UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Sustainable Brewpub Planning

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An Investigation into Sustainable Brewpub Planning

APSC 262 Sustainability Project Report

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ABSTRACT

The Brewpub is one of the topics of interests to be designed and built in the new Student Union Building (New SUB) that will achieve a large degree of sustainability. It will serve as a beer supplier to UBC community including the Pit and the Perch pubs that are also to be built in the new SUB. There is also a possibility that the UBC beer could be sold to other places on campus.

To achieve sustainability, the new brewpub will obtain all the necessary ingredients (hops, barley, yeast and etc)to brew beer from local farmers/suppliers. A few of these suppliers include the UBC farm on Southcampass Road and Dan's Homebrewing Supplies on East Hastings Street all located in Vancouver. The beer will also be primarily sold to UBC community and other places located on campus. This in turn makes the brewpub more environmentally friendly since there is far less fuel consumption in shipping and transportation process. The residual ingredients resulted from brewing could also be harvested and used to feed livestock or used to generate energy via a process known as anaerobic digestion.

The significant heat resulted from boiling the wort could also be used to co-operate with the new SUB's central heating systems to reduce energy needed to heat the building. The cooling of the boiled wort could also be performed using a plate heat exchanger. This method not only cool the wort but also heat up the coolant (usually water) which can be harvested and stored for other uses.

The packaging of the beer is equally important in term of achieving sustainability. For a new brewpub, the use of a 2 litre or 4 litre growlers is a more economical means to sell take-out beer. It is a durable jug usually made out of glass or ceramic and it allows a customer to refill his or her beer rather than buying a new jug. Since the popularity of this "UBC beer" is yet unknown, growler proves to be a good packaging method to start. At a long run, however, an automatic filling and packaging unit proves to be a economic investment as it speeds up production of the beer significantly.

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GLOSSARY

Acetogenesis	A process in which acetic acid, hydrogen and carbon dioxide are produced by anaerobic bacteria
Anaerobic	Pertaining to or caused by the absence of oxygen
Hydrolysis	Chemical decomposition in which a compound is split into other compounds by reacting with water
Mash	Mashing is a process of combining mix of milled grain and water and heating this mixture to form malty liquid called wort
Methanogenesis	The formation of methane
Microbrewery	A brewery which produces a limited amount of beer
Wort	Wort is the liquid extracted from mashing process
Whirlpooling	A process to separate residual grain protein from the wort

1.0 INTRODUCTION

Sustainable brewpub at the new SUB is an extensive project that requires a lot of planning and design efforts. Since the new SUB is intended to achieve the highest green building rating in North America, the brewpub undoubtedly has to achieve a high level of sustainability. As there are many factors when it comes to design a sustainable brewery, our team has narrowed the project down to the idea of re-usability of residual ingredient and energy. This document provides a triple bottom line analysis on all proposed plans and alternatives to harvest these waste products from brewing process.

In addition, this paper outlines several options for beer packaging. These options include traditional glass bottles, aluminum cans and ceramic growler. They are inspected and analyzed in this report based on their recycling rate, material cost, and environmental impacts.

2.0 BEER INGREDIENTS

2.1 INTRODUCTION

The four main ingredients for the beer brewing process are water, fermented sugar, hops and fermentation agent (Granville Island Beer, 2011). Malted barley grain is a common ingredient used as a fermented sugar. When mashed barley grain is washed over by water, the wort is produced, which contains digestive enzyme converting starch to fermentable sugar. The wort is then boiled for about 90 minutes, where hops are added in the boiler to add bitterness, floral and herbal aromas to beer. The resulting product is then cooled and pumped into a fermentation tank where yeast is added to produce alcohol. After days of fermentation, (length of fermentation depends on the beer recipe), the resulting beer is then filtered and ready to serve.

2.2 LOCAL SUPPLIERS OF BEER INGREDIENTS

To achieve sustainability, it is imperative to reduce any unnecessary resources. In particular, by purchasing ingredients from local sources, the brewpub can cut the cost of transportation and fuel significantly. Common ingredients such as barley, grain, and hops can be directly supplied by the UBC farm. However, Andrew Rushmere, the academic coordinator at the UBC farm/Center for sustainable food systems, suggests that additional local suppliers may be required to maintain a steady supply of ingredients since the UBC farm is only capable of acquiring limited amount of ingredients.

