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An Investigation into a Sustainable Laundry Service For the New SUB

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ABSTRACT

The University of British Columbia has deemed sustainability an important issue that needs to be addressed. One of the ways the university plans to display its understanding and knowledge of sustainability is by constructing a new student union building by sustainable means that provides sustainable services.

A large hassle for bikers is the need to carry wet towels; a new service provided will be showers and a towel rental. The towels will be cleaned by the university via a sustainable laundry service. This laundry service was looked into at great detail for this APSC 261 project.

The laundry service was broken down into three categories; washer, dryer and cleaning products. Many assumptions were used throughout the project to evaluate each function and to determine that 934 bikers using the towel rental service are required to achieve a 10 year payback period for energy. Each sub function was researched fully to come up with appropriate evaluation criteria and winnowed down to a final recommendation on the basis of triple bottom line assessment. The final recommendations for the laundry service are five LG model WM2901HVA, thirty Lavatherm T57800 condenser dryers and Natural Formulations LD-Z Bio-Enzymatic Natural Laundry Detergent.

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ABBREVIATIONS

- SUB-Student Union Building
- UBC- University of British Columbia
- CEE-Consortium for Energy Efficiency
- LG-Lucky Goldstar
- GE-General Electric
- MEF-Modified Energy Factor
- WF-Water Factor
- Km-Kilometers
- KWH – KiloWatt Hours
- Cuft- Cubic Foot

1.0 INTRODUCTION

The new SUB being designed for UBC will represent sustainability in the way it's constructed and in the features it has to offer the students, teachers and staff members of UBC. UBC has actively been promoting alternative transportation to campus with the UPass and is now looking at finding ways to get people to bike to campus. One way to bring more bikers to UBC is to make the experience easier. UBC's new SUB will contain showers and a sustainable and ecological-friendly laundry service for towel rentals. This service will provide more room in biker's backpacks and get rid of the need to carry around a wet towel. The design team has approached the project by dividing the main function of a sustainable laundry service into three sub functions; a washer, dryer, and cleaning products. Several products for each sub function will be evaluated using the triple bottom line assessment and functional requirements to provide a final recommendation for UBC's laundry service. Once a choice for each function was clear, a calculation to see how many new bikers the university had to attract to ensure the initial energy costs of the appliances and products were paid back within their 10 year lifecycle was performed.

2.0 BACKGROUND RESEARCH

Background research was completed to ensure the team understood the project requirements and how each subsection fit into the overall project.

2.1 WASHER

Initial research was completed to get an understanding of what features clothes washers have, how they impact sustainability and if they are required by the new SUB. The internet is a great source to find information on companies that produce washers, what makes them sustainable and what features to look for. Companies such as LG, Maytag, Whirlpool, GE, Frigidaire, Unimac, and Bosch were researched to find the most efficient washing machines they had to offer. A North American non-profit corporation called CEE has created a list of the top efficient clothes washers to promote purchasing energy efficient products. This list as of October 15, 2009, ranks hundreds of clothes washers with regards to their MEF and WF rankings. The highest ranked washers from the CEE list along with a few commercial washers were further researched to evaluate which one would suit the new SUB.

2.2 DRYER

Upon the initial investigation of dryers it was found that three main types of dryers are used. The first and most widely used is the tumble dry system this uses an electric heater and a tumbling motion to dry clothes. The next is the condenser system this is the system that is mostly used in combination washer and dryer set-ups as it offers a higher electrical efficiency because instead of using new air and venting it out it utilizes a condenser to remove the moisture and then reheats the air and puts it back into the system. Next is the heat pump dryer this is even more efficient than the condenser; however, its limited availability due to its complex nature and expensive price makes it very hard to find in and especially outside of Europe. Next is a gas or steam assist dryer which utilize natural gas or steam to heat the air that dries the towels. Then the difference between using an industrial dryer or many commercial dryers was explored. The reason that there is not extensive background on the tumble dryer from North America is that dryers in North America do not vary greatly on efficiency as the cost to purchase an efficient dryer is much higher than a normal dryer and energy prices do not yet warrant that market

change. Hopefully within the next couple of years more efficient dryers produced in North America will be available.

