UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

An Investigation Into Sustainable Laundry Services For The New UBC Student Union Building

Duncan Currie

Sam Mason

Erik Roy

Erica Wodzak

University of British Columbia

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AN INVESTIGATION INTO SUSTAINABLE LAUNDRY SERVICES FOR THE NEW UBC STUDENT UNION BUILDING

Duncan Currie

Sam Mason

Erik Roy

Erica Wodzak

APSC 261: Technology & Society

Instructor: Dr. P. Dawn Mills

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Abstract

A laundry facility to accompany showers for bicycle commuters has been proposed for the new SUB. This report analyzes equipment options for such a laundry facility. The maximum load of such a laundry facility is estimated to be roughly 275 pounds of towels per day.

The washing machine is selected such that it is just big enough for only one machine to be needed. This gives a machine capacity of roughly 30 pounds. A comparison of several industry models of commercial washing machines showed the Speed Queen SP30 model to have favourable energy efficiency and water use characteristics. Social and economic factors are believed to have less impact on product selection than environmental considerations. Thus the Speed Queen was chosen.

For drying towels in the new SUB, two methods are considered. First, use of a conventional clothes dryer is proposed. A comparison of three typical dryer sizes reveals that all dryers operate at about the same efficiency. In addition it is observed that dryers are inherently inefficient and it is in the best interest of the new SUB committee to seek an alternative. In addition to dryer inefficiencies, greenhouse gas emissions are a concern. The proposed alternative is a heat recycling natural convection dryer. This device uses heat from electrical resistance heaters in a duct to dry linens and offers greater efficiencies as well as a reduced carbon footprint. Further, heat from the UBC steam utilities can be used as an energy source.

To reduce the environmental impact of the facility, several cleaning detergents were compared. It is recommended that an eco-friendly detergent such as the one produced by Seventh Generation is a readily available and viable option.

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Glossary

Borax: A compound of boron used in detergents and cosmetics.

Electrical Resistance Heater: An appliance used to convert electrical energy into heat

Free Convection: A mode of heat transfer caused by the movement of air particles during heating due to a reduction in density with an increase in temperature.

Forced Convection: A mode of heat transfer caused by the movement of air particles during heating due to an external force such as a fan.

Hard-Mount: Washing machines that must be mounted on the bottom, concrete floor of a building. Typically less expensive than soft-mount machines.

Modified Energy Factor (MEF): A measure of a machines efficiency based on a formula that includes volumetric capacity, electrical energy required, hot water energy required, and the energy required to remove left-over water from the the materials that leave the machine. For further information see the Energy Star website (Energy Star).

Soft-Mount: Washing machines that can be mounted on non-concrete floors, for example on the second floor of a building.

Steam-to-air Heat Exchanger: A device which transfers energy in the form of heat from a high temperature water vapour stream to a lower temperature air stream.

Water Factor (WF): A measure of the water use of a machine. Calculated using volumetric capacity and water use per cycle. For further information see the Energy Star website (Energy Star).

1.0 Introduction

Commuting via bicycle has many benefits. It promotes personal health, has a far reduced environmental impact compared to a car, and allows for a more pleasant and less polluted campus environment. In the interest of promoting bicycle commuting a laundry service for the new SUB has been proposed. The idea is that having showers with towels made available will remove an obstacle for people to switch to bicycle commuting. That is, commuters would be able to have a shower but not have to carry around a wet towel all day.

To that end it is desired to analyze and understand what products should be considered for use in such a facility. Using triple bottom line assessment this report will compare various options for such a laundry service.

2.0 System Load Estimation

The load calculation for the system is estimated in order to determine to the size of equipment necessary. This was based on determining the current proportion of campus residents that currently bike to school, estimating an increase in this amount that would occur due to the implementation of laundry services, and accounting for the growth of the university over the lifespan of the machinery. This results in a needed load of roughly 275 pounds of laundry per day. This was calculated as a conservative value; for details on this calculation please see Appendix A.

3.0 Washing Machine Specification

In specifying a washing machine there are many things to consider. First is what *type* of machine to purchase. There are both household and commercial machines available. As a simplification it was assumed that the more durable construction and designed-for heavier use of the commercial washers would result in a significantly longer lifespan and that this longer lifespan would outweigh the increased production energy required for a commercial washer compared to a household washer.

Having chosen to focus on commercial washers it was necessary to determine what *size* of commercial washer is necessary. These are typically available in sizes ranging from 20 to 165 lb (Speed Queen 1). Figure 1 below illustrates production, transport, and disposal energy vs. washer capacity.

