

COST-BENEFIT ANALYSIS OF IMPLEMENTING WASTEWATER TREATMENT
FACILITIES IN BEER BREWERIES

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ABSTRACT

The purpose of this study was to both see the effects of wastewater on profitability as well as determine an efficient way of dealing with that wastewater. In addition to finding the most efficient way of treating wastewater, the cost of implementing such a technology was also discussed. Two technologies were specifically talked about and those were an anaerobic digester and a two stage anaerobic digester. Between the three breweries that were discussed, two of them use one of those pieces of equipment; Sierra Nevada has an anaerobic digester and Red Hook has a two stage anaerobic digester.

To analyze the two technologies discussed, three financial tools were used. All three show the costs, expenses, as well as the increased revenue that would come from the equipment. Partial budgeting was used to compare the cost of water with and without the technology for Sierra Nevada and Red Hook, net present value was used to determine the present value of the equipment should it be used continuously for the next ten years, and finally a cost-benefit analysis was used to show the cost reductions and revenue increases for each brewery.

Based on the data collected from the three breweries (one of which was not large enough to acquire such a costly piece of equipment), the water costs decreased by a substantial amount and in one case cut costs by nearly 50%. Even when taking into account the immense cost of purchasing the equipment, the savings generated would be enough for a business to either take out a loan or pay off the equipment over the course of several years.

Though the study was in depth, there is room for improvement in terms of data collection. If someone with access to specific brewery data were to take on this study, he or she may be able to provide a more specific analysis as well as review some additional breweries.

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Chapter 1

Introduction

One of the most heterogeneous industries in today's economy are beer breweries. With more and more firms trying to enter the market each year, it becomes increasingly difficult to enter and make a profit without incurring sizeable losses first. When the industry was developing it wasn't nearly as difficult, simply because it wasn't as hard to make one product better than the other. However, with the introduction of new firms it's difficult to differentiate one beer from another in the sense that it's getting harder to persuade consumers to buy one specific beer as opposed to another. A beer brewer must think, "What makes my product different from others?" At the end of the day the final product is a beer. Aside from this challenge, there is the problem of being able to be profitable, especially in this economy. The startup costs for a brewery are anywhere from a million (for smaller breweries) and to ten million dollars for larger ones; this includes all the necessary fermentation equipment, computers, and bottling machinery. With many breweries producing over 20,000 barrels of beer annually an increasingly concerning problem for all firms is the wastewater created through production. This is especially detrimental for microbreweries since their profit margins tend to be much smaller compared to the more established larger breweries. Since water put into the product has a cost and the water that comes out of the production process is just wasted as opposed to being reused it ends up hurting their profitability (in some cases). As an example that will be cited throughout this investigation, a brewery located in San Luis Obispo known as "Central Coast Brewing" will be used to measure the effect of waste on the brewery's performance. There are three kinds of waste in this industry: yeast, water, and sludge. Treating any of the three will reduce the amount of water wasted in the

process of production but there are already a few ways of dealing with the surplus materials.

Although efforts to reduce waste are being made, it still proves to be a crucial problem that needs to be addressed.

Problem Statement

What is the most efficient way of treating wastewater and how does the implementation of these methods affect profitability?

Hypothesis

The amount of wastewater produced is directly correlated with financial losses, and therefore profitability of beer breweries today.

Objectives

- 1) Determine how much waste is produced on average when producing a barrel of beer
- 2) Evaluating the effect of all the waste products on profitability and a firms total costs
- 3) Determining the most efficient way of dealing with waste while using a minimal amount of resources

Significance of the Study

Beer breweries waste a sizeable amount of water, especially the firms that produce on a national level. It is estimated that the water wasted is about five times the amount of beer produced. The cost of wastewater adds up and can hurt a brewery financially. A local microbrewery in San Luis Obispo started production only a few months ago, and they already have minor issues with water that is wasted in the production of beer. Throughout this study, alternative ways to deal with wastewater will be examined and the most efficient method will be investigated. The results of this study will provide local breweries with an idea of how much this waste adds to their total costs, as well as give them an idea of how to effectively manage their wastewater.

Chapter 2

Literature Review

Financial Statements

In feasibility (and profitability) studies, there are many things that need to be considered when the idea of starting a business becomes a potential reality. For one, getting the necessary resources together such as capital, investors, and a business plan is no easy task. One must also consider and more importantly realize that if starting a business actually happens, he or she must accept the fact that the first few years are potentially subject to losses. Having accepted that, if one still feels that they have the necessary resources as well as the determination to pursue this plan then they can go on to conduct some sort of feasibility study to “test” out their business idea.

In starting any business, a feasibility study is necessary in order to weigh your options. Doing this study helps one in preparing the project as well as gives an owner justification for going through with the idea. Furthermore, preparing this study is crucial in attracting potential investors who have the money that you absolutely need. This study entails a few different elements; economic, technical, and commercial. The commercial part of the study is the most important simply because it will define sales revenues, cash flows, and financial projections for the first 3-5 years (Coulter 2011).

In conducting this study, it's imperative that one understands the competition in the industry which they want to pursue. In this case, the beer brewing industry has an ample amount of competitors all of which have different products (ales, light, dark). In this field a big issue is the costs involved with the startup as well as continued production. Starting up a brewery, a

smaller operation in this case, will run roughly \$450,000 to \$800,000 (very basic startup costs) according to Kesmodel (2011). Along with high initial costs there is a high risk of not producing any profit for the first few years. These startup costs may seem high but one must realize all the different components necessary to get the business going. One has to take into account capital cost estimates, operating cost estimates, building costs (lease or purchase), and equipment. Those alone will be a hefty amount, but it's important to recognize that there will be other costs to get licenses and approvals.

