



Brewers Association 2017 Sustainability Benchmarking Report



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Cover photos provided by individual craft breweries. Interior photos provided by breweries unless otherwise noted.

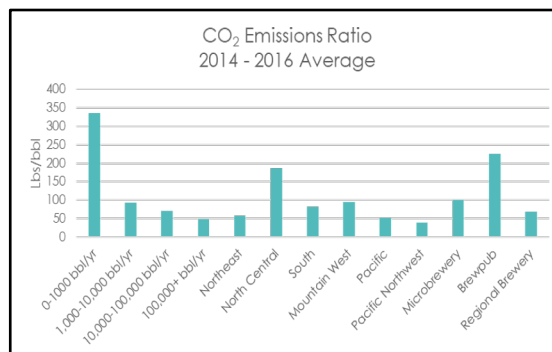
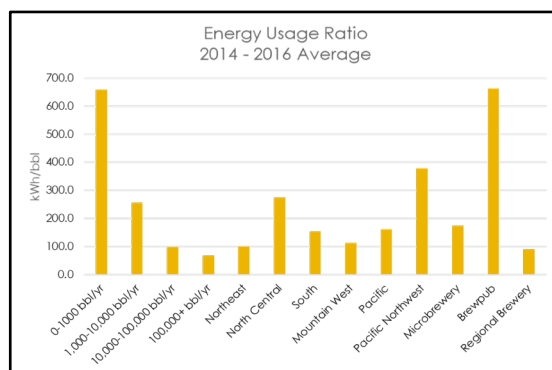
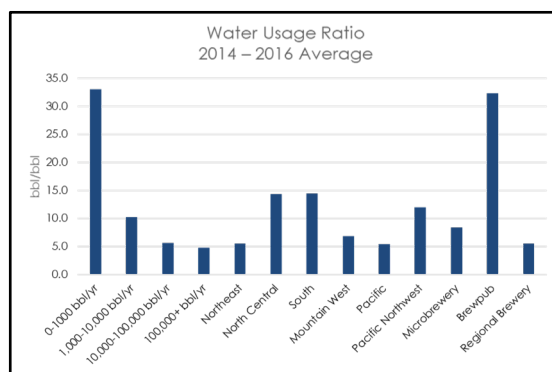
executive summary

The purpose of this benchmarking report is to present calendar year 2016 sustainability-related data submitted by participating craft breweries and to highlight case studies that outline how leading breweries are improving their utility efficiencies, reducing operating costs, and minimizing environmental impacts.

This is the third benchmarking report issued by the Brewers Association (BA). Previous reports have focused on calendar year 2014 and 2015 data. This report also attempts to gain insights from an initial trending analysis of 34 breweries that have submitted complete monthly data sets for all three years of benchmarking (2014-2016). Overall, 117 breweries have participated, with 57 breweries submitting one year of complete monthly data, while 26 breweries have submitted two years of complete data.

Care should be exercised when attempting to extrapolate these results to the craft brewing sector as a whole. Participation is on a voluntary basis and the participating breweries represent a relatively small sample size compared to the total population of operating craft breweries. However, this report provides an informative view of the participating breweries and is helpful to better understand the value in pursuing a more efficient operation. It also identifies and shares brewery best practices that are driving best-in-class performance metrics.

The following graphics summarize data from the 117 participating breweries over the period 2014-2016.



acknowledgments

This ongoing project would not have been possible without the support of the BA Sustainability Subcommittee and the 117 craft breweries (Figure 1) that submitted data and shared best practices. Particular thanks go to the breweries that took the time to enter three consecutive years of data to make the year over year comparisons possible. A list of all reporting breweries is available in Appendix F. The BA recognizes that collecting and reporting data can take considerable time and effort. Sharing sustainability-related data and best practices in the craft beer segment is an ongoing process, and the BA appreciates all member contributions.

We would also like to thank the sustainability management consulting team from [Antea® Group](#) who collected and analyzed the data and developed the benchmarking update.

The BA is excited to support the continued use of the online benchmarking tools and reports. This helps to increase the sharing of best practices and demonstrates the industry's focus on improving efficiency and growing responsibly.

Figure 1:
Location of Participating
Breweries by Market
Segment:
Microbrewery
Brewpub
Regional Brewery

**BREWERS ASSOCIATION
SUSTAINABILITY SUBCOMMITTEE:**

Cheri Chastain* – Sierra Nevada
Brewing Co.

Carol Cochran – Horse & Dragon
Brewing Company

Serena Dietrich – Deschutes Brewery

Christian Ettinger – Hopworks
Urban Brewery

Zac Harris – Alamo Beer Company

Ian Hughes – Brewers Association

Saul Kliorys – Great Lakes Brewing Co.

Peter Kruger – Bear Republic Brewing Co.

Walker Modic – Bell's Brewery, Inc.

Damon Scott – Brewers Association

Chuck Skypeck – Brewers Association

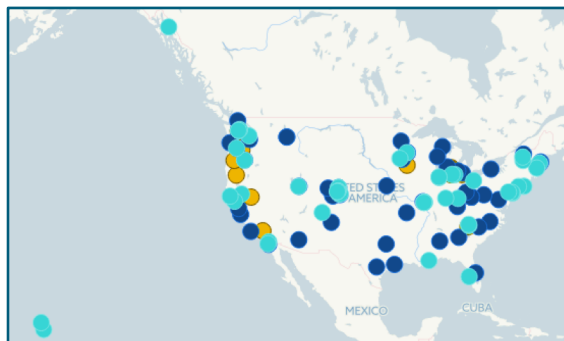
Kris Spaulding – Brewery Vivant

John Stier – Brewers Association

Luke Truman – Allagash Brewing Co.

Katie Wallace* – New Belgium
Brewing Co.

**Committee Co-Chair*



introduction

Established in 2014, the annual BA Benchmarking Reports have been highly anticipated by multiple stakeholder groups including brewers, state guilds, and policy makers. The reports seek to provide an important look into the craft brewing industry's environmental performance.

The BA Sustainability Subcommittee has been tasked with helping current members and future generations to brew the highest quality beers in a manner that strengthens business value, increases the resiliency of the natural environment and agricultural systems that provide brewing ingredients, and enhances workforce and community livelihood. Now in the third year of the benchmarking initiative, this report summarizes the past three years of brewery data.

The benchmarking study focuses on comprehensive analysis of water, energy, and emissions efficiency in the craft brewing industry. This quantitative study provides meaningful comparison by showcasing industry-wide and specific trends for facilities by production size, geographic region (Figure 2), and market segment (Figure 3) by documenting water use, energy use, and total emissions normalized to barrels (bbls) of beer packaged.

Through detailed analysis and benchmarking, the craft brewing sector is defining its environmental footprint and the characteristics that influence

resource consumption to continuously drive improvements in efficiency.

Similar to the 2016 Report, this **2017 Sustainability Benchmarking Report** represents a dynamic data set where facilities were permitted to submit corrections to previous years' data. Breweries are also included in the benchmark even if they do not report data for all three reporting years or for all environmental attributes.

Figure 2: BA Regional Map

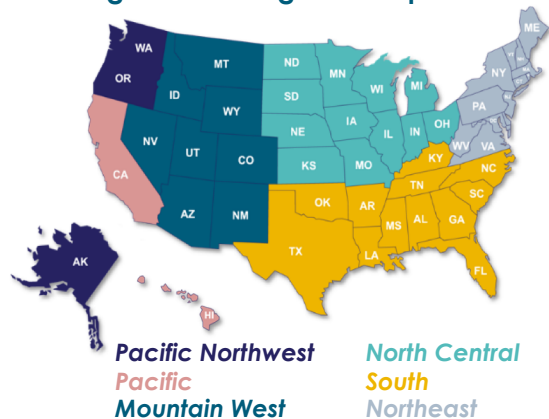


Figure 3: BA Market Segments



Key Terms

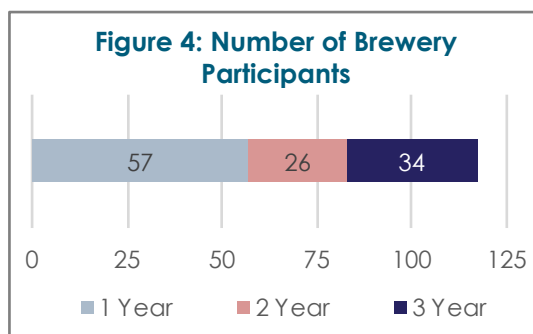
- **Normalizing to Barrels Packaged or Taxable Beer:** Attribute usage and cost were normalized on a per barrel scale for each participating brewery. The term “Barrels Packaged” is used throughout the report as the normalization factor. For the purposes of this report, “taxable beer” reported to the Department of the Treasury Alcohol and Tobacco Tax and Trade Bureau is considered the same as “Barrels Packaged.”
- **Environmental Attributes:** This report primarily focuses on usage ratios for water and energy. The water use ratios are presented in bbls of water used per bbl of beer packaged (bbl/bbl). The energy use ratios are presented in kWh of energy used, combining electricity and natural gas, per barrel of beer packaged (kWh/bbl). Emissions ratios are also presented in the report in units of lbs of CO₂ per barrel of beer packaged (lbs/bbl). The emissions estimates include Scope 1 (natural gas and purchased CO₂) and Scope 2 (electricity).

Data Set Description

At a minimum, breweries were asked to provide information on barrels of beer packaged, which is utilized to normalize usage data for environmental attributes. In addition, breweries provided data on usage and cost for electricity, natural gas, purchased CO₂, water, and wastewater. Figure 4 provides a count of breweries who have submitted complete sets of monthly data for one, two, or three consecutive years.

The 2016 data set includes complete

data from 68 breweries, 15 of which are new participants. In the past, efficiency charts have provided value by illustrating the Bottom 25%, Middle 50%, and Top 25% performance metrics. These are again provided in Appendix B, representing the data submitted for 2016.



Internship Program

Most craft breweries across the nation are highly entrepreneurial, with each co-worker filling several roles to meet the daily demands of a small business. Tracking down utility invoices and entering and analyzing sustainability data requires additional human resources they don't often have. This is one of the main reasons more breweries have not yet participated in the benchmarking project. Graduate level students are being recruited by the BA to assist local craft breweries with collecting, entering, and analyzing sustainability-related data through the Sustainability Benchmarking Tools. More information on the Sustainability Internship Program is available on the BA website:

<https://www.brewersassociation.org/best-practices/sustainability/sustainability-benchmarking-tools/>

trends and observations

The past three years of brewery-submitted data have been analyzed for potential trends that could be helpful for the sector. At this point, the benchmarking sample size is too small to make definitive statements or assumptions about the entire population. The sample size percent of total population increases as the production size range increases. For example, less than 0.03% of the total breweries between 1 to 1,000 bbls/yr are represented, but over 31% of the total breweries between 100,000 and 1,000,000 bbls/yr are included. Participation in the benchmarking is voluntary, so those that participate may skew the results toward breweries that consider sustainability an important element of their business success.

As of the date of this report, more than 280 craft breweries of all production sizes and locations have signed up for access and are entering data into the sustainability benchmarking online tool. There is a gap between the 68 breweries identified in Table 1 and the total of more than 250 breweries currently participating in data entry. Some breweries submitted incomplete or erroneous data for 2016 and were omitted from the report. A good number of breweries just joined the program in 2017 and 2018 and did not have the time or resources to gather historical data for entry. Future benchmarking reports are expected to include larger numbers of breweries, especially in the less than 1,000 and 1,000 to 10,000 barrels per year ranges.

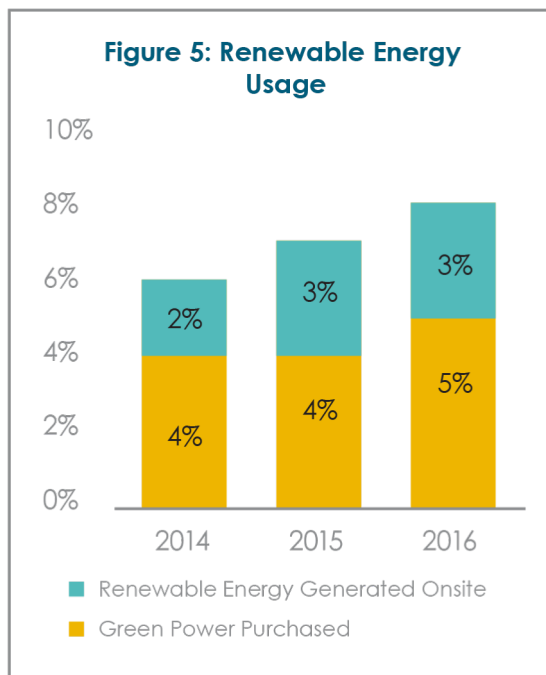
The 2016 benchmarking study participants and total BA membership numbers are presented in Table 1. Additional ratios and average facility metrics are provided in Appendix A and are broken down by production size, geographic region, and market segment.

Table 1: 2016 Benchmarking Study Participants vs. Total BA Membership

Production Volume (bbls/yr)	Participants	Membership
1 to 1,000	7 breweries	3,175 breweries
1,000 to 10,000	23 breweries	1,254 breweries
10,000 to 100,000	28 breweries	218 breweries
100,000 to 1,000,000	10 breweries	32 breweries

Renewable Energy

Over the past three years of benchmarking, the amount of renewable energy usage reported by participating craft breweries has increased from 6 to 8 percent. Some is produced from generation of on-site renewables, and some is electricity purchased through utility renewable or green energy sources (e.g. wind power). Figure 5 presents the percent renewable electricity utilized in the three year participant pool. Once again, these data are only representative of the benchmarking participants, not the entire craft brewery sector. On-site renewable fuel generation (biogas from anaerobic wastewater pretreatment) accounts for about 1% of participant natural gas usage over the past three years.



For an on-site renewable energy project to be successful, there are several challenges to overcome, such as the capital investment, roof or ground space availability, financial rebates available, and site-specific energy potential.

Getting Started with Renewable Energy

Breweries should first work on improving efficiencies within operations; this will also bring additional cost savings. Once a brewery sees progress and reaches the top 25% of benchmarked performance within their production size for efficiency, a renewable energy feasibility screening can be conducted. This can include the evaluation of on-site renewable installation vs. the option of purchasing green energy. Conducting an initial technical and economic feasibility screening can be a simple way to determine the basic potential of renewables at your brewery.

Sixteen participating breweries utilized renewable resources for electricity in 2016:

- Alamo Beer Company
- Alaskan Brewing Co.
- Bear Republic Brewing Co.
- Brewery Vivant
- Butcherknife Brewing Company
- Kona Brewing Co.
- Flying Fish Brewing Co.
- Jackie O's Brewery
- Maine Beer Co.
- New Belgium Brewing Co. (CO)
- North Coast Brewing Co.
- Odell Brewing Co.
- Sierra Nevada Brewing Co. (CA & NC)
- The St. Louis Brewery, LLC
- Upslope Brewing Company.

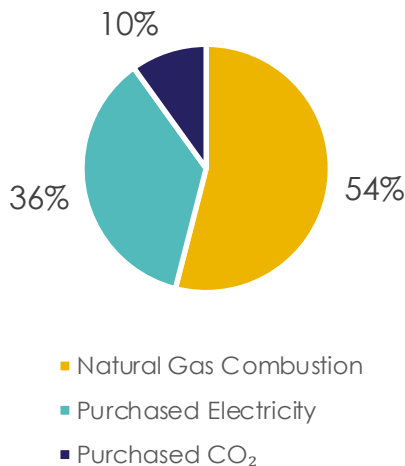
CO₂ Emissions

The craft beer industry utilizes natural gas, electricity, and purchased non-fermentation CO₂ to produce beer. All of these in turn contribute to a brewery's overall CO₂ emissions. Figure 6 outlines the relative contribution of all three components to total CO₂ emissions. A description of how emissions are estimated is outlined in Appendix C.

Benchmarking participants have utilized on-site renewable electric generation, biofuels, and purchased green electricity to avoid at least 3% of total CO₂ emissions each year. Figure 7 illustrates the emissions avoided due to on-site renewables and purchased green energy from the participating facilities in 2014-2016. These breweries avoided over 26 million lbs of CO₂ emissions over the three-year period through renewable energy usage.

In addition, there are also a few larger breweries that have installed CO₂ capture and reuse systems. These systems further reduce overall CO₂ emissions by limiting or altogether eliminating the need for the brewery to purchase non-fermentation CO₂. This is especially feasible for facilities that have a high cost associated with purchasing CO₂. In addition, some breweries have reported taste quality benefits from reusing fermentation CO₂.