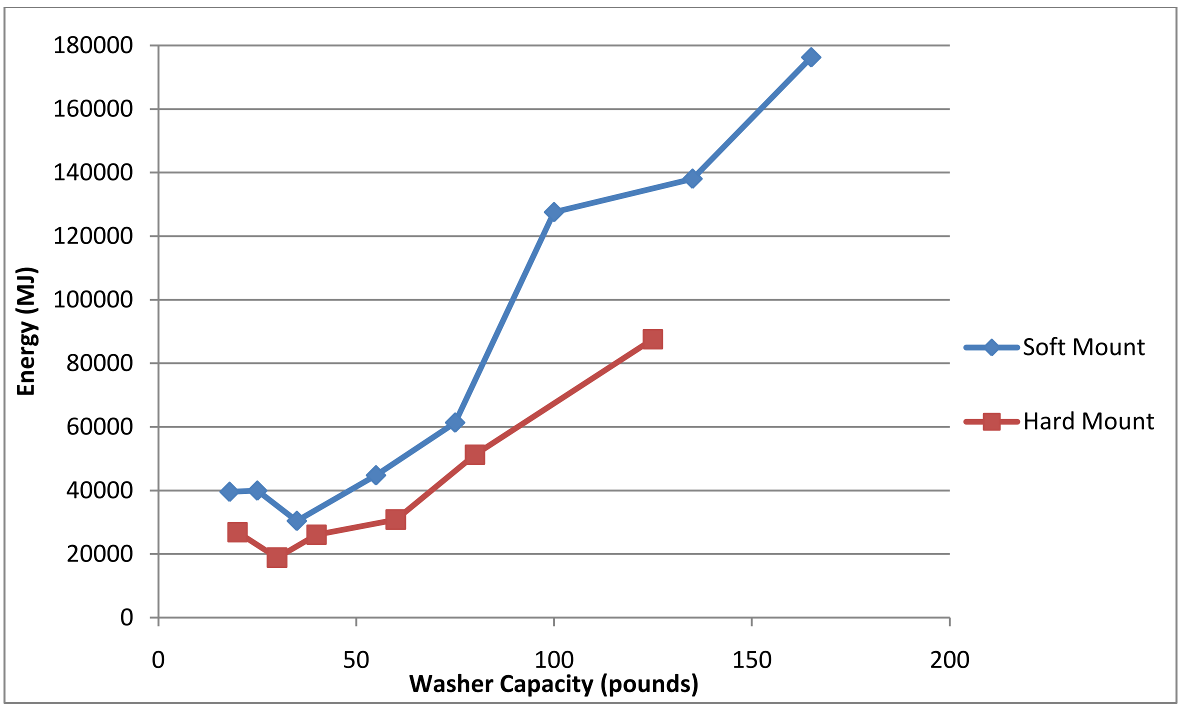

Figure 1 - Production, Transport, Disposal Energy vs. Washer Capacity

Figure 1 is derived from several sources. The information used was taken from Speed Queen's line of commercial washers (Speed Queen 1). Data on the overhead (that is, production and transportation) and lifecycle (disposal) energy costs of a washer weighing a given amount is available from Wattzon and was scaled up based on the weight of Speed Queen's machines (Wattzon). Hard and soft mount are defined in the glossary. The graph shows a dip in overhead energy after a certain capacity. This is because if the machines are too small then two or more are required to meet the daily needs of the facility. Thus it can be determined that the minimum size such that only one machine is needed is ideal. This corresponds to a machine capacity of roughly 30 pounds. Furthermore, hard mount machines are less expensive and less complex and will thus be chosen; the laundry facility must therefore be located on the bottom floor of the new building (Speed Queen 2).

For a specific comparison, several models from prominent brands are analyzed. The brands and models are listed in Appendix B. These machines are all assumed to have similar overhead and lifecycle costs as specified by Wattzon. Lifetime energy use due to the actual *use* of the machine is calculated in Appendix B. This and overhead/lifecycle energy costs are shown in Figure 2.

