Spring 5-2012

Achieving Sustainability In The Craft Brewing Industry

Mike Boden
University of Nebraska-Lincoln

Achieving Sustainability In The Craft Brewing Industry

by

Mike Boden

UNDERGRADUATE THESIS

Presented to the Faculty of

The Environmental Studies Program at the University of Nebraska-Lincoln

In Partial Fulfillment of Requirements

For the Degree of Bachelor of Science

Major: Environmental Studies

With the Emphasis of: Natural Resources

Under the Supervision of Dr. Gary Lynne

Lincoln, Nebraska

May, 2012

ACHIEVING SUSTAINABILITY IN THE CRAFT BREWING INDUSTRY

Mike Boden, B.S.

University of Nebraska, 2012

Advisor: Dr. Gary Lynne

Abstract

Continued growth in the craft brewing industry, coupled with natural resource limitations suggests the need for implementation of sustainable initiatives on a wide scale. These initiatives discussed include the areas of economic sustainability through cooperative growth and equilibrium, social sustainability through employee and community development, and environmental sustainability through energy and water conservation and renewable energy use. Specific techniques to achieve sustainability in the craft brewing industry are reviewed alongside case studies of craft breweries currently implementing these techniques. A sustainable metric is outlined for use in accomplishing these goals.

ACKNOWLEDGEMENTS

I would like to thank Dr. Gary Lynne for serving as my thesis advisor as well as Master Brewer, Rich Chapin, and Hannah Dietrich, M.A. for serving as my thesis readers. In addition, I would like to thank my advisors, Sara Cooper, Sara Winn, and Dr. Dave Gosselin. Each of you has helped me to reach this point and I am grateful for your advice, your encouragement, your enthusiasm, and your dedication.

Introduction

The purpose of my research is to identify and discuss specific goals and strategies that can be used to move the craft brewing industry towards a more sustainable future. In 1987, the World Commission on Environment and Development (WCED) defined sustainability as meeting the needs of the present without compromising the ability of future generations to meet their own needs. There are many definitions of sustainability, however they all require that we view the world as a system that is connected by space and time (IISD). The three overlapping areas that together form the elements of sustainability consist of social, environmental, and economic sustainability. Each of these areas will be addressed separately, yet every aspect will affect the others in some way due to their integrated nature. For the purposes of this paper I define sustainability as:

> "Operation and cooperation within a closed system, in which all energy and materials are obtained from renewable sources and applied to serve as many useful purposes as they may while providing benefits to community and without adversely affecting natural systems."

Sustainability involves the First and Second Law of Thermodynamics, as well as the related Conservation of Mass Law, which state that neither energy nor matter can be created or destroyed and their utility decreases with each use. Sustainability is essential to future life on this planet. Sustainable efforts can and should be applied to all aspects of craft brewing, especially in using renewable energy to accomplish the work leading to the brewery product.

Beer has been the alcoholic beverage of choice among many nations across the world for millennium. It is first mentioned in writing by the Mesopotamians nearly 5,000 years past and continues to be a staple food product today (Kunze). Traditionally associated with the working class, beer has branched out to envelop the connoisseur's palate as well. According to the Brewer's Association (BA) the U.S. craft brewing industry grew 13% in 2011 with a value of 8.7 billion dollars in the retail market. A 2010 Gallup poll concluded that beer remains the beverage of choice among Americans who drink alcohol.

Until fairly recently, the American beer drinker's product choices were limited and strikingly uniform in style and taste, but the last 30 years has seen remarkable growth in the innovative craft brewing industry. By definition, a craft brewer is: (1) small, brewing less than 6 million barrels[1] per year and often substantially less, (2) independent of non-craft brewing interests, and (3) traditional, brewing all malt beers or using adjuncts[2] only to enhance flavor. The number of breweries rose from only 8 in 1980 to over 1,940 in 2011, a number that had not been seen since the late 1800's. Growth of the craft brewing industry has risen steadily in both volume and dollars during the past several years even though overall U.S. beer sales have decreased marginally (BA).

In 2011, craft brewing sales held 5.7% of the beer marketplace by volume. This translates to more than 356 million gallons of beer (BA). These numbers may appear small, but there is a large amount of waste associated with every gallon of beer produced. As the popularity of craft beer increases so will this waste. It is therefore in our best interests to set and achieve certain standards of efficiency in order to guide the craft brewing industry onto a more sustainable path.

---

1 One U.S. barrel is equal to 31 gallons.

2 An adjunct is a material, usually cheaper than malt, used in brewing to increase fermentable sugars without adding additional flavor.

Brewing is similar to many types of production in that it is a resource intensive procedure. The process consumes large amounts of water, energy and numerous other materials per unit of beer brewed. The exact statistics will vary widely depending upon brewery size, technological capability and stance on resource management as well as what is perceived to be the beginning and end of the production cycle. In order to provide a basic understanding of why the processes are resource intensive, a brief description of the biotechnology of malting and brewing[3] is outlined below (Hough):

1. Crushing malted barley to form coarse flour.
2. Adding hot water to the grist, now known as the mash, in order to convert starches to fermentable sugars.
3. Separating the aqueous extract, known as the wort, from the solid material by further application of hot water.
4. Boiling the wort with hops or other additives.
5. Cooling the wort to an ideal temperature for yeast growth and fermentation.
6. Fermenting the wort with yeast that produces ethyl alcohol and CO_2.
7. Further cooling of the beer for filtration.
8. Carbonation of the beer followed by packaging.

Fortunately, some craft brewers are already paving the road towards sustainable production. By increasing awareness of the sustainable movement in the craft brewing industry, sustainable breweries can provide others an opportunity to adopt sustainable practices already in use. Further innovations are likely to arise from the knowledge, guidelines, motivational purpose and resources set forth by the leaders in this movement.

---

[3] Note the processes listed only account for resources used inside the brewery and do not account for growing and harvesting of crops, manufacture of equipment and materials, or the transport of materials. Neither do these processes account for the additional water and energy expended necessary for the extensive cleaning that must take place due to organic residues.