Figure 6: CO₂ Emissions Contributions



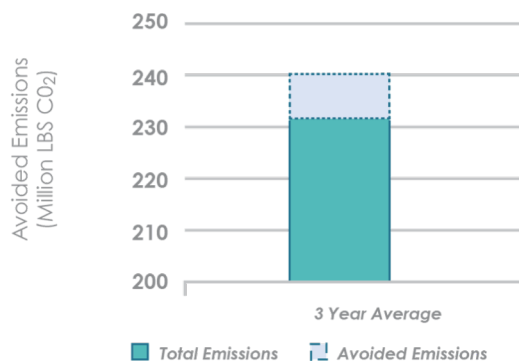
Key Takeaways:

Craft breweries in the benchmarking database are focused on improving efficiencies as the primary means for reducing CO₂ emissions and positioning for long-term success.

Some breweries have used rebates and other incentives to justify investment in their own renewable energy infrastructure. Other breweries are working with their local utilities to purchase electricity from renewable sources.

Larger breweries have invested in CO₂ capture and reuse systems. The economic feasibility of installing these systems in breweries producing less than 10,000 bbls/yr has not been favorable in the past. This could change over the next few years given advances in technology.

Figure 7: Avoided Emissions



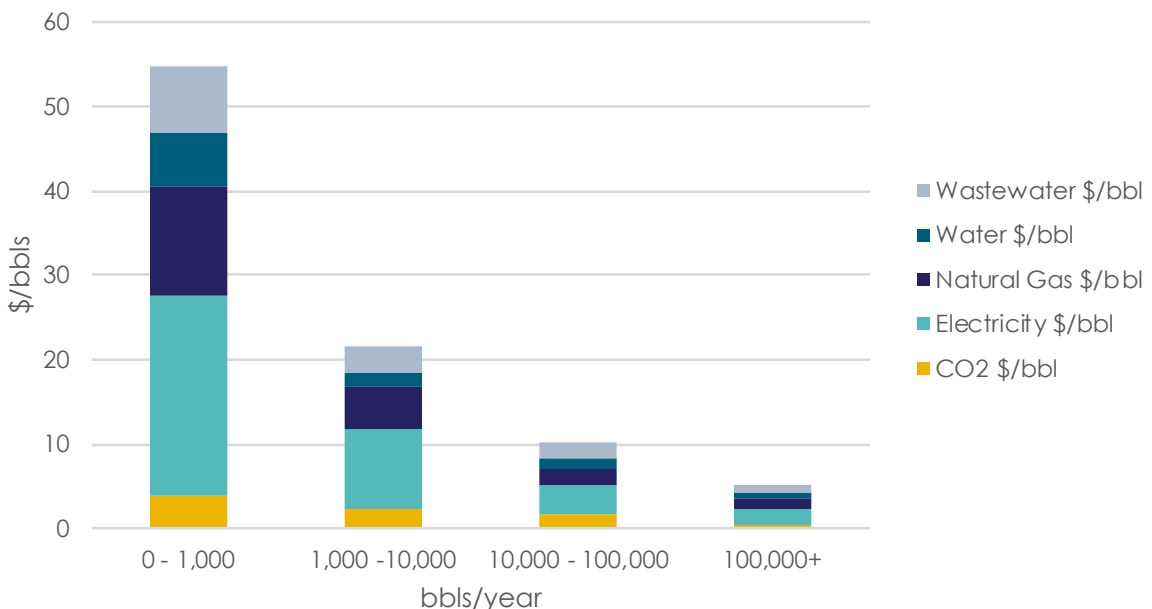
Sustainability-Related Utility Costs

The cost per barrel of sustainability-related utility KPIs has generally decreased over the three-year period for the benchmarking participants. Energy remains a significant utility cost for most breweries, with electricity comprising the majority of energy costs. Water costs have remained relatively constant. Wastewater has continued to take up a larger proportion of participants' utility costs each year at all production sizes. The benchmarking participants have paid over \$1 million for BOD (Biochemical Oxygen Demand) and TSS (Total Suspended Solids) high strength surcharges over the past three years. This trend is expected to continue.

Figure 8 illustrates the relative economy of scale of increasing annual production. As illustrated in Figures 9 through 12, the cost mix changes for some KPIs as production increases, and other KPIs stay relatively constant. Energy costs (electric plus natural gas) comprise about 70% of utility costs for breweries at all size ranges. These percentages continue to point toward a priority focus on energy efficiency improvement first, regardless of production size. Increasing energy efficiency not only reduces operating costs, but also has associated environmental benefits in terms of emissions reduction.

Some participating breweries have focused on water reduction as a priority given their location in water-stressed areas of the country. This decision is often driven by image protection and risk abatement versus pure cost reduction. Reducing water usage could put a brewery in a more resilient position to combat current and possible future water risk. This is further discussed in Appendix D.

Figure 8: Average Utility Costs for All Size Participants



Wastewater treatment has traditionally not been a significant cost for most participating breweries. However, that is slowly changing as the number of craft breweries continues to grow and municipal wastewater treatment plants are faced with increasing costs for treatment of BOD and TSS from brewery wastewater.

Some participating breweries have found centrifuges to be an effective tool in limiting BOD and TSS discharges to the municipal treatment plant. Others are looking to “side-stream” high-strength low-volume sources of wastewater to prevent discharge to the municipal system.

Key Takeaways:

Energy remains a significant utility cost for breweries, and should be a primary focus of conservation as it can lead to both reduced emissions and cost savings.

Water reduction is typically not driven by cost savings, but rather by image and operational protection from potential water shortages in water-stressed communities.

Wastewater is an increasing component of the overall cost. Many breweries have lowered their municipal wastewater charges by side-streaming high-strength sources of wastewater for beneficial reuse as animal feed, energy feedstock, and soil nutrient.

Legend:

Electric Cost	Natural Gas Cost
CO ₂ Cost	Water Cost
Wastewater Cost	

Average Utility Costs

Figure 9: 0-1,000 bbl/yr (\$/bbl)

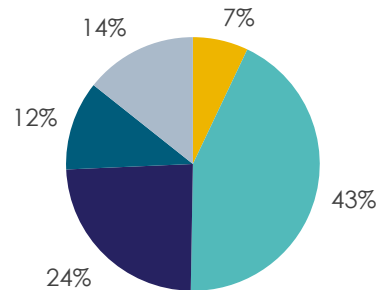


Figure 10: 1,000-10,000 bbl/yr (\$/bbl)

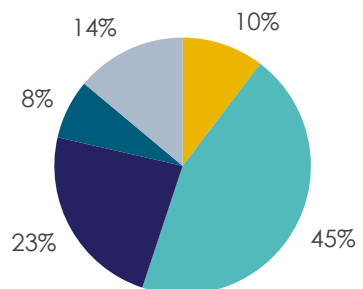


Figure 11: 10,000-100,000 bbl/yr (\$/bbl)

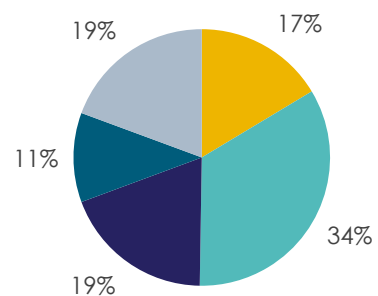
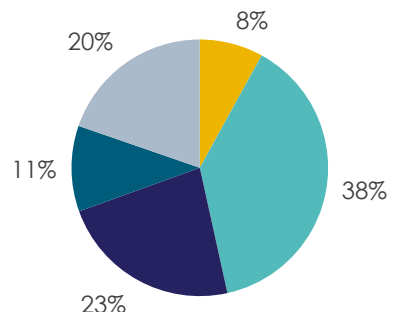


Figure 12: 100,000+ bbl/yr (\$/bbl)



Cost of Energy

The purchased unit cost of energy for the benchmarking participants has generally decreased from 2014 to 2016. Figure 13 illustrates how electricity and natural gas costs have declined over the three-year period for benchmarking participants. The U.S. Energy Information Administration has reported similar reductions in average unit prices as shown in Figure 14. Future energy prices are uncertain and could continue to decrease, flatten, or begin to increase. This energy price volatility creates a necessity for breweries to focus on efficiency improvement regardless of pricing trends. Lowering utility usage per barrel of production essentially creates a future hedge against increasing energy prices.

Key Takeaways:

While breweries may not be able to control the pricing of electricity, fuel, and other purchased resources, proactively reducing consumption and investing in conservation measures can position a brewery to be more resilient in times of price volatility. Lower average energy prices over the past few years have been an advantage to the craft brewing industry, but it is critical to look to the future and minimize the risks associated with these volatile markets.

Figure 13: Participant 2014-2016 Energy Prices

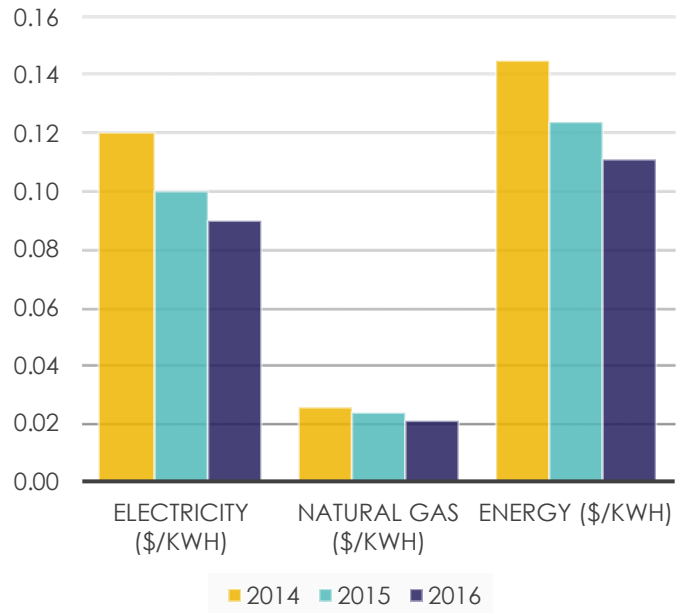
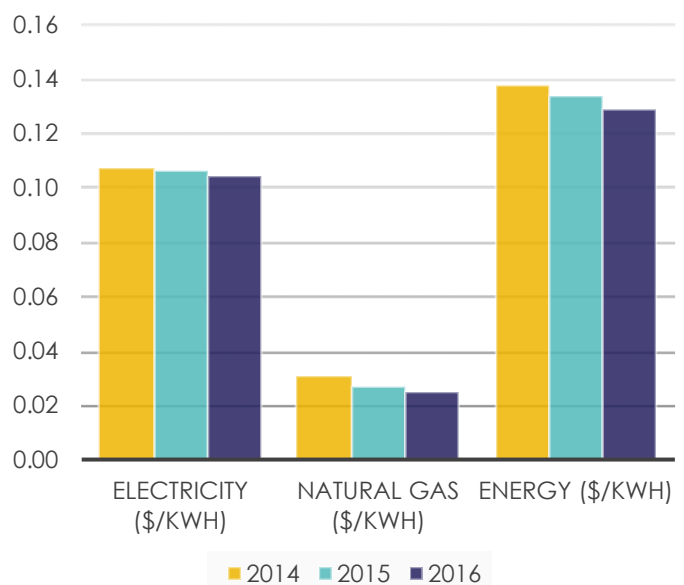


Figure 14: U.S. 2014-2016 Energy Prices (Source: Energy Information Administration)



Improving KPIs: Size Makes a Difference

Certain costs and resources, such as lighting, heating, and cooling, are necessary to operate any brewery regardless of production size. For breweries with production of less than 10,000 bbls/yr, these baseload operating costs represent a significant portion of the brewery's overall utility expenses as discussed in the Cost Per Barrel section.

When production increases, these baseload costs become a smaller portion of total expenses, and the variable costs fluctuate depending on how much beer is produced. The sustainability-related utility usage metrics of breweries producing more than 10,000 bbls/yr do not exhibit the same volatility when related to changes in the production volume; instead, these 10,000+ bbls/yr breweries exhibit more stable KPIs. Their production is high enough that monthly variations in barrels produced do not significantly impact overall usage ratios.

For breweries where baseload-related resource consumption comprises the largest portion of overall resource use, focusing on improving efficiency in the fixed electricity costs (LED upgrades, occupancy sensors, heating/cooling efficiency, etc.) is very effective.

Key Takeaways:

There are many opportunities to reduce baseload operating costs and resource consumption by simply focusing on tracking and managing utility usage. This is a critical time to engage your employees. You are encouraging a new culture of efficient and sustainable operations, which is not possible without employee engagement.

Beer Loss as a Metric

There are significant costs in raw materials, labor, and utilities to produce a barrel of high quality craft beer. Reducing beer loss helps put more beer in the hands of the consumer and more dollars in the hands of the business. Beer loss consists of any liquid that could have made it into the final product for consumption, but instead was lost to sewer, trucked to waste, or evaporated to air. This lost or wasted beer has a direct effect on production-related KPIs and related costs.

Every drop of beer lost represents wasted resources and money. Investing in improvements that minimize loss saves resources like natural gas, water, CO₂, electricity, raw materials, and even time. Many of the participating breweries that saw efficiency improvements have made addressing beer loss a primary focus. Breweries have implemented additional flow meters, valve controls, centrifuges, and equipment-tuning procedures as a means to reduce losses. Several case studies presented later in this report highlight specific initiatives that have been taken to address beer loss.

Although a beer loss metric has not been collected as part of this benchmarking report, it is a critical element of efficiency and should be a priority for efficiency improvement. Future development of a beer loss KPI and collection of benchmarking data is under consideration.

Benefits of Managing Beer Loss First

Making investments in a brewery's culture, procedures, and equipment in order to minimize beer loss can have positive impacts on efficiency improvement and profitability. When evaluating process improvements to justify capital expense and return on investment, consider the compounding effects that these investments will have. They will increase the amount of beer produced and packaged per batch, leading to more revenue. They will also reduce environmental impacts in multiple areas like reduced water usage and CO₂ emissions.

The Sustainability Journey

As a company matures, there are certain aspects of the business that become more efficient. This learning period can be a particularly vulnerable time for a new brewery. The faster an organization can master the learning curves associated with their products, the faster they can become an efficient and profitable business. For example, one brewery contacted for case studies identified multiple challenges with unanticipated waste streams upon opening. However, after adopting disposal solutions, they reduced their pounds of solid waste per barrel by more than 50% in three years.

Information sharing and reviewing industry publications, such as the BA Sustainability Manuals (Appendix E), can quickly aid breweries in taking early actions with immediate payback. Optimizing operational performance should be first on the to-do list and can be attained through a disciplined

approach to preventive maintenance. The following are some examples of how breweries have embarked on the sustainability journey and increased efficiency without large capital investments:

- Steam – Preventive boiler maintenance; frequent steam leak detection surveys and repair; monitoring condensate return; insulating pipes; and routine steam trap inspections.
- Compressed Air – Reducing system pressure as low as practical; adding accumulator tanks if additional storage is needed; and frequent leak detection surveys and repair.
- Water – Observe and control leaks (especially hot water); optimize cleaning procedures; and eliminate once through cooling systems.
- Chilled Water – Perform regular preventive maintenance on chillers and coolers; maintain design refrigerant charge; and check for fouling and corrosion.

Use the BA Resources on Your Journey

Taking the time to understand your operation and optimization of existing systems is critical to improving production efficiency. Buying and installing a technological fix is not usually the path to becoming more sustainable. Creating a culture of employee engagement is key.

There are multiple resources available from the BA to master learning curves quickly and see immediate benefits without large investments. Start your journey by reviewing the BA Sustainability Manuals in Appendix E.

case studies

The case studies in this **2017 Sustainability Benchmarking Report** illustrate the creativity and sustainability initiatives in the craft brewing sector. The case study interviews highlight multiple trends including:

- Emphasizing the importance of preventive maintenance procedures and properly caring for equipment. The benefits of these operating procedures can save breweries thousands of dollars a year by reducing production down-time and limiting malfunctioning equipment.
- Creating an employee culture with a core focus on sustainability and recognizing the importance of operating with environmental stewardship in mind.
- Tracking metrics to gather a baseline of performance and then working toward understanding where and how to set goals for efficiency improvement.
- Utilizing grants from government agencies or utility providers to help fund sustainable initiatives.

These breweries have demonstrated significant improvement over the past three years in efficiency for one or more sustainability-related metrics or are operating in the top 25% performers. Their insights provide valuable knowledge and guidance to others in the craft brewing sector. Those that have shared their stories encourage others to contact them directly to discuss sustainability strategies and to share improvement ideas.

See Appendix E for more information on how you can apply some of these best practices at your brewery.

Stakeholder Insights

Brewers: See what other breweries are doing to achieve top 25% performance in their production size range.

