UBC Aquatic Centre

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

UBC Aquatic Centre

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ABSTRACT

The UBC Aquatic centre is currently spending $400,000 per year in energy costs. The heat is supplied by exchanging heat from hot steam to the pool water. This report will focus on how to increase the efficiency of heating the pool water using steam, as well as suggest an alternative heating approach.

The steam transfers heat to the pool water in a single plate heat exchanger. Adding another heat exchanger will increase the amount of heat transferred to the pool water. Another option is to replace the current heat exchanger with a new double plate heat exchanger. Double plate heat exchangers are known for their increased heat transfer efficiency. This method will reduce the Aquatic centre's yearly energy costs by 14%.

An additional suggestion is to add a dehumidifier to the indoor pool building. About 4500L/day of water evaporates from the surface of the pools, which causes corrosion and mold to damage equipment inside the pool housing. A dehumidifier prevents this by converting the moisture into water, creating a drier air for the indoor pool. There are two large advantages to this: 70% of the water that evaporates could be recycled back into the pool if filtered, and the maintenance cost for the indoor equipment is reduced.

Now, the alternative to the steam heating is using natural gas to heat up the pools' water. There are gas pipelines all around UBC that could be re-routed to the pool. The pool water would be heated in a gas heater, which is quicker and more efficient than steam. We are not causing any environmental harm by doing this because the gas that would normally be used to make the steam at the UBC steam plant would now simply be directly used to heat up the Aquatic centre water. It is more energy efficient, as there is also no transport heat loss that normally occurs when steam is shipped from the steam plant to the pool. The energy cost savings would cover the capital costs of the heaters (approximately $1 million including all installation costs) in just 8 years.

The final conclusion that can be drawn from this analysis is that for short term changes, either a heat exchanger or dehumidifier, or both, should be added to increase heating efficiency. This change would fit the client's current budget. However, in the long run, a gas fired heater should be considered as a new source of heating rather than steam heat exchange.

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INTRODUCTION

The UBC Aquatic centre is made up to two large pools, hot tub and showers. The outdoor pool, which is 54 years old, contains 3 million Litres of water, and the indoor pool, 35 years old, has 6 million L of water. Because of their age, there are a few problems that need to be addressed in the near future. One of those issues is the inefficient heating system. Currently the pool water is heated in a single plate heat exchanger using hot steam from the UBC Steam Plant. This is not a conventional setup for a large pool, but the steam plant is close by; hence, this was the preferred setup at the time of construction.

Unfortunately, the pools are also currently losing almost 60,000 gallons of water per day because of evaporation and leakage. The perfect upgrade for the pools should increase the heating efficiency but also add water to the pool to minimize the need to obtain more municipal water.

The primary short term focus is to improve and increase the efficiency of the current heating technology. The pool water is heated in single plate heat exchanger. To increase the heat transfer efficiency, another heat exchanger could be added in series. However, the cheaper solution is to replace the current heat exchanger with a more efficient type.

An additional idea is to capture the moisture evaporated from the pool’s surface and somehow use it. This water could be filtered and recycled back into the pool.

The secondary focus is on designing a new heating system for the pool. Pools around the country are generally heated by natural gas because it is cheaper and more efficient. The steam that is used to heat the pool is actually produced using natural gas. It would be much more efficient if this gas was used to heat the water directly, as there would be no transport heat loss (which occurs as the steam is shipped from the steam plant to the pools). Therefore, if the piping and heater can be altered to fit the gas heater, it is an excellent alternative. This is a long term solution to the current problems. It will be more expensive to install, but cheaper for long run energy costs.

Steam Heating System

Short Term Solution

PROBLEM DEFINITION

As a facility that consumes a considerable amount of energy, the UBC Aquatic Centre faces the daily challenge of reducing its energy consumption, while maintaining the expected standards of a service provider of the community. Currently, the Aquatic Centre is operating under acceptable conditions; however, further improvements can be made. According to the client, Mr. Lloyd Campbell, the manager of the UBC Aquatic Centre, the facility's main concern is to improve the overall energy efficiency, for its current inability to do so is leading to problems such as the insufficient heating of the showers.

Currently, the UBC pools (both indoors and outdoors) use HEAT$AVR™ as a method to heat up the water in the pools, preventing up 50 to 60% of the evaporation. This harmless fluid consisting of 90% isopropyl alcohol works as an invisible sheet on top of the water, which keeps its heat from escaping. This, however, is not enough. As part of the SEEDS project, a feasible option for the swimming pool to effectively regulate its energy consumption is studied. This alternative includes reusing the steam condensate in the swimming pools as a heat reclaim source. The short term proposal for this project addresses three of UBC's pillars of sustainability: Water, Energy and Financial. Defining the problem lead to the identification of variables such as techniques of heat recovery, costs of the techniques to be implemented and, last but not least, health and liability. More specifically, these included the amine content in the steam condensate at the Aquatic Centre and the one added at the steam plant used to control the PH levels in the returning condensate, and most importantly, the operation of the current heater versus the installation of a new heat recovery system, a double walled plate heat exchanger. To analyze this, a rough estimate of the capital and operation cost is conducted as well as the advantages of the possible implementation ideas over other options are compared, all aiming for a more sustainable facility.