In general, there has been much work done on the subject of sustainability. There are also many short, albeit informative articles written on the subject of brewery sustainability. A number of scientific articles have also been written on the specific areas related to the brewing process such as water usage, water treatment, steam collection, CO2 collection, and energy and material efficiency. The only attempts to bring the three broad areas of sustainability together, however have been in the form of sustainability reports written through the collaborative efforts of an entire brewery using specific strategies to meet specific goals. Therefore, the objective is to identify a metric for sustainability in the craft brewing industry based upon qualitative standards and guiding principles borrowed from craft brewers already involved in this process. Specific strategies and methods available to achieve these standards and principles will be discussed. While many technologies currently exist and are utilized by large breweries that allow for improved efficiency concerning resource use, many are cost prohibitive to smaller craft breweries. Because the scope of this paper is limited to craft brewing the discussion will focus on measures that are practical and have the greatest likelihood of being implemented by a given craft brewery.

Methods

Research will be presented in a case study approach, using sustainability reports gathered from various craft breweries across the U.S. Sustainability reports vary from company to company, but the primary purpose is to outline the reasons behind a company's desire to become sustainable, the main areas in which they are working towards sustainability, and the methods they are using within each area as well as the results they have achieved. Five breweries of varying size, representing different regions of the U.S., have been selected to address challenges each may face due to geographic location, capacity, climate, institutions, available resources, consumer base and other factors. Brewing science manuals will be referenced to briefly describe the brewing processes and to address waste and potential sustainable solutions for those processes. Most data collected will be qualitative, however, quantitative data such as relative water, energy, and material consumption will be compared, accounting for size and technological differences between respective breweries.

From Grain To Glass

"From grain to glass" is an old expression in the brewing industry that encompasses all the processes necessary for brewing beer beginning in the field where barley and hops are grown and ending in the container from which the beer is consumed. This expression holds particular significance today as more and more brewers are looking at every link in the chain to maximize their efficiency and profits, while also seeking to move toward more sustainable methods of production. In actuality, these processes represent more complex, continuous cycles although it is often the practice to distinguish a definite beginning and end based on a traditional, linear view. In order to address the issues of brewing sustainability in a pragmatic manner, boundaries must be drawn around the processes directly affecting and affected by the brewing industry. In doing so, we need to acknowledge that there are factors lying outside these boundaries that must also be taken into account if true sustainability is to be achieved. Some of these factors would be well suited for continued study and integration in the future.

Brewing Processes

Before we begin to improve brewing procedures we must first understand the essential ingredients and the processes involved as well as why they are necessary. As with most processes, there are a number of means that achieve the same end. The methods discussed here are those most commonly used in the craft brewing industry. New technologies or those used by larger breweries that may become viable to smaller brewers in the near future will occasionally be highlighted.

Although many alternative ingredients can be used in the brewing process, we will focus on the four classic components utilized by every brewery: barley, hops, yeast and water. Barley, once properly malted, provides the starch that will be converted to fermentable sugars. Hops, although not used throughout history, are nearly inseparable from any style of beer except those calling for the addition of other herbs and spices. The hop flower (or cone) imparts characteristic bitterness as well as other tastes and aromas due to its chemical compounds, while also serving as a natural preservative. Yeast, a unicellular fungi, of the *Saccharomyces cerevisiae* species, performs the work of converting sugars into alcohol (ethanol) and CO_2 (Kunze). However, none of these ingredients could ever become beer were it not for the presence of water, which makes up more than 90% of the finished product (Bamforth).

With all these ingredients in hand the brewer's very first step in the creation of beer is the milling or crushing of the grain to be used. This reduces the size of the malt particles and exposes the endosperm that will be degraded by enzymes during the mashing process (Kunze).

Mashing is the most important process performed in the production of beer. In simplest terms, the crushed malt, now called grist, is mixed with water and then heated to specific temperatures. The typical ratio of water to grist is in the range of 3-4:1. The water allows the starch molecules to swell and burst in a process known as gelatinization. The starch can now be directly attacked by specific enzymes, but only at optimal temperatures. The enzymes involved are not important to the purpose of this paper, however the temperatures required for them to do their jobs ranges from 60-75^{o}C. Not only do these temperatures need to be reached, but they must also be maintained for periods in excess of one hour (Kunze).

These starches are converted into a mixture of sugars and process continues with the separation of this extract from the spent grain. There are currently two methods that can be used to achieve this. One method, known as mash filtration, is more commonly used by larger breweries. In essence, the mash mixture is pressed between plates by a hydraulic system creating water tight pockets through which hot water is run and the sugary liquid is drawn off. The more traditional method, known as lautering, relies on a vessel with a large diameter to height ratio into which the mash mixture is pumped forming a shallow bed. At the bottom of this vessel is a false bottom with fine slits that allow the liquid to pass through while excluding the grain husks. Over this bed, a supply of hot water is slowly added and the liquid pumped out until the remaining sugar content falls to a specified level. Lautering times can exceed 2 hours depending upon a variety of factors such as additional grain types used, available technology such as turbidity meters and differential pressure transmitters, as well as the methods employed by the brewer (Kunze).

During the lautering process, the aqueous solution of the mixture, now referred to as wort, is constantly being pumped to another vessel called the boil kettle (or copper) where it is heated. Since this is a slow transfer, heat is applied throughout so that the final volume of wort will reach boiling temperature in as short a time as possible. The method of heating the wort in most modern systems is through condensed steam. While the exact methods include variations on internal and external boiling systems that also vary in efficiency it nevertheless requires a large amount of energy. Traditionally, long boiling times of up to two hours and high evaporation rates of up to 15% were desired. While this method is still practiced, another method known as dynamic low pressure boiling has allowed the boiling process to be shortened to as little as 40 minutes. This method increases evaporation of volatile substances while using considerably less energy. No matter what method is used, boiling is essential for several reasons. First, boiling sterilizes the wort by killing any bacteria that may have been present up to this point as well as destroying any remaining enzymatic activity. Second, precipitation of protein-polyphenol-compounds responsible for haze formation occurs during this time. Third, water evaporates, resulting in higher extract concentrations while undesirable volatile aroma substances are driven off. Among the most important processes that occurs during the boil is the isomerization, or changes in structure of certain hop compounds, that allows them to be soluble and thus impart their characteristic bitter qualities (Kunze).

After completion of the boil, the wort is then cast into the next vessel known as the whirlpool. The whirlpool is simply a cylinder into which the wort is pumped tangentially. The rotational flow produced causes the coagulated proteins, also known as the hot break, which are detrimental to the quality of the product, to settle in the middle of the vessel (Kunze).