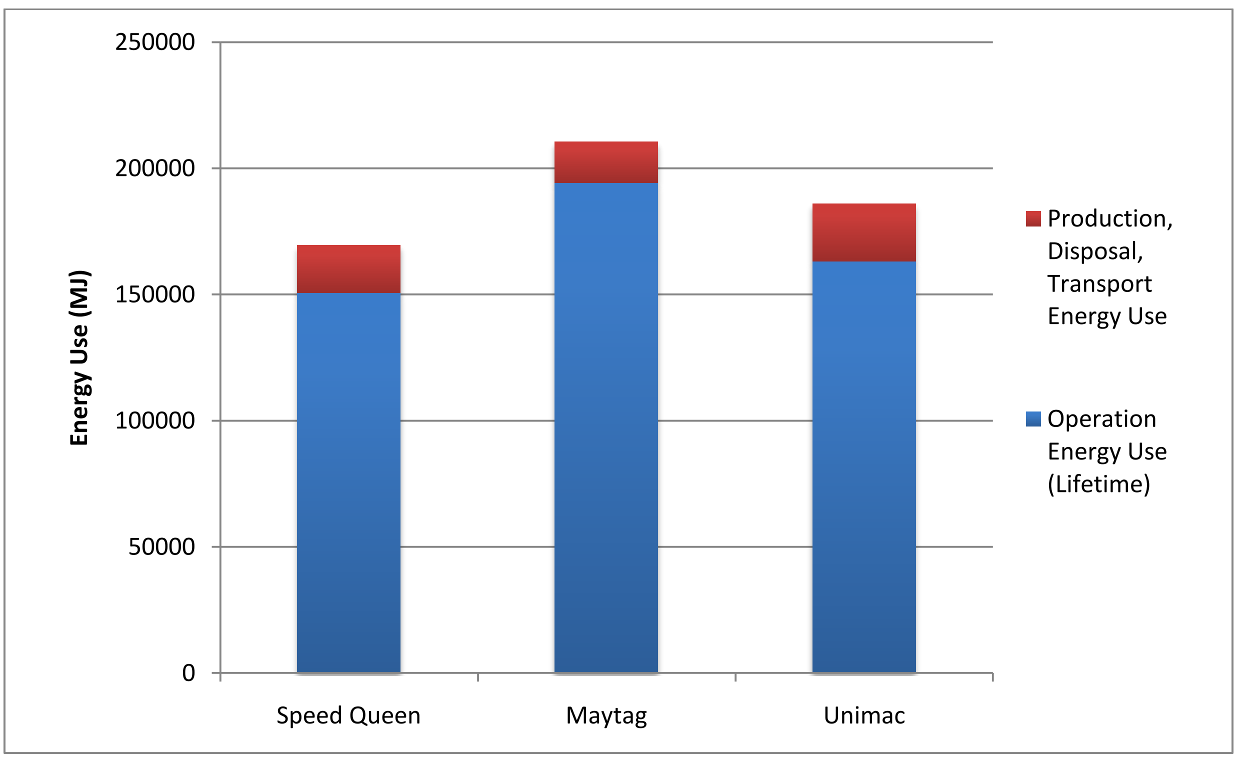

Figure 2 - Lifetime Energy Use of Selected Machines

A further environmental impact of a washing machine to consider is water consumption. This is also calculated for each machine in Appendix B and shown graphically in Figure 3.

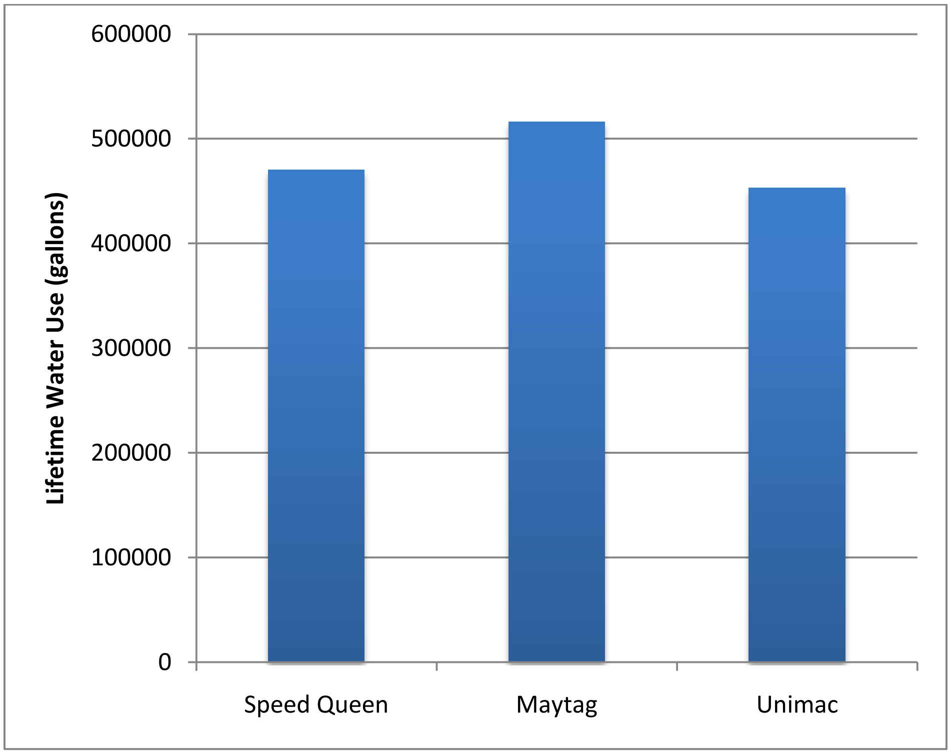

Figure 3 - Lifetime Water Use of Selected Models

Again, the production of both of these graphs is outlined in Appendix B.

Having assessed the environmental impact of washing machine selection it is necessary to assess the social impact of washing machine selection. Although it is hard to quantify or even qualify the impacts of these respective machines, it is reasonable to suggest that their impacts are difficult to differentiate. None of the companies in question have human rights issues and these machines are necessarily manufactured in modern, North American facilities requiring skilled (and therefore well-paid) labour. In North America washing machines are also tested by various government agencies to assure the safety of the user. Furthermore, each will require roughly the same amount of operator input and they are, again, difficult to differentiate from an "employment opportunities supplied" standpoint.

The economics of these washing machines, however important, is difficult to determine. Vendors of commercial washers typically do not advertise or make available prices without direct contact with the company. Based on the price of residential washers it is probable that these machines will cost on the order of $1000-$2000 dollars. Given the difficulty of ascertaining the actual price of these machines and the probability that their prices will not significantly vary, the problem has been (unfortunately but necessarily) simplified by assuming that the initial cost of the machines will not significantly vary from brand to brand (given that all models are high efficiency models of similar performance).

Given these three analyses, it is reasonable at this point to recommend the Speed Queen SC30 commercial washer. Although its water use is somewhat higher than that of the Unimac model, this is made up for by its superior energy use. In a place such as Vancouver where water is abundant, it is reasonable to suggest that energy should be given higher priority.

4.0 Drying Methods

Previously, it was estimated that the laundry services in the new SUB will require the capacity to clean and dry 360 towels per school day. Outside of school days, it is estimated that the capacity is reduced by one quarter. This means that in one calendar year, the laundry services must be able to handle an equivalent of 160 peak capacity days in which 360 towels are washed and dried. This equates to 57 600 towels per year! What follows is the comparison of two drying methods: the conventional commercial dryer, and a heat recycling natural convection dryer. Each is evaluated based on its associated environmental, economic, and social impacts to determine the most appropriate choice for the new SUB.