METHODOLOGY

A steam plant uses the energy produced from burning fossil fuels, such as coal, oil and natural gas, to heat water and produce steam. It is this steam which is then carried through a network of pipes to heat buildings.

The aquatic centre at The University of British Columbia heavily relies on its steam power plant to provide adequate heating for its buildings and pools. Since the pools' design is considered to be old, a number of problems arise. Currently the pools are heated by the steam sent from the steam plant. However, after heating up the pool water, the steam condensate is released into the drain which makes the process very inefficient and serves as a major problem. The released condensate is believed to be warm enough to be used once again in heating the pools' water as well as the showers if needed. In trying to conserve some of this energy a number of solutions are suggested in this report. The short term solution proposed is outlined below.

Additional or Replacement Heat Exchanger

This method is requires the instillation of a double walled plate heat exchanger, a filter and a pump. The pump would to take out the hot condensate and sending it to the filter. The hot condensate then can be sent to the heat exchanger to heat up the pool water. It is also worth to mention that the same procedure mentioned above can be used to heat up the water used in the showers if another piping line is used.

Dehumidifier

This method requires the installation of a dehumidifier system in order to reduce the relative humidity levels inside the pool facility.

Recycling the cold condensate to the steam plant or into pool

Currently the condensate is discarded; thus, the process is not considered to be sustainable. However, if the cold condensate is recycled back to the steam plant, the water will be conserved. This will not be covered in detail in this report, it is a mere suggestion for future improvements if condensate cannot be filtered and used as pool water.

The condensate could be filtered and used as pool water; this would avoid the Aquatic centre from needing to buy municipal water, hence making the pools more sustainable.

RESULTS & DISCUSSIONS

The UBC Aquatic Centre, including an outdoor pool, indoor pool, and other various facilities, is mainly heated by the steam provided by UBC steam plant. The current swimming pool configuration is not very different from an ordinary swimming pool. A drainage system, powered by a motor pump, takes the water out of pool and sends it to a filter. The filtered water is then sent to the heater where the steam coming from the steam plant heats up the water. The heated water is then returned to the swimming pool and the steam condensate is disregarded.

The condensate, however, is still warm and it has approximate temperature of 60°C. The condensate can be re-utilized by sending it to the heat exchanger to heat up more water. Moreover, the cold condensate can also be recycled. In addition, a dehumidifier can be installed to reduce the amount of warm air discarded. Below is an analysis on the effectiveness of the new system and how it can be implemented.

The steam sent to the pools varies throughout the year due to the variance in the weather. Data have been collected for the past 8-10 years showing the amount of steam provided per month. Typically, during the winter (December, January and February) the steam sent to the aquatic center is about 200,000 LBS. This amount of steam is only used once before it gets thrown out. Using the hot condensate to help heating up the water can reduce the energy cost per year by 14%. The energy cost per year is $400000, so $56000 can be saved each year if this new system is implemented.

The capital cost of the new system is indeed practical. The approximated cost is about $10,000. All what is needed to implement the new system is double walled heat exchanger, a filter and a pump. The pump will be installed to suck out the hot condensate from the reservoir. The filter will be installed after the pump to remove any suspended contaminants before it gets sent back to the heater to heat up the pools' water. Alternatively, the condensate can be used to heat up the shower water. The same procedure is followed with another piping configuration.

In addition, the cold condensate that comes out from the double walled heat exchanger can also be used as a source of water. Two options were investigated in order to evaluate the best use of the cold condensate. The first option is to mix the condensate with the pools' water. However, there are some problems regarding this option since the composition of the condensate includes harmful components such as Amine. Nevertheless, an advanced filtering system might be used to filter out the containments before mixing the condensate with the pools' water.

Table 1: Composition of Water Streams shown from the CARO Potable Water Quality Test

Source: Jeff Griffin e-mail attachment [Appendix B]

	Guidelines	Condensate	City Water
Metals			
Aluminum	0.1	0.05	0.05
Antimony	0.006	0.001	0.003
Arsenic	0.01	0.005	0.005
Barium	1	0.005	0.005
Boron	5	0.02	0.02
Cadmium	0.005	0.0001	0.0001
Calcium	none	1	0.5
Chromium	0.05	0.005	0.005
Copper	1	0.001	0.003
Iron	0.3	0.1	0.2
Lead	0.01	0.001	0.001
Magnesium	none	0.1	0.2
Manganese	0.05	0.002	0.005
Mercury	0.001	0.0005	0.0003
Potassium	none	0.1	0.2
Selenium	0.01	0.003	0.005
Silicon	none	2	1
Sodium	none	0.1	0.2
Uranium	0.02	0.0002	0.0005
Zinc	5	0.01	0.3

As can be seen from the above table, the amount of Calcium and Silicon in the aquatic centre condensate water exceeds the drinking water guidelines. In addition, the condensate has anticorrosive substances. The suggested technologies include treating the condensate by reverse osmosis as well as using ozone filters. However, due to health risk reasons as well as a very high capital cost, it was found that implementing such systems is not practical for UBC aquatic centre case; thus, it is not recommended to mix the condensate with pools' water.