The next stage involves cooling the wort to temperatures that are suitable for fermentation. Since different types of yeast prefer different temperatures, the amount of cooling required will depend upon the style of beer to be produced. In any case, the hot wort, around 95^{o}C, must be cooled to temperatures in the range of 6-22^{o}C. This is achieved by an airtight device known as a heat exchanger in which the hot wort and cold water flow in opposite directions transferring heat across channelized metal plates. This method requires a large supply of very cold water, around 3^{o}C, that must be stored in a separate vessel. Upon transfer of heat the temperature of this water is raised to above 80^{o}C and can no longer be used to cool the hot wort. Two stage cooling, in which the larger volume of water is used for pre-cooling and a smaller volume of water is kept at 1^{o}C and used to complete the cooling is a more energy efficient method compared to more common one stage method, however, this requires a larger initial expenditure and a more complicated procedure (Kunze).

Finally, the time has come to convert this sugary liquid into beer. This is accomplished through the addition of yeast (*Saccharomyces cerevisiae*). Given the proper environment and structural elements the yeast will reproduce on a logarithmic scale while consuming sugars and excreting ethanol and CO_2. Heat is also released from the large amount of yeast metabolizing sugars and further energy is thus required to maintain optimal temperatures within the medium. For this reason, fermentation vessels are double walled and equipped with cooling jackets. The cooling can be accomplished either directly through the use of compressed ammoniac evaporation, or indirectly whereby the evaporated ammoniac is used to cool a secondary cooling agent (Kunze).

Once primary fermentation has slowed down the beer must be cooled to near freezing temperatures. This is necessary to clarify the beer as well as to collect the yeast that will drop out of suspension during this conditioning period (Kunze).

At the end of the maturation stage most (but not all) of the yeast has fallen out of suspension. The beer is typically filtered next to remove any yeast still in suspension as well as additional components that will cause turbidity during its shelf life. Filtration not only ensures clarity, but also provides stability of flavor over the long term. Filtration also requires the use of filter mediums that inevitably become waste products. For most breweries that package their beer with the intention of transporting it, the shelf life can be extended through filtration (Kunze).

Depending upon where the brewer intends to sell the beer, the next step may be the last. Carbonation of the finished beer usually takes place under pressure at near freezing temperatures to ensure the highest absorption rate possible. This carbonated beer is then served under pressure from serving tanks that also must be kept at an optimally cool temperature. If the brewer intends to sell their beer off premise, as is the case with most microbreweries, there is another traditional alternative to forced carbonation known as krausening. This involves adding a small amount of freshly fermenting wort to the finished beer just before packaging. A similar process, known as bottle conditioning, may also be used. This requires that a small amount of fresh yeast and fermentable sugar be added prior to packaging. In all three cases, the carbonated beer must then be packaged into kegs, cans, or bottles. The beer must be kept cold throughout the packaging process and optimally throughout its lifespan. Every packaging material has its own advantages and drawbacks including oxygen absorption, weight and size as it relates to transportation, energy required to assemble and ease of reuse or recycling.

Three Areas of Sustainability

Searching for conformity within an industry that takes pride in individuality can be challenging as different breweries address the same issues in slightly different ways. The three main categories of sustainability, however, are always addressed by sustainable brewers.

In the discussions of economic, social and environmental sustainability that follow some of the processes that can be achieved more effectively and efficiently will be addressed. This includes steps that some U.S. craft brewers have taken to close the gap in the sustainability loop.

Economic Sustainability

The success of any economy depends upon the vitality of the society in which it is based. With a happy and healthy society, labor and intellectual capital is highly valued. One person's contribution benefits the society as a whole and influences the direction in which the society grows. Cooperation between individuals, organizations, and governments is more prevalent. In the absence of happiness or the neglect of human and environmental health a society is merely driven by an innate instinct to survive. The same can be said about businesses if they are not striving to benefit in ways other than financial gain. An economic bottom line focus has proved to be extremely profitable, but also extremely destructive. This business model has passed its time. We can no longer draw on our "inexhaustible resources", but instead must design products that come around full circle "cradle to cradle", not "cradle to grave". This change doesn't mean financial downfall for production companies like breweries. Profits made in more than just the monetary sense will continue to provide stability much further into the future than traditional business practices, providing that craft brewers have plans in place for nearly every occurrence.

Ecological economics lays the groundwork for sustainability by redefining basic economic concepts to make them more applicable to environmental issues. For example, "land" is one of the three factors in most economic models, yet for some reason it does not receive the attention it is due when compared to human-made capital and labor. From a modern economics standpoint it is assumed that technology will overcome any limitations imposed by "land". Ecological economists have expanded this view of "land" so that it encompasses all natural systems that make human economic activity possible such as water, air, biotic elements, and minerals. This natural capital then, should be treated as being at least as important, if not more so, than human-made capital. Because this is generally not the case, a great error has been made in our accounting system that tracks depreciation of human made capital, yet ignores depreciation of natural capital. In fact, when we use a natural resource such as timber, its sale counts only as a positive contribution to national income while the loss of this resource, in economic, environmental, or social value is unaccounted for. Ecological economists are working towards the inclusion of natural capital depreciation in our national accounting system. Techniques advocated by ecological economists include physical accounting of natural capital, determination of sustainable yields, and determination of the absorptive capacity of the environment. Together, these measures form the principle of natural capital sustainability. The main concept is that nations work towards the conservation and replenishment of their natural resources for future use. This concept, when implemented on the microeconomic scale for use in individual businesses can have a bottom up effect (Harris). Because brewers are in a niche demand sector they can have influence on what type of crops are grown as well as how they are grown. Brewers who stand together and demand raw materials for the production of their craft can ensure that "land" is always available by offering premium prices to agricultural producers (Dornbusch). To achieve sustainable pricing and supply, brewers need to contract a given variety. This allows the grain and hop dealers to make firm forecasts to the growers who will then make the investment in time and materials to ensure that his product is available and of good quality. The large brewers will continue to drive the demand curve for any given variety. So if craft brewers favor a hop which is in decline, contracting is essential to encourage the grower to continue production (Brewers Supply Group).