So if someone wanted to actually startup a brewery, what would that really entail? Coulter (2011) states that for starters you need a solid business plan, a target market, and investors unless you have adequate capital. If you were to condense all the elements needed into several steps it would be as follows: Conceptual examination, market examination, feasibility examination, project justification, financing, project planning, construction/implementation, final inspection/testing, and operational management. To say the least it's a long process, and that list doesn't include all the details needed for each step.

One thing that needs to be decided when opening a brewery is the type that is to be pursued. A microbrewery is usually more possible since it produces on a smaller scale and is easier to finance in comparison to a larger brewery; also there are so many large beer companies nationwide, that entering the market is extremely difficult. Over the past decades microbreweries continue to get more and more popular because their products are unique compared to the typical products offered from companies like Anheuser Busch according to Carroll and Swaminathan (2000). Examining the success of these microbreweries is essential for the project since the feasibility study will be conducted for a brewery that serves consumers on more of a local scale rather than national.

Microbreweries are more prevalent in today's economy because of the simplicity of starting one as opposed to acquiring capital to open a larger operation. Although many microbreweries find it useless to use anaerobic treatment because of the price tag, they still need a way to dispose of wastewater efficiently. Kleban and Nickerson (2011) discuss how microbreweries are successful because of their product uniqueness as well as their image. A contributing factor to this image is their level of environmental friendliness; while they cannot be the most eco-friendly they can still make a notable effort. Microbreweries typically produce at around 15,000 bbl. (barrel of beer, 31.5 gallons) per year so their wastewater costs won't be too excessive. O'Neil (2006) talks about when a business should consider installing an anaerobic system, and comes to the conclusion that if wastewater charges surpass about \$250,000 its time to start thinking about it. According to him a brewery that produces around 15,000 bbl. will have wastewater charges in the \$19,000-\$22,000 range annually. With costs like that, many times a brewery will turn to an outside source to treat all their wastewater to save themselves the expense of installing their own system unless they are a very large company such as Anheuser Busch.

Wastewater is an issue in a plethora of different industries; some are worse off than others. Ramalho (1983) says that the main sources of wastewater are domestic sewage, industrial wastewater, agricultural runoff, and urban runoff. Within these categories come all the specific sources of wastewater such as wineries, breweries, food processing plants, and dairies. Within wastewater there are organic and inorganic substances. For brewery wastewater, Goldhammer (1999) discusses the characteristics of this byproduct both physical and chemical. Physically, there is oil, grease, and TSS or a total suspended solid, which refers to any solid particle that may have been chemically created through the brewing process. Other components of brewery effluent (wastewater) include BOD (biochemical oxygen demand), phosphorus, and COD as

emphasized by Vasso and Russ (2007). Biochemical oxygen demand is an indicator of water quality; though it is not widely used, it is the amount of dissolved oxygen that organisms in effluent require to breakdown certain inorganic and organic substances according to Speece (1983). Vasso and Russ (2007) go into the wine industry as well, and the issues it has with effluent. From the cleaning process to having finished producing a bottle of wine, they estimated 1 m³ of effluent for every 1 m³ (in other words a 1:1 ratio) of wine produced; since there are a multitude of wineries with vastly different production rates, effluent can be low or extremely high.

In dealing with wastewater, there are a few different methods that are used, some more than others. Speece (1983) discusses two widely used methods known as Aerobic and Anaerobic treatment and highlights the key differences. The technical aspect of the two methods are similar, however the way in which they treat water is somewhat different in terms of electrical usage and the byproducts they produce. Speece (1983) emphasizes that the major factors that separate the two are electrical power usage, methane gas production, and excess microbial cell production. When all is said and done, Speece (1983) states that cost difference between the two will end up being \$250-\$300 per metric ton of waste. However, Speece (1983) also points out that the excess microbial cell production adds an additional disposal charge and can vary industry to industry. As mentioned earlier, effluent is an issue in a variety of industries. Malina and Pohland (1992) state that anaerobic treatment is more prevalent in industries simply because the COD (chemical oxygen demand) in industrial wastewater is so high; a COD in excess of 20,000 mg/L calls for anaerobic treatment. Currently, sectors that are served by full-scale anaerobic treatment are alcohol distilling, fruit processing, landfills leachate, pharmaceuticals, paper, and the meat packaging industry.

Some breweries produce on a smaller scale and thus, are unable to purchase the capital required for anaerobic water treatment. At times, firms will elect to simply dispose the wastewater into sewage and pay a fee or treat the wastewater to the point where it is allowed to be disposed in sewer systems. Drinan and Whiting (2001) discuss the process of discharging effluent into the environment, and highlight the idea that it is strictly regulated by the EPA. Some industries will discharge to ocean waters through the use of a diffuser after the effluent has been diluted to a point where it is safe to dispose.

A newer method of treating wastewater doesn't involve any form of modern technology, but rather utilizes wetlands that already in place. Wetlands suitability have been questioned for adequately treating effluent because of the lack of technology used in this process. Though this method has been used for years on a smaller scale, professionals tend to be unconfident in its ability to treat large quantities. Verhoeven and Meuleman (1999) go through the two main methods of wetlands treatment which are surface-flow wetlands and infiltration wetlands. Both are effective to some degree and have been proven through observations done on a wetland in the Netherlands. Surface-flow wetlands contain a variety of plants which have bacteria that are able to breakdown contents of the wastewater; this process can take up to ten days. The process includes the following: 1) settlement of suspended solids, 2) Diffusion of dissolved nutrients into this sediment, 3) mineralization of organic material, 4) Nutrient uptake by micro-organisms and vegetation, 5) Microbial transformations into gaseous components, and lastly 6) Physiochemical adsorption and precipitation in the sediment.