The efficiency improvement journey typically starts with tracking utilities for cost purposes. Think about beginning to track utility cost, and tracking usage will easily follow.

Community Leaders: Look for partnership opportunities as local breweries continue to put emphasis on making a positive environmental and social impact in the community.

State Brewers Guilds: See what sustainability initiatives are occurring at breweries and the impact on local communities in your state. Encourage others to join the effort!

Legislators: Small businesses have a key role in the community. These stories show that local craft breweries are making an economic and environmental improvement in the local communities that you represent.

Regulators: Craft breweries are voluntarily practicing pollution prevention and making environmental improvements without the need for specific regulatory action.

Alaskan Brewing Co.

Alaskan Brewing Co. has continued to showcase the achievements of its inventive, problem-solving team of employees. Based in Juneau, the group sometimes confronts tough issues that other breweries may not ever face. These difficulties, along with the founders' original passion for innovation, have fostered a pioneering culture, and challenges are viewed as opportunities to create solutions rather than as obstacles. They take great pride in demonstrating that Alaska, and specifically Juneau, is a great place to establish a business that can be a successful manufacturing operation.

Some of the difficulties the brewery has had to address include access to resources where other breweries might have well-established infrastructure in their local city or nearby surrounding area. Many times, the cost to transport materials helps the brewery justify efficiency investments. Some of the unique situations the brewery has faced include:

- Addressing the lack of cost-effective CO₂ suppliers – all purchased CO₂ needs to be shipped to the facility, thereby increasing costs substantially.
- Finding options for spent grain disposal – Juneau does not have any livestock farms.

- Determining efficient use of diesel fuel – natural gas is not a large-scale fuel option in Juneau.

But when people say something can't be done, Alaskan Brewing Co. finds a solution. Below are some of the distinctive solutions the brewery has found to address its challenges.

- They were the first craft brewery to install CO₂ reclamation. The system had a return-on-investment of less than three years.



Market Segment:
Regional



Alaskan Brewing Co. Team in Front of Their Variety Pack Assembly Line

- The brewery has been drying its spent grain for years because it needs to ship it to farms in Washington State. Out of this practice, innovative thinkers have established “Beer Powered Beer.” In 2010, they implemented a system to burn the dried, spent grain for heat. They had some difficulties at first and had to implement a fuel introduction system to get the grain to efficiently burn; however, after figuring out maintenance issues early on, they now have the process dialed in. The brewers use a mash filter press, which allows for the use of very fine grain. The grain is then dried in a rotary drier and blown into the furnace. The heat from the furnace is then used to dry the next batch of spent grain.
 - They have developed a more efficient water heating system that consumes less instantaneous steam, helping to reduce swings in boiler loading. It is similar to an “on-demand” heating system. This equipment goes hand-in-hand with preventive maintenance procedures for their steam systems, including regular trap checks, insulation replacement, and leak repair.
- The Alaskan Brewing Co. founders are well connected to the outdoors, and committed to being good stewards to the environment and community. All brewery employees have those same values too, so everyone remains on the same page to make sure their brewery operations better the environment and support the area in which they all live.

Bear Republic Brewing Co.

Bear Republic Brewing Co., located in Northern California, has had to adapt its operations to account for natural resource shortages and natural disasters. Their experiences emphasize the importance of addressing environmental impacts in daily life. During the recent droughts, strong opportunities existed for connections to be forged between peoples' livelihoods and natural resources. The drought conditions pushed the brewery and its employees to change behavior and make resource conservation part of their culture, such as when coworkers turn off a rinse-down hose if it has been running too long during a cleaning process. Because of this engrained awareness of a strong association between water usage at the brewery and continued impact in operational areas, it's now easier to transfer that mindset to other resources. Wastewater in particular has been the logical next step for efficiency improvement initiatives.

The brewery's overall wastewater flow has been reduced over the past few years through multiple initiatives:

- The focus on improving their water use ratio has led to a natural reduction in wastewater.
- The facility has added a new centrifuge, which allows for side-streaming their yeast from the fermenters. This has reduced biochemical oxygen demand (BOD)

loading to the drain by 6,000 gallons of yeast per week and has reduced their beer loss during transfer from 6% to 3% in the cellar. As an added benefit, they are also able to offer their non-GMO yeast to dairy farms as organic feed for cows.

- By utilizing low-strength wort left in the mash tun as strike water for the next brew, they have reduced about 5,000 gallons of effluent per week with an approximate BOD of 30,000 mg/L. This reuse of "scrap," which contains extract, has reduced the amount of barley the brewery needs to purchase.

Bear Republic has also installed a wastewater pretreatment system with both anaerobic and aerobic components. The new 30kW micro-turbine that runs on the biogas generated from the anaerobic digester operates in tandem with a 65 kW micro-turbine that runs on mixed natural gas and any extra biogas from the digester that is not used in the 30kW unit.

Location:
Healdsburg, CA

Market Segment:
Regional





Bear Republic Brewing Co. Team

The facility has also installed a 125 kW PV solar system, which is complementary to its micro-turbine system. The cogeneration units are constantly producing electricity and waste heat, offsetting 95% of the steam from the boiler needed to produce process water. A new pre-heat tank captures the process water and also serves as a water-saving “buffer” by capturing all of the water used to chill the wort. This has prevented about 7,500 gallons of potable water from going down the drain as wastewater per week, and has improved their water balance.

Although Bear Republic Brewing Co. has seen a slight increase in their overall natural gas usage, these new equipment

improvements have decreased electricity usage and overall energy costs. For their brewery, this change in consumption makes sense economically because, due to their location, electricity costs roughly 20 times more than natural gas on a per-joule basis. In addition, utilizing more natural gas is a cleaner source of energy as well, and the new co-generation equipment reduces the boiler load and NOx emissions.

They are looking forward to a continued decrease in overall energy usage as they further utilize their co-generation system.

Elliott Bay Brewhouse & Pub

Elliott Bay Brewhouse & Pub, located in Burien, WA, has been an active participant in the BA Benchmarking initiative for the past three years. However, their journey to implement sustainable practices began even before the first benchmarking report was published and breweries had dashboard access.

As one of their first steps along their sustainability journey, an external team conducted a site visit to identify areas where the brewery could make possible efficiency improvements. One outcome of this meeting was an opportunity to utilize their extra glycol chiller as a way to contain excess water that was spilling onto the floor. Since that original facility review, the extra glycol chiller has been connected into the facility plumbing and runs diverted city water to the glycol-chilled heat exchanger before it hits the beer heat exchanger. This trims a few degrees off the city water, in turn allowing more heat exchange capacity which helps compensate for the brewery's lack of a cold liquor tank. This system is utilized during the warmer months to prevent the chiller from using more energy to work harder during the colder months when it is not as necessary to cool the city water.

The brewery also made some improvements to its basement mechanical room, which houses their boilers, air compressor, and glycol chiller. A lack of air inflow and waste heat in the

room contributed to a facility air balance issue. The old boilers were not getting the proper flow of combustion air, which further reduced their efficiency. Air compressors are especially sensitive to inlet air temperature, and efficiency drops as air temperature increases. To remedy this situation and increase efficiency, the brewery replaced their 20-year-old boiler around 1.5 years ago and installed a thermostat-controlled exhaust fan to move heat out of the small space. After installing the exhaust fan to remove the built-up waste heat, the brewery noticed substantial improvement in metrics and operational efficiency.

Elliott Bay Brewhouse & Pub has also experienced efficiency losses resulting from steam trap failures. The traps had issues with corrosion and would not open and close properly.



case studies:

Elliott Bay Brewhouse & Pub



Elliott Bay Brewhouse & Pub Team

Not all of the steam was making it to the kettle, so the brewery decided to replace these steam traps. Now the brewery has steam traps on a scheduled annual maintenance plan, which is an easy common practice for any brewery to adopt. Because of this preventive maintenance, the brewery typically only needs to replace the gasket material instead of replacing the entire trap, which saves significant cost in the long run.

The brewery has also moved to act on energy savings by replacing overhead fluorescent lights in addition to evaluating incentives available through their utility provider. They also utilize motion detectors in their working spaces

and cold rooms to help save electricity. Another new initiative they have recently implemented in their cold rooms includes evaporator relays. When the evaporators are operating, the relay fans will run until they achieve a set point, such as 40 degrees. At that point, the evaporators shut off and only some of the fans stay on as circulators. The relays allow the brewery to run half of their fans during the circulation phase, which saves a considerable amount of energy.

As their journey progresses, the brewery is excited to continue to invest in other sustainability initiatives such as lab space improvements and additional quality control equipment.

Horse & Dragon Brewing Company

Sustainability is engrained in the operations at Horse & Dragon Brewing Co., particularly in their approach to waste management. Their journey started shortly after the brewery became operational. As is sometimes observed at many startup breweries, there was not a clear understanding of the variety of waste streams that a brewery produces, as well as the city's infrastructure and where the waste could go. Shortly after realizing what their waste streams entailed, they were able to reduce their waste and increase recycling and composting. Despite increasing production, their solid waste production per barrel has decreased by 50% over the past three years.

Horse & Dragon Brewing Co. has had unrelenting support from employees, the community, local businesses, and city government. Some of the initiatives at the brewery regarding waste reduction include:

- Hand dryers – On average, 80% of the waste in their residential-sized garbage bin was used paper towels, so the brewery installed electric hand dryers in the restrooms to reduce paper towel waste.
- Small trash can – Horse & Dragon Brewing Co. has one small trash can in the brewery to help remind customers and staff that they should not be wasteful. This small can has often become a central point of

discussion among customers and employees and sparks the conversation about waste.

- Spent grain recycling – Horse & Dragon's location affords them easy access to agricultural land where they can send spent grain. Local farmers (5 miles away) come to the brewery to retrieve material such as spent grain, hops, and coffee grounds to supplement feed and use on the soil that needs nitrogen and acid.
- Clear Intentions – A Denver-based glass recycling company has installed recycling bins on-site. Employees and community members can bring their own glass to the brewery for recycling with Clear Intentions.
- Local recycling – Horse & Dragon makes twice-a-month trips to recycle all non-food waste, except Styrofoam.



Market Segment:
Microbrewery



Location:
Fort Collins, Co

case studies:

Horse & Dragon Brewing Co.



Horse & Dragon Brewing Company Team

- Waste from events – The brewery requires any groups using the brewery space to be responsible for their waste, meaning guests pack out their trash after their event ends. This is not because Horse & Dragon is unable to dispose of the trash, but instead it serves to remind people of the volume of waste they are capable of producing. Customers have embraced this practice, and Horse & Dragon has received positive feedback.

Because of their waste practices and focus on recycling, one of the brewery's largest waste streams is currently trub. They are already reusing yeast for up to nine generations, but wastewater quality is an area of focus for improvement in the years to come.

Another area of interest at the brewery is water recycling. Employees currently collect all water that is left in glasses throughout the day and use it to water outdoor plants. This saves approximately 2 gallons per day.

Being based in Fort Collins has given Horse & Dragon access to the city's Climatewise program, which constantly suggests (and supports) new environmental sustainability initiatives.

The brewery is thrilled that its employees are eager to participate in waste reduction and other sustainability initiatives. Horse & Dragon Brewing Co. wants to use this excitement to improve their own sustainability story-telling to their employees and the community.

Jackie O's Brewery

Jackie O's Brewery is strategically thinking about operations at its locations for the long-haul. They don't want to save money on the front end only to pay for it later. The brewery invests in good equipment and operational procedures to optimize brewery functionality and ultimately put their beer on the shelf for consumers. Part of this thinking has led them to invest in sustainability measures that sometimes have longer payback periods. They take a "slowly but surely" approach as there are some occasions where economics play a part and may delay sustainability efforts; however, they try to push forward to be both sustainability and community leaders.

One example of their long-term thinking includes their investment in a 20-acre farm as a place to divert their organic waste, revamp the soil over the next decade, and reduce their load to the municipal WWTP. This investment and long-term strategy was supplemented with the installation of a centrifuge in early 2018. They'll be making their beer bright and the dirt dark at the same time.

They also invest in American-made equipment. Although it might not be as cost-effective as imported equipment, the brewery believes this is an important community investment. They've found that American-made equipment is extremely high quality, has an unparalleled longevity, and provides a great return on investment. One

example of their choice to invest in American-made equipment relates to their variable frequency drives (VFDs). AC motors are abundant in a brewery, and Jackie O's Brewery has made a choice to source the most efficient equipment. Their employees are equipment savvy and will fine-tune the VFDs to work at their most efficient level. The brewery could not operate at its current level without VFDs. The brewery hasn't specifically measured the return on investment, but process-wise, they aren't shredding valves, tripping breakers, or slowing down operations like they were with their old 3-phase motors.

Additionally, Jackie O's Brewery was able to utilize grants and install solar panels, which will see a longer-term payback. When their electricity demand is higher than their solar production, they purchase renewable energy certificates (RECs) to ensure 100% of their facilities' energy usage is green. On top of this effort, they have also retrofitted all of their lighting to LEDs.



case studies:

Jackie O's Brewery



Jackie O's Brewery Team

In 2015, the brewery expanded to 17,000 square feet, and part of this expansion included adding radiant floor heating. According to the brewery, the facility is almost getting too hot because the radiant floor heating is so efficient. They are currently testing out the plant glycol chilling system to see if they can offset the radiant heat. Within the last few years, Jackie O's Brewery has seen increased fuel efficiency, it attributes these efficiencies to building sustainable processes into the recent expansion and investing in new efficient technology, with plans to benefit from future returns.

Relating to a change in infrastructure, but also including a behavioral change, Jackie O's Brewery has changed its waste management process by switching to rolling garbage bins and two large recycling dumpsters, as opposed to their previous system of garbage dumpsters and rolling recycling bins. The brewery notes that when the company culture makes it easy to

recycle, people will recycle. They have not had pushback, but sometimes do not see follow-through, so they continue to work on changing behavior – sustainability has to be a community effort. Jackie O's Brewery is located in Athens, OH, a busy college town, which is a key factor in their focus on sustainability and their determination to save the planet one day at a time. This has always been a backbone of their operations, and as they've grown, the team has always looked to sustainability to improve operations, not only for utility costs and usage, but also for employees' lives. Jackie O's Brewery strives to source locally, make locally, and serve locally. Their local influence puts Jackie O's Brewery in a great place to be active members, and they are proud to support many of the events in their community.

Kona Brewing Co.

Kona Brewing Co. is committed to being a leader in safety, quality, continuous improvement, and efficiency, and further emphasizes sustainability within the company culture. It especially helps that Hawaiians are naturally connected to the environment, so Kona Brewing's company culture builds on that local foundation. Because of their location on a remote Hawaiian island, it is critical for their brewery to be conscious of resource consumption. Kona Brewing Co. has implemented a number of operational procedures as well as equipment upgrades over the past several years to drive resource management and efficiency improvements.

An important practice the brewery has implemented is tracking KPIs, or Key Performance Indicators, from utilities to beer loss and brewhouse efficiency. The KPIs help create a path forward to improvements. The more information at hand, the better the chances that operations run smoother and more efficiently. The brewery cites its practice of tracking KPIs as being key in driving success, and they have monthly meetings to discuss KPIs, which bolsters the whole team's awareness of resource efficiency. The brewery can then develop specific projects related to the metrics, including initiatives focused on continuous improvement. One of the ways that Kona Brewing Co. drives progress is by making many incremental changes instead of large operational

overhauls. They continuously improve systems that impact multiple metrics, such as reducing hot water usage to save both water and fuel. One example of this is a simple retune of their hot water boiler, which significantly improved efficiency for both water and propane. This mechanical improvement was also supplemented by a new boiler in 2016, which further improved thermal efficiency KPI. In addition to these heat savings, they've also been reducing water usage since replacing their kegging line in mid-2015. Instead of running the keg system by filling until overflow, they now measure by weight. This change in operation was a little challenging at first since they have many different sized kegs, but they are focused on reducing water usage for cleaning, reducing beer loss, and ultimately putting a consistent product out the door.

Location:
Kailua-Kona, HI



Market Segment:
Regional





Kona Brewing Co. Team

Kona Brewing Co. also addresses maintenance issues as soon as they arise. Pipes that contain liquid flowing at a hot or cool temperature are insulated, and employees focus on keeping all pipes tightly wrapped to reduce energy loss. Reducing heat waste improves the efficiency of processes, for example, hot water reaching the mash tun at the correct temperature vs. adjusting. There are always ongoing insulation checks, and if there is a break, it immediately becomes a focus to fix. This practice also helps the brewery's cooling system run as efficiently as possible. Colder glycol means less waste when filtering, carbonating, and filling kegs. Cooling is an especially important factor at the Hawaii brewery since average daily temperatures rarely fall below 70 degrees Fahrenheit.