4.1 Commercial Dryer

Excluding the refrigerator, the clothes dryer is the largest energy consumer of all household appliances (CEE). Currently in North America, the tumble dryer is the only type of clothes dryer on the market. Residential and commercial dryers are essentially the same, the only key difference being that commercial dryers are larger capacity. Capacities of the largest residential units are around 7 – 7.5 cubic feet (or roughly 200 L) while commercial units can be as large as 1500 L. Tumble dryers use either a gas or electric heating element combined with a fan to force hot air over damp clothing contained in a rotating drum. Since the mode of heat transfer in all cases is forced air convection, energy consumption is roughly the same for all dryers (CEE).

The energy efficiency of a dryer is quantified using an energy factor (CEC). The energy factor is measured in kilograms of clothing per kilowatt-hour of electricity. In Canada, only dryers with electric heating elements are required to have an energy factor rating. Further, all the dryers have the same minimum rating of 1.4 kg/kWh. For gas dryers there is no rating (NRC). In the United States gas dryers have an energy factor but the minimum rating is less than that for electric units (CEC). Since all dryers are rated the same from an efficiency standpoint, “clothes dryers are not part of an ENERGY STAR program” (CEE, 2006). As such, the Consortium for Energy Efficiency (CEE) does not require dryers to be tested and thus does not certify dryer efficiencies (CEE). If all dryers are basically the same, and inherently inefficient, how can an environmentally conscious consumer make an informed purchase?

Despite a lack of energy ratings, there are ways in which dryers can be differentiated from one another in terms of energy consumption. Although gas dryers don’t have efficiency ratings, they are slightly more efficient than their electric counterparts. Additionally, dryers which utilize moisture sensors to sense when clothes are dry will have shorter drying times and thus will reduce energy consumption by roughly 5 percent (CEE).

Table 1: Emerging Clothes Dryer Technologies

Technology	Efficiency Compared To Conventional Dryer	Drying Time Compared To Conventional Dryer	Barriers to Production
Modulating Gas Dryer	25-30% Increase	30-40% Decrease	Unknown
Heat Pump Dryer	up to 60% Increase	Significantly Higher	Expensive Long Dry Times
Microwave Dryer	25% Increase	25% Decrease	Technological Issues Metal on clothing

(Source: Consortium for Energy Efficiency. (2006). *Potential for an Energy-Efficient Residential Clothes Dryer*. Retrieved October 20, 2009, from http://www.cee1.org/cee/mtg/01-07ppt/eaton2.pdf)

Although the current market is limited to the conventional tumble dryer, there are emerging technologies that have the potential to greatly improve dryer efficiency. If a conventional dryer was purchased for the new SUB, it is likely that a microwave or heat pump unit would be available on the market when it comes time for replacement. Table 1 shows some emerging clothes dryer technologies.

4.1.1 Environmental Assessment

The clothes dryer is an energy-intensive appliance, both in use and in overall lifecycle. Table 2 shows an estimate of the embodied energy of a typical residential clothes dryer.

Table 2: Embodied Energy of a Clothes Dryer

	Mass (kg)	Embodied Energy (MJ)
Raw Materials	70	3828.1
Steel	56	2447.2
Plastic	4.9	490
Other	4.2	420
Aluminum	2.1	388.4
Glass	2.1	46.2
Paint	0.7	36.3
Manufacturing		1456
Transportation (13,904 km)		243.3
Use		51188
Disposal		6.3
Total	**70**	**56722.1**

(Source: Wattz-On. (2009). *Embodied Energy Database.* Retrieved November 15, 2009, from http://www.wattzon.com/stuff)

The embodied energy shown in Table 2 is an estimate of the total energy required for the manufacture of the dryer including raw materials, manufacturing processes, and required transportation along with the energy needed for its disposal.

Average greenhouse gas (GHG) emissions for clothes dryers are estimated at 2 kg of CO_2 per drying cycle (ECO FX). Based on 360 towels per day, with an average of 9 towels per load for a residential dryer (see section 1.1.2 for details), 40 loads per day are required for 160 peak days per year. This equates to an alarming 12,800 kg of CO_2 per year!

4.1.2 Economic Assessment

To quantify the total cost of a dryer throughout its life cycle, three configurations are compared. First, the feasibility of residential dryers is considered. A typical electric dryer and gas dryer for home use are analyzed. These units are then compared to a large capacity industrial gas unit. Table 3 shows an overview of the analysis.

Table 3: Dryer Life Cycle Analysis

Dryer Type	**Residential Electric**	**Residential Gas**	**Industrial Gas**
Manufacturer/Model	GE / UPVH880E	GE / DNCD450GGWC	Unimac / UT120
Capacity (litres)	212	198	1021
Estimated Purchase Price	$900	$1,000	$6,000
Estimated Maintenance Costs	$800	$800	$1,000
Average Load Time (hours)	1	0.8	0.8
Energy Factor (kg/kWh)	1.40	not rated	not rated
Energy Consumed/Load (kWh)	2.20	2.20	38.57
Energy Consumed/Year (kWh)	14219	14219	14219
Energy Cost ($/kWh)	$0.08	$0.08	$0.08
Energy Cost/year	$1,138	$1,138	$1,138
Number of Dryers Required	5	4	1
Average Life Span (years)	18	18	18
Cost to Recycle	$250	$200	$95
Total Life Span Cost	$25,276	$24,467	$26,570