Dan's Homebrewing Supplies is a local supplier on East Hastings Street in Vancouver that supplies barley, hops, and yeast. The general price for barley flakes is $1.25 per pound; $2.50 per ounce for hops; $3.75 per 11 grams for yeast (Dan, 2012). They also sell several miscellaneous brewing equipments such as electric heater, grain mill or cooling tanks.

2.3 METHODS OF REUSING WASTE INGREDIENTS

2.3.1 Livestock Feeding

One of the key points in sustainability is the reusability of the waste created in the process of beer brewing. According to the Zero Research Institute, 92% of the brewing ingredients are wasted, and most of it is spent grain (O'Brien's, 2007). After the brewing process, it is essential to separate the wort from the remaining solid material in the mash to obtain spent grains. The spent grain is very nutritious because of its high protein and fibre. Animal feeding is one of the most common methods to reuse the solid ingredient waste, mostly for livestock such as cattle, pigs and goats (O'Brien's, 2007)

2.3.2 Anaerobic Treatment

Anaerobic treatment is a series of chemical and biological processes that convert organic waste into usable energy source such as methane and carbon dioxide which can be made into electrical energy (Monnet, 2003). There are three main stages in the anaerobic digestion: hydrolysis, acetogenesis and methanogenesis (See Figure 1).

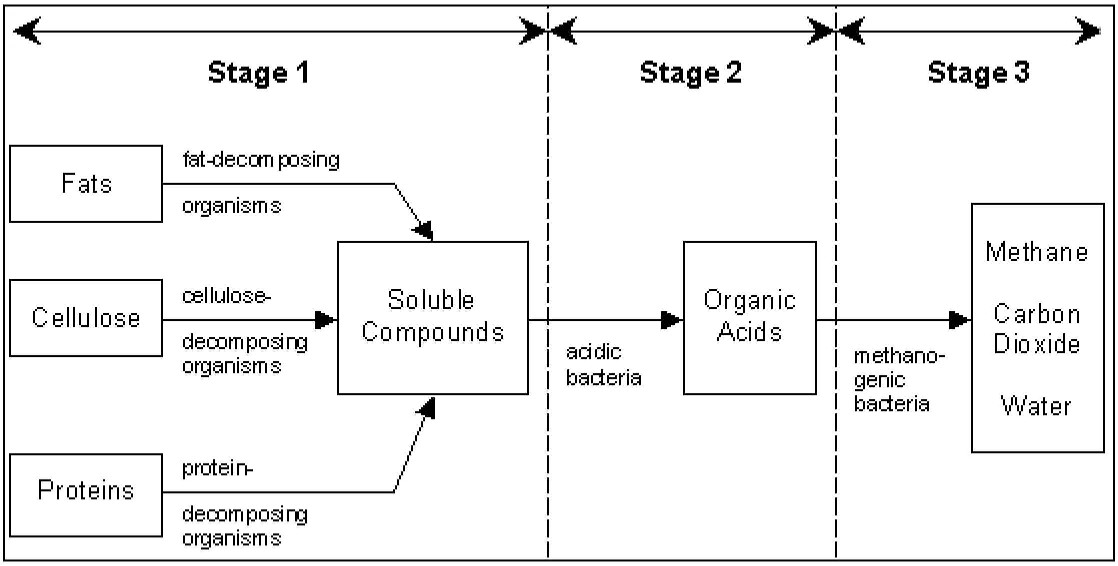

Figure 1 Three stages in the process of anaerobic treatment

Adapted from U.S. Department of Energy. (n.d.)

According to Monnet (Monnet, F, 2003), during the hydrolysis stage, the organic matter is broken down into sugars, amino acids and fatty acids. In addition to the original waste, it is possible to add chemicals into the process to act like a catalyst to speed up the digestion process and yield a higher amount of methane. In the second stage, the product produced in the first stage is further broken down into organic acids, carbon dioxide and hydrogen. It is important that acidogenic bacteria (acid formers) is present at this stage. Finally, methanogens, also known as methane formers, convert the products from preceding stages into methane carbon dioxide and water during the stage of methanogenesis.

All of the processes are done without the presence of oxygen. After the acquisition of methane, or biogas, it is possible to convert it into electrical energy by incorporating an internal combustion engines or power turbines (Navaratnasamy et al., 2006).

Anaerobic treatment can provide the brewery a solution to sustain the energy requirement in brewing process by reusing the organic waste that is created along the process. The treatment requires a retention time of 2 days to 60 days, depending on the amount and the concentration of organic waste (Navaratnasamy et al., 2006). Unfortunately, it is difficult to calculate the efficiency of the treatment since there are numerous variables to consider.