Dehumidifier

Regarding the discharged warm air, a dehumidifier system can be installed. The current indoor swimming pool losses a considerable amount of energy in discharging the warm humid air from the indoor pool enclosure. In fact, the exhausted air must be discharged in order to prevent moisture damage. Therefore, it is recommended to replace the existing ventilation system in the indoor pool area with a swimming pool dehumidification system.

When pool water is heated to the swimming temperature, a large amount of moist is released into the pool room enclosure. This moisture contains chlorine or bromine disinfectants. These chemical are caustic and like acid will cause ruin to metal surfaces. In addition, they contribute to the blistering paint and rapid decay of furniture. If left uncontrolled, pool room moisture will cause mould and mildew to the pool room.

The dehumidifier resembles a freezer and a heater in the principle of operation. Inside the dehumidifier, with the help of a fan warm air is blown over the cold coil. When the air is condensed, moisture is pulled out in the form of water. After that, the cold air is passed through the hot coil bringing it back to the room temperature (Figure 1). The temperature at which dehumidifiers work best is above 65°C with 40-90% humidity. The following is a picture of a dehumidifier.

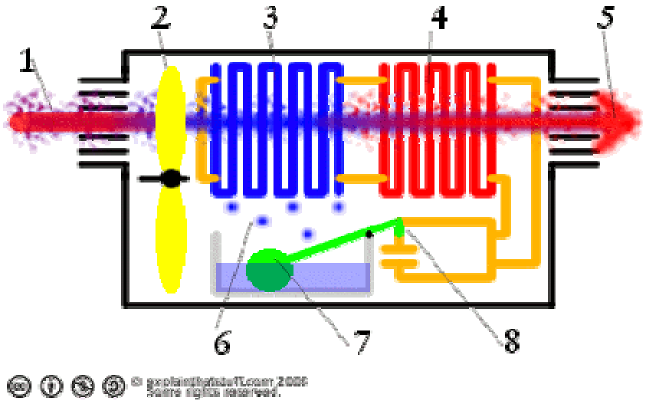

Figure 1: Diagram of a typical Dehumidifier

Source: http://www.explainthatstuff.com/dehumidifier.html

The amount of moisture that evaporates into the air will depend on three factors: the surface area of the pool, the amount of activity in the pool, and the evaporation rate factor. The moisture load (ML) can be determined by the following equation:

$$ML = A * AF * ERF \tag{1}$$

where 'A' is the water surface area, 'AF' is the activity factor, and 'ERF' evaporation rate factor.

The typical activity factor for a public, school swimming pool can be assumed to be 2, and the evaporation rate factor is assumed to be 0.019 (based on the pool temperature of 82°F and the surroundings temperature of 84°F). Below is the calculation performed using Eq. (1).

$$ML\left(\frac{L}{day}\right) = (13{,}454.89\ ft^2)\ (2)\ (\ 0.019)\ \left(10.886\frac{kg}{day}/\frac{Ib}{hr}\right)\left(\frac{m^3}{997\ kg}\right)\left(1000\frac{L}{m^3}\right)$$

The calculated moisture load per day is found to be 5,500 L/day.

Implementing an indoor pool dehumidification system can significantly reduce the need to exhaust large quantities of indoor air. The main advantages can be summarized as follows:

- Reduce energy consumption cost
- Cut down in both operating and maintenance costs
- Improve indoor humidity levels control
- Reduce potential moist damage to pool room, and interior finishes

It may be recommended to return the moisture condensed by the dehumidifier to the pool to reduce the need to add make-up water to replace evaporated water. The best location to install the dehumidifier unit is under an exterior window and above the pool water level Thus, The collected moisture can be drained by gravity back to the pools' water. Due to heath concerns, however, it is suggested to filter the collected moisture before using it. Installation costs of a dehumanisation system ranges between $20,000 to $70,000 depending on the surface area of the pool, ease of connecting to existing air and pool water circulation systems, and availability of electrical and other services. Consulting an engineering organization is necessary to implement an efficient dehumidification system.