Ecological economics frames the traditional economic system as embedded within the larger planetary ecosystem by recognizing physical and biological concepts such as the laws of thermodynamics and that of carrying capacity. Standard macroeconomic theory imposes no limitations on economic growth, however ecological economists argue that resource and environmental factors impose practical limits on economic activity, due to the economy being within the larger ecosystem, and that an optimal level must be attained in order to achieve sustainability (Harris). We have often experienced limiting natural resources: however, there has nearly always been a substitutable resource available. This has become more challenging as we continue to deplete the finite quantities of fossil fuels. As we continue to use decreasingly suitable substitutes, especially in the form of energy sources, the full, and potentially quite negative, effect of unlimited growth economics is becoming increasingly clear. For the craft brewing industry this means that its phenomenal growth must eventually slow down to reach equilibrium based on the use of mainly renewable resources.

Growing slowly and responsibly is key to sustainable efforts. It is wise to build a strong core customer base that will continue to support a product when new brands arise. Expanding too far, too quickly can leave a business vulnerable for any number of unforeseen circumstances. In the craft beer market specifically, there has been an enormous amount of expansion in the last several years as growth continues in both volume and dollars. Many brewers have found it impossible to keep up with demand and have pulled out of distant markets in order to keep up with supply for their local customer base. This is due in large part to the slower growth of the industry in the late 1990's and early 2000's. During this time period many craft brewers expanded to distant markets to increase volume and when sales began to pick up found they had overextended themselves (The New Brewer). In the future the same overextension can be prevented through better forecasting and adequate planning. As many established craft brewers have noted, the initial investment for larger equipment is costly, but can save energy, resources, money and time in the future.

Social Sustainability

We would be hard pressed to say that we can truly separate business from our social lives. Nearly every aspect of what we do on a daily basis revolves around our economy. We all have basic needs that must be met for survival. Beyond these needs we all have wants that may or may not be fulfilled based upon our economic and social status. Among these wants some may list the desire to help those less fortunate than ourselves to achieve a better quality of life. For many in the craft brewing world, this ethic is an integral component of daily operations. It would be difficult to assess exactly how much time, effort, and money is donated by all U.S. craft breweries, but the collective numbers are substantial and meaningful. In 2007, the Brewers Association estimated the amount of charitable donations to be $20 million dollars. One of the forerunners of the sustainability movement, New Belgium Brewing Company, located in Fort Collins, CO, has donated over $5 million to non-profit organizations in the communities where their beer is sold since their founding in 1991 and will donate $700,000 in 2012 (NBB). But the goal of social sustainability reaches far beyond any dollar amount given or hours volunteered. In the words of NBB, "creating positive change occurs through educating leaders, influencing policy makers, and raising public awareness." This company, along with many other craft brewers, actively supports legislation to protect watersheds, promotes smarter transportation, works to increase recycling rates, and advance responsible energy policy.

Breweries can play an important role in moving their local communities toward a sustainable future. From a sustainable business perspective, they generate jobs, put money into local economies, donate goods and services as well as expertise. Socially, they serve as a gathering place where new ideas are generated, friendships are strengthened, and new contacts are made with fellow community members. This has been true since the establishment of society. Social events often occur at a drinking establishment or involve consumption of alcohol. This is not a nod towards the dangers of alcoholism, but rather an acknowledgement of the type of camaraderie that can develop due in large part to these social hubs.

Any successful sustainability program should include people as its greatest asset. This belief is demonstrated by the Great Lakes Brewing Company as outlined in the company's hiring process. In 2010 they achieved a 93% retention rate in the brewery; as they note.

> "Our employment philosophy is to hire for attitude and train for skill. We try to employ those who embrace our company culture and principles, to train them in the skills that they need to succeed and to find them a role in which they can be successful." (GLB Sustainability Report)

In any business, the employees should be encouraged to contribute ideas and watch for areas of possible improvement, thus placing responsibility in the hands of everyone rather than just a few. In this way, problems are addressed quickly by those with intimate knowledge of their area and needs are met that will help improve performance. When given the necessary resources, whether that means the right tool for a job or a room full of mutually interested/invested co-workers to bounce ideas off of, individuals and collective groups are capable of accomplishing far more than without. The recognition of efforts by employers and peers can foster continued growth of community within the workplace and gives everyone a deserved sense of importance and motivation to help move their company towards sustainability. Another topic of great concern to brewery employees is the lack of industry standard salaries for specific jobs. A variance occurs according to duties performed, experience, and geographical location as it does in other professions, however pay rates differ considerably even when all of these factors being equal. Brewery employee salaries can be far below other food industry employees performing similar tasks. Taking into account that brewery employees, more often than not, perform duties that fall under several different categories it is suffice to say that they may be undervalued. Therefore, it would be prudent for a standardized wage system to be created that would allow brewery employees to make a living wage. Given an environment that includes the components mentioned above, a high employee satisfaction and retention are expected.

Developing community is not only important within the workplace, but outside of it as well. There is a wide array of non-profit organizations in need of the support that can be given by businesses. Breweries are making a name for themselves and for the organizations they help support within their local communities. When people participate fully in their community they are more likely to feel accountable for its health and find ways to protect it (Driver 1996, Kelly and Hosking 2008). Many breweries or brewer's guilds/associations hold or sponsor festivals with portions of the proceeds going to charity. From the brewer's perspective, supporting local communities builds a loyal customer base and strong reputation. A craft brewery that invests in its community can become the anchor that holds local businesses and people together.

Environmental Sustainability

Energy

Energy is a requirement for all life on Earth. Humans require energy not only to sustain life, but also to sustain our lifestyles by using it to power devices that make our lives easier and more enjoyable. When energy is released through transformation of one substance to another it has an effect on the Earth's systems. Science has proven through the study of the Earth's spheres[4] that these systems are interconnected. We cannot make a change in one system without affecting another in some way. The majority of human activity, however, is in opposition to this natural order. To ensure our continued existence and reasonable quality of life, humans need to shift their actions and the thought processes that influence those actions away from the self. Rather, humans should think about how their actions affect and have an effect on the complex web of living and nonliving interactions that sustain this planet. Human activity must also shift from the short term to the long term. Hardin's (1968) Tragedy of the Commons describes how individuals acting only in their individual self-interest will ultimately deplete a shared limited resource.