The next method of wastewater treatment via wetlands is known as infiltration. This involves surrounding a wetland with a drainage ditch that has a lower water table. This forces the wastewater vertically into the sediment where the nutrient removal process begins. This method

has been known to be more effective; however it may take longer for the water to be fully treated. In the Netherlands, performance of an infiltration wetland was observed and the removal of COD, BOD, nitrogen, and phosphorus was recorded. The infiltration method was able to remove 95% BOD, 80% COD, 35% nitrogen, and 25% phosphorus according to Verhoeven and Meuleman (1999). Treating wastewater through the use of wetlands has been known to be more effective for smaller quantities of effluent, that is to say don't expect a company like Anheuser Busch to come and start using wetlands on a full-scale. This however could be a reasonable alternative for smaller microbreweries, since they usually don't have the capabilities of investing in anaerobic treatment facilities.

This study requires one to go through all the different aspects of the company, both good and bad. An issue in breweries today is managing all of their waste that comes about from production. Fillaudeau and Daufin (2006) state that their main waste product is the water that comes from producing beer, but along with this there is a surplus of yeast and sludge that many places sell off to be used for compost, feed for livestock, or even raw materials in construction. Different presentations and reports have been documented saying how much wastewater is produced in a barrel of beer. The different statistics range from 2-10 bbl. of waste water per bbl. of beer, but a more typical estimate is 2-6 bbl. wastewater per bbl. beer according to O'Neil (2006). His presentation, which was used at the Midwest technical conference in 2006 states all the costs associated with treating wastewater for different sized breweries. For a brewery that produces 1,000-15,000 bbl., costs for wastewater can exceed \$10,000 annually; keep in mind that 1,000-15,000 bbl. is not very much in comparison to the brewery goliaths that are in production today. A larger brewery that produces roughly 600,000-2,000,000 bbl. will have wastewater costs ranging from \$1,000,000-\$4,000,000; although that is a huge brewery and they most likely

have the funds to cover that cost it is still a number that can be reduced through the use of wastewater treatment. O'Neil (2006) states that this amount of wastewater gives a company a bad image and the improvement of this image can lead to higher profits since they could be considered "environmentally conscious". Next, two methods are outlined: aerobic and anaerobic treatment. Aerobic treatment uses bacteria to reduce BOD, or biological oxygen demand, in wastewater which is good however a problem with this process is that it can produce a lot of solids that require additional handling or disposal. Anaerobic treatment is similar to aerobic treatment in the sense that it still uses bacteria to reduce BOD, but it tends to be a more popular method because it creates a renewable energy by-product known as biogas which is a type of biofuel. In many breweries this biofuel is renewed and used to heat the boilers in breweries. Veolia Water, a secondary wastewater treatment plant, puts out reports that state breweries energy costs can be cut by up to 10% depending on the size of the plant.

Anheuser Busch which is the largest beer producer in the U.S. uses anaerobic treatment in nine of their twelve breweries worldwide. Getz and Aquilino (2008) wrote an article for the New York Water Environment Association that discussed a new initiative they have started is the BERS method, which is used to pretreat wastewater. The acronym stands for bio-energy recovery systems, and is basically the same thing as anaerobic treatment but at the end of this process it reuses the energy back in the brewery. Though this is a somewhat new technology and not many breweries use it, it is something to take note of since more and more firms will undoubtedly use this technology. The costs as well as the benefits will be sought out to see whether or not this will be a viable option for almost all breweries in the near future.

Mcateer (2011) who is also an employee of Veolia Water put out a report representing the company that discusses the benefits of anaerobic treatment. The report covers UK breweries,

but the market for beer is massive outside of the U.S. According to the report, for a medium size brewery anaerobic treatment would reduce wastewater costs by roughly £900,000 which is \$1,483,926. While breweries in the U.K. have the option of discharging their waste to the sewer or river, they must purchase a permit that allows them to do so which can cost up to £20,000 annually; in the long run it doesn't make sense to keep this paying fee. The report uses this data to support the idea of using anaerobic treatment mainly because of the renewable energy produced which can be used for onsite boilers, which will therefore reduce energy costs.

Various professionals' throughout the industry offer their input about the different aspects of beer production on forums online such as Probrewer Interactive. Although anaerobic treatment is the most sought out method, it can be very costly and not worth it if producing on a small scale. Some microbreweries move their wastewater to a treatment plant where it may be anaerobically treated; others dispose of it in the sewers at a certain cost. When producing on a small scale, though it may be a reoccurring cost it is so minimal that breweries don't have any other option aside from aerobic treatment, but even that will run a company \$400,000-\$900,000 according to O'Neil (2006).