Gas Heating System

Long Term Solution

PROBLEM DEFINITION

The UBC aquatic center has two pools, the outdoor pool which is 54 years old, and the indoor pool which is 35 years old. The pools are currently heated via steam which is retrieved from the UBC steam plant. The pool currently has leakage problems in which all reasonable solutions have been attempted to stop it, yet the problem still exists. The only solution that would stop this leakage is rebuilding the facility, which brings us to the main problem. The UBC aquatic center spends approximately $400,000/year to purchase steam from the UBC steam plant.

A gas heating system will save the aquatic centre money in energy costs. It will also make the pool more sustainable and better to the environment. Most pools around Canada are currently being heated by natural gas because it is cheap, efficient and quick. The direct heating contact would avoid losses incurred in the heat exchange from steam to water.

The detailed breakdown of the costs of implementing and running such a gas heating system will be discussed. A specific heater will also be proposed to fix the inefficient heating of the pools at the UBC Aquatic Centre.

METHODOLOGY

Gas swimming pool heaters are a great source of quick and controlled heat for swimming pool. This type of heaters can burn propane or natural gas to heat up the swimming pool water. There is also oil-burning model available. Basic gas pool heater consists of a series of finned copper tubes running back and forth above a burner tray. Gas enters through gas pipe and air enters through a vent. Gas is ignited on the burner tray which is in close proximity to the copper tubing. The cold water in the tube from the filtration system is warmed as heat is exchanged through the copper tube and the pool water absorbs heat as it travels through the heated copper plumbing inside the pool heater. Finally it exits through the heater outlet to return to the swimming pool.

There are many gas heaters available for commercial pools. The **Jandy Hi-E2 Pool Heater** (Figure 2) is currently one of the most efficient gas heater systems available. It has several models capable of handling different pool size. The maximum capacity is 350k BTU. This system could be implemented for UBC pool as one of its major use is for extended swimming seasons. Since UBC pool is very large in dimensions, there is a need to heat up huge volumes of water, ideally in relatively short amount of time. To meet this criteria several of this heater has to be setup in series.

Figure 2: The Jandy Hi-E2 Pool Heater

Source: http://www.jandy.com/html/products/heaters/hie2hie2r/index.php

Another major aspect other than the main heating system is plumbing. However, plumbing installation for a gas swimming pool heater is very simple. There are only two connections, one is clean water from the pool filter entering the heater and the other is heated water coming out of the heater to return to the pool. Furthermore, the Jandy heater has an automatic flow valve which controls the flow rate through the heater at about 150gal/min. So, there is no need for any external control valve or system. However, if the filter system has a higher flow rate, then a bypass pipeline has to be linked in order to stabilize the pressure throughout the system. Moreover, the machine has to be connected to a source of fuel. Natural gas piping line goes near UBC Aquatic Centre to the nearby residential area. Hence, natural gas is the convenient source for the pool heating system. Gas line installation is the more expensive and complex side of the setup since local codes has to be followed strictly.

The heater system needs to be installed in a place where there is adequate air supply. This is required for ventilation and combustion air supply. Additionally, it must be installed on level surface of non-combustible construction.

So, the big investment is the gas heater and along with it is the requirement to install the gas supply to the heater. This means, developing a pipeline network from the main gas pipeline. Finally, the two water connections into and out of the gas heater. The new heater could be implemented with the currently used pump depending on the piping and filter system already in use.

RESULTS & DISCUSSIONS

This section of the report examines the cost of implementing a natural gas heating system. The energy used by the UBC Aquatic Center was estimated based on the size of the pool, the amount of water lost, and the desired pool temperature. Then, knowing the energy demand, the number of heater units was approximated and the ongoing savings was calculated (refer to *Calculation*, page 15 of this report).

From calculating the heat lost from the pool surface and heat needed to raise the temperature of replacement water (since a large volume of water is lost every day), the energy demand of the pool is approximated to 4,863,625 BTU/hr. For additional usage of energy elsewhere in the facility, we have assumed an additional energy demand of 20%. The gas heater we choose out of the options in Table 2 should the one with the highest efficiency because the objective of this project is to aim for high standards of sustainability. Therefore, we have selected the Jandy Hi-E2 heater as it has an efficiency of 95% while the other heaters we researched have efficiencies of 85%. With this new efficiency, the energy demand of UBC Aquatic Center is 5,119,605 BTU/hr.

Table 2: Heater properties

Model	**MasterTemp**	**Sta-Rite Max-E**	**Jandy Hi-E2**
BTU/hr Input	400,000	400,000	350,000
Efficiency	84%	84%	95%
Cost per Unit	$2220	$1900	$4980
Required BTU/hr Input	5,721,912	5,721,912	5,119,605
Units Required	15	15	15
Total Cost for Heaters	$33,300	$28,500	$74,700

The downside to choosing the most efficient heater is that it is almost the most expensive choice. Table 3 shows a cost analysis of the current steam heating system as well the projected cost of a gas heating system. According to Lloyd Campbell, the manager of the UBC Aquatic Center, it would take roughly 1 million dollars to implement a gas heating system, which includes excavation for gas pipelines and retrofitting for the heaters. This cost summed with the cost of the heaters make our capital cost. The annual cost of natural gas is assuming the prices of natural gas does not fluctuate significantly from the price as of April 17, 2010 - $4.89/GJ. This table shows that the annual cost reduction from switching to gas heaters could offset the caption cost in nearly 7 and half years. After that, UBC aquatic center could be saving thousands of dollars.