How does this concept apply to the business of craft brewing? Businesses are typically viewed as singular entities, but should be viewed as parts of a collaborative whole where each affects the other and their surrounding environment. Craft breweries are individual businesses that, when taken as a whole, form a part of the manufacturing and food industry. Individually, the impact on the Earth's system is small, but collectively they require large amounts of energy. On average, the entire production process will consume 60 kWh for every 26 gallons of sales beer produced (Kunze). The average American home consumes nearly 12,000 kWh of energy per year so the amount of energy used by all craft breweries in one year is enough to supply more than 70,000 American homes for one year[5] (EIA).

---

4 Spheres refers to the lithosphere, hydrosphere, atmosphere and biosphere.

5 In 2010, the average annual electricity consumption for a U.S. residential utility customer was 11,496 kWh, an average of 958 kilowatthours (kWh) per month. Tennessee had the highest annual consumption at 16,716 kWh and Maine the lowest at 6,252 kWh.
U.S. Energy Information Administration (EIA)
http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3
365,000,000 gal/26 gal = 14,038,461x60 kWh = 842,307,692 kWh/11,496 kWh = 73,269 homes

How can changes be made to decrease energy usage? Plan ahead during construction or remodeling to consider energy saving devices, automation and techniques. A first step might be to break down each process and determine where energy is wasted. Then take the necessary steps to eliminate the waste or use it for something else. For example, beer is approximately 90% water. Due to water's high specific heat, much energy is expended in heating water during different stages of the brewing process. There are many ways to conserve energy as it applies to heating water. An efficient boiler or other heating unit is essential. If the brewery is small, like many craft breweries starting today, a brewer might consider using tankless water heaters, heat pumps, or solar heating. Other opportunities to save heat energy include recapturing steam generally lost during boiling and using the warm water collected during the heat exchange process to begin another brew. These efforts will provide a substantial amount of savings and can be achieved easily with a reasonable investment (Bamforth).

Refrigeration is required in the production of beer and constitutes the largest electrical energy consumption in the brewery (Kunze). Electricity costs vary by geographic location, but investment in efficient refrigeration and automation of this system will pay for itself over time. The total energy required to keep beer cold can also be decreased through airlocks and proper insulation. Simple actions such as ambient cooling during cold weather periods can decrease refrigeration costs. Housing fermentation equipment in a below ground cellar can maintain cooler temperatures year round. In fact, until the advent of refrigeration this was the only method available for brewers to maintain cool temperatures (Hornsey). Although today's high production schedule and consistency standards require exact controls we may still derive some benefit from using techniques of the past.

Alternative energy sources may also be an option for breweries in some areas. Solar power generated from large arrays in our nation's deserts, wind farms of the plains, biomass, hydropower and geothermal all present significant opportunities for breweries interested in supplementing traditional fossil fuel energy with renewable energy. A prime example of a craft brewery using such alternative energy sources is New Belgium Brewery. They have purchased 100% of their electrical needs from wind-generated power. They also have a water treatment plant that produces methane, which can supply up to 15% of their electrical requirements. In addition, NBB installed a photovoltaic array that supplies 3% of their total yearly electricity (NBB). Some of these power sources may not be available or practical for smaller breweries, but not implausible. For instance, the Outer Banks Brewing Station in Kill Devil Hills, NC installed their own wind turbine to help offset traditional electrical costs (OBBS).

Water

Water usage efficiency checks need to start at ground level. Growers need to minimize water usage during irrigation. A reduction in the amount of water used, and thus cost of production for raw materials used to make beer, would translate to a savings for the brewery by lowering prices of hops and grains. This savings would be passed along to the consumer as well as allowing the 'excess' water to be used for other purposes. Where water resources are limited, competing uses are ultimately apt to drive up the cost of water and in doing so, drive out the users who can't afford the higher costs (Manning).

Brewers should be inclined to do the same in the brewing process by conserving water from beginning to end. Reengineering processes to save water should be among the first areas assessed when performing a brewery audit. Water usage to finished product ratios can vary widely amongst breweries with some measuring in near 10:1. The industry average ranges from 4-7:1 (Kunze). Larger brewers can reach water footprints of 3-4:1, but this has much to do with automation. Most small breweries cannot afford this level of automation, yet have the most room for improvement. Fortunately, there are a number of conservation options that are economically feasible. Staff education should be among the first to be employed. Water usage should be a priority for all members of the brewery. Those in charge of the processes need to know how much they are using and be mindful of overuse.

Nearly every step of the brewing process uses water, however the largest percentage is used in the brewhouse, during packaging and cleaning (WBG). Evaporation rates from 4-15% can be expected during the boiling process. Traditionally, a higher rate of evaporation was desired to precipitate as much high molecular weight protein as possible. Today, a lower rate is desirable for better foam retention. Because of this lower rate of evaporation, less water should be used during the lautering process. Other means of water conservation in the brewhouse have already been discussed as they also involve energy conservation.

Due to the biological nature of beer production there is a considerable amount of residue left over after fermentation takes place in the fermentation vessels. The water used during cleaning of tanks need not be fresh for every rinse cycle. The use of Clean In

Place (CIP) systems provide a means of storage for cleaning water that may be used multiple times.

Packaging requires rinsing and sanitation of all vessels to be filled with finished beer in order to prevent contamination and ensure a long shelf life. The water used during this process may be reused for pre-rinsing of tanks or cleaning other items in the brewery that do not have direct contact with beer.

Regardless of purpose, at every stage, a water meter should be installed in order to monitor actual usage. All opportunities to minimize water use in every step of the process should be identified and a centralized water collection area be developed where water with the potential to be reused can be stored. The quality of this water should be analyzed and its use for washdown or other purposes investigated.

Other Factors Involved In Creating A Sustainable Brewery

Achieving a sustainable business can seem like an overwhelming undertaking, best addressed by starting with the basics. First, put it in writing. Without clear, defined goals and strategies to achieve them, many things can be misconstrued or forgotten. The business plan must include sustainability in its core.

Ask the basic questions that any business must consider during their planning stages. What is it you are trying to produce? Brewers want to make a quality beer. What processes and materials are needed to achieve that basic product? We have already reviewed many of those processes and the materials involved. Brewers need water. Consider where the water comes from, how much is used, how usage can be reduced and reused, and what happens with wastewater. Brewers also use grain, hops and yeast to make their product. By applying similar questions regarding source, use and waste it is then possible to ask what suppliers are doing to be more sustainable. If the answer is unsatisfactory, then consider alternative suppliers. Already existing state and national brewer's associations can be used to work toward sustainable initiatives. Though one small business may not be able to exert enough pressure on a supplier, a collaborative effort by many small businesses with a common need or purpose may encourage them reconsider their business practices.