Kona Brewing Co. also conducts preventive maintenance processes to address concerns before they become efficiency issues. Part of the focus on maintenance stems from their proximity

to the ocean. Salt water has impacted their equipment to the point where some of the equipment and linkages become rusty. However, with a good maintenance program and visual checks, they are able to keep things running efficiently and address issues prior to emergency setbacks. The standard procedures to include preventive maintenance were implemented in early 2015, and since then, employees have noticed things running more efficiently, reducing the need for reactive maintenance and improving KPI efficiency metrics. The brewery does not look for a silver bullet in terms of what can make their system better, but they make incremental improvements to existing systems and evaluate their operations holistically. Based on the success of this preventive maintenance, Kona Brewing Co. plans to build off the success of its preventive maintenance program by implementing more predictive maintenance measures in the future.

North Coast Brewing Co.

North Coast Brewing Co. has created a corporate culture with sustainability at its foundation. To showcase their commitment, the brewery achieved Certified B Corp status and changed their articles of incorporation to become a benefit corporation, which is unique in the industry. The primary tenet of the B Corp movement is to use business as a force for good in the world. To this end, North Coast Brewing Co. has partnered with Fortunate Farm in nearby Caspar, CA, by investing in the acreage, equipment, and infrastructure. The brewery has made it possible for a young farmer to establish her business with sustainability at the core of her practices. Not only does this farm grow vegetables, it is part of a long-term agricultural study of the effects of carbon sequestration on soil health. Referred to as "carbon farming," composted spent grain is applied regularly to the fields. The soil's carbon and microbial content is continuously monitored. The results indicate improved soil health with increasing carbon levels. Carbon farming is seen by many as a way to help reverse the impacts of climate change, and it provides North Coast Brewing Co. the opportunity to repurpose their spent grain in a manner that is beneficial to the planet.

In brewery operations, greater efficiencies have been realized by upgrading older, less efficient equipment. Replacing a 1970s vintage

steam boiler with two modern, tubeless steam boilers resulted in a 23% reduction in fuel consumption per barrel of beer produced. Replacing an outgrown lauter tun with a mash filter press provided enormous improvement. Malt usage decreased by 6% on beers of average strength (for which the lauter tun was sized) to greater than 10% for big beers where the lauter tun was too small to be efficient. The mash filter press has also reduced fuel gas usage by an additional 9.4%. Water usage/bbl of beer produced has also decreased by 10% (down to 4 bbls water/bbl of beer) due to the efficiency of the mash filter press.

Adding processes to reclaim energy and CO₂ have also yielded gains. Brewhouse upgrades in 2010 included a vapor-condensing system on the brew kettle that reclaims the energy in the vapor created by boiling the wort. A regional shortage of liquid carbon dioxide in 2013 forced the brewery to look for innovative ways to reduce CO₂ usage or cut production.

Location:
Fort Bragg, CA



Market Segment:
Regional





North Coast Brewing Co. Team on a Coastal Clean-up Day

The cellarmen began cleaning bright beer tanks with an acid cleaner instead of caustic, allowing them to clean the tank under pressure to preserve the CO₂ environment in the vessel. To ensure there was no buildup occurring, the bright tanks would be opened every third cleaning, which necessitated a CO₂ purge after sanitizing. With large fermenters in high krausen adjacent to the bright beer tanks, the idea of piping CO₂ from the fermenter's blowoff through a sanitized tank of sterile water (to remove vapor and reduce volatiles) was implemented, and a process that required a significant amount of bulk CO₂ was replaced by one that recycled gas generated during fermentation.

Increased training and education has led to greater awareness among employees on the importance of using resources efficiently. Managers hold weekly meetings to discuss operations and procedures and seek input from employees to further improve both

efficiency and safety. These discussions have resulted in employee action, such as sweeping up hop debris instead of washing it into the drain with a hose. This measure saves water as well as reducing the brewery's effluent load on the municipal waste water facility. Employees also utilize large, reusable elastic bands to secure empty kegs instead of wrapping the palletized kegs with plastic stretch film. There are scores more examples of these little changes that seem trivial on their own, but when added up, produce a meaningful cumulative result. The brewery has empowered employees to be part of innovation by providing a mechanism for offering new ideas and celebrating viable solutions with employee recognition and reward. This strategy has led to strong buy-in with staff and has undoubtedly contributed to the brewery receiving Platinum Level Certification in their first attempt to achieve Zero Waste Facility status.

Rising Tide Brewing Co.

Rising Tide Brewing Co. has been continually improving its energy efficiency over the past few years through a number of equipment and process changes. The brewery reports that energy efficiency has continued to increase as production volume increases, and as discussed in this report, electricity is part of the baseload for operations at all breweries. Economies of scale do not necessarily play a part until production greatly increases. In line with the industry, Rising Tide Brewing Co. was experiencing overhead costs for electricity use, regardless of whether they were making beer at the time. This overhead cost added up over time. They noted efficiency improvement once their production began increasing.

In an effort to further increase their electrical efficiency, the entire facility is undergoing a lighting retrofit to LEDs. Because of their increased production, the brewery was also able to program their steam boiler to run 24 hours a day, seven days a week. With this new operation, the boiler gives off continual waste heat from the brewing process; however, the facility utilizes its waste heat in the winter to heat their building. Also, they've changed their brewing process to maintain the temperature of their hot liquor tank hot at all times, which eliminates the need to reheat the tank after three to four days of sitting idle. In 2016, they installed a high-efficiency air compressor with a 400-

gallon storage tank for their canning operations. This set a wide tolerance range so that the compressor does not short-cycle. It cycles on and stays on until the system reaches the high set point, and then allows the pressure to drop to a low set point before turning back on. This runs a lot more efficiently than their old compressor, which ran constantly regardless of cycle length.

The biggest hurdle Rising Tide Brewing Co. faces is determining the impact modifications will have on their production process. Sometimes impacts are unknown and could be positive or negative; these unfamiliar results stem from data limitations and unidentified interdependent processes - it can be challenging to gather the appropriate measurements when a brewery is running at full tilt. Another hurdle is dealing with beer loss as it has a direct correlation to product volume, profitability, and KPIs. Rising Tide Brewing Co. has noted their losses primarily at the fermentation/brite tank stage and at packaging.



case studies:

Rising Tide Brewing Co.



Rising Tide Brewing Co. Production Team

Rising Tide Brewing Co. has implemented measures to reduce beer loss including:

- Sending clean beer to the fermenter with low hop/yeast residue qualifications so they can pull beer from the bottom of the tank instead of the top utilizing the racking arm, in turn saving 1 bbl/batch;
- Monitoring overfill of packaging and dissolved oxygen by using combined meters and tuning equipment;
- Training operators to view the packaging line as an instrument instead of a machine, which minimizes shutdowns and spills;
- Pre-chilling the line so that less beer is lost at the start of a batch; and,
- Monitoring the flow meter to determine the primary source of beer loss.

One area of focus for the next year is increasing CO₂ usage efficiency, as Rising Tide Brewing Co. experiences significant venting loss during filling. The brewery currently pays more than the industry average for CO₂, and minimizing CO₂ loss will prove more valuable from an environmental and cost-benefit perspective. They are installing new meters and looking to move to a bulk CO₂ system instead of their two 750 lb tanks.

Rising Tide Brewing Co.'s culture has made sustainability a focus in every part of their operations. They have been working to empower their staff, who appreciate the focus on sustainability. The brewery has now formed an official sustainability team, and they are hoping for ideas, initiatives, and improved efficiency results to come out of this in-house group.

Sierra Nevada Brewing Co.

Sierra Nevada Brewing Co. has two locations in the United States: the original brewery in Chico, CA, and a recently built brewery in Mills River, NC. Over the past few years, the breweries continue to showcase increasing efficiency trends at both locations. Their internal sustainability team actively uses the online BA dashboard to track their utility metrics, and they continuously reach out to determine how some of their unique brewery operational practices can be classified within the utility categories.

In order for their employees to hit the ground running on sustainability initiatives, the company has developed a robust new employee orientation program. On day one of employment, each person receives a reusable coffee cup and shopping bag. This showcases the company culture and sets the expectation that all employees participate in sustainable practices not just at work, but in their everyday lives. They spend an hour reviewing sustainability initiatives with new employees during onboarding, which sets the stage for new hires to understand the processes and beliefs of the company. Part of this discussion teaches everyone that all of the resources utilized to make beer are valuable – any waste of time, packaging, water, electricity, and ultimately the beer itself is an inefficient use of resources and money. This has made an overall impact on company culture and how employees

view materials and resources.

In addition to new-hire onboarding, there is also training for departments related to achieving goals set by the brewery. This ensures that the responsible party has the proper tools to meet the goals. These goals have been tied to employee bonuses as an incentive for the entire company to play a part in improving sustainability practices. Sierra Nevada Brewing Co. recognizes that the tie between sustainability goals and bonuses helps bring a larger awareness to the issue of using resources efficiently.





Sierra Nevada Brewing Co. Ladies on Pink Boots Brew Day

There are multiple goals related to improving sustainability metrics, including waste reduction and increased recycling. For example, there is a company-wide goal to increase the amount of material recycled and decrease amount to landfill, all while decreasing the waste as measured by lb/bbl. The brewery is diverting material from landfills and recycling 96% of their waste material (excluding spent grain).

In addition to employee training and goal-setting, Sierra Nevada has also installed new equipment to improve operational efficiency to further boost sustainability metrics. Previously, the Chico facility had a 1-MW fuel cell system, but in 2015, this was replaced with a gas fired 2-MW micro-turbine system that co-generates steam and electricity. This new system was fully operational in May 2016 and works in tandem with their 2-MW solar array. The

microturbine system load follows with the brewery electrical demand, so it changes the energy output based on what the brewery needs. As the sun rises, the turbines will throttle back due to the output of the solar array, and as the sun sets, the turbines will increase their output. Additionally, hot water recovery after the steam generation provides additional energy into the plant, further reducing the demand placed on the boilers. In 2017, Sierra Nevada also installed a 500kW Tesla battery system in Chico to further reduce electrical demand charges.

Sierra Nevada is also utilizing Capstone microturbine technology at their Mills River brewery. The brewery has a 400 kW system that runs on biogas generated at the on-site wastewater treatment facility. This system works in tandem with a 600 kW solar array, all providing renewable energy for the brewery.

Ska Brewing Company

One of the mentalities at Ska Brewing is that if you don't measure it, you can't manage it. Initially, the brewery started tracking utility costs to measure financial trends for their leadership team. Over time, Ska Brewing expanded tracking to focus on utility usage and costs.

By late 2015, individual department heads were responsible for tracking, overseeing, and reporting their utility metrics. The departments hold meetings to present metrics and trends, creating employee interest and interaction. Employees moved to not only track and measure their performance, but to also share and compare their performance amongst their peers, which has naturally driven efficiency improvements. This measurement, tracking, and sharing created ownership and effected change within operations because the employees became self-aware of their behaviors. There is an excitement around responsible and efficient natural resource use at Ska Brewing, and employees translate this excitement into contributing ideas on how to continue increasing efficiency to improve operations. In addition to the individual department meetings, all-staff meetings include sustainability information, and a monthly HR newsletter now includes a quarterly sustainability update. Ska Brewing's journey has developed from tracking financials to measuring and improving utility metrics while holding fast to the Ska Brewing value of quality

over quantity as they continue to push for more improvement by attaining their metric goals set last year.

Although Ska Brewing has made great progress, the brewery still faces limitations when the most efficient brewing technology costs are not feasible for their scale. For example, the brewery would like to implement a system to recover CO₂; however, it is difficult to find an effective solution for a brewery of their size. Ska Brewing would also like to more effectively measure their actual waste disposal. They downsized their facility dumpster from an 8-yard to a 6-yard and received some pushback at first; however, through operational and behavioral change, they were able to effectively reduce their waste disposal.



Location:
Durango, CO

Market Segment:
Regional





Ska Brewing Team

Ska Brewing has made a number of efficiency improvements including equipment upgrades and changes in standard operating procedure. Some of these include:

- Xeriscape bier garden with flagstones instead of grass, natural shade, drip irrigation, and herbs grown on-site for use in the kitchen;
- Retrofitted swamp coolers with timers to reduce energy consumption;
- Continual water, steam, and compressed air leak checks;
- Significantly reduced clean-in-place cycles and changing the cleaning solution supplier and concentration;
- Installed low-volume hand sinks;
- LED retrofit and lighting controls;
- High efficiency boiler and increased steam header size;
- Increased hot liquor storage for more efficient heat recovery;
- Ionized air rinse on packaging lines instead of water rinsing;
- Efficient, on-demand, de-aerated water system for packaging; and
- Turning on kitchen equipment 30 minutes before opening instead of on employee arrival, saving three hours of natural gas usage per day.

Ska Brewing is also mindful of its beer loss (primarily in fermentation and filtration). They have installed two flow meters and have tuned their packaging equipment to reduce beer loss by over 1%, equating to thousands of cases of packaged beer for their consumers. Addressing beer loss will continue to be a focused initiative and they're excited about the installation of a 67.8 kW photovoltaic solar panel system completed in June 2018.

Upland Brewing Co.

Upland Brewing Co. showcases their sustainability initiatives in many ways at their Bloomington, IN facilities. At a high level, the company is strongly focused on environmental stewardship – even their logo pays tribute to the natural environment. Culturally, their entire organization is engaged and plays an active part in reaching their sustainability goals and objectives.

As a smaller regional brewery, the brewery staff faces some limitations to the projects that can be pursued. Upland Brewing Co. addressed this challenge by creating illustrative charts for natural gas, electricity, and water, depicting costs for each of their seven locations. They use these charts to deliberately analyze the financials to determine areas where investment could have the biggest bang for the buck while also improving their efficiency.

Upland Brewing Co. also relies upon grants for financial support of sustainability initiatives; recently, they conducted a solid waste survey and received a grant to implement composting. They have targeted a 20-30% reduction for their waste-to-landfill amount. This composting initiative will be implemented in the next year.

Upland Brewing Co. also has many other sustainability initiatives in place that are increasing their utility usage efficiency, such as:

- Boiler timers – Timed cycling allows the boilers to run only when needed; instead of running 24/7, the boilers

turn on a few hours before production four to five times a week and turn off overnight.

- Blow down boilers daily – Every day the brewers blow down the boilers and use a meter to check conductivity throughout the process.
- Local contractor inspections – Once a quarter, a local mechanical contractor (certified boiler inspector) conducts an inspection, which always goes well!
- Preventive maintenance for boilers – The brewery takes good care of its equipment, and if something breaks, they fix it right away.
- Variable thermostats – Programming and locked controls minimize the use of heat when people are not at the facilities (overnight).
- Solar water heating – The downtown pub uses a solar water heater for all process water.
- Spent grain recycling – The facility sends all spent grain to local farmers.



Location:
Bloomington, IN



Market Segment:
Regional



Upland Brewing Co.'s Sours Brew Crew

- Water usage tracking – The brewery tracks water usage metrics diligently to refine their internal processes; they do not want to use water when it is not needed.
- Variable speed hoods – All kitchens have variable speed hoods to help increase energy efficiency.
- Geothermal heating – One of the restaurants utilizes geothermal heating, helping to reduce their natural gas use, which typically spikes in the winter due to their northern location.

The brewery location also prompts extra awareness on wastewater management. The local municipality has started to impose surcharges based on incoming water for BOD and TSS exceedances over 300 ppm. To avoid the extra charges, the brewery has implemented a partial wastewater treatment system for phosphorous and pH. To limit their BOD and TSS, they utilize a centrifuge and side-stream waste. They are not yet large enough to justify the costs to implement a full wastewater treatment system, but Upland Brewing Co. is very vocal about

wastewater management within the craft brewing industry because they want new breweries to be proactive in this area. Currently, wastewater is their biggest opportunity for cost reduction.

Because of the focus on wastewater management to limit their operating costs, they've had to implement procedural changes for side-streaming waste that require extra steps and extra cleaning. After the initial hesitation by employees to the proposed changes, it is now the new normal for operation. The employees understand the importance and want to do what's best for the environment as well. They are anticipating a similar positive outcome when they start composting, which will require some extra steps for restaurant staff. And again, their culture plays a big part in the operational alignment with sustainability. Sometimes these new efforts require follow-up, diligence, and reminders, but employees believe in working toward improving efficiency and bettering the environment, and they hold each other accountable.

goal setting

Participating breweries have demonstrated that it is possible to track sustainability-related metrics, gain understanding of performance and trends, set goals to strive for efficiency improvement and then reap the environmental and financial gains.