2.3 CLEANING PRODUCTS

Research on cleaning products was done on the internet which provided an easy access to company websites to compare product features amongst competitors. Research was focused solely on biodegradable soaps and detergents in case of an accidental leak in the system that would allow water containing the detergent to leach into the ground. Distance in shipping and availability in bulk industrial size quantities were the leading factors in calculating the best choice of detergents.

3.0 ASSUMPTIONS

Assumptions were used throughout the course of the project to be able to narrow the scope of the project. The assumptions made for each subsection are listed below.

3.1 WASHER

For initial research of the clothes washer an assumption needed to be made on the approximate size or cuft capacity required for the laundry service. The following steps were assumed to achieve an approximate washer capacity of 15.5cuft. As a note this was for initial research only and didn't take into consideration any new bike riders that UBC might attract.

- In 2008, 800 people travelled to UBC by Bicycle (assumed the same for 2009) (http://www.trek.ubc.ca/research/status/TSR_Fall2008_6Feb09.pdf)
- Assumed 75% of those 800 will use the showers provided by the new SUB and use one towel each
- Assumed that on average 17 towels will fit into a 3.5cuft clothes washer (http://www.washing-machine-wizard.com/sears-kenmore-washing-machine.html)
- Assumed an 8hr/day work period, with capacity to perform 8 loads per day.

$$\frac{(800 * 0.75) towels}{8 loads\ per day} * \frac{3.5 cuft}{17 towels} = \mathbf{15.5 cuft\ capacity}$$

3.2 DRYER

For the dryer the assumptions made were that the weather outside did not affect the decision to use a vented or closed system. This is due to the fact that if the weather was cold during the operation of the dryer it would not be wasting any heat as it would simply be acting as an extra heater in the building while in the summer the heater would add a heating load to the building. Another assumption was that the number of students that biked every year and every month is independent of the time of year. The towels are assumed to weigh one kg each. Another assumption is that shipping a dryer from Europe to Canada costs 2000 dollars. The final assumption is that the cost of an action (manufacturing, shipping) is directly transferable to its energy cost which is assumed seven cents per KWH.

3.3 CLEANING PRODUCTS

For chemical cleaning products an assumption was based on the information of detergent used per load. Websites gave an estimate of a certain amount of ounces a load, but did not specify if the size of the load was regular household size or industrial size washers. Assumptions will be made that the amounts given of ounces per load will be the same amount of ounces used per load in the size of our washers.

4.0 EVALUATION CRITERIA

A list of each evaluation criterion and why they were chosen to determine the best appliance/product for each sub function is discussed below.

4.1 WASHER

After the initial research was completed a list of 17 possible washers was created, shown in Figure 1: *Initial List of Clothes Washer Options*. The top seven choices are commercial products and the remaining are household appliances. The Unimac products were removed from the list prior to rankings because they are really expensive, not sustainable and too large for the services required by the SUB. The remaining models highlighted in blue were removed as they were the five least efficient appliances. The un-highlighted models were evaluated against criteria produced from research and functional requirements.

Option #	Company	Model #	Type
1	Unimac	UX100	Frontload
2	Unimac	UX75	Frontload
3	Unimac	UX55	Frontload
4	Unimac	UX35	Frontload
5	Unimac	UX25	Frontload
6	Maytag	MVWB850WR	Topload
7	Maytag	MAH22PRAWW	Frontload
8	Whirlpool	WTW6500WW	Topload
9	Whirlpool	WFW9450WR	Frontload
10	Whirlpool	GCAM2792TQ	Topload
11	Kenmore	47531	Frontload
12	Bosch	WFMC8440UC	Frontload
13	GE	GBVH5200J	Frontload
14	GE	WPDH8900JMV	Frontload
15	LG	WM2901HVA	Frontload
16	LG	WM3001HRA	Frontload
17	Frigidaire	FAFW3577KR	Frontload

Figure 1: Initial List of Clothes Washer Options

The evaluation criteria that the team found important to determine the best possible washer are;

Loads/day-An assumption was made earlier that the capacity required would be 15.5cuft. This number was used to determine how many loads/day each washer would require, the less loads required the better.