Packaging

Every brewery uses some type of package in order to deliver and serve beer to the consumer. Materials used in packaging can range from serving directly out of stainless steel bright tanks to kegs, bottles and cans. What are these materials made from? Where are they manufactured? Can they be recycled or better yet reused? The cost of shipping will vary according to package weight. Therefore, it makes sense to pick a packaging material that is lightweight. However, there is a minimum thickness that a can, bottle or keg can have and still hold its contents under pressure and maintain its structure during the shipping process. Stainless steel kegs have been the industry standard for decades, but there are lighter weight, plastic kegs available today. While these may save on shipping costs, the impact of materials they are made from must also be considered. Likewise, brown glass bottles have traditionally been used for packaging craft beer because their dark color allows little light penetration and increased product stability. However, many craft brewers are opting towards canning their product because cans are lighter than glass, allow no light penetration or oxygen uptake and are more easily recyclable. Another idea, one that was once commonplace, is that of returnable containers. Returnable containers do not require energy input to be made anew, they are simply returned by the customer or retailer to the producer where they are cleaned and reused. This system requires that the necessary infrastructure is in place so that returns are made in the most efficient manner possible. It would also require that the customer is aware of the benefit of reuse as well as some type of incentive to get them to do so. In the past, this was accomplished using a bottle deposit that was paid by the consumer at the time of purchase and then refunded to them upon return of the intact package. Ten states have a bottle bill: CA, CT, HI, IA, ME, MA, MI, NY, VT and OR (BBRG). For craft brewers who are truly concerned about sustainability this is an area with much room for improvement. A direct line from the brewer to the consumer in regard to reuse of their packaging may be a viable option. This could be accomplished by setting up drop off points and times at local retailers who would compensate the customer and hold the returns for a minimal amount of time until the producer made their pickup. Even more directly, the consumer could bring their returnable packaging to the brewery and receive either monetary or product reimbursement. Using proper education and incentive, a plan of this type could build consumer awareness of the importance of this issue to the participating craft brewer as well as create brand loyalty in the consumer.

Transportation and Distribution

An important aspect of sustainability to consider once beer has been packaged is how it will reach the consumer. The least costly option with the least environmental impact is to sell on premises, but this is only an option for very small breweries and brewpubs. For the majority of craft brewers transportation and distribution will be necessary to reach a market large enough to sell their product.

In many states, a three-tier system is in place that requires all beer, wine and spirits to be sold first from the producer to a wholesaler and finally to a retailer who can sell to the consumer (NBWA). This system is set up to protect the wholesaler's share of the profits and provide proper regulation of alcohol sales, but many wholesalers cannot represent the interests of the small craft brewer due to the extremely large number of participants. In response to this, many small, specialty distribution companies have started to take on the task of handling new brands. These smaller distributors may listen to concerns from craft brewers more readily.

Self-distribution is an option in some states, which allows the craft brewer to directly represent their product to retailers in the most favorable light and deliver it in a way that exemplifies a brewer's stance on sustainability. Since every state sets its own liquor laws this process is a prime example of an area that could be changed through lobbying so that craft brewer's interests are better represented. A system that allows craft brewers the option of self distributing, under proper regulation, within their home state or going through a preferred wholesaler could also be considered. In this scenario, a small craft brewer could choose to transport their product by means most effective to them while staying within the groundwork of their sustainable vision. For example, ABC Brewing Co. wants to make sure that they transport their product to their customers in a time efficient manner while making as small of an impact on the environment as possible. They may choose to purchase a vehicle that runs on cleaner biofuels for self-distribution. This could become a selling point for their market niche as well as travelling advertisement for their product. Another company may have a good working relationship with their distributor and decide it is actually more productive to influence their current distributor to upgrade to more environmentally friendly vehicles than it is to purchase their own and thus have one more vehicle crowding the roadways.

Agriculture

The sustainability of the grain and hop supplies are threatened as pressures on land for food production increase worldwide due to population growth as well as using more agricultural products for biofuels. These pressures create volatile markets and the brewing industry is likely to have less of an impact on what barley growers or farmers in general will plant in the future. The brewing industry is a niche demand sector and thus, tends to pay premium prices for top quality products, giving them an advantage in securing new materials. During supply shortages they can outbid the competition if necessary. The best way to avoid these spikes is to have multiple suppliers to spread the risk in terms of quantity and price (Dornbush).

Sustainable practices in agriculture include water and nutrient management, soil conservation, as well as the use of satellite images to more accurately assess the stresses of a crop. This is an area known as precision agriculture (Brady). These responsibilities lie with the farmers and any agencies in place that have the administrative powers to either regulate or influence the use of more efficient and conservation minded farming practices. Yet, true sustainability will never be achieved by precision, efficiency, and conservation alone. Current practices in these areas still consume massive quantities of non-renewable, fossil fuel energy. Ultimately, these fossil fuels will need to be replaced by renewable energy sources such as hydrogen, wind, solar, and water.

Don't Waste An Opportunity

We need to model human activities around the natural laws of circular exchange and movement of materials and product, such as in the natural hydrologic, carbon, and nitrogen cycles. Each waste material must become an input for a different use. For example, eco-industrial parks have become more popular in recent years. These parks have been modeled after the first of such sites located in Kalundborg, Denmark where a fish farm, power plant, gypsum wallboard manufacturer, pharmaceutical company, cement factory, oil refinery and local farmers use each other's by-products of production (Kalundborg Symbiosis).

Capturing CO_2, the byproduct of fermentation for artificial carbonation of beer or pressure dispensing is a way to offset carbon emissions and to save money that would be spent buying it from bulk gas suppliers. Impurities in the captured CO_2 may require a filtration system (Bamforth). Other alternatives include using it to feed algae in a brewery waste treatment facility or supplementing on-site greenhouse requirements at a brewpub.

Spent grain and hops, which make up a large amount of brewery waste, can be dealt with in several ways. Most breweries simply sell them to local stockowners as nutritional feed, but spent grain can also be used as a medium for growing mushrooms and raising earthworms for feed. When the usefulness of these processes has diminished, it can then be made into Biochar -- a carbon negative material that stores CO_2 and is a valuable soil amendment (IBI).