2.4 TRIPLE BOTTOM LINE ANALYSIS

2.4.1 Environmental Indicator

Getting most of the necessary ingredients from local suppliers qualifies the sustainability requirement, mainly because of lower fuel consumption from transportation. This would minimize the impacts to environment in comparison to obtaining ingredients from distant suppliers, where larger fuel consumption from transportation is needed.

The use of the spent grains as animal feed ensures minimal waste produced. This operation would also contribute greatly in helping the environment. Furthermore, it is supported that feeding spent grains to livestock would not have any side effects on the health of the animals nor the product they produced, such as milk (Aliyu & Bala, 2011). On the other hand, an anaerobic treatment system would produce renewable energy for the brewpub and the new SUB. Anaerobic treatment is a very sustainable method to treat solid waste.

2.4.2 Social Indicator

Reusing the spent grains as livestock feed a positive social indicator as doing so could minimize the need to dispose such waste. In other words, the brewpub would be paying less to dispose unnecessary residual ingredients. This would reduce the feeding cost at the local ranches if these residual ingredients are sold at a fairly low price to these ranches.

Obtaining brewing ingredient from a local supplier could not only reduce the transport cost, but it also contributes greatly to local beer ingredient business. The cost of the final product may be offered at a lowered price for the local community.

2.4.3 Economic Indicator

Anaerobic digester could require a high capital cost and a long payback period depending on the size of the digester. For a small operation size brewpub in the New SUB, the cost of the system is estimated to be $160000 to $315000, excluding operation and maintenance cost, which could cost around $3200 per year (Monnet , 2003). Although the payback period might be as long as 10 to 14 years, the anaerobic treatment system could be the key factor to retain sustainability at the new SUB (Navaratnasamy et al., 2006).

2.5 CONCLUSION

Based on the above analysis, obtaining all necessary brewing ingredients from local suppliers is necessary. It not only significantly reduces transport cost and time, but also reduces the fuel consumption from transporting the ingredients. Residual ingredients could either be sold at lower prices to local ranches or be fed into a process known as anaerobic digestion. Both of these meet the requirement of sustainable brewpub. However, the process of anaerobic digestion could be expensive depending on the scale of the process. Yet, the brewpub could save a lot of money from renewable energy in a long run.

Since the brewpub is still in the development and planning stage, it is recommended that the residual ingredients wasted be used to feed livestock first. Implementation of an anaerobic treatment system could be the second alternative if budget allows.

3.0 WASTE HEAT TREATMENT

3.1 INTRODUCTION

A common method for boiling the wort is by deploying a tall, thin and cylindrical boiling unit outside the boiling kettle. The cylinder consists of many tubes upwards through which the wort is pumped through. This would cause the total volume of the wort to circulate inside this cylinder about 7 to 12 times an hour, ensuring even heat dissipation. During the boiling of the wort, usually lasts between 15 to 120 minutes, significant amount of heat and steam are produced from water vaporisation. At the end of the boiling process, the wort needs to be cooled down to fermenting temperature (20~26 degrees Celsius) (A.G. Kanaris, 2008). The use of a heat exchanger could effectively cool the wort down, while warming the coolant (usually water) to a high temperature very close to boiling point. With proper control of the flow of wort and the coolant, the resulting water would be heated very well and stored for other uses.

3.2 TECHNIQUES OF RECOVERING HEAT ENERGY

Plate Heat exchanger is a device used commonly in many breweries to cool the boiled wort. Its design consists of series of thin and corrugated plates welded together in parallel. See Figure 2 for a schematic diagram of the plate heat exchanger and the flow of both hot and cool liquid (A.G. Kanaris, 2008). The cooling effect is achieved by the parallel plate structure compressed rigidly together, forming an parallel flow channel with alternating hot and cold liquid. This design also speeds up the process of cooling, since the plates have larger surface area for heat exchange.