The process of tracking and monitoring data to boost efficiency and implement lean practices reduces a brewery's environmental footprint and ultimately avoids significant operating costs. Through the online BA Benchmarking Tools, the "progress to targets" function can be utilized by any member brewery at any point along their sustainability journey.

Through the benchmarking work and sustainability manuals, the BA and the Sustainability subcommittee encourage conscientious brewing practices that will ensure the long-term success of the craft beer industry.

We continue to seek and encourage other breweries to join the effort to participate in the benchmarking tools, identify trends, and share best practices, so that the entire craft beer sector can continue to grow in a responsible manner.

It is recommended that breweries utilize the 2016 data benchmarking snapshots in Appendix B when setting new goals. These give a clear overview of the different performance classes for each KPI. Consider these steps:

- Compare yourself to others in the same production size category. If you are likely to move into a larger production size category in the next 12 months, compare yourself to the larger category.
- If you are in the bottom 25%, look to break into the middle of the pack. Reference the efficiencies between the median and the Top 75%.
- If you are a middle-of-the-pack performer, break into the Top 25%. Reference the efficiencies between the best-in-class performer and the median to set targets.
- If you are a Top 25% performer, set a target to reach best-in-class efficiency.
- If you are a best-in-class performer in your current production size, look to the production size category one level above your current characterization. Economies of scale help utility usage efficiency increase with production size.

Goal Setting

appendices

Appendix a –

Participant Results

Appendix b –

2016 Benchmarking Snapshots

Appendix c –

Greenhouse Gas Estimations

Appendix d –

Water Risk Assessment

Appendix e –

Sustainability Resources

Appendix f –

Reporting Breweries

appendix a:

participant results

The pages within this appendix section include three tables focused on water, energy, and CO₂ emissions. The usage ratios are presented and broken down by multiple categories to help breweries identify different comparisons between their peers and help them identify where they fall in relation to other production sizes, regions, and market segments. The water, energy, and CO₂ emissions metrics are categorized by:

- Production Sizes –
 - 0-1,000 bbls/yr
 - 1,000-10,000 bbls/yr
 - 10,000-100,000 bbls/yr
 - 100,000+ bbls/yr
- Market Segments –
 - Microbreweries
 - Brewpubs
 - Regional Breweries
- Regions –
 - Northeast
 - North Central
 - South
 - Mountain West
 - Pacific
 - Pacific Northwest

As mentioned throughout this report, the small participant sample size may not be representative of the entire sector. The changes from calendar year 2014 through 2016 are more reflective of the participant pool that year versus any sector trends.

Water Use Ratios are calculated by water use (bbl) per barrel of beer packaged (bbl) in the respective category; results are presented in units of bbl/bbl.

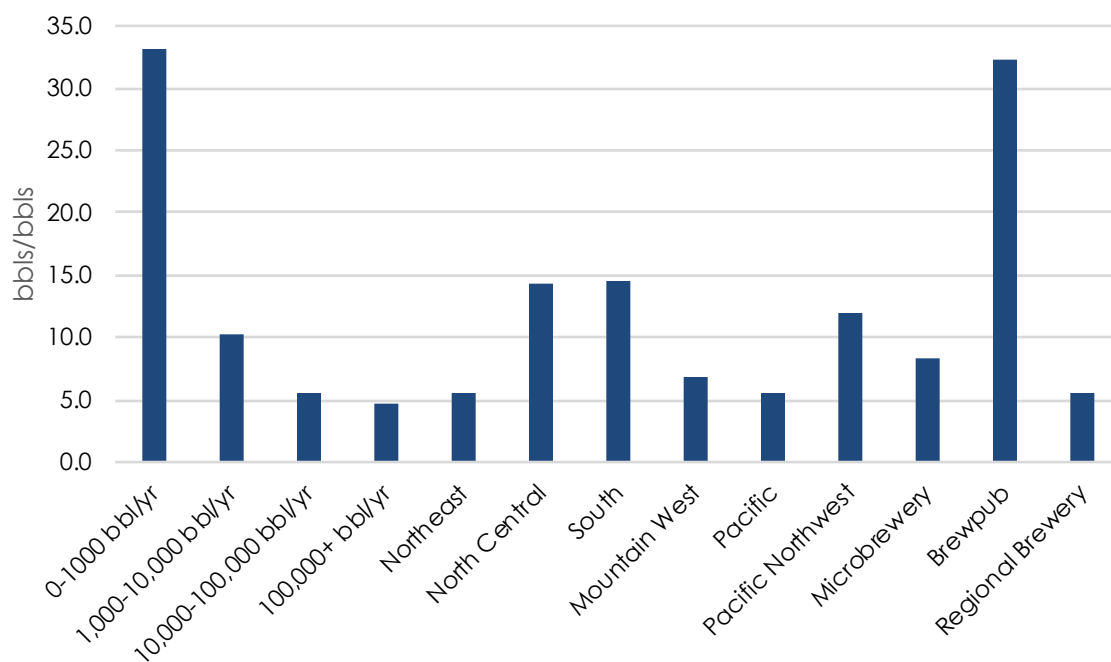
Energy Use Ratios are calculated by combining electricity and natural gas usage in kilowatt hours (kWh) per barrel of beer packaged (bbl) in the respective category; results are presented in units of kWh/bbl.

CO₂ Emissions Ratios are calculated by converting the total energy usage into pounds of CO₂ emissions (lbs) per barrel of beer packaged (bbl) in the respective category; results are presented in units of lbs/bbl.

participant results

	2014	2015	2016
Water Use Ratio (bbl/bbl packaged)			
0-1,000 bbls/yr	37.33	43.95	17.97
1,000-10,000 bbls/yr	10.46	11.37	8.78
10,000-100,000 bbls/yr	6.21	5.58	5.86
100,000+ bbls/yr	4.52	4.96	4.89
Northeast	5.08	5.30	6.16
North Central	14.86	20.31	10.12
South	20.05	13.94	9.29
Mountain West	5.90	8.62	5.99
Pacific	6.24	5.00	5.14
Pacific Northwest	18.08	12.55	5.29
Microbrewery	8.02	9.85	8.26
Brewpub	39.94	43.90	13.30
Regional Brewery	5.51	5.24	5.93

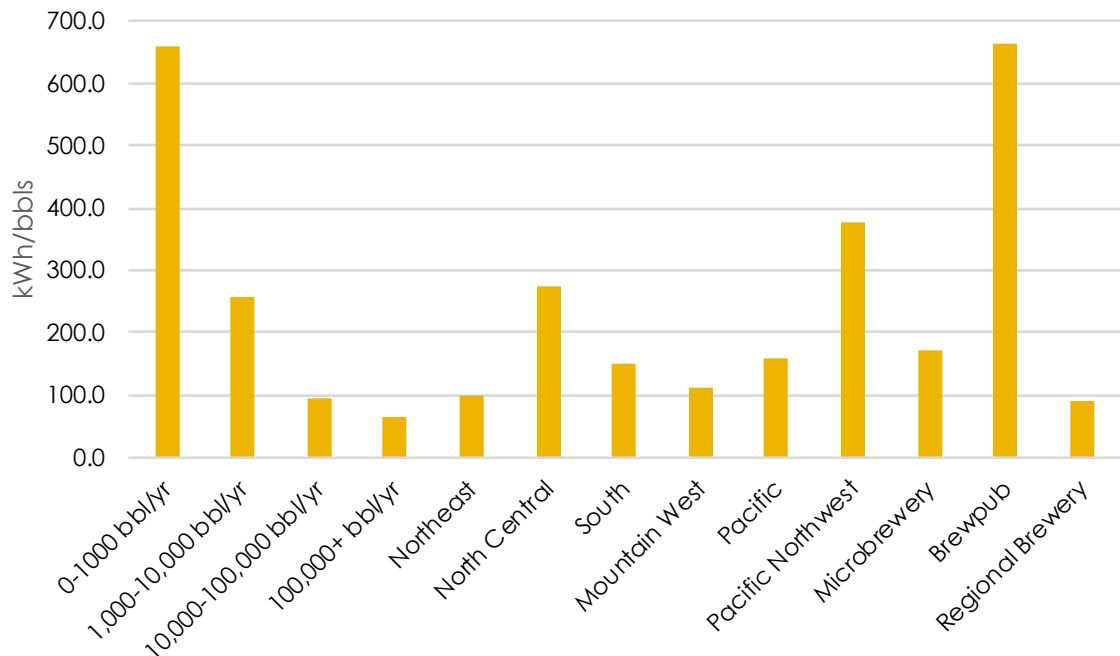
Water Usage Ratio
2014 – 2016 Average



participant results

	2014	2015	2016
Energy Use Ratio (kWh/bbl packaged)			
0-1,000 bbls/yr	621.96	602.53	751.73
1,000-10,000 bbls/yr	211.45	297.68	258.38
10,000-100,000 bbls/yr	88.11	95.15	107.20
100,000+ bbls/yr	63.54	69.91	64.83
Northeast	89.50	99.18	112.52
North Central	264.05	294.55	260.52
South	148.00	175.85	132.35
Mountain West	80.91	134.14	122.06
Pacific	199.82	210.23	73.55
Pacific Northwest	340.43	369.79	427.05
Microbrewery	179.63	158.83	183.72
Brewpub	565.97	684.80	739.84
Regional Brewery	78.21	90.03	100.13

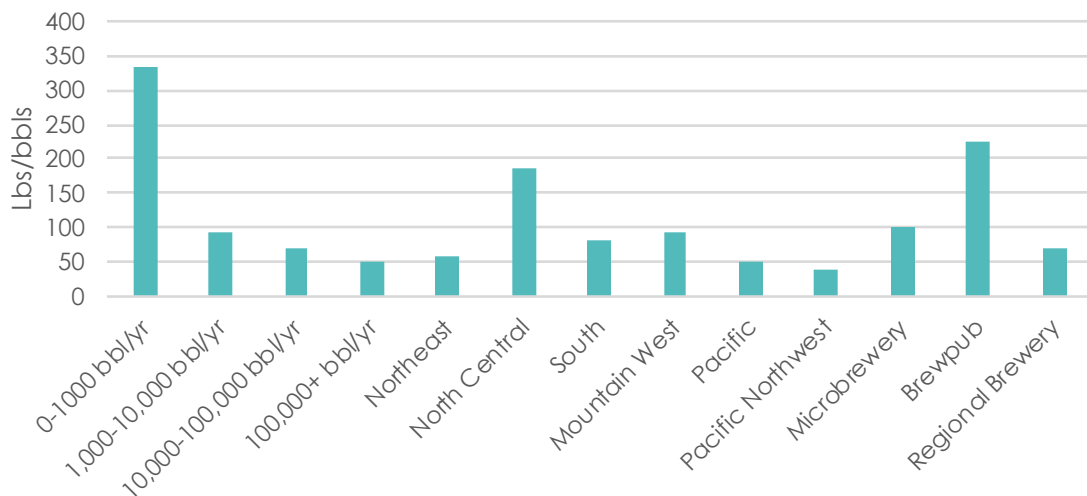
Energy Usage Ratio
2014 - 2016 Average



participant results

	2014	2015	2016
Emissions Ratio (lbs CO ₂ /bbl packaged)			
0-1,000 bbls/yr	259.09	240.86	502.93
1,000-10,000 bbls/yr	70.29	125.04	85.65
10,000-100,000 bbls/yr	55.02	72.58	86.79
100,000+ bbls/yr	34.28	41.88	72.20
Northeast	47.57	59.04	66.53
North Central	201.72	179.11	177.14
South	N/A	72.17	91.27
Mountain West	41.25	63.52	179.69
Pacific	63.26	43.05	51.33
Pacific Northwest	40.62	28.00	48.13
Microbrewery	55.21	110.58	134.37
Brewpub	259.09	190.79	No Data
Regional Brewery	47.74	49.78	111.04

CO₂ Emissions Ratio
2014 - 2016 Average



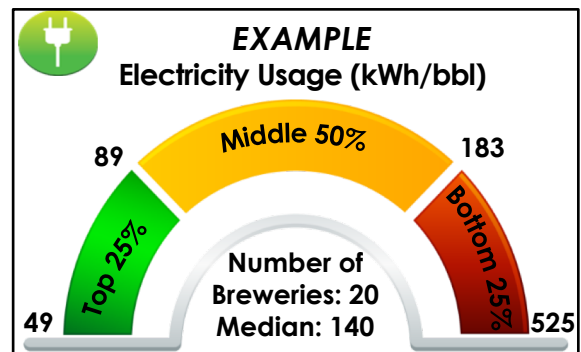
appendix b – 2016 benchmarking snapshots

The pages within this appendix section include the 2016 efficiency charts for water, electricity, natural gas, and purchased CO₂. These charts provide a quick and simple way to review the performance of breweries in terms of bottom 25%, middle 50%, and top 25% for each respective environmental attribute. There are pages designated for the following categories:

- Production Sizes –
 - 0-1,000 bbls/yr
 - 1,000-10,000 bbls/yr
 - 10,000-100,000 bbls/yr
 - 100,000+ bbls/yr
- Market Segments –
 - Microbreweries
 - Brewpubs
 - Regional Breweries
- Regions –
 - Northeast
 - North Central
 - South
 - Mountain West
 - Pacific
 - Pacific Northwest

In addition to the efficiency charts, there are two other graphics that provide further insight. First is a chart outlining the average cost per barrel associated with each sustainability-related KPI. This chart provides a relative sense of which KPIs are adding the most costs to each barrel of beer.

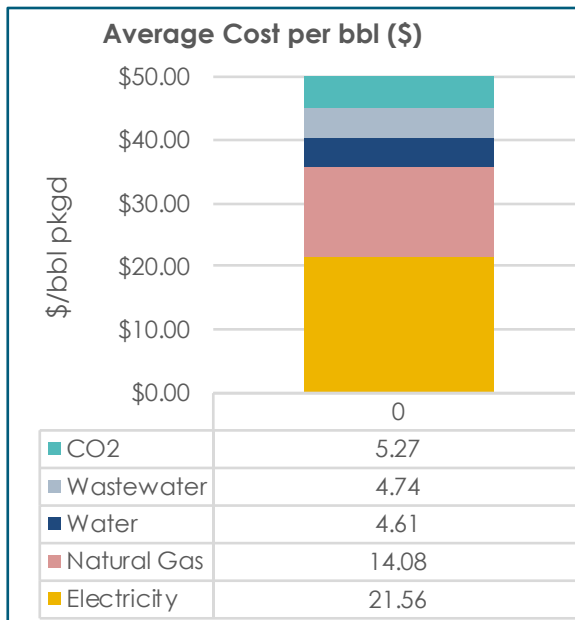
The second chart provides a snapshot of the potential for cost avoidance by setting and hitting targets for sustainability-related KPIs. For example, if a brewery is currently in the bottom 25% efficiency for their production size range and moves to the median or middle-of-the-pack efficiency, what are the potential annual dollar savings? In addition, if a brewery is currently in the middle of the pack efficiency, what would the annual dollar savings be by moving into the top 25% performers?



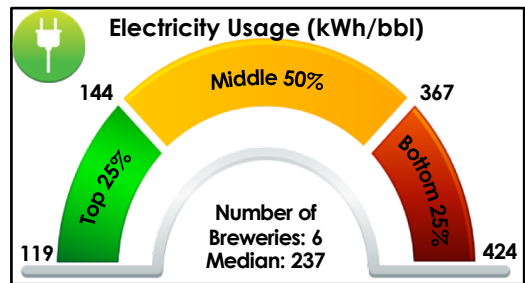
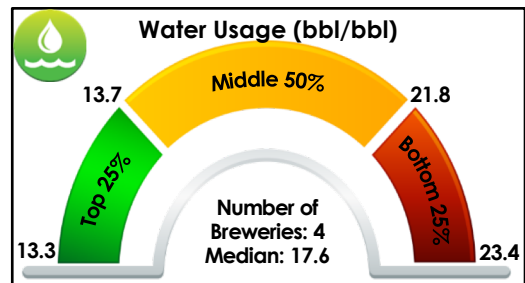
What you'll see: The above figure is an example of an efficiency chart used to show the top 25%, middle 50%, and bottom 25% of performers in production categories. A separate chart is created for each of the four attributes analyzed in this update. In this case, a brewery operating at 75 kWh/bbl would be in the top 25% of peer breweries. This graphic is meant to stimulate awareness of peer efficiency so best practices can be shared and the overall sector can continue to improve.