Chapter 3

Methodology

Procedures for Data Collection

To achieve the objectives in this study, a few different approaches will be used. The first and most crucial part is to obtain all the necessary costs involved in the startup of a brewery. This is essential because it will determine a potential brewer's initial costs as well as show what types of expenses are to be incurred over the forthcoming years. Startup costs in this case would include brewing equipment (capital), wages, building, license fees, office supplies, packaging, and administrative costs as well as other components of each of these categories. For example, wages will include the ability to pay a brewer, manager, marketer, administrators, accountants, and consultants. Though these costs may not start until production actually begins, it is essential to take them into account right away. In order to obtain the data, a series of in-depth interviews will be conducted with professionals from Sierra Nevada, Redhook, and Central Coast Brewing, however the focus will be on microbreweries since the feasibility of starting a "macrobrewery" is extremely difficult and is not the objective of this study. In addition to using interviews, some breweries have past financial statements online which can help to give an idea of what kind of costs to expect on a yearly basis. Although some of these financial statements will be for very large firms, they can be used for reference to get familiarized with what to expect. To determine how much the capital will be (buildings and equipment), various vendors provide prices for brewing equipment. In addition, online forums have plenty of information regarding anything involving brewery startups.

Another piece of data that will be necessary is the amount of wastewater that is produced in the production process for one barrel of beer. Although it is not fully documented, some breweries estimate that waste water is roughly five times the amount of beer produced; however this may be an estimate for larger breweries. This information can be obtained via in-depth interviews or through studies that have been reviewed in online journals such as *The Journal of Environmental Science & Technology*. Most likely however, this will require going to an actual brewery and asking how much wastewater is produced per barrel of beer produced, and then using that information to calculate the total amount produced monthly or even annually. This data will all be provided in supplemental pages where the cost of the wastewater can also be calculated to see whether or not it has a significant impact on a firm's total costs or profitability.

In addition to the amount of waste produced, an essential part of this study is taking note of the various ways breweries treat their waste. Some firms use anaerobic treatment while others use physical treatment. As for determining the most efficient way of dealing with waste products as a result of production, various methods have been tried and assessed over the years. Some breweries treat their water and reuse it for cleaning purposes so the waste products still have some utility.

As part of this study, identifying the most commonly used method of treating wastewater is an important element to know. While all three major methods of treating wastewater will be outlined, eventually the most "efficient" method must be determined to reach some conclusion. Furthermore, to solidify any claims made about what is the most efficient way to deal with wastewater, industry averages will be used from Anheuser Busch since many companies are unable to divulge any information concerning profitability or utility usage.

Procedure for Data Analysis

Once all this information is gathered and organized the analyzing process can begin, which will eventually lead to answering the main question for this study: What is the most efficient way of dealing with brewery wastewater and how does it affect financial performance? Before we go into the main question, it's imperative to get all the startup costs set up so the effects of wastewater produced can be determined. Since this study doesn't focus on startup costs specifically, the costs for a microbrewery as well as a larger one will be covered briefly to give an idea of what to expect. The costs will be laid out as well as the expenses for the first few months up the point where a brewery actually starts production. After this the cost of wastewater can be observed and the effects can be measured based on how it changes initial revenues as well as other costs.

Once all the startup costs are gathered, we can begin to determine the amount of wastewater produced at breweries. This information will be collected through the use of in-depth interviews as well as presentations found online. Determining the amount of wastewater is important because it will allow us to see what that by-product costs the firm during the production process; the wastewater produced per month as well as per year will be needed.

For this project, two analytical techniques will be used since they both are involved in the study. Technology comparisons will be combined with profitability to determine what types of technology prove to be the most lucrative for different breweries. The different technologies involved in this case are anaerobic treatment, aerobic treatment, and physical treatment. A new method of treating wastewater known as BERS (bio-energy recovery systems) is being used at Anheuser Busch facilities but it's very expensive and has yet to be used on a large scale since

only the largest producers can justify using it; nonetheless this technology will be outlined as well. Anaerobic treatment is the most common and proves to be the most cost effective in terms of reducing waste as well as reducing the amount of energy used. In observing these different types of technologies, it's important to take note of how much it costs to implement as well as the returns the technology will provide for the firm.

Once the costs of anaerobic treatment are taken into account, the costs of aerobic treatment as well as physical treatment must be taken into account. Aerobic treatment will most likely be less but it doesn't necessarily treat the wastewater to the fullest. Still, it's important to outline all the methods so a decision can be made based on statistical evidence.

After all the costs have been taken into account, we need to see how it affects profitability. In order to do this, profit figures need to be compared before and after the technology implementation to see whether or not it benefits the firm or is actually a detriment. The firm's expenses as well as profits need to be weighed against each other to accomplish one of the main objectives, which is determining the most efficient way of dealing with wastewater.

To see how these technologies effect profitability a cost-benefit analysis can be used to determine the costs and the money saved from these new implementations. Furthermore, the concepts of net present values can be used to determine how future cash flows will be changed due to an investment made in a wastewater treatment system. To use net present value calculations, the initial capital needed to implement a wastewater treatment system is required and then the amount of time it will take to pay for the equipment itself needs to be projected. After this, one can see how many years of revenues it will take to fully pay back the money borrowed on implementing the wastewater treatment system. Along with these two analytical tools, partial budgeting can be used since all the costs data will be obtained. Partial budgeting

involves taking the costs of one technology and comparing it to the costs of a newer technology to compare the benefits and detriments of the two. This analysis will allow us to put all the needed information into dollar terms so a solid conclusion can be made about which technology would serve a firm more efficiently.

Assumptions

Certain assumptions will have to be made throughout this study for reasons that are out of one's control. Any energy and wastewater treatment costs will be cited from various sources such as secondary companies that do this work for breweries, or the information will be taken directly from breweries that have on-site treatment. It's not possible to obtain this cost information from a large number of breweries and treatment plants, so for the sake of this study it will be assumed that the cost of energy and wastewater are somewhat similar throughout the industry. Another assumption that will have to be made is that a brewery would consider installing an anaerobic system even though it may not be cost effective for them since the installation costs can be so high.