(Source: Natural Resources Canada. (2009). *Buying and Operating Tips: Clothes Dryers.* Retrieved November 14, 2009, from http://oee.nrcan.gc.ca/residential/personal/appliances/clothes-dryers-tips.cfm?attr=4)

The specific dryers analyzed in Table 3 are units which best represent large capacity residential and industrial dryer types. Any dryer of similar capacity and type will produce similar results. Note that the gas units have no energy factor rating. Although gas units are known to operate more efficiently than electric units, no reliable information could be found which quantified this increased efficiency. Also, as mentioned previously, the minimum energy factor for gas dryers in the U.S. is lower than that of electric dryers. Thus, for the purposes of this analysis, the energy factor of all dryers is assumed the same. As a result, energy costs are the same for all three configurations.

The differences between each configuration lie in the drying times and number of units required. Gas dryers have a larger heating capacity and thus shorter drying times. Natural Resources Canada (NRC) provides information used to estimate the capacity of a residential dryer. The average yearly consumption based on 416 drying cycles is 914 kWh for an electric residential dryer (NRC). Given a towel weight of around 0.35 kg (John Lewis), 9-10 towels can be dried per load. Since the drying time for a gas unit is roughly 10 minutes less than the electric dryer, more cycles can occur in a typical 8 hour workday for a laundry worker. As a result, only 4 gas residential units are required as opposed to 5 electric units. Comparatively, a single large capacity industrial dryer will meet all requirements.

The 18 year life span and associated maintenance cost for the electric dryer is determined from NRC data. No data could be found indicating a different average life span for gas units so it is also estimated at 18 years. The cost of recycling the dryers at the end of their life-span is marginally greater for multiple units. Figure 1 below shows a lifecycle cost comparison of the units.

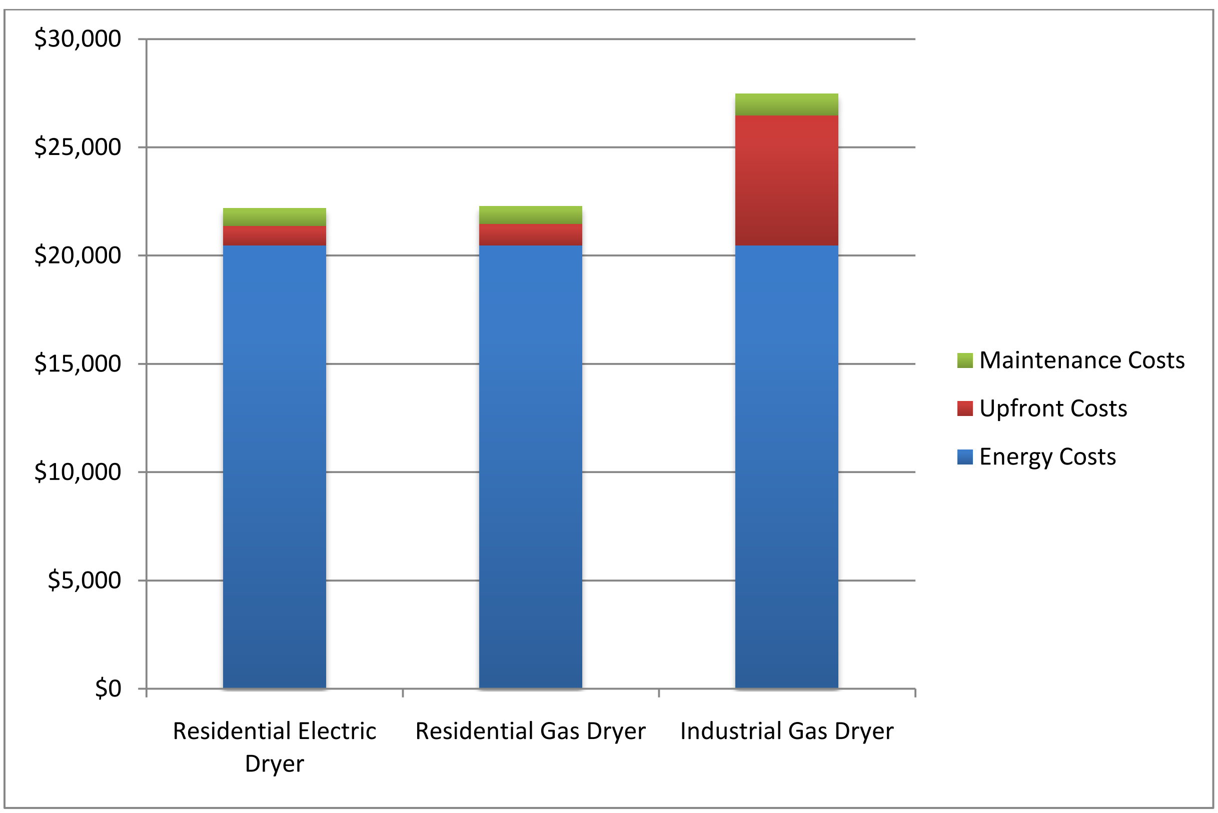

Figure 4: Lifecycle Cost Comparison

(Source: Natural Resources Canada. (2009). *Buying and Operating Tips: Clothes Dryers.* Retrieved November 14, 2009, from http://oee.nrcan.gc.ca/residential/personal/appliances/clothes-dryers-tips.cfm?attr=4)

Examination of Figure 1 shows that the lifecycle costs of the two residential gas dryers are the same, while the industrial unit is slightly more expensive. This is due mainly to the higher purchase price included in the upfront costs. An advantage of the larger unit is that the maintenance costs will likely be lower than actually shown since the hours of operation will be much lower than the residential units which will need to run continuously throughout the workday. Also note that the life-span of the residential units will be less than 18 years since they will be running nearly twice as often as in a typical residential environment. One disadvantage of the industrial dryer is the lack of redundancy a single unit offers should it break down. Nonetheless, it is recommended for use over the residential units for its durability. It should be noted that the provision of natural gas service is a consideration when selecting a gas dryer. Should no gas service be available, smaller electric units are the only option.