As stated previously, a substantial amount of yeast is produced through the fermentation process. To give an example, if one liter of yeast is introduced to 100 liters of wort, the quantity of yeast will be nearly 40 times greater by the end of fermentation (Kunze). Therefore, the volume of yeast produced presents its own problems. While some of it will be harvested and reused in another batch of wort, this quantity is quite small by comparison. All too often, this extra yeast is simply put down the drain, but this introduces a large mass of foreign material to the water supply and can cause sanitary and plumbing issues. Clearly, this is an area that should be addressed particularly because it provides ample opportunities for improving in sustainable efforts. Currently, yeast may be reused as a cattle feed and human nutritional supplement, however this practice is not yet widespread.

Brewery effluent is all the water that is not contained in the finished beer or by-products and has not been evaporated. Depending upon a given brewery's efficiency the amount of waste water will vary, but usually makes up at least half of all water used in the brewing process (Kunze). Contaminants in brewery effluent include beer and wort residue, caustic and acid cleaners, yeast, adhesives, salts and many other soluble and insoluble materials. This can be costly to the brewery, but it is necessary that this waste water be treated before introduction back into streams, groundwater and municipal supplies. The effluent can be treated either aerobically or anaerobically. Aerobic treatment involves the introduction of air into the waste water and decomposition of substances by microorganisms. Anaerobic treatment occurs without the presence of air and has the added benefits of using no external energy input as well as supplying energy in the form of combustible methane gas. The methane gas may be used by the brewery to provide electricity if properly equipped to do so. Because the composition of effluent differs at various times of the day in a brewery, a mixing and balancing tank is beneficial to neutralize highly acidic or basic waste water, equalize temperature differences, and dilute high concentrations of chemicals to a large extent (Kunze).

Environmentally, the brewer should strive to release as little waste material into the water supply as possible. Economically, this waste material constitutes potential savings and/or revenue. Socially, the brewery may be looked upon in a more favorable light by consumers when they are made aware that these materials are being dealt with in an environmentally responsible manner.

These are just a few methods that can be utilized to decrease a brewery's ecological footprint while simultaneously increasing their economic bottom line and a material's overall productivity. Some examples can illustrate how breweries in the United States have instituted sustainable business practices.

Who's Who In Sustainable Brewing

Hopworks Urban Brewery[6] (HUB) is Portland, Oregon's first Eco-Brewpub, and an example of how sustainable practices can be implemented in a dense metropolitan area. Hopworks claims to be 100% renewably powered and carbon neutral. They used recycled materials in the construction of their facility, energy efficient lighting and appliances, flow meters to minimize water usage, biodiesel from their own kitchens to heat their brew kettle and power their delivery vehicle as well as organic malts.

---

[6] http://hopworksbeer.com/green-culture/going-green.

Long Trail Brewing Co.[7] of Bridgewater Corners, VT has taken water conservation to the next level by reducing their ratio of water used to beer produced down to 2.37:1. The average ratio is 4-7:1. They do this by condensing steam back to water and in the process use the excess heat energy to prepare their next brew. Long Trail also takes water drawn from artesian wells and fully treats any wastewater that results before returning it to the ground via underground injection into on-site leach fields. Long Trail also gives its spent grain to local dairy farms and in return receives methane generated electricity for it brewing operations. This demonstrates the cycle of sustainability through reuse of waste products.

Brewery Vivant[8] of Grand Rapids, MI has also made an impact in the world of sustainable brewing by becoming the first LEED certified microbrewery. Besides sustainable building techniques, Vivant has gone above and beyond to support its community by donating 12.5% of profits to local charities, sourcing 50% of food inputs for their pub and 25% of beer inputs from within 250 miles of their location and employing over three quarters of their staff from within three miles of the brewery. Environmentally, they have supported the cap and trade system by purchasing nearly 900,000 kWh of renewable energy credits to completely offset their electricity usage. They have diverted over 23 tons of organic matter from the waste stream by composting and located their business in a refurbished building in a walkable community.

Great Lakes Brewing Co.[9], of Cleveland, OH is dedicated to social sustainability through investment in their employees and their community. One of their goals is to

---

7 http://www.longtrail.com/about-us/eco-brewing.aspx
8 http://breweryvivant.com/images/uploads/BV_sustainability_final_black.pdf
9 http://www.greatlakesbrewing.com/sustainability/triple-bottom-line

retain satisfied employees and they do so by implementing a training and development program that encourages workers to maximize their potential and follow their own motivations. In 2010, they helped establish one of the largest urban farms in the nation. Ohio City Farm, a cooperative for families of refugees, is located on six acres of vacant land just one mile from downtown. Great Lakes is also committed to economic sustainability as they follow what is known as Slow Money principles; a movement to organize investors and donors to steer new sources of capital to small food enterprises, organic farms, and local food systems.

New Belgium Brewing Co.[10] is one of the largest craft brewers on the market today and they take their responsibility toward people and the planet very seriously. They are a forerunner in sustainable brewing achievement, setting the example for others to follow. NBB uses their excellent reputation for corporate responsibility to bring together disparate interests in order to effect meaningful transformations in the brewing industry, the communities they are a part of and the ecosystems we are all connected with. They use advertising not only to sell their product, but also the idea of sustainability that is attached to their brand name.

All of these companies, big and small, exist for a purpose greater than simply making a profit. Along with many others, they believe that a positive change can result from their actions and that this change will be compounded. They have made a conscious effort to include sustainable efforts into their business models and mission statements. Success has allowed them to become more sustainable, yet sustainability has driven their success.

[10] http://www.newbelgium.com/culture/alternatively_empowered.aspx

Sustainable Metric

In order to assess sustainability there must be set standards that are clear, that can be utilized by all craft brewers, and are adaptable to individual circumstances. In order to obtain standards that fit these criteria an industry wide evaluation must take place in all three categories of sustainability. This means that each brewery will need to take the initiative to audit their performance in these categories. These results will then need to be analyzed by trusted professionals in the industry that will represent every craft brewery in a fair and just manner to determine these standards. The following sustainable metric accounts for the three areas of sustainability discussed and the examples presented in this text.

