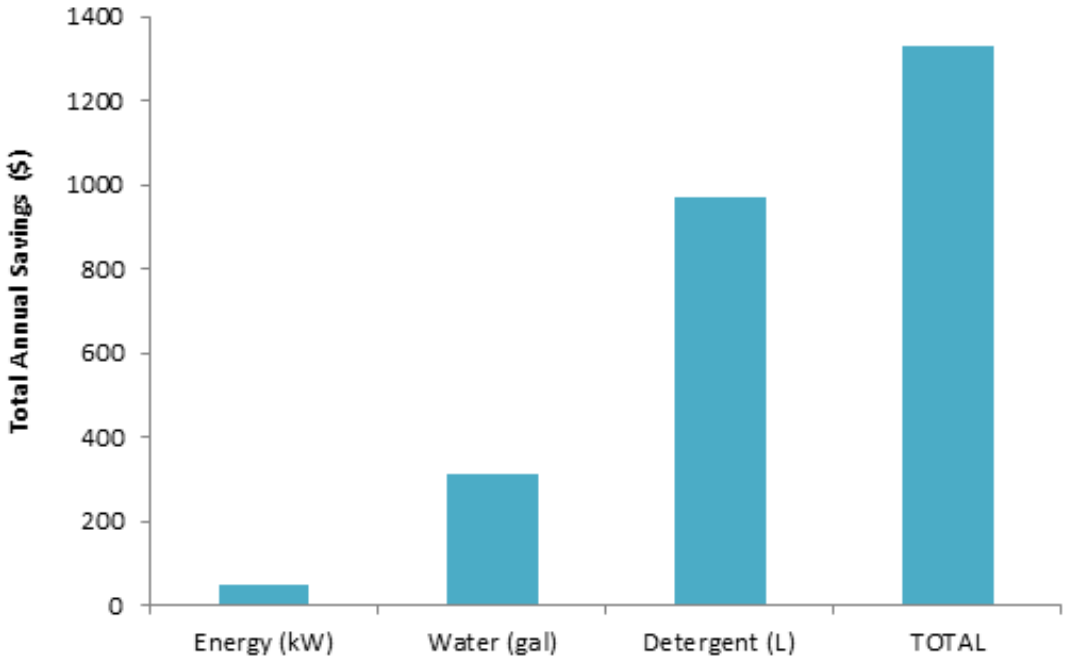

Figure 8 Total annual savings in dollars of energy (kW), water (gal), detergent (L) and the total savings of all 3 if every load was done 100% full.

5.0 DISCUSSION

The purpose of this study was to determine the amount of energy, water and detergent that the 3 Dalplex washing machines currently consume per cycle. This information could be useful to assess and compare the efficiency of each machine, as well as shed light on the costs and environmental impact associated, in order to determine if any improvements could be made to the Dalplex's laundry operations. These improvements could be through the purchasing of newer washing machines, or implementing policy changes aimed at increasing the efficient use of the machines currently in place.

Several research methods were used to collect and dissect the data in order to come up with appropriate recommendations. While data collection was the primary method, observation was also used to properly understand the Dalplex employee's laundry habits and increase the trustworthiness of the data. Finally, communication with Dalcam Solutions and Wascomat laundry services via phone calls and email was also used in order to obtain important information that was not directly accessible.

Based on the data collected, it was found that the Dalplex does about 7 loads of laundry per day at an average of 65 to 75% capacity, adding up to roughly 51 loads per week. Using this information, the average costs of water, energy and detergent was calculated and revealed that at least $4314.81 is spent per year on laundry operations at the Dalplex. When this total cost is broken down, it is shown that a large majority is spent on chemical detergent alone. Next to that is water costs, and only a rather small amount is spent on energy.