4.1.3 Social Assessment

The manufacturers of dryers considered for purchase include General Electric and Unimac. Other similar products are available from Whirlpool, Maytag, and Speed Queen. Each of these manufacturers produces dryers in the United States and have been for many years. There is no reason to believe that any dryer manufacturer violates human rights during production. Such violations would include using parts produced in sweatshops.

The use of a commercial or residential dryer to dry towels in the new SUB has an added benefit of providing job opportunities for students. To operate the laundry facility, a single employee will be required for a daily shift. This position could be designated a work-study position to ensure only students are candidates for employment.

4.2 Heat Recycling Natural Convection Dryer

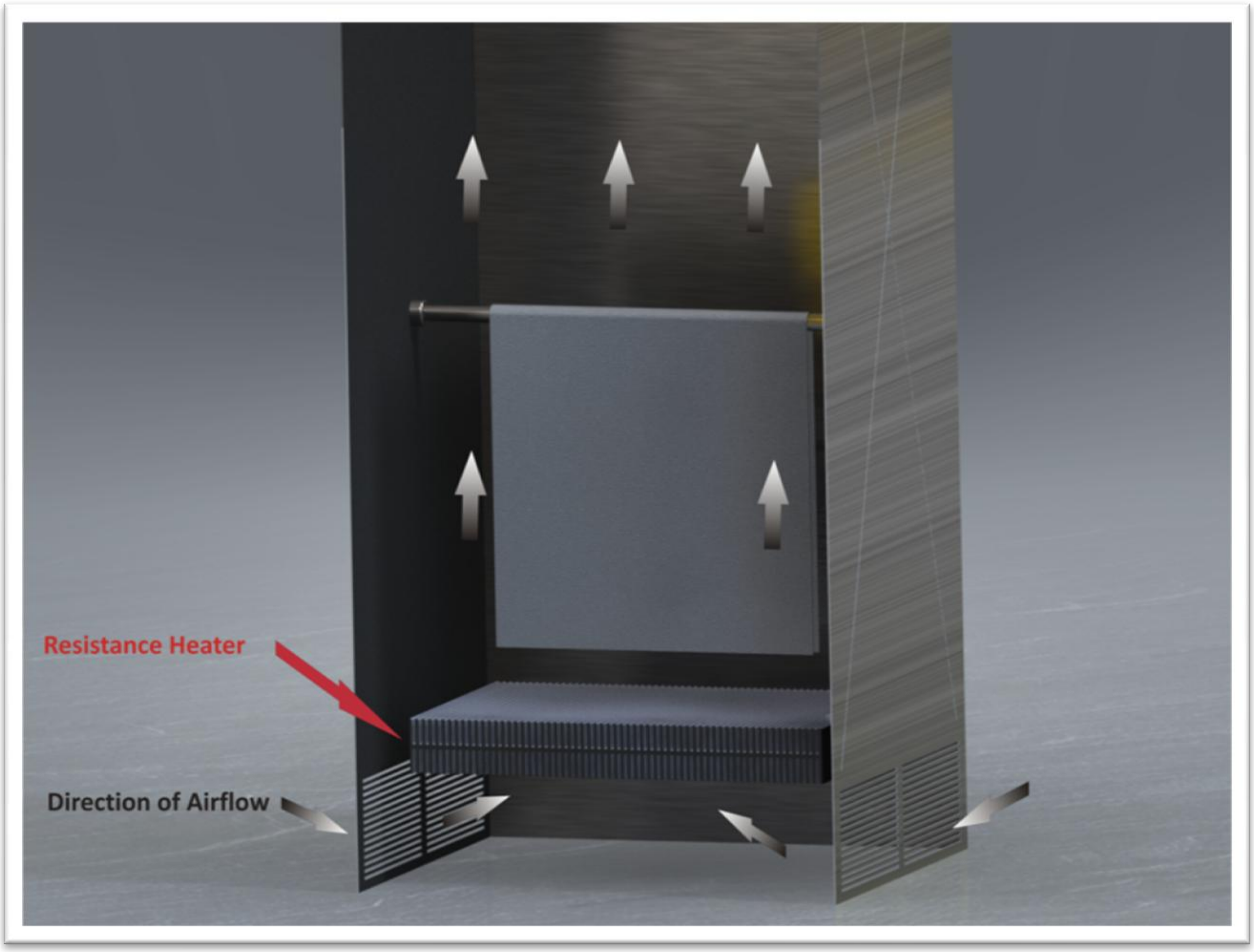

Figure 5: Proposed Heat Recycling Natural Convection Dryer

As previously mentioned, traditional dryers are inherently inefficient. Much of this inefficiency is due to the byproduct heat being rejected into the atmosphere outside the building. Additionally, there is energy being consumed by the dryer in the tumbling action of a traditional dryer. To combat these inefficiencies the following approach is proposed: electrical resistance heaters are used to heat surrounding air, which then is moved up the duct by free convection. This warm air heats the towels, absorbing moisture as it moves past. After heating the towels the air is transferred to other areas of the building to be used as general building heat. There are two energy saving aspects of this approach:

1. The air that dries the towels is naturally drawn up and over the towels by convection, as this air moves upward, fresh cool air is pulled in from vents underneath the ducting, thus eliminating the need to tumble towels.