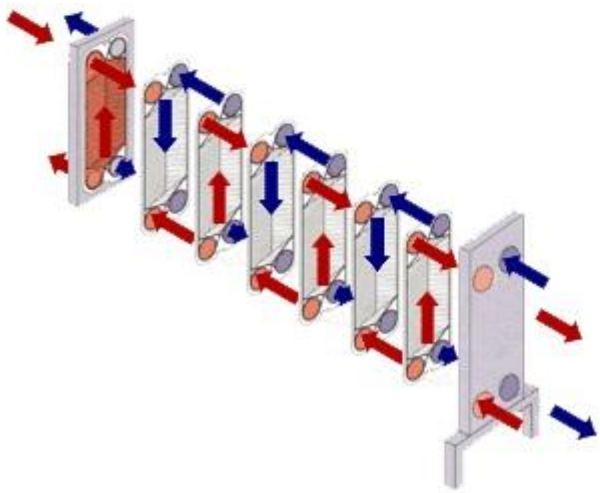

Figure 2 Schematic Diagram of a plate heat exchanger

Adapted from www.heatexchangersuk.com/new-phe.htm on March 28, 2012

Inproheat industries LTD is a local company located on Raymur Avenue in Vancouver, which supplies all welded, brazed and semi-welded plate heat exchangers (Inproheat Industries, 2011). The price range of such device is not displayed on the official website, but it is always available to request a quote by giving the office a call. The typical use of such heat exchanger is liquid to liquid cooling, which satisfies the purpose of cooling the wort with water.

3.2.1 Reuse the Heated Water for Other Uses

In the process of cooling in the plate heat exchanger, one of the outputs is the cooled wort, (about 25 degrees Celsius), this will go through a process known as “whirlpool” before going directly to the fermentation tank, where yeast is added to convert sugar to alcohol. The other output of the heat exchanger is the heated water. By carefully adjusting the flow rate of the cold water at the input, one can maximize the temperature of the heated water at the output.

This heated water will be stored in a hot water tank for further uses. This includes cleaning of the boiling and fermentation tanks, or it can be supplied to other part of the new SUB where hot water is needed. In addition, this conserved water could be used to boil the next package of wort. With already heated water in place, it would take much less energy to bring the water to boiling point.

3.2.2 Reusability of Steam

Since the brewpub is a part of the building plan for the new SUB, it is possible for the produced hot steam to be integrated in the new SUB’s central heating system to heat the entire building. This would require extra heat pipes to be installed to connect to the central heating unit. However, the steam resulted from boiling may contain undesirable odor. Instead of directly vented this steam out of the building, we can have it gone through a heat pipe or a conducting copper pipes where the heat is harvested through conduction. The resulted cool steam could then be vented out of the building.

3.3 TRIPLE BOTTOM LINE ANALYSIS

3.3.1 Environmental Indicator

The plate heat exchanger is a very efficient piece of device, which could perform cooling effectively and quickly while causing minimum damage to the environment. Since water is a common coolant used to cool the wort, it is more environmentally friendly than any other chemical coolant. The resulted hot water could be recycled and reused for other purposes, whereas the hot chemical coolant will have to go through a radiator to cool, and then back to the heat exchanger to complete a cycle.

3.3.2 Social Indicator

Employing plate heat exchanger and recycling of hot water could passively benefit the UBC community, especially at the new SUB. Some of its hot water could be supplied to the other part of the SUB to help heating up the building, or use it to pre-boil another boiler in the tank. These benefits may be passive, but in a long run, these benefits and energy savings to the new SUB may become significant.

3.3.3 Economic Indicator

The plate heat exchanger could cost ranging from about $50 to $1000 depending on the size of the plate, (*Inproheat Industries LTD, 2012).* The larger the size, the more efficient the cooling is. The lifetime of such unit is about 10 to 20 years if the liquid used is non-corrosive. In the case of the brewpub, the boiled wort does not contain corrosive element such as chlorine; it would not corrode the exchanger extensively. Based on the expected lifetime and approximated cost, the units are not likely to be replaced often and thus it satisfies the idea of sustainability.

3.4 CONCLUSION

Based on the discussion and analysis above, it is clear that a plate heat exchanger has many benefits for the brewpub. It is efficient, clean, durable and environmentally friendly. The new brewpub should have at least one of this device for each boiler in the brewpub. It is also recommended to reusing the steam from boiled wort to heat the other parts of the new SUB as it could reduce the energy cost of the new SUB's central heating system.

4.0 PACKAGING

4.1 INTRODUCTION

Choice of packaging is one of the important factors to meet sustainable standards of the brewpub. Although the AMS BrewPub will start as serving the beer in sleeves, pints and pitchers, bottling is necessary when it comes to vendorizing beers to the community.

There are several different methods in beer packaging: glass bottles, beverage cans, and large size growler. The first step for packaging is to rinse the empty bottle with water and air, which then have carbon dioxide injected to the bottle to decrease the oxygen remained inside. Next is to fill the bottle from the beer storing tank. Final step is to label and pack the bottle for shipping.