0-1,000 bbls/year

Cost Efficiency

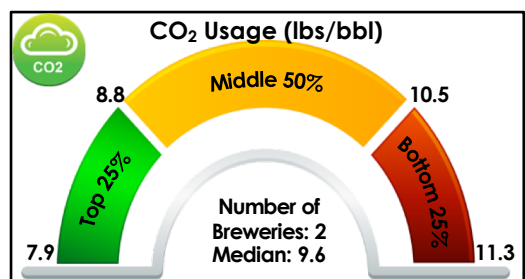
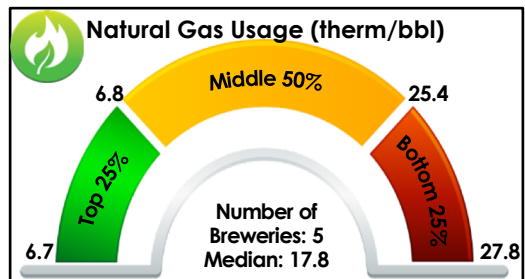
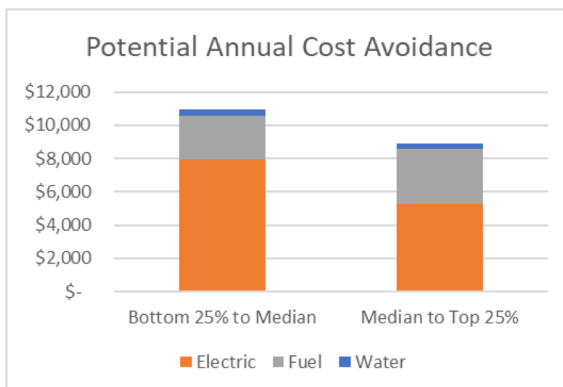


Usage Efficiency



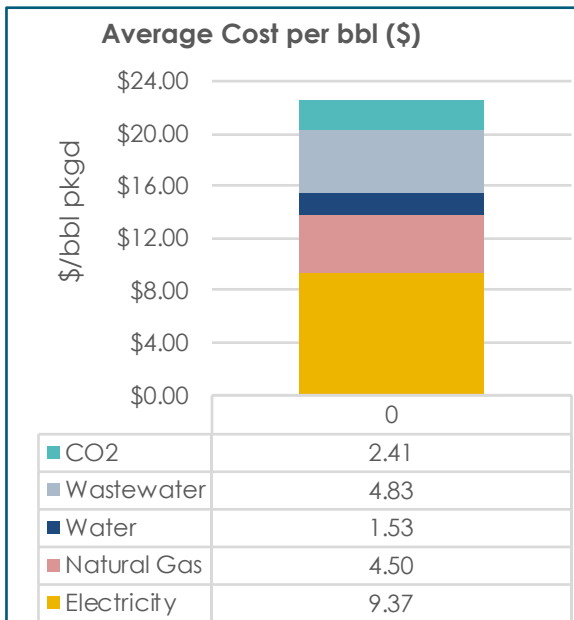
Potential Cost Avoidance by improving efficiencies and moving from the:

- Bottom 25% to the Median; or
- Median to Top 25%

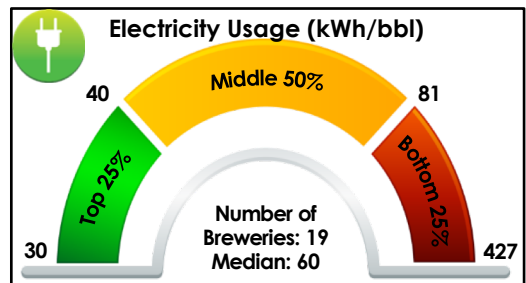
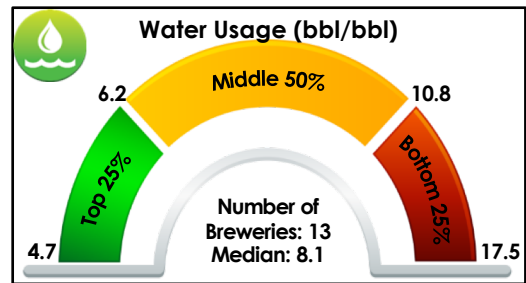


1,000-10,000 bbls/year

Cost Efficiency

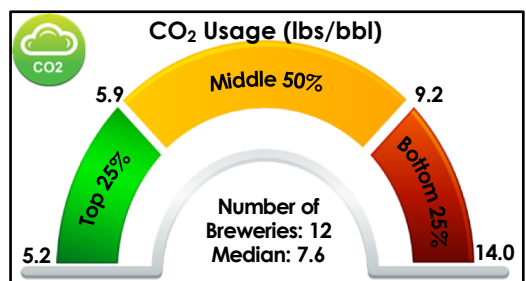
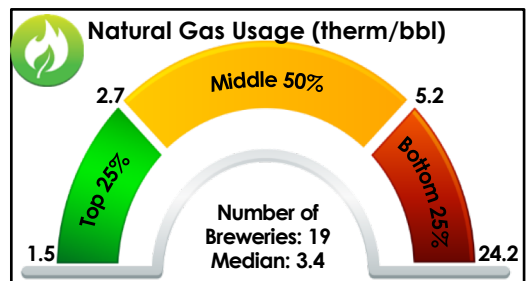
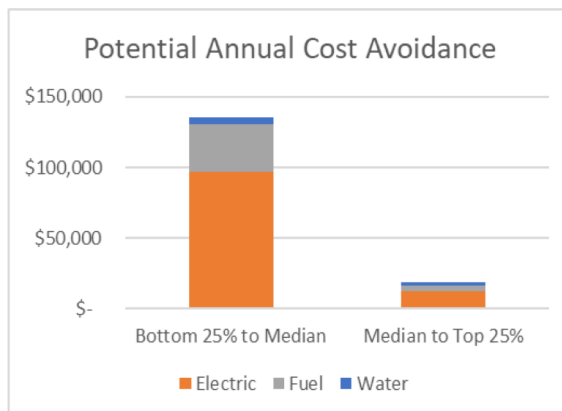


Usage Efficiency



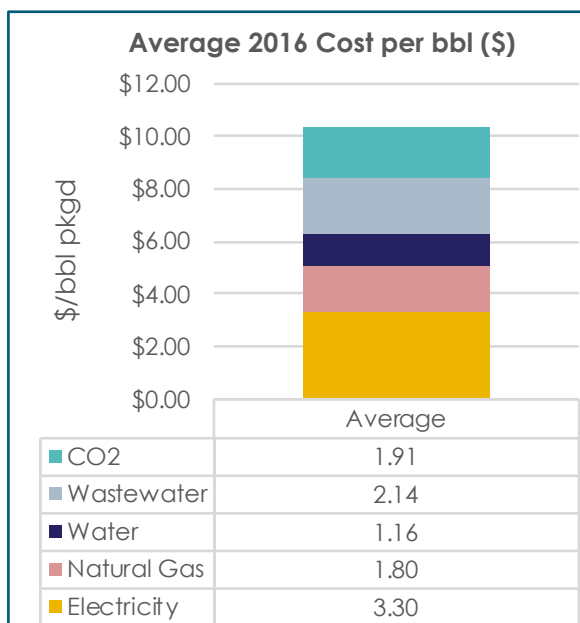
Potential Cost Avoidance by improving efficiencies and moving from the:

- Bottom 25% to the Median; or
- Median to Top 25%

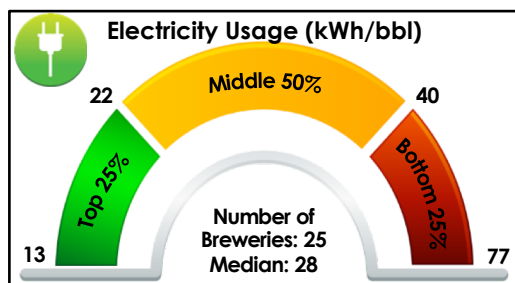
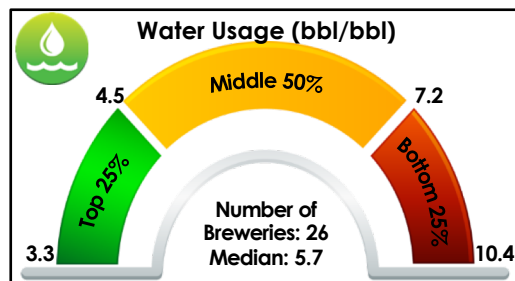


10,000-100,000 bbls/year

Cost Efficiency

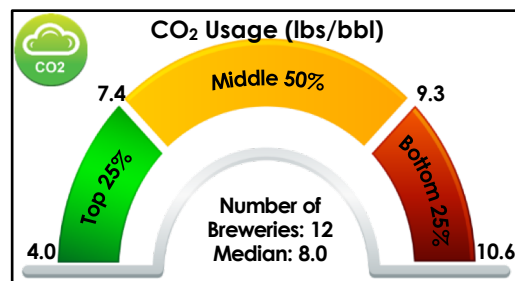
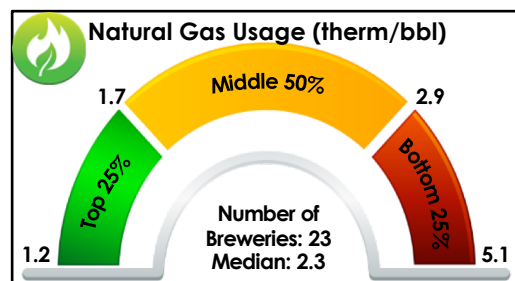
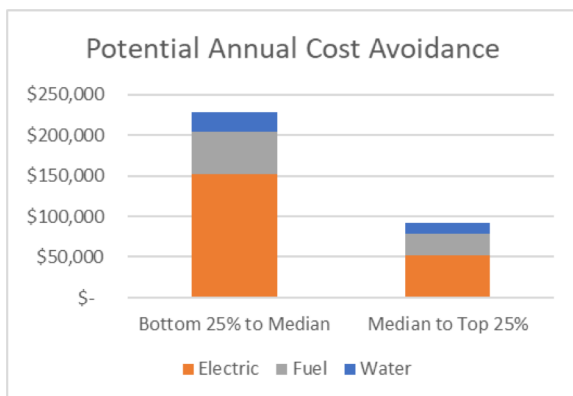


Usage Efficiency



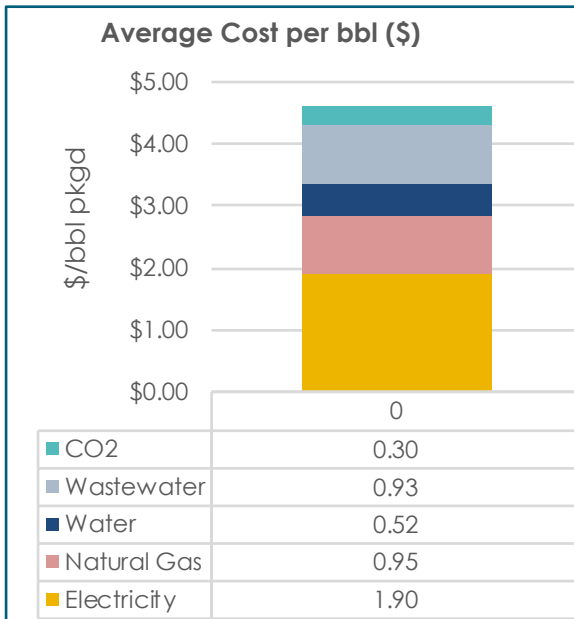
Potential Cost Avoidance by improving efficiencies and moving from the:

- Bottom 25% to the Median; or
- Median to Top 25%

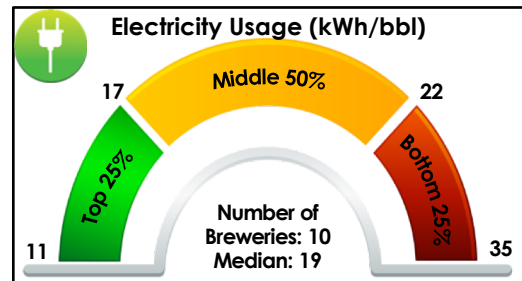
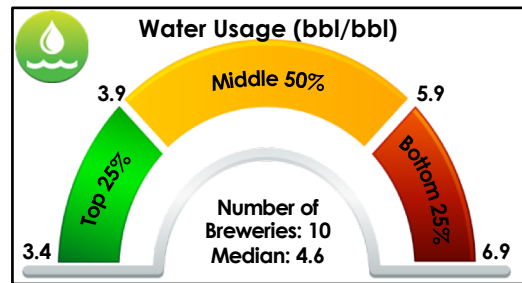


100,000+ bbls/year

Cost Efficiency

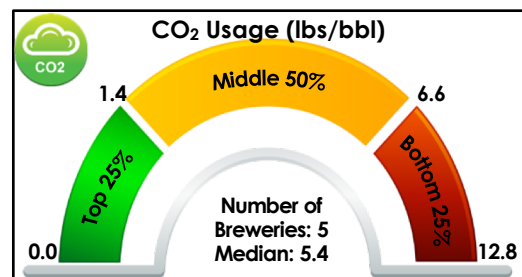
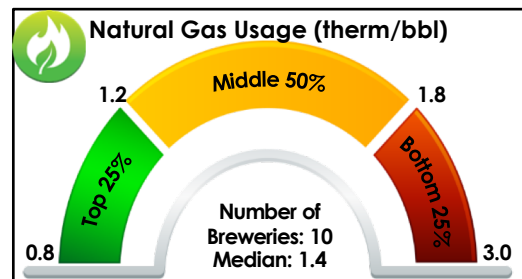
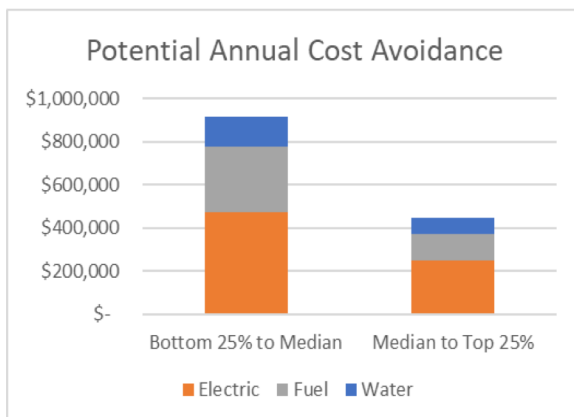


Usage Efficiency



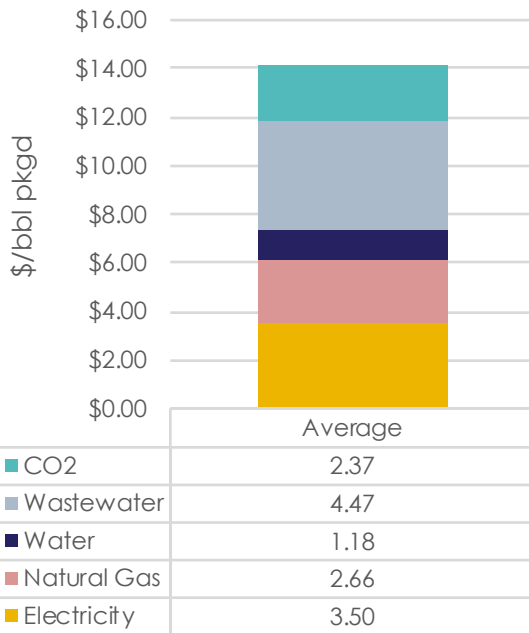
Potential Cost Avoidance by improving efficiencies and moving from the:

- Bottom 25% to the Median; or
- Median to Top 25%

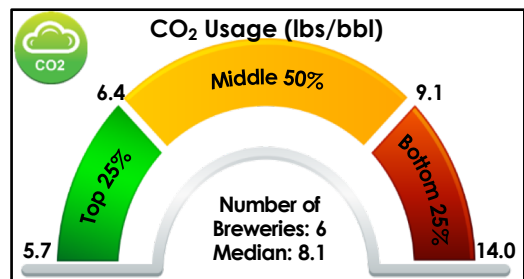
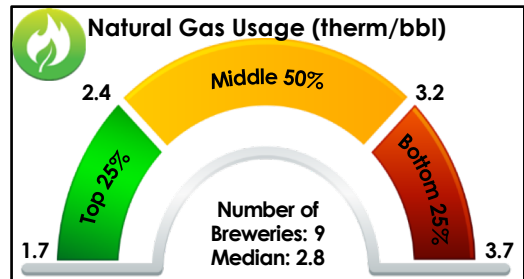
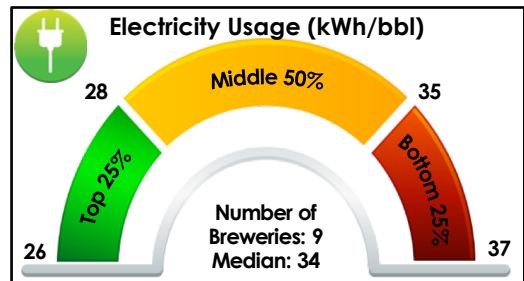
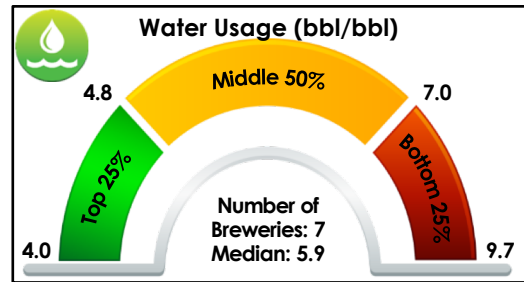


northeast

Average 2016 Cost per bbl (\$)