MEF-This ranking shows how many cubic feet of laundry can be performed with one kWh of electricity. The higher the number the more efficiently run machine.

WF-This ranking is how many gallons are required for each cubic foot of laundry. The lower the number the less water consumed and the higher the efficiency.

Speed (RPM)-A higher rotation speed is ideal; as more water will be removed from the towels and less drying will be required.

Programming-The more features/programs the washer has the higher the efficiency. If the appliance can perform under different temperature settings and adjust to different load sizes the less energy and water wasted.

Price-The cost of the appliance is a requirement from the client. A reasonably priced washer for the requirements required is desired.

Distance to UBC-The distance travelled from the manufacturing facility to UBC is really important in terms of creating a low carbon footprint. The lower km's the smaller carbon footprint.

4.2 DRYER

After the initial research three types of dryers were selected this includes: an efficient tumble dryer which could be found in North America, a condenser dryer that can be found in Europe, and an industrial dryer. The evaluation criteria that has been used in the dryer section are that the dryer must be manageable and have the lowest energy cost from its start life moving to shipping and finishing with the operation cost of twelve years as the life cycle of an average dryer is approx 12 years. To find these the purchase costs of each product was assessed as well as the excess travel costs and finally the operating costs. The number of dryers necessary to accommodate the volume of towels must also be manageable as work hour's increase with the greater number of required loads.

4.3 CLEANING PRODUCTS

After gathering information on a handful of products they were narrowed down to the top three seen here in Figure 2: *Top 3 Cleaning Products*. If the product was not biodegradable it was thrown out right away as biodegradable cleaners minimize the harm to environment, and degrade over time if they are accidentally released into the earth. The next criterion to remove options was if the product was able to be shipped in larger amounts to the SUB. This would help reduce the amount of containers needed to hold the materials which will reduce the impact of chemical products on the carbon footprint of this project. Price per amount was taken into account, and any unreasonable prices resulted in the product being taken off the list. Solvents that were cheaper per quantity if bought in bulk were put at the top of the list. Lastly, the distance travelled by the products to get to UBC from their manufacturer was roughly calculated. This factor wasn't weighted that much into the ranking because if companies a little further away were willing to ship more volume of content at one time, it would be more beneficial than having multiple trips being taken to allocate the same amount of product from another manufacturer.

	Bio-Degradable?	Size of Container	Loads per container size	Price for Container (USD)	Shipped from
LD-Z Bioenzymatic	Yes	30 gallon	1740	$478.50	Illinois, USA
BioKleen	Yes	5 gallon	1280	$93.75	Michigan, USA
Charlie's Soap	Yes	5 gallon	1280	$150	North Carolina, USA

Figure 2: Top 3 Cleaning Products

5.0 CONCEPT SELECTIONS

Several choices for each sub function were evaluated against the evaluation criteria from Section 4.0. The winnowing process for the washer, dryer, and cleaning products is explained below.

5.1 WASHER

The evaluation criteria were put into a table and weighted with what the team felt their importance deserved. This table is called a weighted decision matrix and can be seen in Figure 3: Weighted Decision Matrix for Clothes Washers. The more sustainable criteria like the MEF, WF, and distance to UBC were weighted the highest around 22-23%. The capacity, speeds, programming and price were all ranked about the same 5-10%. Each model was ranked against each other based on the data tabulated in Appendix A. The top model in each category received a 7, second best a 6, and so forth until the last model got a 1. In the event of a tie each model received the same number. As can be seen In Figure 3: *Weighted Decision Matrix for Clothes Washers*, the top choice is the LG-model WM2901HVA. This appliance will be discussed fully in the final recommendation section.