- A certification process identifying the overall sustainability of businesses and their products taking into account the triple bottom line of economic, environmental and social sustainability.
- Establishment of limited growth rate in cooperation with other sustainable breweries and raw material producers.
- Zero waste goals through higher recycling rates, reuse of waste materials, and product longevity.
    1. Recycling 100% of glass, plastic, cardboard, paper, and metals.
    2. Collecting spent grains from mashing for use as animal feed or for other purposes.
    3. Collecting and reusing yeast from fermentation for use as animal feed or vitamin supplement.
    4. Investment in durable, reusable packaging materials.

- Eco-efficiency achievement through reduction of energy, water, and material use and increase in renewable energy sources.
    1. Install energy and water meters to measure and control consumption throughout the facility.
    2. Recover heat from wort cooling to preheat water for mashing the next batch.
    3. Use a steam recovery system to condense vapors from the wort vessel. Recovered energy may be used as hot water in a variety of applications.
    4. Control and optimize evaporation in wort boiling.
    5. Ensure effective insulation of steam, hot water and refrigerant pipes, brewhouse vessels, fermentation vessels and storage tanks.
    6. Optimize refrigeration system operations.
    7. Optimize the operation of large electric motors by installing variable speed drives.
    8. Optimize cleaning-in-place (CIP) plants and procedures to avoid unnecessary losses of water and cleaning chemicals (e.g. by saving water from the last rinse for use as the first rinsing water in the next CIP cycle).
    9. Recover water from process stages and reuse where possible, for example, in cooling and rinsing activities.
    10. Adoption of anaerobic and aerobic treatment of waste water.
    11. Optimal use of raw materials to increase yield and reduce

solid and liquid waste.

- Work place well-being through job satisfaction.
    1. Providing job training and enhancement opportunities.
    2. Increase responsibility and give team members the necessary resources to succeed.
    3. Encourage contribution from all team members during problem solving processes.
    4. Promote an environment conducive to trust.
    5. Reward team members through recognition.
- Community benefits derived through locally provided goods and services, charity, enhancement of local economies, and establishment of a living wage.
    1. Support non-profit organizations in the local community.
    2. Organize fun and charitable events.
    3. Sponsor other charity events through donations.
    4. Provide job opportunities to those in the local community.

Conclusion

There are many areas in which sustainable efforts can be made in the craft brewing industry. The motivation to make these improvements should be driven by a desire to operate in a responsible manner from an economic, social, and environmental perspective and needs to be an integral part of the business model. By following the guidelines set forth by an industry wide, sustainable metric, craft brewers will be able to lower their water, energy, and raw materials use. Employee satisfaction and retention will rise through implementation of training programs and engagement. Community development will be aided through the organization and donations of local craft breweries. This development will lead to further economic stimulation in these areas.

The fact is that most start up breweries do not have the resources necessary to be truly sustainable and therefore must begin under less than ideal conditions in order to build to this point. Breweries can help this cause by including sustainable measures in their business models and adhering to them. These new breweries are likely to go through the same pattern of growth and development that has given rise to much of the global sustainability issues we are currently dealing with unless help is offered from those in a position to do so. This is one aspect of the craft brewing community that makes it so unique. The brewing community is open to new brewers and freely offers assistance to those in need.

Industry wide organization of sustainable standards would need to be advocated by the Brewers Association of America with consent from its members. Funding would be necessary for data analysis and possibly to assist smaller brewers with the purchase of energy efficient equipment as deemed necessary according to size and environmental impact. This would be a lengthy and ongoing process due to the number of craft breweries in the industry today, however, once achieved, these standards may be used by new breweries in their planning process and will assure that all participating craft brewers have access to the same set of guidelines, appropriate equipment, and communal support.

Future study in this area should include the influence of the craft brewing industry over entities such as commercial agriculture and the distribution chain, consumer preferences regarding sustainability, small business incentives in place to encourage sustainable growth, as well as institutions that hinder sustainable development.

Hopefully, the philosophy, ingenuity and resourcefulness that pioneered the craft beer movement will meet the new challenges of sustainability by continuing to think innovatively, while also considering the tried and true methods of the past.

Bibliography

Bottle Bill Resource Guide (BBRG). **http://www.bottlebill.org/legislation/usa.htm**

Brady, C. N., Weil, R. R. Elements of the nature and property of soils. 3rd edition. Prentice Hall, NJ.

Brewers Association (BA). http://www.brewersassociation.org/pages/business-tools/craft-brewing-

Brewers Supply Group. http://www.brewerssupplygroup.com/Hops.html

Dornbush, H., Drexler G., Konig, W., Ward, I. (November/December 2011). 2011 harvest report. The New Brewer: The journal of the brewer's association. Vol. 28. Issue 6.

U.S.EnergyInformationAdministration(EIA). http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3

Environmental Health and Safety Guidelines for Breweries. Internation finance corporation. World bank group. www.ifc.org/

The Gallup Organization. http://www.gallup.com/poll/141656/drinking-rate-edges-slightly-year-high.aspx

Great Lakes Brewing Company. 2011 Sustainability Report Draft

Hornsey, I. S. A history of beer and brewing. The Royal Society of Chemistry. Thomas Graham House, Science Park, Milton Road.

Harris, J. Environmental and natural resource economics: A contemporary approach. 2nd edition. Houghton Mifflin College Division.

Hough, J. S. The biotechnology of malting and brewing. Cambridge University Press.

The International BioChar Institute (IBI). http://www.biochar-international.org/

The International Institute for Sustainable Development (IISD). http://www.iisd.org/sd/

Kalundberg Symbiosis. www.symbiosis.dk

Koger, Winter. What on earth are we doing? (2010). The Psychology of Environmental Problems. 3rd Ed.

Kunze, W. Technology brewing and malting. 3rd edition. Versuchs-und Lehranstalt fur Brauerei in Berlin.

Manning, J.C. Applied principles of hydrology. 3rd edition. Prentice Hall, N.J.

National Beer Wholesalers Association (NBWA). http://www.nbwa.org/

New Belgium Brewing Company (NBB), Inc. Sustainability Management System Version 2009http://www.newbelgium.com/Community/local-grants.aspx

Kitsock, G. Sounding Retreat. The New Brewer: The journal of the brewer's association. Vol. 29, No. 2.

Outer Banks Brewing Station (OBBS). http://obbrewing.com/

World Bank, 1997. "Industrial pollution prevention and abatement: Breweries." Draft technical background document. Environmental department, Washington, D.C.

The World Commission on Environmental Development (WCED). http://www.un-documents.net/wced-ocf.htm