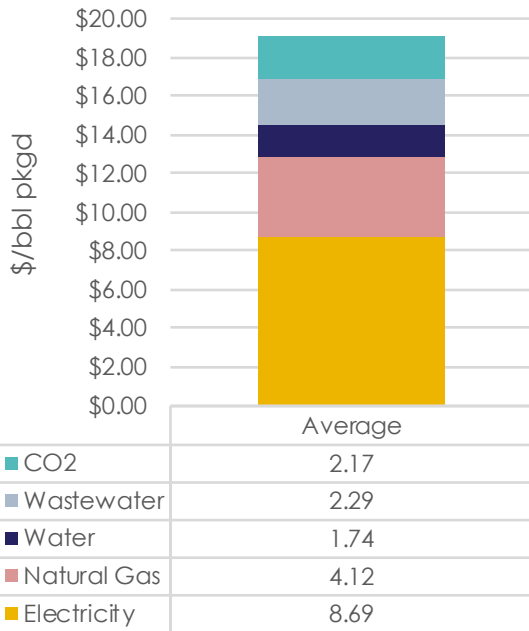


Usage Efficiency Charts

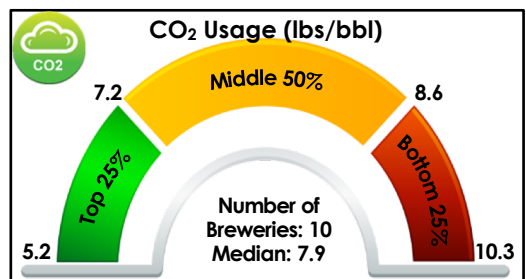
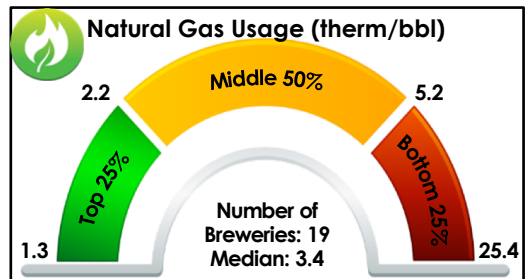
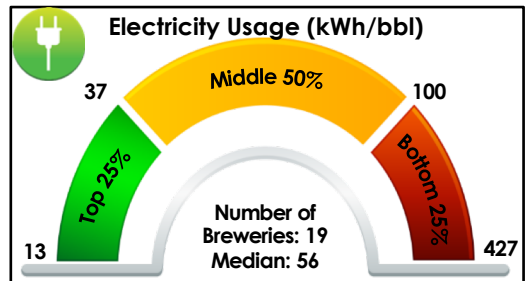
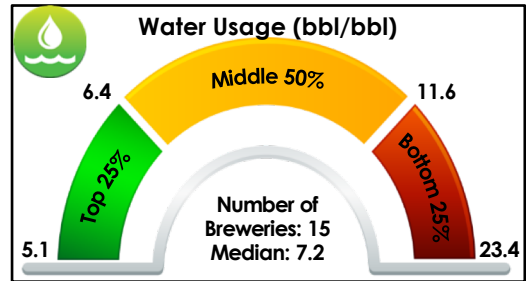


north central

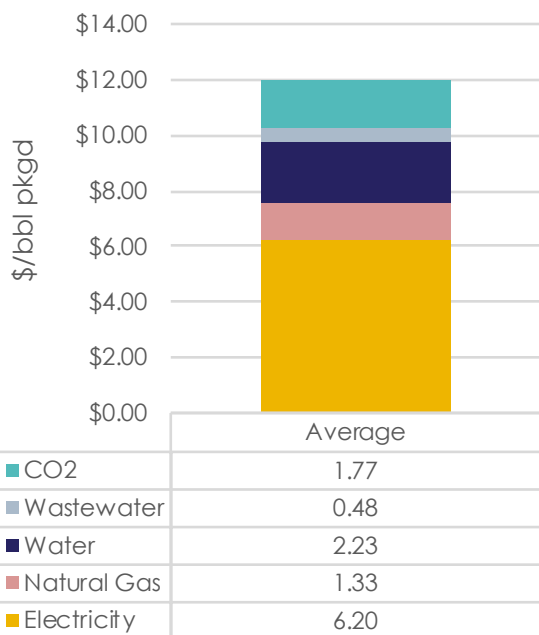
Average 2016 Cost per bbl (\$)



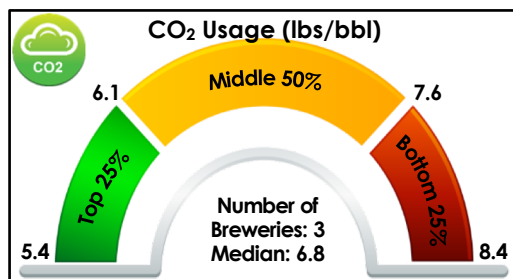
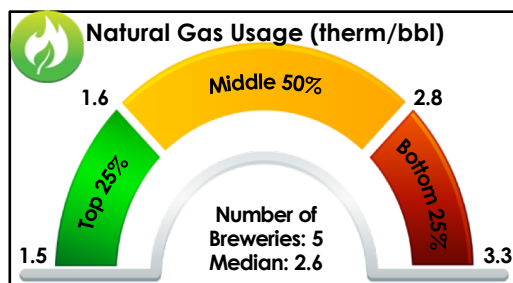
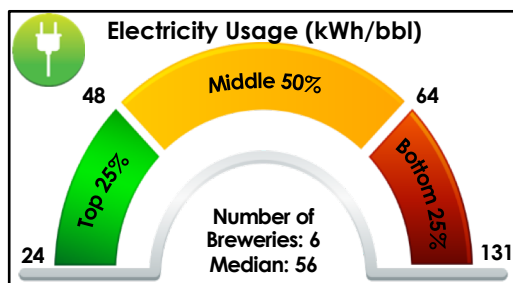
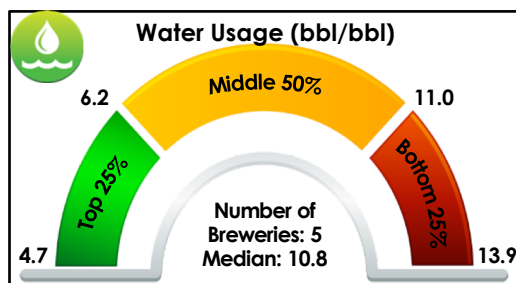
Usage Efficiency Charts



Average 2016 Cost per bbl (\$)

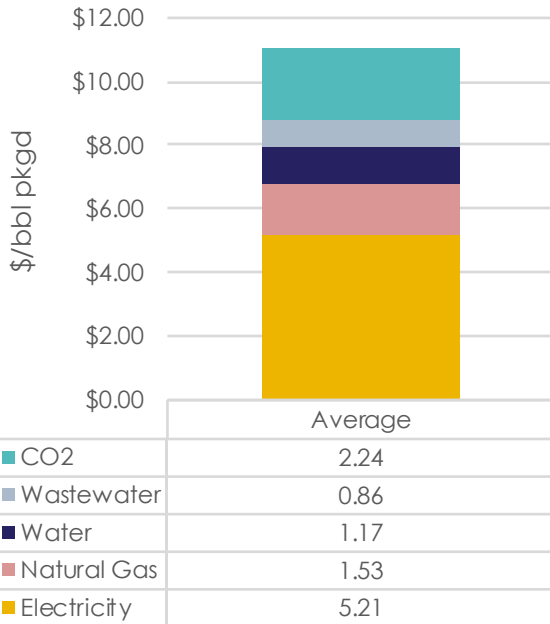


Usage Efficiency Charts

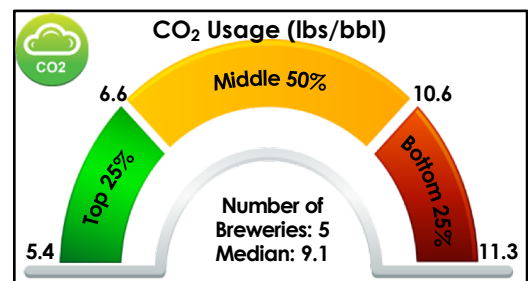
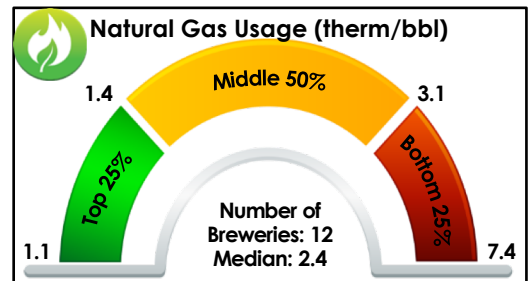
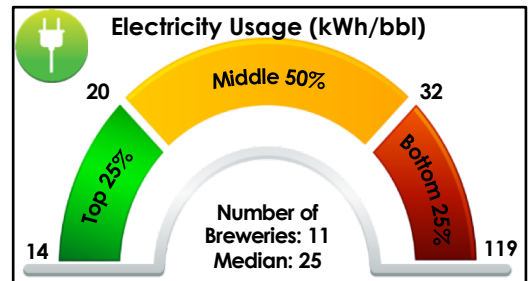
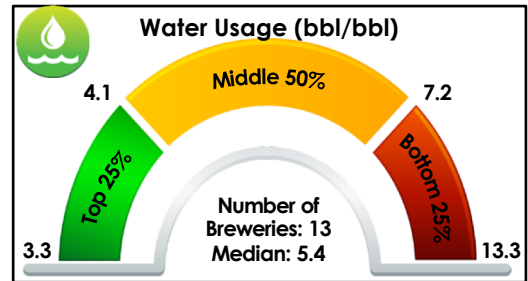


mountain west

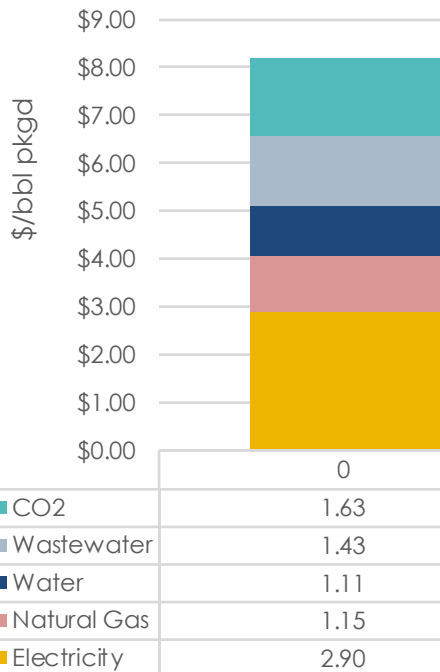
Average 2016 Cost per bbl (\$)



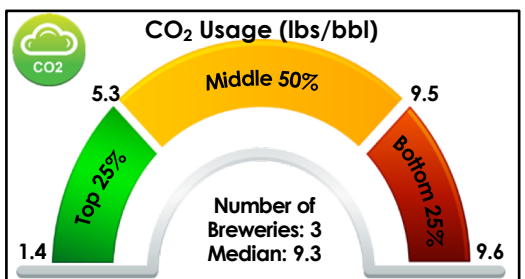
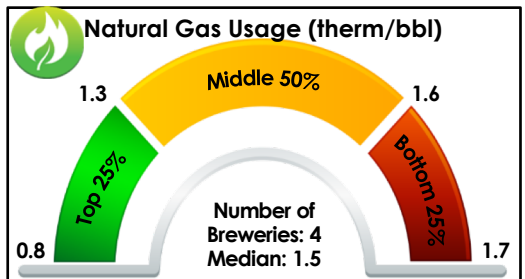
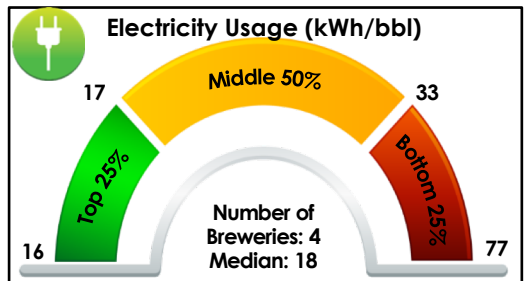
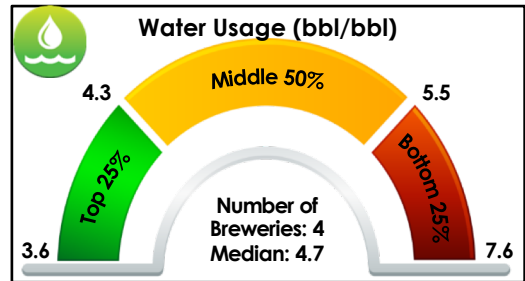
Usage Efficiency Charts



Average 2016 Cost per bbl (\$)

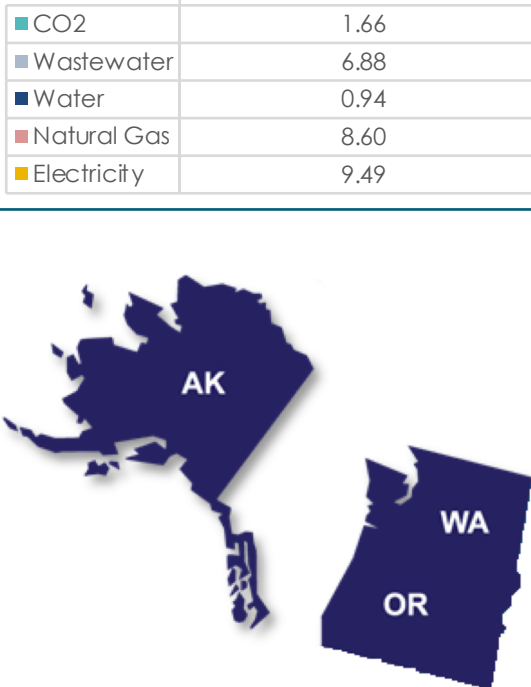
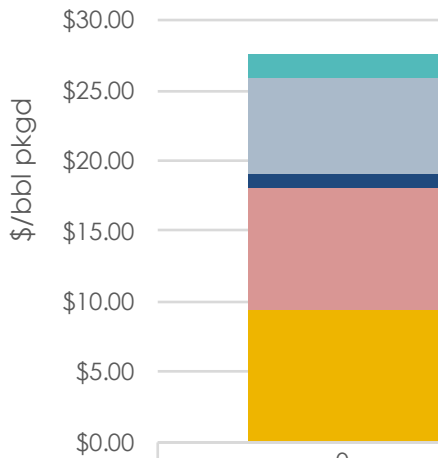


Usage Efficiency Charts

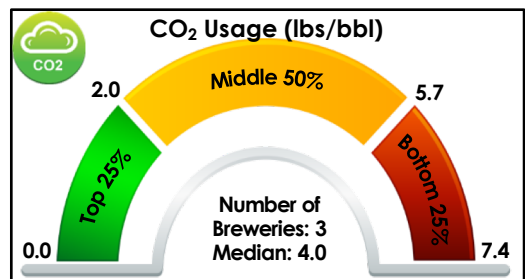
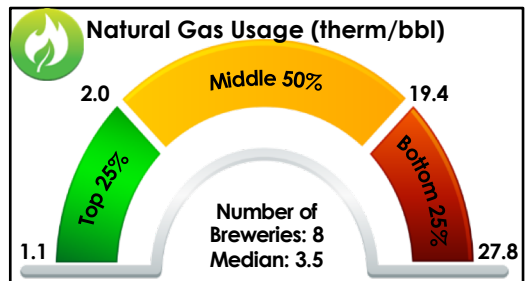
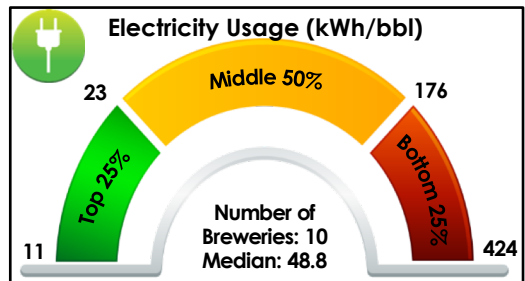
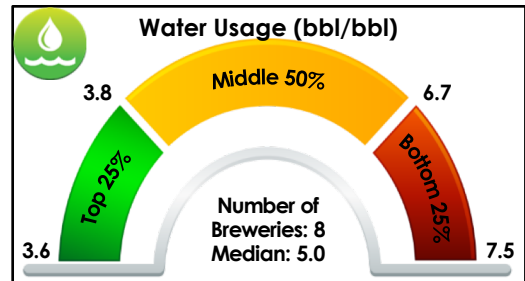


pacific northwest

Average 2016 Cost per bbl (\$)