		Maytag	Whirlpool	Whirlpool	GE	LG	LG	Frigidaire
	Weighted %	MVWB850WR	WTW6500WW	WFW9450WR	WPDH8900JMV	WM2901HVA	WM3001HRA	FAFW3577KR
Loads/day	10	7	7	3	2	5	5	1
MEF	23	2	3	5	1	7	6	4
WF	23	1	2	5	3	7	7	5
Speeds (RPM)	8	3	3	7	7	4	7	3
Programming	5	7	7	5	1	5	2	5
Price	9	5	7	4	2	3	1	6
Distance to UBC	22	6	6	6	7	3	3	1
Total	100	375	439	509	345	522	490	342
Final Ranking		5	4	2	6	1	3	7

Figure 3: Weighted Decision Matrix for Clothes Washers

5.2 DRYER

Concept selection was based on the evaluation criteria. The following table, Figure 4: *Energy lifecycle* indicates the energy entered into each process and the total energy over 12 years. It also indicates the number of dryers required to keep up with the volume of towels.

	Cost (Dollars)	Energy from cost (KWH)	Shipping cost (Dollars)	Shipping Energy (KWH)	Energy to operate (KWH/kg)	Twelve Year Operation	Total over twelve years (KWH)
Samsung Dryer*27	21600	308571	10800	154286	0.732	1.29E+06	1.75E+06
Lavatherm T57800 Condenser Dryer*30	42000	600000	36000	514286	0.333	5.88E+05	1.70E+06
AD-464 Industrial Dryer*1	not listed	Unknown	1000	14286	9517	1.68E+10	1.68E+10

Figure 4: Energy lifecycle

This Figure indicates that while only one Industrial size dryer is required it is massively inefficient compared to other products. The difference between the tumble dryer and Lavatherm condenser is small. The deciding factor was that Lavatherm has an environmentally friendly manufacturer and it is unclear as to where the manufacturer of the dryer is situated. So based on this information the Lavatherm condenser dryer was chosen because even though it is an international company the increased efficiency offsets that.

5.3 CLEANING PRODUCTS

The selection of the teams choice for laundry detergent was weighted based on factors the team found to be most important to sustainability. The weighted decision matrix can be seen in Figure 5: *Weighted Decision Matrix for Cleaning Products* and the lower the total the better. Weighted most was the product being biodegradable. Second was the amount of usage we got from a product. If one gallon only lasted for 10 loads, it wasn't very efficient or worth it to buy. Products that gave a reasonable amount of loads were favored. Followed, was the amount of quantity that one could purchase, the number of containers it came in, and the price per amount of quantity. If two products came in thirty gallons, but one came in one container, and the other product came in thirty one gallon containers, the product that came in one big container was chosen. This was because it has fewer parts that can't be recycled, for example thirty bottle caps, compared to one cap. Lastly, distance was taken into affect. As long as it was from North America, it wasn't too big of a deal where exactly it came from. Avoiding oversea travel was a factor the group took into consideration as those modes of

transportation are costly and harmful to the environment. This last point was also a bit hard to take into perspective based on the amount of product shipped from that general location. The group didn't mind going a little further from UBC if it could yield more product for a cheaper price and a bigger quantity in one shipment, overall cutting down on the total amount of distance needed to be travelled throughout the lifetime of this project. After weighting everything out, the team decided to choose Natural Formulations LD-Z Bio-Enzymatic Natural Laundry Detergent which will be discussed more in a later section.

	Weighted	LD-Z Bioenzymatic	BioKleen	Charlie's Soap
Bio-Degradable?	50%	1	1	1
Size of Container	15%	1	2	2
Loads per container size	10%	2	1	1
Price for Container (USD)	10%	1	2	3
Shipped from	15%	1	2	3
Total Weight	100	110	140	165

Figure 5: Weighted Decision Matrix for Cleaning Products

6.0 FINAL RECOMMENDATIONS

The final choices for the washer, dryer and cleaning products are discussed in detail in the following section.