The individual machines were also compared and contrasted based on their energy, water, and detergent usage. As hypothesized, machine 3 was proved to be the least efficient and cost the most per cycle. It had the highest energy consumption of 1.09 kW per cycle while also consuming the highest amount of water, 100 gallons per cycle. Machine 2 was the found to be the most energy efficient with a usage of 0.78 kW per cycle, while machine 1 was the most water efficient consuming only 80 gallons per cycle. Seeing as how detergent usage was consistent across the 3 machines, it could not be used for comparison

By averaging the usage of all 3 machines, it was found that a single load of laundry costs about $1.66. Considering the average load capacity was only 65-75%, a lot of excess energy, water, detergent, and especially money is being wasted each load. If the Dalplex limited their laundry operations so that loads were only done at 100% full capacity it could save the Dalplex up to $1,300 in 1 year, with a significant amount of this savings being detergent. For this reason, focus should be not only put towards doing full loads of laundry but also towards reducing the detergent usage in order to reduce the overall cost of laundry operations. This of course is easier said than done. While there are many published studies on laundry detergent reduction, the major focus seems to be around household washing machines as opposed to the industrial machines and techniques. According to Mary Marlowe, a laundry operation expert, there are different ways to decrease the amount of detergent use, from insuring proper measurement of detergent to completely substituting it for baking soda (Marlowe, 2016). However, these methods are not exactly suitable for the Dalplex seeing as they use precise automatic dispensers to distribute detergent, and would not allow for the use of substitutes such as baking soda in their washing machines.

6.0 CONCLUSION

While it may not be considered a major sustainability issue on the Dalhousie campus, the laundry operations at the Dalplex have a significant annual costs and negative impacts on the environment. This study thoroughly examined the laundry operations at the Dalplex while also providing insight into the amount of water, energy, and detergent used by each of its 3 washing machines and the associated costs. From there it was possible to calculate how much is roughly being spent on laundry operations each year, and suggest recommendations that will help Dalhousie University save money while also decreasing their environmental impact. It became immediately apparent that washing machine 3 was the least efficient of the all; however, it was also used considerately less compared to the other 2. This means that the Dalplex is already making some sustainable choices and working towards significantly reducing the costs and environmental impacts related to these machines. However, it appears that using the washing machines at their full capacity is perhaps the most effective way the Dalplex can achieve this goal. For this reason it is recommended that a policy be put in place that requires employees to only do loads at full capacity, which will reduce the energy, water and detergent use and help save up to $1300 annually. It is also suggested that a yearlong study be done on the Dalplex laundry operations, in order to have a more accurate estimate of the amount of water, energy, and chemicals being used, the associated costs and even further recommendations to improve efficiency.

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9.0 APPENDICES

Appendix A: Data collection table used by the ECC staff during study period.

Date				
Time				
Cycle Settings: (i.e. Button 1, 2, 3, 4, 5, or 6)				
Approximate size of laundry load **(circle one)**	25%	50%	75%	100%
Laundry Type	Towels	Uniforms	Mixed	Other
Signature				

Appendix B: Compiled data from each completed data collection table for the 3 machines in the Dalplex

Table 1: Compiled data for Machine #1 in the Dalplex

Machine #1				
Date	**Time**	**Cycle Setting**	**Laundry size (%)**	**Laundry Type**
11/03/2016	7:00am	1	50	Towels/rags
11/03/2016	11:21am	1	50	Towels/rags
11/03/2016	1:50pm	1	50	Towels/rags
12/03/2016	7:00am	1	100	Towels/rags
12/03/2016	11:46am	2	100	Uniforms
12/03/2016	4:35pm	1	100	Towels/rags
12/03/2016	7:00pm	1	50	Towels/rags
13/03/2016	9:15am	1	25	Towels/rags
13/03/2016	1:10pm	1	100	Towels/rags
13/03/2016	6:28pm	1	50	Towels/rags
14/03/2016	11:40am	1	100	Towels/rags
14/03/2016	12:30pm	1	75	Towels/rags
14/03/2016	4:07pm	1	75	Towels/rags
14/03/2016	7:51pm	1	100	Towels/rags
14/03/2016	8:35pm	1	100	Towels/rags
15/03/2016	8:30am	1	100	Towels/rags
15/03/2016	11:30am	1	75	Towels/rags
15/03/2016	5:17pm	1	100	Towels/rags
15/03/2016	7:45pm	1	50	Towels/rags
16/03/2016	5:55am	2	50	Uniforms
16/03/2016	9:05am	5	50	Towels/rags
16/03/2016	10:03am	1	50	Towels/rags
17/03/2016	5:35am	1	100	Towels/rags
17/03/2016	8:45am	1	75	Towels/rags
17/03/2016	3:50pm	1	25	Towels/rags