Table 3: Cost analysis of different heating systems

Annual cost of steam system:	$400, 000
Capital cost of gas system:	$1, 074, 700
Annual cost of gas system:	$259, 714
Annual reduction in cost with gas system:	$170,286
Years to offset capital cost:	7.66

Calculation

Energy demand of pool per hour (H_{lost}):

$H_{surface}$ = Energy lost by surface of the pool, including thermal conductivity and heat lost to evaporation

H_{rise} = Energy to heat the replacement water for leakage and evaporation

k = Surface heat loss factor

A = Surface area

ΔT_{diff} = Average temperature difference between the air and the pool water (Specified to 82°F)

m_{lost} = Mass of water lost per day; = volume lost*density

C_p = Standard heat capacity of water

ΔT_{rise} = Average temperature difference between municipal water and pool water

$$H_{lost} = H_{surface} + H_{rise} \qquad (2)$$

$$H_{lost} = [k\cdot A\cdot \Delta T_{diff}] + [m_{lost}\cdot Cp\cdot \Delta T_{rise}/24hr] \qquad (3)$$

For indoor pool:

$$H_{lost} = 8.33\,\frac{BTU}{hr\cdot ft^2\cdot °F}\cdot 13455\,ft^2\cdot 9.5°F + 50456\,\frac{gal}{day}\cdot 8.34\,\frac{lbs}{gal}\cdot 1\,\frac{BTU}{lbs\cdot °F}\cdot 23°F\,/24\,hr$$

$$H_{lost} = 1{,}468{,}033\ \ BTU/hr$$

For outdoor pool:

$$H_{lost} = 11.11\,\frac{BTU}{hr\cdot ft^2\cdot °F}\cdot 8200\,ft^2\cdot 23°F + 61500\,\frac{gal}{day}\cdot 8.34\,\frac{lbs}{gal}\cdot 1\,\frac{BTU}{lbs\cdot °F}\cdot 23°F\,/24\,hr$$

$$H_{lost} = 2{,}584{,}999\ \ BTU/hr$$

Assuming there is an additional 20% of energy use for the rest of the facility

$$\text{Total } H_{lost} = \%120\cdot[1{,}468{,}033\ BTU/hr + 2{,}584{,}999\ BTU/hr]$$

$$\text{Total } H_{lost} = 4{,}863{,}625\ BTU/hr$$

<u>Ongoing cost of natural gas per year (C)</u>:

$$C = \text{price of natural gas} \cdot \text{energy demand of facility per year} \qquad (4)$$

$$C = {}^{\$4.89}/_{GJ} \cdot [\, 5{,}119{,}600 \, \frac{BTU}{hr} \, 24 \, \frac{hr}{day} \cdot 365 \, \frac{day}{year} \cdot \frac{1 BTU}{1055000\, GJ} \,]$$

$$C = {}^{\$259{,}174}/_{year}$$

ENVIRONMENTAL IMPACTS

If no changes are made to the current operation of the aquatic centre, it will remain quite environmentally harmful. The leak and water loss of about 60,000 gallons is not only a considerable amount, but also a contaminant for the soil around the pools (Figure 3). The inefficient heating is causing unnecessary greenhouse emissions. To make the pools more “green” and more sustainable, changes must be made.

Consumption of clean fresh water is becoming precious, so limiting its use will help reduce the footprint of UBC’s pools. Therefore with the installation of a dehumidifier, some of the lost water from the pool can actually be recycled, and this will reduce the Aquatic centre’s need for fresh water. Note, however, that the moisture collected does contain harmful chemicals (Figure 3) which might need to be filtered.