6.1 WASHER

The washing machine recommended by the project team is the LG model WM2901HVA and can be seen in Figure 6: *LG Clothes Washer Model WM2901HVA*. Five of these appliances will be required to ensure all towels are washed daily, assuming that there are 934 people/day using the laundry service. More information into the amount of people using the service is discussed in Appendix B: *10 Year Payback Period*.

Figure 6: LG Clothes Washer Model WM2901HVA

Of the units researched, this particular appliance is the most efficient in water and energy usage, the actual data for the washer can be seen in Appendix A. LG's manufacturing plant for washers is in Englewood Cliff, NJ, USA, thus resulting in a low carbon footprint compared to products from other continents. Its price at Sears near UBC on 41st Ave is $1599cdn.This is a very reasonable price as it has many features not considered in the previous research that make it even more appealing. Features such as; multiple temperature settings, multiple program settings, and TrueBalance™ anti-vibration system. One of the main selling points on this particular appliance is its wash/rinse cycle where it automatically adjusts the cycle length with regards to water hardness and detergent levels. Another important aspect to

the washer is the TrueSteam™ Technology created by LG. This technology generates steam to reduce wrinkles and more importantly odors. More can be learnt on this innovative technology by searching http://ca.lge.com/truesteam/. LG as of January 5, 2009 has partnered with Waste Management Inc. to create a Recycling Program. This free program provides LG's consumers with an easy way to recycle their products once they are no longer required.

6.2 DRYER

Due to the current price of energy being so low in North America the market still has not moved over to more expensive higher efficiency models of dryers. In Europe however new dryers are being developed to incorporate a higher efficiency. Hopefully in a couple of years a manufacturer in North America will find that consumers are willing to pay that extra dollar and more efficient dryers will be produced in North America. In lieu of that time the team has chosen the Lavatherm T57800 condenser dryer for its energy efficiency over the other products, as seen in Figure 7: *Lavatherm T57800 Condenser Dryer*. Although this product is made internationally it is made by a responsible manufacturer and with a lifecycle of 10 years it will regain the energy used in the transportation process.

Figure 7: Lavatherm T57800 Condenser Dryer

To successfully manage the amount of drying required 30 dryers would need to be purchased. The price of each dryer is $1200. Other products that held interest were some steam heated dryers except these were very inefficient at the drying process. Using approximately the same energy as the gas industrial dryer which was several thousand times the smaller models. Pending the introduction of these more

efficient dryers making their way to Canadian manufacturers the team finds this one to use the least energy in the overall course of its life.

6.3 CLEANING PRODUCTS

The cleaning product chosen by the team was the Natural Formulations LD-Z Bio-Enzymatic Natural Laundry Detergent, a smaller sample can be seen below in Figure 8: *Bio-Enzymatic Natural Laundry Detergent*.

Figure 8: Bio-Enzymatic Natural Laundry Detergent

This product stood out compared to the rest due to the manufacturer being able to ship a large quantity for a discounted price. Natural Formulations has container drums of 30 gallon volumes for a price of $478.50USD a container. The website of the manufacturer, also allows shipment orders for multiple 30 gallon drums, which would allow UBC to stock up on supplies for a given amount of time at once. This will significantly reduce the carbon footprint of the chemicals. Orders for this product from the website are shipped directly from the manufacturer whom is located in Skokie, Illinois in the Unites States of America. Having a company that is not overseas in another continent is beneficial as the cleaner does not have to travel a long distance to get to UBC.