Limitations

The information obtained for wastewater treatment costs are values that have already been calculated as a result of actually running the system. Obtaining these costs are usually done by actually implementing the system, although estimated numbers can be used to get a general idea of what the figure may look like. Similar to the assumptions, a limitation that may present an issue is that energy costs vary throughout every region of the U.S. so numbers from a few wastewater companies will be used to represent the costs involved. Furthermore, some breweries may find it unnecessary to install a system that costs up to one million dollars so they may just

decide to pay a fee to dispose of their waste as opposed to treating it. Lastly, the biggest and most hindering limitation is the fact that many companies will refuse to give out certain financial statements. Companies that are not publicly traded usually will not release any information about internal costs as well as profitability. This will be most hindering when calculating water costs for a larger company like Anheuser Busch because even though they are publicly traded, they are still not at liberty to give out specific costs for parts of their business such as their water rates. For the sake of the project we will assume they have a similar water rate to other beer breweries such as Sierra Nevada and Red Hook. Furthermore, industry averages must be used as a comparison to substitute for the firms that are unable to divulge the information needed.

Chapter 4

Development of the Study

Data Collection Problems

Originally, the main goal of the research was to get as much data as possible with regards to wastewater production. As it turns out, many companies are either uncooperative in giving out such information as it is “sensitive” or simply didn’t have a detailed enough answer for it to be actually useable in this investigation. A common problem that came about through the data collection problem was finding specific water costs which in turn would help deduct the cost of wastewater. Specific water costs were attained for Sierra Nevada, however only partial figures were attained for Red Hook. Specifically this refers to the cost of water without using an anaerobic digester for the Red Hook brewery. Another issue with data collection was gathering water cost data for Anheuser Busch. Though they do put how many gallons of water they use on an annual basis, there is no real way of delineating specific costs or water rates that they may pay. Though they show a downward trend in water usage since 2007 (Ab-inbev 2011), they don’t give out any information as to why their water usage decreases; it is assumed that it is because of their new B.E.R.S. technology (bio-energy recovery system). Many firms are unable to give out specific cost information (even publicly traded ones) for whatever reason with the exception of Sierra Nevada and Red Hook Ale. Another problem that came about was finding specific costs for wastewater treatment plants. According to Diane Greer, who wrote an article about anaerobic digesters in an edition of *BioCycle* in 2007, these treatment facilities cost about \$1,000,000 and are subject to little variation since they are more or less the same (Greer 2007). Another aspect of

calculating implementation costs for these treatment facilities involves calculating utility costs (electricity mainly). Due to the fact that no company that produces on that scale will give out that information, all cost-benefit analyses will be done without taking into account utility costs however for the sake of this study we can assume that they would be relatively low. Lastly, the plan was to collect data for a multitude of breweries including two local breweries in San Luis Obispo (Tap It and Central Coast Brewing). For whatever reason, one of the breweries never got back to me after reaching out to them on several attempts (Tap it) so unfortunately they were taken out of the study; however another brewery was investigated instead (Central Coast Brewing) and the Red Hook brewery was added as well. Though Central Coast Brewing is a small operation and doesn't have the need to implement a wastewater treatment facility, they can be used as an example as to show when the anaerobic digester and the two stage anaerobic digester is unnecessary due to the fact that a business of that size will not have the necessary capital.

Analysis

In order to analyze and accomplish the objectives stated in earlier chapters, a few methods were used to determine whether investing in wastewater treatment equipment would be worth it for a brewery. The three methods used were net present value (NPV), partial budgeting, and a cost-benefit analysis (partial budgeting and cost-benefit are somewhat similar). For NPV, a discount rate is used as a minimum rate of return that would be considered acceptable for the business. Due to privacy laws, all companies involved in this study were unable to give a real figure for acceptable return so for the sake of this study we assume its 10%. Typically, discount

rates are derived using the current bank loan rate and adding 4%. Due to the size of the investment, the current bank loan rate was taken and 7% was added giving a discount rate of 10%. Partial budgeting was done on both Sierra Nevada and Red Hook only for the year that the digester was installed. Since it only covers the first year, the full price of the anaerobic digester (\$1,000,000) is not shown in the partial budgeting table. Instead, a total of \$142,857 is shown on the right side of the table which is the first year payment for the equipment. For Sierra Nevada, this analysis shows that the benefits (income due to change) outweigh the detriments (costs due to change) by \$747,143. For this analysis, the only added costs due to change was the cost of implementing the anaerobic digester. The payback period for the equipment is about 7 years which is an average payback period in most cases (Greer 2007), so the partial budgeting shows only the first years payment of \$142,857. Below is the partial budgeting table for Sierra Nevada.

Added income due to change:		Added costs due to change:	
Water costs:	\$ 421,296.20*	Anaerobic Digester:	\$142,857*
Reduced costs due to change:		Reduced Income due to changes:	
water cost:	\$ 349,305.00*	none (utilities, maintenance unattainable)	
Sewer cost:	\$ 119,398.80*		
subtotal	\$ 890,000.00	subtotal	\$142,857

$$\text{Net change} = 890,000 - 142,857 = \$747,130$$

Above is a partial budgeting table for Sierra Nevada. As shown, the implementation of an anaerobic digester will save the firm money on water costs and this money saved could be thought of as an addition to the company's income. Partial budgeting for this project (Sierra Nevada) only accounts for income changes and cost changes for first year. Without the digester

being put in place, the brewery pays roughly \$890,000 as opposed to \$468,703. They are saving \$421,296.20 per year or \$35,108.01 a month; after payback is done all additional savings that are a result from anaerobic digester can be used in other divisions of the company. According to Diane Greer who wrote an article about implementing anaerobic digesters for various companies, the average payback period ends up being about seven years (Greer 2007). To further show the reasoning for implementing this technology, an NPV analysis and cost-benefit was done on Sierra Nevada. Below is the cost-benefit analysis as well as an NPV table.