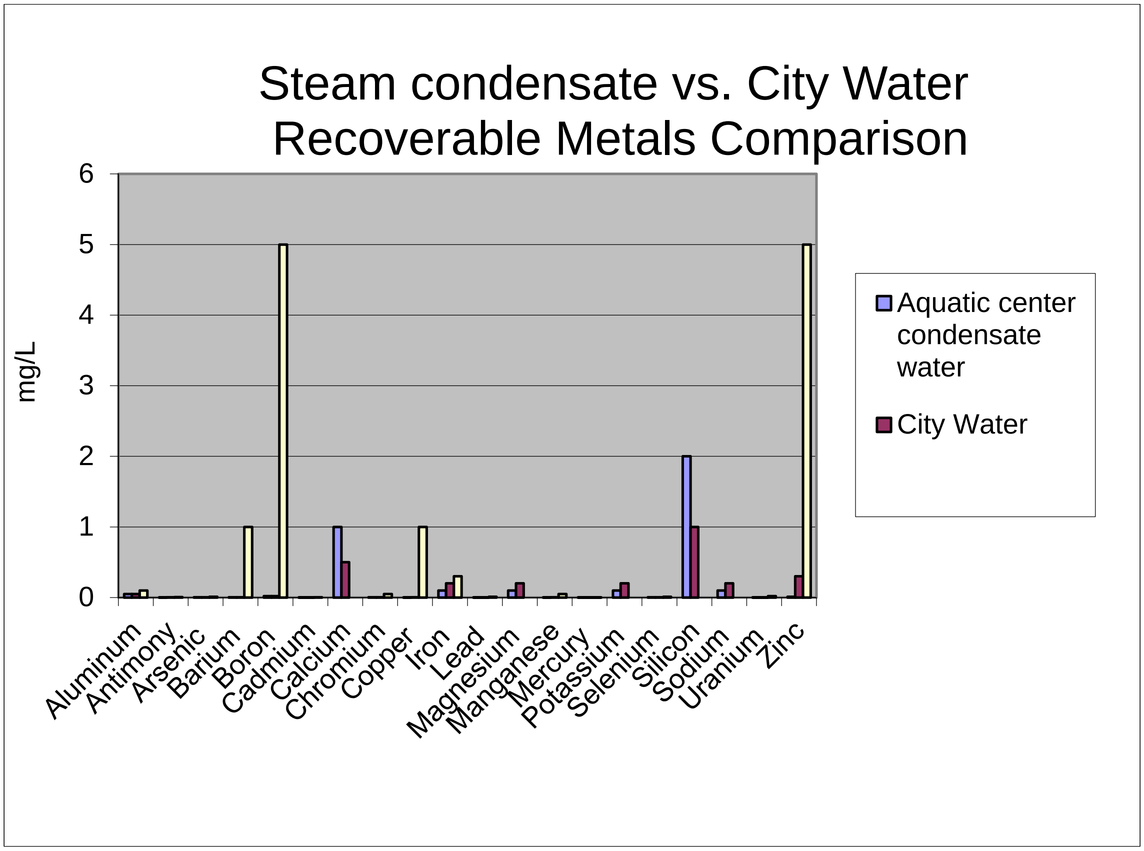

Figure 3: Composition of Water Streams shown from the CARO Potable Water Quality Test

Source: Jeff Griffin e-mail attachment [Appendix B]

If the heat transfer efficiency can be increased, then less steam would be needed on a monthly basis. If less steam is needed, less natural gas would be needed in the steam plant. Hence, in a "domino-effect" manner, by needing less steam at the aquatic centre, less greenhouse gases will potentially be released from the natural gas plants. This is generally the case when designing a more efficient heating system.

For the gas fired heater, the positive impact created is the lower natural gas demand by UBC. Because the natural gas would be heating the pool water directly, much less is needed. At the steam plant the natural gas would need to make water into steam, which is more energy rigorous than heating up water. Hence, when steam is used for heating the water, more natural gas is shipped to UBC for the same process. Also, when the steam is shipped from the steam plant to the pools, heat will be lost into the surroundings. By directly heating the pool water with gas, it is direct contact between the fossil fuel and the water. The "domino-effect" described before applies here as well, and so the gas heating system would emit less greenhouse gases then the steam heating system (even if it was operating at its maximum efficiency).

CONCLUSIONS

Steam Heating System

The UBC Aquatic Centre receives 200,00lbs of steam per month from the UBC Steam Plant. This steam is used only once. Reusing the steam condensate from the pool as a heat reclaim source can reduce 14% of the energy used per year. The annual energy cost is $400,000, meaning that if the proposal were to be carried out, $56,000 would be saved.

The proposed short term solution includes the purchase and installation of a pump, a filter and a double wall plate heat exchanger. This type of heat exchanger is the most adequate to the scenario because it has large surface areas and fluid flow passages for more efficient heat transfer in comparison to the shell and tube heat exchanger. In addition, it is space efficient for it can easily have its heat transfer capability enhanced by having a stacked-plate arrangement. The three components, pump, filter and double wall plate heat exchanger, sum up to less than $10,000. As can be seen from the cost analysis, the proposed short term option meets the client's budget of $10,000.

As shown by Giffin's CARO water portability tests, the amount of some metals such as calcium and silicone are above the guidelines or the norm. Moreover, this test did not measure the amine content used in the steam plant, or more specifically, the cyclohexylamine and morpholine contents. The next test with an activated carbon filter also did not show promising results, for it did not contribute to the reduction of the amine content. Cyclohexylamine and morpholine are known to be toxic, therefore, it is not recommended to reuse the condensate in the water of the pools. Although the current disinfectant used, chlorine, reacts with the amines to form ammonia, which would in theory just evaporate, the liability of such is not enough for implementing the proposed idea of the reuse of condensate in the pool's water. This leads to the conclusion that the next step in the study is to incorporate a filtering system for the cold condensate used in the heat exchanger. The technologies commonly used, reverse osmosis and ozone filters, are efficient, but are costly to install and maintain. Hence, the heat recovery aspect of the project is the only part that can be securely implemented.