Table 2: Compiled data for Machine #2 in the Dalplex

Machine #2				
Date	**Time**	**Cycle Setting**	**Laundry size (%)**	**Laundry Type**
11/03/2016	7:00am	2	50	Uniforms
11/03/2016	11:45am	1	75	Towels/rags
12/03/2016	7:10am	5	100	Other
14/03/2016	5:50am	2	50	Uniforms
14/03/2016	11:40am	1	75	Towels/rags
14/03/2016	2:30pm	1	50	Towels/rags
14/03/2016	4:07pm	1	100	Towels/rags
14/03/2016	6:20pm	2	50	Other
14/03/2016	7:51pm	2	50	Uniforms
14/03/2016	8:45pm	2	50	Other
15/03/2016	2:00pm	2	100	Uniforms
15/03/2016	5:17pm	1	50	Towels/rags
15/03/2016	7:45pm	1	25	Towels/rags
16/03/2016	5:40am	1	75	Towels/rags
17/03/2016	6:30am	2	50	Uniforms
17/03/2016	11:30am	1	75	Towels/rags
17/03/2016	1:35pm	1	100	Towels/rags

Table 3: Compiled data for Machine #3 in the Dalplex

Machine #3				
Date	**Time**	**Cycle Setting**	**Laundry size (%)**	**Laundry Type**
11/03/2016	7:10am	6	75	Other
11/03/2016	8:20pm	2	75	Uniforms
12/03/2016	7:30am	1	75	Towels/rags
13/03/2016	9:15am	6	75	Other
14/03/2016	5:50am	6	50	Other
14/03/2016	8:45pm	1	50	Towels/rags
15/03/2016	6:30am	6	75	Other
16/03/2016	5:54am	6	75	Other
17/03/2016	7:00am	6	75	Other

Appendix C: Table 4: Calculated number of loads per week, average number of loads per day and average load size (%) for each of the 3 Dalplex washing machines

	Machine 1	**Machine 2**	**Machine 3**	**TOTAL**
Number of Loads per Week	25	17	9	51
Average Number of Loads per Day	3.57	2.43	1.29	7.29
Average Load Size (%)	72	66	69	

Appendix D: Table 5: Values of volts, amps, and watts for each of the 3 Dalplex washing machines

	Machine 1	**Machine 2**	**Machine 3**
Volts (V)	208	208	208
Amps (A)	6.2	5	7
Watts (W)	1289.6	1040	1456

Appendix E: Energy, Water, and Detergent Usage

Energy Usage

Table 6 Electricity usages in kilowatts per cycle, daily, weekly and annually for each of the 3 Dalplex washing machines

Electricity Usage (kW)	Machine 1	Machine 2	Machine 3
Per Cycle	0.97	0.78	1.09
Daily	3.45	1.90	1.41
Weekly	24.17	13.27	9.86
Annually	1260.31	691.82	514.17

Water Usage

Table 7 Water usages in gallons per cycle, daily, weekly and annually for each of the 3 Dalplex washing machines

Water Usage (Gallons)	Machine 1	Machine 2	Machine 3
Per Cycle	80	90	100
Daily	285.6	218.7	129
Weekly	1999.2	1530.9	903
Annually	104,244	79,826	47,085

Detergent Usage

Table 8 The amount in litres of each chemical used per cycle and the total. These values are consistent for all 3 of the Dalplex washing machines

Type	Usage per Cycle (L)
Detergent	0.11
Laundry break	0.055
softener	0.055
peroxo	0.055
Total	**0.275**

Table 9 Detergent usage in litres per cycle, daily, weekly and annually for each of the 3 Dalplex washing machines

Detergent Usage (Litres)	Machine 1	Machine 2	Machine 3
Per Cycle	0.275	0.275	0.275
Daily	0.98	0.67	0.35
Weekly	6.87	4.68	2.48
Annually	358.34	243.91	129.48

Table 10 The total annual usage of energy in kilowatts, water in gallons and detergent in litres of all 3 washing machines in the Dalplex

Category	Total Annual Usage
Energy (kW)	2466.30
Water (gal)	231154.50
Detergent (L)	731.23