Natural Formulations detergent is also biodegradable which will help keep negative impacts to the environment to a minimum. The product also stood out due to the amount of usage per load; Natural Formulations recommends at most using 2 ounces a load. With the purchase of a 30 gallon drum, each drum is therefore able to provide UBC with a usage of 1920 loads per 30 gallon drum. This means that if UBC purchases these 30 gallon drums in a large quantity from the supplier, UBC may not have to buy from the supplier that frequently, helping ease the payback period time slightly.

6.4 TEN YEAR PAYBACK PERIOD

After each function was satisfied with the best possible product more in depth calculations were done to ensure the laundry services would be paid back within 10 years. The assumptions made, and the steps to perform this calculation are shown in Appendix B. The result from the calculation was that 334 people need to change their transportation method of either bussing or driving to campus and start biking. This would result in a total of 934 people using the laundry service. With the assumption made that every new biker to campus will use the laundry facilities the service will be paid back via energy savings in 10 years.

7.0 CONCLUSIONS AND FUTURE RECOMMENDATIONS

By breaking the main function of laundry services into three sub functions of a washer, dryer, and cleaning products the team was able to fully research and evaluate different products. The triple bottom line assessment was considered when choosing evaluation criteria, by not only taking into account the function of the appliances/products but also the impact they have on the economy, environment and society.

The final recommendations for the laundry service are five LG model WM2901HVA, thirty Lavatherm T57800 condenser dryers and Natural Formulations LD-Z Bio-Enzymatic Natural Laundry Detergent. An assessment was completed to find that 343 new bikers to UBC or a total of 943 students, staff or faculty would be requiring the service in order to achieve the requested 10 year payback period.

Before this service is put into effect, more considerations should be taken into the assumptions made throughout the project to assess how reasonable they were and if any further research is warranted. Further research will be needed once the trend for sustainability and efficiency has been integrated into the dryers, as currently there are no highly efficient dryers in North America.

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Appendix A: CLOTHES WASHER DATA

Washer Sustainable Features:

Option #	Company	Model #	Type	Manufactured	Km from Manufactuing Plant to UBC	Energy Consumption (kWh/yr)	MEF (highest)	Water Consumption	WF (lowest)	Energy Rating	Materials
1	Unimac	UX100	Frontload							ARCATGREEN	
2	Unimac	UX75	Frontload							ARCATGREEN	
3	Unimac	UX55	Frontload							ARCATGREEN	
4	Unimac	UX35	Frontload							ARCATGREEN	
5	Unimac	UX25	Frontload							ARCATGREEN	
6	Maytag	MVWB850WR	Topload	ohio, USA	4099km	277	2.25	13-22gal/cycle	4.3	commercial tech, energy star, Tierr III	polypropylene, SS
7	Maytag	MAH22PRAWW	Frontload				2.4		4.4	commercial energy adv., Tier III	porcelain, SS
8	Whirlpool	WTW6500WW	Topload	ohio, USA	4099km	252	2.29	16-21gal/cycle	4.2	energy star, Tierr III	SS, Poly, Painted SS
9	Whirlpool	WFW9450WR	Frontload	ohio, USA	4099km	150	2.46	12-16gal/cycle	3.8	energy star, Tierr III	SS, Poly, Painted SS
10	Whirlpool	GCAM2792TQ	Topload					25.22gal/cycle			
11	Kenmore	47531	Frontload			161	2.58		4	energy star, Tierr III	SS basket, Painted SS
12	Bosch	WFMC8440UC	Frontload			150	2.52	5786gal/yr	4.5	energy star, Tierr III,ecoaction	polypropylene, SS
13	GE	GBVH5200J	Frontload			142	2.22		4	energy star, Tierr III	SS basket
14	GE	WPDH8900JMV	Frontload	Louisville, Kentucky	4018km	191	2.23	10-15gal/cycle	4	energy star, Tierr III	SS, Poly
15	LG	WM2901HVA	Frontload	Englewood Cliff, NJ	4815km	126	2.87	8-19gal/cycle	3.4	energy star, Tierr III, truesteam tech.	SS, Poly, Porcelain
16	LG	WM3001HRA	Frontload	Englewood Cliff, NJ	4815km	126	2.71	8-19gal/cycle	3.4	energy star, Tierr III, truesteam tech.	SS, plastic, painted SS
17	Frigidaire	FAFW3577KR	Frontload	Georgia, USA	4840km	175	2.31	11-17gal.cycle	3.8	energy star, Tierr III	SS, poly