Our proposal for the brewpub is to focus on larger size glass growler, where customers can purchase. The customer who purchased the growler can bring back the glass bottle for refilling. This packaging method will reduce the number of beverage cans and glass bottles needed for the AMS BrewPub.

4.2 BACKGROUND OF DIFFERENT BEER PACKAGING

4.2.1 Container Cost

Based on Northern Brewery, a store that vends equipment and materials for beer brewing, the growler (64 oz.) costs approximately $6.00 per bottle. Smaller glass bottle (12 0z.) costs approximately 50 cents per bottle. As the prices are for individual containers, purchases made with a larger quantities may obtain a better discount.

4.2.2 Container Distribution

The following table shows that most beer sold in Canada were packaged in small bottles. In B.C., the recycling rate, or the return rate of package, is 94.88% for glass bottles and 94.53% for aluminum cans (Brewers Association of Canada, 2009).

Year	2008	2009
Large Bottles	2.7%	2.6%
Small Bottles	62.8%	60.7%
Cans	34.5%	36.7%

Table 1 Statistic for packaged beer sold in Canada

Adapted from Brewers Association of Canada. (2009)

4.3 TRIPLE BOTTOM LINE ANALYSIS

4.3.1 ECONOMICAL

The beer filling assembly line could cost $10,000 to $100,000 US dollar, depending on the quality and quantity of the packaging. An automated assembling system is capable to cap glass bottle and aluminum can. It features sensor control, which stops the machine if no bottle is detected.The operating lifetime of this assembly line is approximately between 15 to 20 years, and thus makes this unit an economical investment.

4.3.2 SOCIAL

Based on the statement that Canadian beer market is “characterized by bottled beer” (Agriculture and Agri-Food Canada, 2012), bottles are generally preferred by the public. The choice of purchasing beer in can, bottle or growler depends on how an individual drinks beer. With tin cans, one normally pours beer into a glass before drinking. With a bottle, one often drinks directly from the bottle. With a growler, one is likely to pour it into a glass to drink. In occasions such as parties, bottles are more prefered due to its convenience.

4.3.3 ENVIRONMENTAL

To assessing the environmental factor, multiple things need to be considered. First a life cycle assessment (LCA) may be reviewed to see the impact of a glass bottle or a tin can throughout its lifetime. However, here we find that LCA dwelves too deep into the technical chemical content. A simple comparison can be as below: Growlers, large-sized (64 oz.) glass bottles are often used in microbreweries in North America. They are purchased back and reused by the brew pub at a relatively high price, and hence, the brew pub is the one responsible for the cleaning process of the bottles. Smaller sized glass bottles (12oz) are recycled by the BC Liquor Store. On the other hand, tin cans are recycled by City of Vancouver. Since glass bottles can be reused immediately 15-20 times (Agriculture and Agri-Food Canada, 2012), we consider it to be more environmental than tin cans.

4.4 CONCLUSION

Based on the above discussion and analysis, aside to serving beer just on tap to customers in store, it is definitely beneficent to have a packaging line for the AMS brewpub in a long run. There is a good market where customers can choose to purchase the beer and bring to a gathering. It is also recommended to use the glass packaging method over tin cans for the brewpub since this method is more sustainable.

5.0 CONCLUSION AND RECOMMENDATION

Based on the discussion above, residual ingredients and excessive heat from brewing process can be effectively and efficiently harvested with proper equipment. It is recommended that residual ingredients be collected and used to feed livestock, or gone through anaerobic digestion, which turns waste into energy. Yet, the latter could be expensive (around $160000 to $315000 without labor cost) and thus we recommend this as an alternative method if budget allows.

We also recommend the use of plate heat exchanger to cool the hot wort while collecting and storing hot water. Depending on the size and efficiency of the plate heat exchanger, its price could range from a few dollars to a thousand. With a lifetime of 10-14 years, it proves to be a very economical investment. The heat energy generated from boiling the wort could also be reused at the new SUB's central heating system before venting it out.

Lastly, for beer packaging, it is recommended to instal an automatic filling and packaging line if the brewpub intends to operate over a long time span. This unit could cost from $10,000 to $100,000 USD depending on the production rate. The operating lifetime is within an acceptable range, making it a very economical investment. However, at the early period of the brewpub operation, growler jar is recommended due to its larger volume capacity, cheaper cost and high reusing rate.

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