Appendix F: Energy, Water, and Detergent Cost

Energy Cost

Table 11 Electricity costs per cycle, daily, weekly and annually for each of the 3 Dalplex washing machines

Electricity Cost ($)	Machine 1	Machine 2	Machine 3	TOTAL
Per Cycle	0.06	0.05	0.07	0.18
Daily	0.21	0.12	0.09	0.42
Weekly	1.49	0.82	0.61	2.92
Annually	21.81	42.73	31.76	96.30

Water Cost

Table 12 Water costs per cycle, daily, weekly and annually for each of the 3 Dalplex washing machines

Water Cost ($)	Machine 1	Machine 2	Machine 3	TOTAL
Per Cycle	0.35	0.40	0.44	1.20
Daily	1.27	0.97	0.57	2.81
Weekly	8.87	6.79	4.01	19.67
Annually	462.46	354.13	208.89	1025.49

Detergent Cost

Table 13 The cost per 20 L container and the cost per cycle for each chemical and the total, consistent for all 3 of the Dalplex washing machines.

Type	Cost per 20 L Container ($)	Cost per Cycle ($)
Detergent	79.80	0.11
Laundry break	88.80	0.055
softener	79.95	0.055
peroxo	107.45	0.055
Total	**356.00**	**0.275**

Table 14 Detergent costs per cycle, daily, weekly and annually for each of the 3 Dalplex washing machines

Detergent Cost ($)	Machine 1	Machine 2	Machine 3	TOTAL
Per Cycle	1.20	1.20	1.20	3.60
Daily	4.28	2.92	1.55	8.75
Weekly	29.99	20.41	10.84	61.24
Annually	1563.66	1064.34	565.02	3193.02

Table 15 Cost per cycle in energy (kW), water (gal) and detergent (L) for machine 1, machine 2, machine 3 and the average for each.

Cost per Cycle ($)	Machine 1	Machine 2	Machine 3	Average
Energy (kW)	0.06	0.05	0.07	0.06
Water (gal)	0.35	0.40	0.44	0.40
Detergent (L)	1.20	1.20	1.20	1.20
Total	1.61	1.65	1.71	1.66

Table 16 The total annual cost of energy in kilowatts, water in gallons and detergent in litres of all 3 washing machines in the Dalplex and the total cost for all 3 categories.

Category	Total Annual Cost ($)
Energy (kW)	96.30
Water (gal)	1025.49
Detergent (L)	3193.02
TOTAL	**4314.81**

Appendix G: Estimated Savings

Table 17 Number of loads if all were 100% full, the new average loads done per day and the amount of loads saved per day for all 3 Dalplex washing machines

	Machine 1	Machine 2	Machine 3
Number of Loads Eliminated per Week	7	5.75	2.75
New Average Number of Loads per Day	2.57	1.61	0.89
Number of Loads Saved Per Day	1	0.82	0.40

Table 18 Amount of Electricity saved daily, weekly and annually for each of the 3 Dalplex washing machines

Amount saved in Electricity ($)	Machine 1	Machine 2	Machine 3	Total
daily	0.06	0.04	0.03	
weekly	0.42	0.28	0.19	
annually	21.81	14.42	9.85	**46.08**

Table 19 Amount saved in water cost daily, weekly and annually for each of the 3 Dalplex washing machines

Amount saved in Water ($)	Machine 1	Machine 2	Machine 3	Total
Daily	0.35	0.33	0.18	
Weekly	2.48	2.29	1.24	
Annually	129.54	119.50	64.77	**313.82**

Table 20 Amount saved in chemical costs daily, weekly and annually for each of the 3 Dalplex washing machines

Amount saved in Detergent ($)	Machine 1	Machine 2	Machine 3	Total
Daily	1.20	0.98	0.48	
Weekly	8.39	6.88	3.38	
Annually	437.43	358.70	174.97	**971.10**

Table 21 The total annual savings in energy (kW), water (gal) and detergent (L) of all 3 washing machines in the Dalplex and the total saving in all 3 categories.

Category	Total Annual Savings ($)
Energy (kW)	46.08
Water (gal)	313.82
Detergent (L)	971.10

Appendix H: Info-graphic summarizing findings (Designed with the help of Piktochart)