Summary of Costs and Benefits:

	Cost Description:
costs of new proposed project:	
Equipment purchase:	(925,000.00)*
Installation:	(75,000.00)*
increased revenue:	421,296.20
reduced water costs:	468,703.80
Net Savings:	(110,000.00)

NPV (for first 10 years)

	minimum acceptable return = 10% for 10 years
	use 6.144 as annuity
<u>income from technology</u>	factor
years 1-10	
\$ 421,296.20	421,296.20(6.144) = \$ 2,588,443.85
	less initial investment \$ 1,000,000.00
	NPV = <hr/> \$ 1,588,443.85

Above, the cost-benefit analyses as well as the NPV calculations are shown to provide sufficient evidence as to why using an anaerobic digester is beneficial (for Sierra Nevada). The cost benefit analysis may show a loss in net savings, however it shows that the price for the

equipment purchase as if it was paid up front. As shown in the partial budgeting calculations, the company would pay off the equipment on annual basis in increments of \$142,857 (*see appendix for calculations). The installation and cost of equipment was obtained from an article written by Diane Greer in a magazine called *Bio Cycle*. The increased revenue could be considered savings, but it represents the money saved because of the anaerobic digester. Without the digester Sierra Nevada would pay \$890,000* in water costs, however the digester saves the company \$421,296 per year (see appendix A.2). As for the NPV table, it uses the income gained from the digester for the upcoming ten years. Since it's a constant stream of income for the next ten years we use a factor of 6.144 which was obtained from an annuity table. After, the initial investment was subtracted from the present value of the income and it shows that NPV is positive indicating that this is a technology worth investing in (see appendix A.2 for calculations).

As for Red Hook, the same analysis tools were used to determine whether or not the two stage anaerobic digester was a worthwhile investment. First, the partial budgeting table will be analyzed followed by the cost-benefit analysis and then the NPV analysis will be last.

Added income due to change:		Added costs due to change:	
Water costs (money saved):	\$183,103.00	Anaerobic Digester:	\$142,857
Reduced water costs due to change:		Reduced income due to changes:	none (utilities, maintenance unattainable)
water cost:	\$231,775.00		
Sewer cost:	\$48,672.75		
subtotal:	\$463,550.75	subtotal:	\$142,857

Above is the partial budgeting table for the Red Hook brewery. The table shows that the brewery saves \$183,103 per year in water costs and this is due to the anaerobic digester. The

reduced water costs of \$231,775 and \$48,672.75 were derived using the cost per cubic foot of water (CCF) which is equivalent to 748 gallons (see appendix for data). The two stage anaerobic digester allows Red Hook to pay a total of \$6.05/CCF as opposed to paying \$10/CCF without it. The brewery on average has about 95,000 gallons a day in their waste water system which is 172 CCF's. Based on this number, the cost per month and year can be calculated. On the right side of the table, the first year cost of the digester is shown. The total cost of the equipment is \$1,000,000 but as explained earlier, the payback period is typically seven years so the first year's payment would be \$142,857.

Next, a cost-benefit analysis will be reviewed to show how the costs of implementing a two stage anaerobic digester weigh against the revenue or money saved from the equipment.

Summary of Costs and Benefits:

	Cost Description:
costs of new proposed project:	
Equipment purchase:	\$(925,000.00)
Installation:	\$(75,000.00)
increased revenue:	\$183,103.00
reduced water costs:	\$280,447.75
Net Savings:	\$(536,449.25)

Though it may be brief due to the fact that data concerning utility charges (electricity, cleaning, etc), it still gets the main point across. This shows the cost against the benefits for the first year that the equipment was used. The net savings do show a sizeable loss, however as with Sierra Nevada this analysis uses the full equipment purchase price as opposed to only using the payment that would be made for the first year (\$142,857). Both the reduced water costs and increased revenue will compile over time and will both help save the company money as well as

help pay off the equipment in a reasonable amount of time. If the first year payment was used (\$142,857) as opposed to the full price of \$925,000, the net savings would end up being a positive \$245,693.75. A business may want to see what the net savings would look like however with the full price as a precautionary measure to ensure it's a worthwhile investment.

The last analysis to be discussed is the NPV of this investment. As before, this will give us the present value of the investment in future dollars to determine whether or not this project should be seriously considered or perhaps put aside.

<u>NPV (for first 10 years)</u>	minimum acceptable return = 10% for 10 years	
<u>income from technology</u>	use 6.144 as annuity factor	
years 1-10		
\$ 183,103.00	183103(6.144) =	\$ 1,124,984.83
	less initial	
	investment	\$ 1,000,000.00
	NPV =	<hr/> \$ 124,984.83

The same basic process was used for this NPV calculation as the one previously discussed for Sierra Nevada. An analysis for the first ten years of the equipment was done and assumed a steady income stream of \$183,103. Since it was a constant income, we were able to use an annuity factor of 6.144 which is the same as before. This allowed us to get the present value of the investment which we could then use to get the actual NPV. As shown above, the NPV was \$124,984.83 indicating that this is an investment a company should consider doing unless they have a better alternative or they simply don't have the necessary capital.