2. The warm air is not rejected outside the building; it is instead reused to heat the rest of the building. Thus, the energy used to dry the towels is used twice.

This approach takes advantage of the natural tendency of warm air to rise through convection. To be implemented properly, this system would need to be placed in the lowest level of the building, capturing the coolest air in the building and allowing it to rise through the rest of the building.

Some important assumptions of this method are that the entering air is at 20 degrees Celsius and 78% relative humidity. 78% relative humidity is the average level for Vancouver during winter months (BBC). The exiting air is heated to 25 degrees Celsius. The heater will dry a towel in approximately 2 hours and consumes 1215 Watts if running continuously (Refer to Appendix B for detailed calculations).

This option achieves a good triple bottom line status through promoting the social health aspects of cycling, saves money over a traditional dryer by recapturing heat that would normally be wasted and minimizes environmental impact through recycled heat generated by electricity from either solar panels or the hydroelectric grid. As an option, the UBC Steam Utilities could be utilized with a steam-to-air heat exchanger in the place of the electrical resistance heater, to reduce costs. However UBC Steam Utilities generates heat through combustion of natural gas and the carbon footprint of this option may not fit with the goals of the SUB Renewal Project.

5.0 Cleaning Products

When selecting an appropriate laundry detergent to be used in the SUB laundry service, two key concepts must be evaluated: the cost of the detergent, and its environmental impact.

Many of the commonly used detergents on the market today, such as Tide or Gain, have an extremely vague ingredient listing. In some cases no ingredient listing exists. According to SixWise.com, a bottle of laundry detergent will typically list the following as its ingredients:

- Cleaning agents
- Buffering agent
- Stabilizer
- Brightening agent
- Fragrance

Since these ingredient names are extremely vague, it's difficult to know what kinds of chemicals are actually used in detergents (SixWise); though your clothes may smell and feel fresh and clean, they're likely full of toxins and chemicals.

SixWise lists some common laundry detergent ingredients, including Linear Alkyl Sodium Sulfonates (LAS), Petroleum Disillates (aka Napthas), Phenols, Optical Brighteners, Phosphates, Ethylene-Diamino-Tetra-Acetate (EDTA), household bleach, and artificial fragrances. There are many concerns linked to these products, both environmental and relating to the health of those exposed to these compounds. For example, Napthas "have been linked to cancer, lung damage, lung inflammation and damage to mucous membranes" (SixWise, 2009). Optical brighteners, which do not actually affect the cleanliness of clothing, "have been found to be toxic to fish and cause bacterial mutations" (SixWise, 2009). Sodium Hypochlorite, or household bleach, is a highly toxic compound that is linked to more household poisonings than any other chemical (SixWise); furthermore, when it reacts with organics in the environment, it creates carcinogenic and toxic compounds that case reproductive, endocrine and immune system disorders (SixWise).

It is clear that from an environmental perspective, perhaps the generic brand detergents are not necessarily the most eco-friendly and sustainable route to take for the SUB laundry service. The question that remains to be asked is what are the alternatives? It seems that these detergents are so well marketed and widely purchased that any alternatives might be difficult to find/obtain.

Due to the current awareness/trend toward more environmentally friendly household cleaning products, there are a number of options for eco-laundry detergents that claim to clean effectively while eliminating the toxic effects of the run-of-the-mill detergent. Seventh Generation makes a "Natural 2X

Concentrated Laundry Liquid" (Seventh Generation) that contains "a combination of plant-derived cleaning agents and enzymes to power out even the toughest stains" (Seventh Generation, 2009). This product is available in Vancouver, at most local grocery stores, and therefore the environmental impact of product transportation is likely very low. According to LuckyVitamin.com, a 100oz bottle will cost approximately $20 (Lucky Vitamin).

Another environmentally conscious brand of laundry detergent is EnviroRite, who claim to have developed their detergent "by and for people with allergies, asthma and chemical sensitivities" (EnviroRite, 2009). Additionally, EnviroRite claims that their product "contains no hazardous ingredients, phosphates, petroleum distillates, chlorine, perfumes, dyes or animal by-products" (EnviroRite, 2009), as it is a vegetable based product that breaks down quickly and safely (EnviroRite). This product sells in a 64oz container for approximately $15. Unfortunately, as it is an American company that is fairly new, the products are not readily available in Vancouver or Canada at this time.

One final option in the search for an eco-friendly laundry detergent is the „made-at-home' option. This method is not too well known, however those who use this type of detergent seem to be extremely happy with it (Eco Friendly Daily). Typically, powdered detergents are made using a bar of (non-antibacterial) soap, borax and baking soda (EFD). Borax is a chemical compound that is not completely non-toxic, but requires larger doses in order to cause toxic effects (Wise Geek). Though this method would seem to be favourable, the effects of Borax are not 100% positive, and therefore the compound should not be relied on to maintain UBC's "Environmentally Sustainable" name.