Gas Heating System

The UBC aquatic centre is wasting money every day with the current heating system. An analysis was made to determine how much energy is required to heat up and maintain the pool at the desired temperature. It was determined that it will take 15 heaters to carry out the job. The Jandy Hi-E2 heater was chosen to be the most suitable heater because of its high efficiency equating to 95%. The cost of the gas per year assuming the rate doesn't change is $259,714. This is 35% cheaper than the current cost of the steam which is $400,000. Implementing the new heating system is expected to cost approximately $1,074,700. This capital cost can be covered within 7.66 years, and after those years all the savings will be profit. The environmental impact exists, but in comparison to the current method, this alternative is more environmentally friendly as the heating is done on site which results in less energy wasted. UBC has the choice of implementing this idea right away or when the pool is re-built. Either way, it needs to be acknowledged that the current heating system isn't the most efficient method and that it should be replaced if the pool is ever rebuilt.

The overall solution, then, is to install a new heat exchanger in the heating system train, as well as add a dehumidification system to the indoor pool housing. These two changes will immediately increase the Aquatic Centre's effectiveness in heating up the pools, as well as reduce energy and maintenance costs. However, the gas heating system should not be overlooked in future budget analyses. This is a great option as an alternate, new heating system since it is much more efficient than the steam heating, and has an 8 year pay off period.

REFLECTION ON UBC & SUSTAINABILITY

Two suggested solutions, implementation of new gas heating system and new heat exchanger, would help UBC to save their budgets to use it on other researches. Furthermore, by applying this new method UBC will have a sustainable swimming pool which other universities do not. It also shows that UBC is capable of changing and implying new technology. As both of new technology is installed, economically, the cost reduces distinctively. By using gas heating system, maintenance fee, and energy cost reduce dramatically. Similarly, installing new heat exchangers and dehumidifier will reduce energy cost by 14% each year. There are, not only economic benefits exist, but also, social and environmental benefits are resulted. For example, in both cases, the pool saves energy, which is environmental friendly. By installing new heat exchanger, the pool uses more energy from the given steam, whereas before more energy from the same steam was wasted. Not only that, but also significantly less NOx is emitted by new gas heating system. These two solutions will lead to social benefits because patrons complain less about cold showers and pools. Furthermore, using the dehumidifier, a healthier environment for both patrons and furniture will be provided. These better conditions will bring more user groups to the pool.

RECOMMENDATIONS

UBC Aquatic Centre

Installing a new heat exchanger and dehumidifier is recommended since UBC aquatic center currently has a low budget, too low to install the new gas heating system. Although, the heat exchanger solution costs less and seems less effective, it does bring 14% reduction of energy cost per every year. The heat exchanger solution is most feasible and easiest solution to implement currently; since, all the pipe lines exist to install new heat exchanger. Furthermore, the dehumidifier is also easy and cheap to install compared to the new gas heating system. More importantly, dehumidifier provides better quality of air and the environment to swim. On the other hand, if it is possible to install new heating system, this is also recommended because it results more savings in long period of time. The estimated cost will be cover within 7.5 years and have much more saving every year compare to the heat exchanger solution.

Future CHBE 363 Groups

Another solution that can be discussed is the filtration of condensed steam. After heating up the pool with steam, water condensed. However this condensate is still hot enough to increase temperature of pool water. The compounds that need to be filtered are calcium and silicon. Since calcium is one of the compounds that are in hard water, the recommendation is to use ion exchange process, whereas filtering silicon is needed to be researched further. The process of filtering need to be done fast, thus the more energy can be conserved. Another recommendation is to have more breakdown cost for installation of pipe lines, since estimation made is too brief. Finally, if the filtration of water does not work, then a sustainable use would be to recycle the condensate back to the steam plant.

ACKNOWLEDGEMENTS

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- Naoko Ellis, professor and supervisor for CHBE 363
- Lloyd Campbell, UBC Aquatic centre manager
- Jeff Griffin, Special Projects Manager, Alternative Energy (working for UBC Steam Plant)

We would also like to give a special thanks to the SEEDS organization that allowed us to participate in the program and work on making the pools more sustainable.