Based on the above analyses, implementing either a anaerobic digester or a two stage anaerobic digester will have benefits. Though those benefits may come with an initial cost, at the end of the day the benefits do outweigh the costs as shown in the partial budgeting analysis. Water costs can go down by as much as 50% which Sierra Nevada has demonstrated. Before using the anaerobic digester they paid \$7/CCF as opposed to only \$2.75/CCF. Though using

either technology requires that the business be producing a relatively large scale, it is something that smaller businesses should think about in the event that they do expand. A company like Central Coast Brewing however simply does not have the financial capacity to undergo a project like this. Even if they went to the bank for a sizeable loan, the interest alone would cost a fortune let alone the amount of time it would take to pay off the equipment. A business of that size is better off dumping the waste in the sewer and paying the penalty.

Chapter 5

Summary, Conclusion, and Recommendations

Summary

The main objective of this study was to determine a cost effective way to deal with the waste water produced by breweries. Originally it was thought that wastewater was correlated with financial losses, however it was a little more complicated than expected. Breweries use so much water that their rates decrease due the volume they use on an annual basis. Though it may not be directly correlated with financial losses, there is still an ample amount of money to be saved through the use of anaerobic digester as well as two stage anaerobic digesters. Implementing the equipment is quite costly for a company; however with this new equipment the savings generated can justify taking on such a high cost. As shown throughout this study, the equipment can decrease water costs by up to 50% which was demonstrated by Sierra Nevada and backed up with the use of partial budgeting.

Conclusion

Based on all the analysis, it is safe to say that if a company has the necessary assets, implementing wastewater treatment facilities is very cost effective. Though it may be a hefty expense to incur at first, in the long run, the business will increase its net cash flows and profits with the equipment. The analyses done go to show that should a company, whether it be big or small, question the idea of using this technology that it may be in their best interest to try and accumulate the capital necessary to do so. Sierra Nevada was able to decrease its costs from \$7/CCF to \$2.75/CCF while Red Hook was able to decrease its costs from \$10/CCF to \$5/CCF. This decrease in water costs cut the annual water costs for production by up to 50%. Both partial

budgeting and NPV show that the investment brings on immense savings that would be hard for a company to forgo. In the analyses done here it was assumed that the business had the money readily available however there is always the option of going to the bank which is very viable when dealing with an investment like this.

Recommendations

Though the analysis may have not been fully completed (due to data complications), the overall result is still useful. If a beer brewery were to actually go through this study, he or she may actually find it useful and may research further to see whether it's a viable option for their business. Using this research as a guide for one's own business may not be the best way to go about it, but it definitely shows the benefits and detriments of using this technology. If further research were to be conducted, more data would need to be collected. As mentioned earlier, many companies are unable to give out information so perhaps someone who has access to the relevant data could move forward with this research. Another way to make this research more useful would be to use a wider variety of breweries as opposed to just using the three used here. Someone who is actively involved in the beer brewing industry could perhaps access the necessary information to do a more complete and specific analysis of the effects of wastewater on profitability.

Bibliography

- "Biogas Production in Breweries." *Biothane | Wastewater Treatment Specialist*. Veolia Water Solutions & Technologies. 10 May 2011. <http://www.biothane.com/en/articles/14856.htm>
- Carroll, R. G. and Swaminathan, A. 2000. "Why the Microbrewery Movement? Organizational Dynamics of Resource Partitioning in the U.S. Brewing Industry." *Amer. J. Sociology* (106: 3) November. pp. 715-762.
- Chastain, Cheri. 2011. Sustainability Coordinator. Sierra Nevada Brewing Company. Phone Interview (Oct. 20).
- Coulter, M. "Cemcorp - Building a Microbrewery." 2011. *Cemcorp Canada - Engineering Excellence*. The New Brewery. (<http://www.cemcorp.com/articles/brewery1.htm>)
- Drinan, Joanne E., and Nancy E. Whiting. 2001. *Water & Wastewater Treatment: a Guide for the Nonengineering Professional*. Lancaster: Technomic Publishing.
- Fillaudeau, L., P. Blanpainvet, and G. Daufin. 2006. "Water, Wastewater and Waste Management in Brewing Industries." *Journal of Cleaner Production* (14:5) pp. 463-71.
- Getz, Thomas and Aquilino Michael. 2008. "Energy Conservation at Anheuser Busch: Brewery WWTP Improvements Create Big Energy Savings." *New York Water Environment Association Inc*. May. pp. 36-42.
- Goldhammer, T. 1999. *The Brewers' Handbook: [the Complete Book to Brewing Beer]*. Clifton: Apex Publishers.

Greer, Diane. 2007. "Financing an Anaerobic Digester".

BioCycle (48:12) December. p. 44.

Henze, M., P. Harremoës, and E. Arvin. 2009. *Wastewater Treatment: Biological and Chemical Processes*. Berlin: Springer Publishers.

Jennings, Ken. Facility Supervisor. Red Hook Ale, Inc. Phone interview (Nov 2).

Kesmodel, David. "More Entrepreneurs Brewing Own Beer, Starting Microbreweries, Pubs - WSJ.com." *Business News & Financial News - The Wall Street Journal - Wsj.com*. Wall Street Journal. Web. 27 Apr. 2011.

Kleban, J and Nickerson, I. "The U.S. Craft Brew Industry." Paper presented at the Allied Academies International Conference, Orlando, April 5-9. 2011.