Washer Other Features:

Option #	Company	Model #	Load Capacity	Loads/day	Speeds (RPM)	Temp Range	Programming	Price From Sears Website
1	Unimac	UX100	16.07	1	800			
2	Unimac	UX75	10.74	1	1000			
3	Unimac	UX55	8.26	2	1000			
4	Unimac	UX35	5.83	3	1000			
5	Unimac	UX25	3.35	5	1000			
6	Maytag	MVWB850WR	5	3	1100	5	14cycles	$1,099
7	Maytag	MAH22PRAWW	3.4	5	800			$968
8	Whirlpool	WTW6500WW	5	3	1100	4	14 cycles	$949
9	Whirlpool	WFW9450WR	4.4	4	1300	4	12 cycles	$1,349
10	Whirlpool	GCAM2792TQ	3.2	5	640		8 cycles	
11	Kenmore	47531	3.6	4	1100	3	6 cycles	$639(website)
12	Bosch	WFMC8440UC	4.2	4	1200	3	12 cycles	$1,699
13	GE	GBVH5200J	3.8	4	1000	4	14 cycles	
14	GE	WPDH8900JMV	4.2	4	1300	5	8 cycles	$1,649
15	LG	WM2901HVA	4.5	3	1200	5	12 cycles	$1,599
16	LG	WM3001HRA	4.5	3	1300	5	9 cycles	$1,899
17	Frigidaire	FAFW3577KR	3.5	4	1100	5	12 cycles	$999

Appendix B: TEN YEAR PAYBACK PERIOD

The assumptions made to find the payback period were that 75% of the 800 people that UBC trek says bike to UBC will use these showers. That 50% of the people who choose to bike will come from driving a car and 50% from taking the bus. The average distance that bikers will come from is 10 km. Purchase and shipping costs can be turned into energy costs by the cost of energy today (7 cents/KWH). The energy used by a biker is 200W and the velocity is 24km/hr. A car uses 0.1 l/km and the energy consumption of a person riding the bus is 5 times that of a biker, but a seventh of a person driving a car. Bikers bike every day that they travel to the university which will be for two semesters. Finally a lifetime of the washer and dryer of ten years was used. This estimate does not take into account possible saved washing at the bikers own home nor does it take into account the cost of producing a vehicle to drive in. The energy required for the product per use was based on its cost per load. The energy for the washing and drying cycles were based off of tested values.

The equation utilized was a basic balance equation used to find the number of people necessary to switch over to biking to make the initial energy cost of making and moving the washer and dryer.

U is the number of uses. C is the energy per trip used by a car. B is the energy per trip used by a bus. I is the initial energy investment of the washer and dryer. E is the energy used per trip by the washer dryer and product (per towel). Bike is the energy used by a biker. P is the number of people required to switch from driving a car and bus to biking.

$$U(0.5Cp + 0.5Bp) = I + U(Ep + EN + pBike)\ ; \qquad p = \frac{I+UE}{U(0.5C+0.5B-E-Bike)}$$

To find the initial energy investment put into the washer and dryer that have to be overcome by the change in number of bikers, the team estimated the energy to create and ship the products using the cost and shipping of the products. This number was then multiplied by the number of washers or dryers required and combined to make the initial energy investment.

To find the number of uses the number of trips made in ten years to the university by a student who goes 5 days a week for two semesters was estimated. The number of initial users was estimated at 800 users by UBC trek. The energy for a biker was estimated from the average energy output of a biker and from the average velocity of a biker. The car estimate came from a normal vehicles km/l value and the chemical energy contained in gasoline.