- Brenda Sawada, UBC SEEDS manager

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APPENDIX A

CONTACT INFORMATION

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APPENDIX B

INTERVIEW NOTES & CORRESPONDENCE

Lloyd Campbell Interview 1 – February, 2010

Lloyd Campbell Interview 2 – April 9, 2010

Jeff Griffin E-mail – April 9, 2010

Lloyd Campbell Interview – Intro in February

Major issue: energy inefficiency; leakage

- Usually gas used, but UBC uses steam plant
  - Gas more efficient and less $, but UBC has steam plant (therefore monopoly)
- Cost of energy/yr to maintain pools $150000
- Looking at solar power as possible energy source (but not likely to happen due to high capital cost. However, it could be used in the showers)
- Future goal: H2O thrown away anyway, should reuse in showers
- Leakage: 100,000 gallons lost/day
- Problem: showers get cold; steam is not enough
- 6-8 inches of H2O loss/day by evaporation (indoor)
- Loss of water (outdoor pool): 12inch/day therefore most inefficient
- H2O used comes from UBC central H2O supply
- Swimming pool covers that are designed to trap the heat and reduce the evaporation are ineffective for such big pools
- Instead, HEAT $AVR fluid used to heat up water in pools and can prevent 50-60% of the evaporation
  - Fluid = isopropyl alcohol 90% (harmless)
  - 1st yr UBC using the fluid
  - 1 gallon can last 1.5weeks for both pools (outdoor and indoor)
  - it works as an invisible sheet on top of the water whenever nobody is swimming.
- Total amount of water in both outdoor and indoor pool: 9million litres (indoor 6, outdoor 3)
- 6 million litres replaced every 2hrs
- Indoor pool is 35 yrs old; outdoor 54 yrs old
- New energy efficient pool would cost 50 million dollars to replace
- Pools cost: 7-8million dollars to replace with stainless steel
- Highest energy consumer on campus
- Other examples to look at are:
  - West Van pool use geothermal as energy resource: ineffective = disaster
  - City centre Coquitlam uses solar power
- Expected budget to fix problem < $10000: all they need is a filter and a pump (?)
- About the leakage problem, they tried to fix it by draining all the water and then looking for the leakage in the pipes. However, they couldn't find exactly where the leakage is, so they filled the area with concrete. The concrete slowed down the leakage but didn't stop it

Lloyd Campbell's contact info: 6048228743; lloydc@interchange.ubc.ca

Lloyd Campbell Interview - Apr 9, 2010

Steam heat pros:

??

Steam heat cons:

- Very far from steam plant
    - For every 100 ft that the steam travels, 5% of BTU is dissipated
- Cost over $400, 000/yr for heating cost
    - In comparison, this is equivalent to the cost of all of Burnaby's public pool together
    - SFU cost near $50, 000
- Steam plant cannot generate enough steam for its demand

Natural Gas Pros:

- Pipe lines are close by
    - Houses across the street uses gas
- Heating cost would reduce dramatically

Natural Gas Cons:

- Boilers need to be retrofitted
- Nearly a million dollars to revamp heating system total

Companies that sell natural gas heating units for pools.

- In-line pumping
- Best buy pool supply

E-mail from Jeff Griffin – April 9, 2010

From: jeff.giffin@utilities.ubc.ca
To: [redacted]
Date: Fri, 9 Apr 2010 15:28:42 -0700
Subject: RE: SEEDS project for CHBE 363 course

Hi Erika,

Your idea of reusing the steam condensate in the swimming pools is great one. It could save about 14% of the energy consumption and massive amounts of make up water due to evaporation from the pools.

About a year ago I conducted a number of tests on the steam condensate at the Aquatic center for that exact purpose the results are attached to this email.

The first test was a water portability test which showed promising results, however it did not measure Amine continent which is added at the steam plant and used to control the PH levels in the returning condensate. For the next test I installed an activated carbon filter which did nothing to reduce the Amine continent..

Cyclohexylamine, Morpholine are the two types of Amines we use… For health and liability reasons it is not recommend to mix the condensate with pool water even though the Chlorine should react with the Amines and form ammonia which would then evaporate off. Therefore the option remains to try and eliminate the amines. Reverse osmosis and Ozone filters are the two most promising methods however Ozone requires significant electrical energy and the reverse osmosis is expensive to buy… I did not explore these option in too much depth as the capital and operation expenses I believe would have defeated the whole purpose..

Another option that could be considered is chemical treatment. I do not feel that I have enough expertise in this area to properly evaluate this opportunity and due the risks of getting it wrong i.e. someone gets a rash and sues the Aquatic center, I now feel it's better to explore a more conventional heat recovery option like plate heat exchangers.

To make a long story short I am currently a CEEN graduate student working under Professor David Wilkinson in the CHBE and have proposed to do my final project on energy efficiency and conservation at the UBC Pools. So it seem that we share a common goal of making the swimming pools more energy efficient and I think we should collaborate on this together. The condensate is only one of many low hanging fruits that could be explored.

Please let me know what your thoughts are on this… I plan to begin working on this project this summer…

Best Regards,

P.S. Feel free to call my cell phone to discus this further.
[redacted]

Jeff Giffin
Alternative Energy
Special Projects Manager