Malina, Joseph F., and Frederick G. Pohland. 1992. *Design of Anaerobic Processes for the Treatment of Industrial and Municipal Wastes*. Lancaster: Technomic Publishing.

Manley, Bill. 2011. Communications Coordinator, Sierra Nevada Brewing Company. Phone Interview (Oct 18).

Mcateer, Jon. 2011. *Brewery Wastewater Treatment*. Rep. Veolia Water.
(www.ibd.org.uk/cms/file/857)

O'Neil, Michael P. *Applied Technologies*. Proc. of MBAA Midwest Technical Conference, Royal Park Hotel, Rochester. Watts Communication Inc., Sept. 2008.

Ramalho, R. S. 1983. *Introduction to Wastewater Treatment Processes*. New York: Academic Publishers.

Smith, R. 1968. "Cost of Conventional and Advanced Treatment of Wastewater." *Water Pollution Control Federation*. (40: 9) September. pp. 1546-574.

Speece, R. E. 1983. "Anaerobic Biotechnology for Industrial Wastewater Treatment." *Environmental Science & Technology* (17: 9) May. pp. 416A-427A.

Verhoeven, Jos T.A., and Arthur F.M. Meuleman. 1999. "Wetlands for Wastewater Treatment: Opportunities and Limitations." *Ecological Engineering* (12:1). January. pp. 5-12.

Wesson, Tom, and Joao Neiva De Figuerido. 2001. "The Importance of Focus to Market Entrants: A Study of Microbrewery Performance." *Journal of Business Venturing* (16:4). July. pp. 377-403.

Appendices

A.1

	Sierra nevada		Red Hook Ale	
barrels produced monthly or annual	800,000 annually		140,000 annually	
cost of producing barrel of beer	\$20		\$45	
wastewater system?	two stage anaerobic		anaerobic digester	
wastewater/barrel of beer	3 to 1		7 to 1	
revenue 2010	\$ 180,000,000.00		\$ 1,686,000.00	
wastewater in system/day	260,000 gallons/day		80,000-110,000/day	
cost of system	\$ 1,000,000.00		\$ 1,000,000.00	
benefits of system	decrease in cost of water*		decrease in water cost*	
cost of water per CCF (748 gallons)	\$3.69/CCF		\$6.05/CCF	
cost of water annually	\$468,703.00		\$ 280,453.80	

Notes: * cost of water without system would be \$7/CCF for Sierra Nevada and cost of water without system would be \$10/CCF for Red Hook Ale

	Central Coast Brewing	
Barrels produced monthly	700 barrels	
Cost of producing barrel of beer	\$35-\$40 perbarrel	
Wastewater system	None (disposed in sewer)	
Wastewater/barrel of beer	3 to 1	
Wastewater in system/month	2100 gallons monthly	
Cost of system	N/A*	*no system used since they produce on such a small scale
Benefits of system	N/A*	*no benefits since no system is used
Cost of water per CCF	\$14.90/CCF	CCF = 748 gallons
Cost of water annually	\$15,552 per year	

Anheuser Busch

startup costs	N/A (over 100 million, not needed)
production	11 billion bottles/cans a year
profit from operations in 2010	\$10,897,000
Water usage since using BERS technology	
2007 water usage	1,903 billion h/l (hectoliters) or 50,271,941,563.76 gallons
2008 water usage	1,789 billion hectoliters or 47,498,135,014 gallons
2009 water usage	1,626 billion hectoliters or 42,954,375,713.43 gallons
2010 water usage	1,578 billion h/l (hectoliters) or 41,686,349,862.12 gallons
daily water use (one brewery) in Florida	6.2 million gallons daily with old permit New permit allows 4 million gallons to be pumped/day
water usage per barrel	On track to use about 3.5 gallons of water for each gallon of beer produced

A.2

*equipment purchase price of \$1,000,000 (equipment is \$925,000 and installation is \$75,000) was taken from an article written by Diane Greer in an edition of *BioCycle* published in 2007.

Sierra Nevada calculations:

Brewery goes through roughly 260,000 gallons per day in wastewater system. Keeping in mind that 1 cubic foot of water (CCF) equals 748 gallons, one could say that they use 348 CCF's a day or 127,020 CCF's per year.

Sierra Nevada pays \$2.75/CCF for water plus an additional \$.94/CCF (for sewer costs) with the anaerobic digester (total of \$3.69). Using this number (3.69) we can see that their total water cost

equals \$468,703.80 (127,020 x \$3.69). Without the anaerobic digester, they pay \$7/CCF so before they installed the equipment which makes their annual water cost \$890,000. Based on this simple calculation alone, one can see their water cost is nearly cut in half and decreases by \$421,296.20.

Red Hook calculations:

Red Hook brewery typically has 95,000 gallons of wastewater in their system per day, however it can range from 80,000-110,000 gallons. For the sake of simplicity, 95,000 gallons was used in all calculations. With the anaerobic digester, the brewery pays \$5.00/CCF for water and \$1.05/CCF for sewer costs. If the same method as before is used to calculate how many CCF's are used annually, it comes out to be 46,356 CCF's per year. Using this number, their annual water cost ends up being \$280,453.80 (46,356 x \$6.05). Without the two stage anaerobic digester, the brewery pays \$10/CCF which would make the annual water cost \$463,560 (46,356 x \$10). Based on these two calculations, the net savings from the equipment can be calculated and they end up saving about \$183,106.20 per year in water costs. Though their range for water usage is somewhat large, the savings would still be a sizeable amount.