In conclusion, using an environmentally friendly, readily available product like Seventh Generation's laundry detergent is the most favourable option for laundry detergent. Despite the minimal cost of the „made-at-home' option, the importance of thorough cleaning of publicly used linens renders it unworkable. In addition, Seventh Generation is a large company and would likely be able to meet the SUB's demands for amounts of detergent required per week or month, and the effects of the product on the environment are proven to be very minimal.

6.0 Conclusion

Our analysis shows that a laundry facility such as the one proposed for the new SUB is certainly feasible. With regards to the washing machine a machine that is as small as possible without requiring multiple machines was chosen. This has the added advantage that should facility use decline, it is possible to continue doing small laundry loads rather than having to do half-full loads on a very large laundry machine. A comparison of several machines suggests that a Speed Queen SP30 is the best option.

The dryer analysis revealed that conventional drying machines are highly inefficient and big energy users. As a result our group chose to analyze an alternative option – a heated chamber in which towels would air-dry. If enough towels are kept in stock such that it is feasible to have the drying process take a longer time then the added time required for this option will not be an issue. The heating for the room could be run off of existing UBC steam utilities and would not have high energy requirements.

For the detergent selection several options were considered. Traditional detergents were found to have too many harmful chemicals. On the other hand, available made-at-home options, while environmentally friendly, were deemed to have too much risk involved, in that publicly used towels should be thoroughly washed. As a compromise a well-established, environmentally friendly detergent was selected despite a slight increase in cost.

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Appendix A: System Load Estimation

Estimating the Daily Washing Load

			Source
Bike trips to UBC per day, 2008	**800.00**	trips	(UBC TREK)
Projected UBC growth	**2.00**	% per year	(see below)
Projected impact of showers	**10.00**	% increase in bike trips	estimate
Percent of cyclists who would use showers	**33.33**	%	estimate
Equipment life-span	**15.00**	years	(CEE 1)
Equipment use at end of life span	**358.90**	users per day	calculated from above
Mass per towel	**0.35**	kg each	calculated from above
	0.76	lb each	calculated from above
Pounds washed per day	**272.88**	lb/day	calculated from above
School days	**124.00**	days	(UBC Student Services)
Non-school days, excl weekends	**136.71**	days	calculated from above
Non school day capacity	**25.00**	%	estimate
Equivalent full days per year	**158.18**	days	calculated from above
Lifetime equivalent full days	**2372.68**	days	calculated from above

University Growth Estimation

Year	Population	% Growth	Year	Population	% Growth
1969/70	22,382	n/a	1987/88	26,054	1.51
1970/71	22,509	0.57	1988/89	26,616	2.16
1971/72	21,198	-5.82	1989/90	27,139	1.96
1972/73	20,583	-2.90	1990/91	28,352	4.47
1973/74	21,358	3.77	1991/92	31,067	9.58
1974/75	23,185	8.55	1992/93	30,949	-0.38
1975/76	23,989	3.47	1993/94	31,615	2.15
1976/77	24,335	1.44	1994/95	31,118	-1.57
1977/78	24,258	-0.32	1995/96	31,331	0.68
1978/79	23,897	-1.49	1996/97	32,464	3.62
1979/80	24,344	1.87	1997/98	33,474	3.11
1980/81	25,194	3.49	1998/99	31,971	-4.49
1981/82	25,194	0.00	1999/00	33,175	3.77
1982/83	25,831	2.53	2000/01	35,382	6.65
1983/84	26,935	4.27	2001/02	38,067	7.59
1984/85	26,219	-2.66	2002/03	39,421	3.56
1985/86	25,933	-1.09	2003/04	41,092	4.24
1986/87	25,666	-1.03	2004/05	42,516	3.47

35 Year Average Growth: 1.91 % **Source:** (UBC Archives)

Approximate this as 2%.

Appendix B: Specific Washer Model Comparison

	Speed Queen	Maytag	Unimac
Model	SC30	MFR30PN	UWN035T3V
Capacity	30	30	35
Weight	496	430	600
Extract G	73.3	100	300
Assumed model	STG*79***	MFR30PD	LTUA7***
MEF	2.16	1.84	2.04
WF	5.2	5.2	4.9
Vol ft^3	4.19	4.6	5
Cycles per full day	9.10	9.10	7.80
Lifetime cycles	21581.69	21581.69	18498.59
Energy per cycle (MJ)	6.98	9.00	8.82
Lifetime energy use (MJ)	150712.11	194235.18	163222.84
Overhead/lifecycle energy use (MJ)	18878.37	16366.33	22836.74
Water Use per Load (gallons)	21.79	23.92	24.50
Lifetime Water Use (gallons)	470221.78	516233.94	453215.41
Source	(Speed Queen 3)	(Maytag)	(UniMac)

Little information was available for the Unimac, thus some reasonable assumptions were made for the machine's weight and volume. Calculations also use data for APPENDIX A. Moving down the above table is the direction in which the calculations proceed.

The Modified Energy Factor (MEF) and Water Factor (WF) data is difficult to obtain. Manufacturers do not readily supply this and the external organizations that tabulate it have information that does not always match model names. Thus data must be assumed to be similar to similar models; this is the "Assumed Model" category. Data shown in blue was obtained from the Consortium for Energy Efficiency (CEE 2).