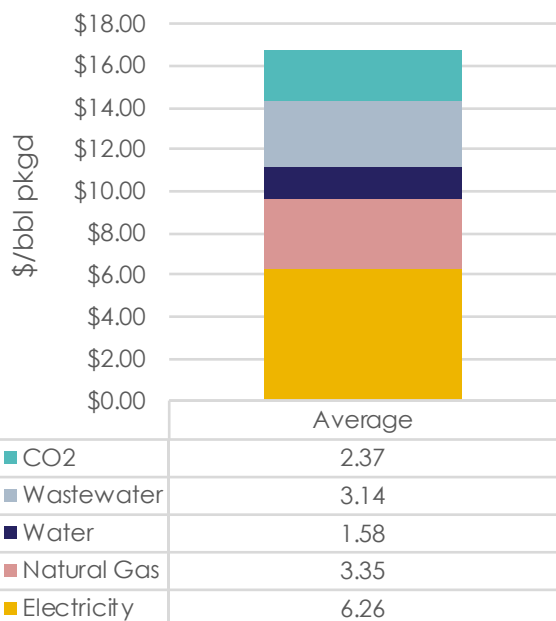


Usage Efficiency Charts

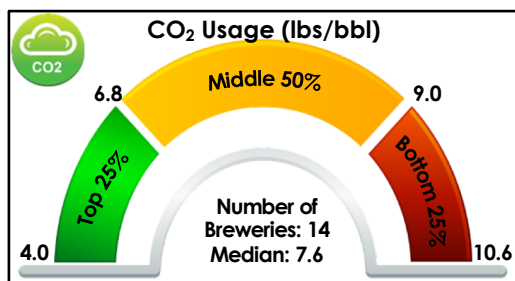
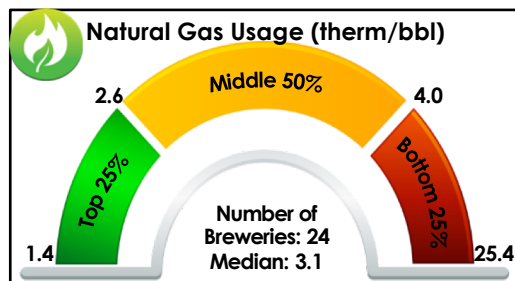
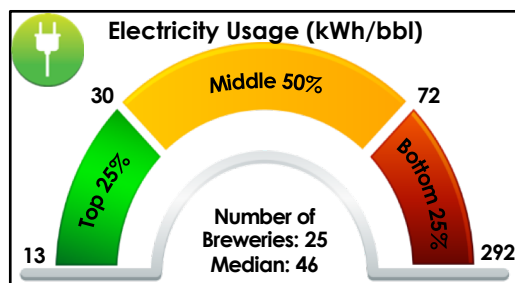
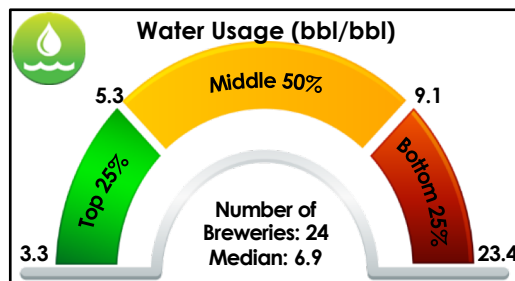


microbreweries

Average 2016 Cost per bbl (\$)



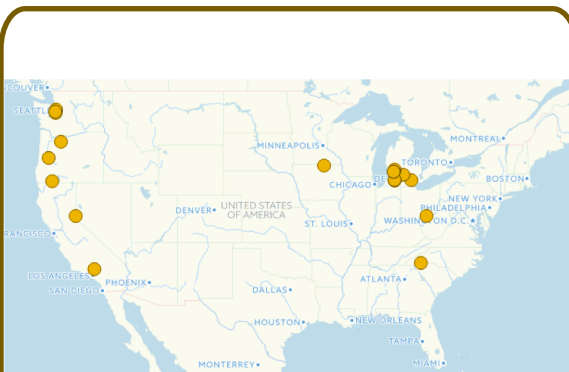
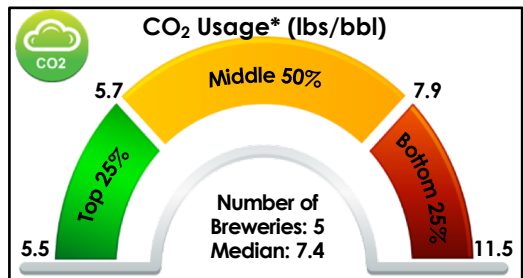
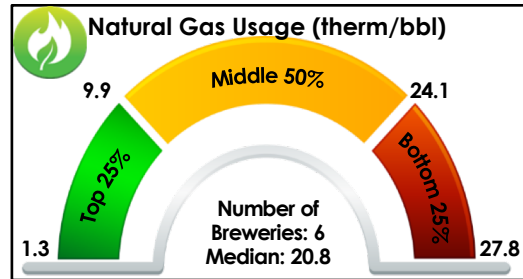
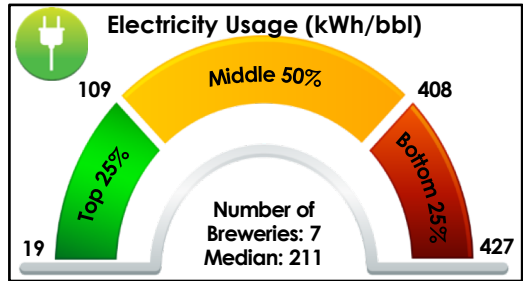
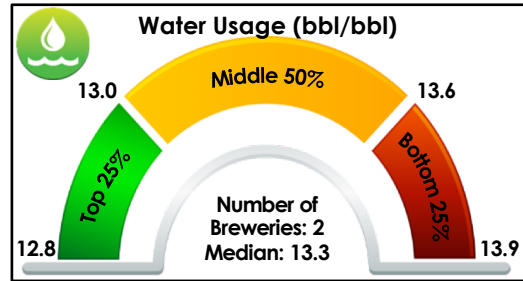
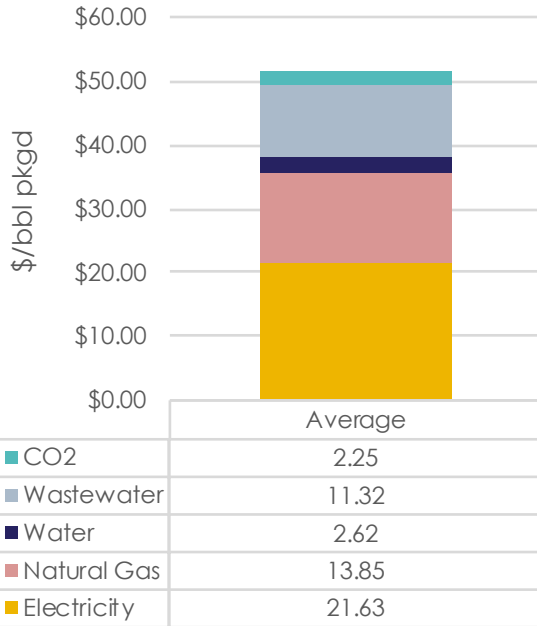
Usage Efficiency Charts



brewpubs

Usage Efficiency Charts

Average 2016 Cost per bbl (\$)



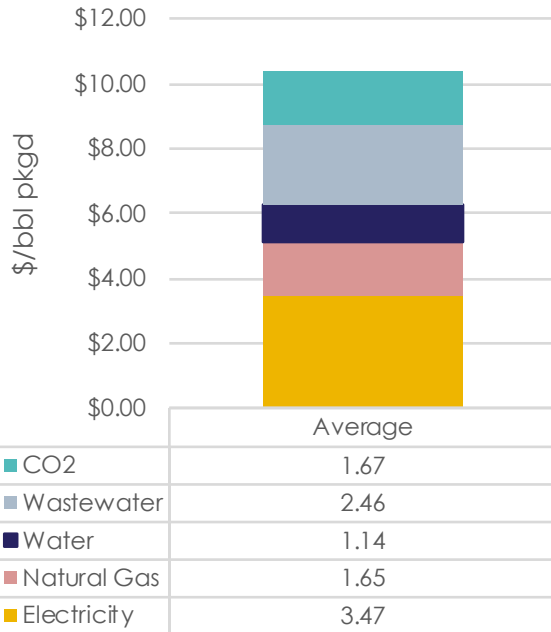
*2015 data is used for CO₂ usage and wastewater cost benchmarking. Not enough 2016 data was provided to create benchmarked performance metrics

Brewpubs

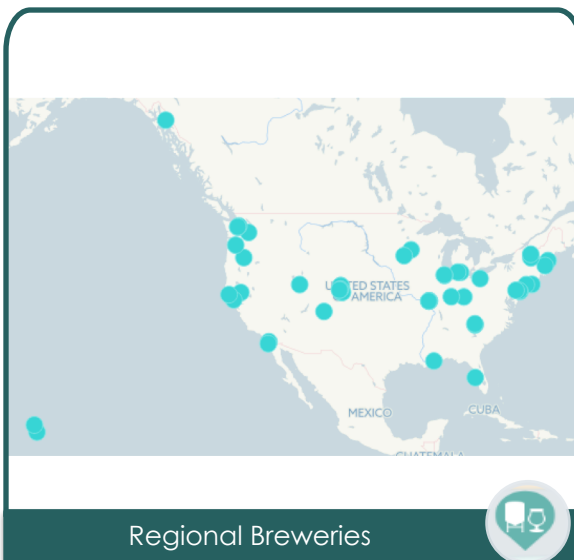
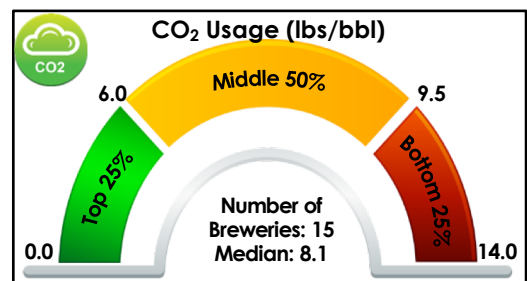
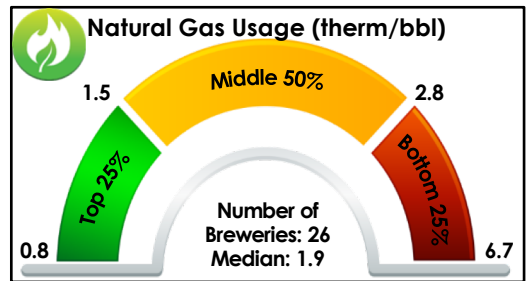
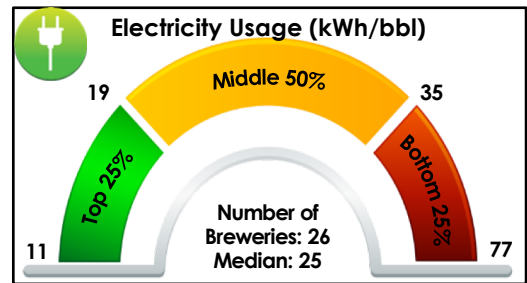
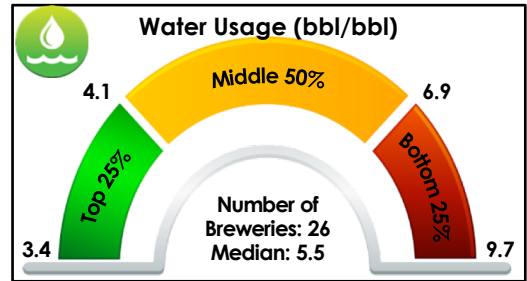


regional breweries

Average 2016 Cost per bbl (\$)



Usage Efficiency Charts



Regional Breweries

appendix c – greenhouse gas estimations

CO₂ is among the gases that trap heat in the atmosphere, commonly referred to as greenhouse gas (GHG) emissions. Breweries generate CO₂ through fermentation, purchased CO₂ for process needs, and the use of both on-site and offsite energy. This report calculates simple estimates of total CO₂ emissions for education and awareness. These estimates should not be used for formal GHG reporting purposes. Emissions were estimated as shown on the following page.

- Scope 1 emissions include fossil fuel combusted at the brewery site and fossil fuel-based CO₂ purchased by the brewery from an outside vendor.
- Scope 2 emissions are related to the amount of electricity purchased from the brewery electricity provider. It reflects the emissions generated at the power plant to provide electricity for the brewery.

The U.S. Environmental Protection Agency has developed CO₂ emission factors for the on-site combustion of fossil fuels in small boilers and heaters¹. These factors have been used to estimate on-

site generation of CO₂ at breweries from the combustion of natural gas. The USEPA has also developed CO₂ emission factors associated with electric power generation (commonly referred to as the eGRID database) for geographic regions in the United States². Brewery locations were identified and assigned the applicable Subregion emission factor. For non-U.S. breweries, the international emission factors were obtained through the International Energy Agency³.

For estimation purposes, all purchased fossil fuel-based CO₂ is considered released as Scope 1 emissions. In reality, the majority are more likely released as Scope 3 emissions by the consumer.

CO₂ generated through brewery fermentation is considered biogenic and is not included in these emission estimates.

For more information on calculating brewery GHG emissions, please refer to the Beverage Industry Environmental Roundtable [guidance document](#)⁴ that outlines direction for beverage sector GHG emissions reporting.

1. <https://www.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub>. EPA Center for Corporate Climate Leadership GHG Emission Factors Hub, Version 2. EPA. November 2015.
2. <https://www.epa.gov/energy/emissions-generation-resource-integrated-database-eGRID>. EPA eGRID subregion and GHG emissions finder tool – Power Profiler ZIP Code Tool with eGRID2014v2 Data, Version 7.1. EPA. February 27, 2017.
3. <https://www.iea.org/statistics/topics/CO2emissions/>. IEA CO₂ Emissions from Fuel Combustion. OECD/IEA. Paris, 2016.
4. http://docs.wixstatic.com/ugd/49d7a0_6339d006853c4d3bbdf6087b43d91580.pdf. Beverage Industry Sector Guidance for Greenhouse Gas Emissions Reporting, Version 3.0. Beverage Industry Environmental Roundtable. December 2013.

appendix c – greenhouse gas estimations

Total Emissions – Scope 1 Direct + Scope 2 Indirect Emissions

Scope 1 + Scope 2 Emissions (lb CO₂) = Natural Gas + Purchased CO₂ + Electricity

Scope 1 Direct Emissions – Natural Gas and Fossil Fuel-Based Purchased CO₂

Natural Gas Combustion (lb CO₂) = therms × $\frac{5.934 \text{ kg CO}_2}{\text{therm}}$ × $\frac{2.2046 \text{ lb CO}_2}{\text{kg CO}_2}$

Scope 2 Indirect Emissions – Electricity

Electricity (lb CO₂) = kWh × $\frac{\text{eGrid factor (lb CO}_2\text{)}}{\text{kWh}}$

appendix d – water risk assessment

Water scarcity is becoming increasingly prominent as fresh water resources continue to be threatened by climate change, pollution, overuse, natural disasters (flood and fire), and increasing demand. Businesses in the beverage industry are particularly sensitive to the growing focus on water availability, as water is a key component of beverage production for brewers.

This discussion on water risk includes an analysis of current and future water scarcity using the World Resources Institute (WRI) Aqueduct tool, a widely recognized water risk assessment mapping tool. The water risk mapping included all 122 breweries who have submitted data for the past three years to evaluate their water use relative to water stressed geographies. Of the 122 facilities analyzed, WRI Aqueduct data was available for 120 facilities (over 98%).

The table to the right outlines the WRI Aqueduct risk framework and the factors used to determine each risk. The following pages provide graphics depicting the number of breweries and their respective current water risk, future water stress, and future water supply.

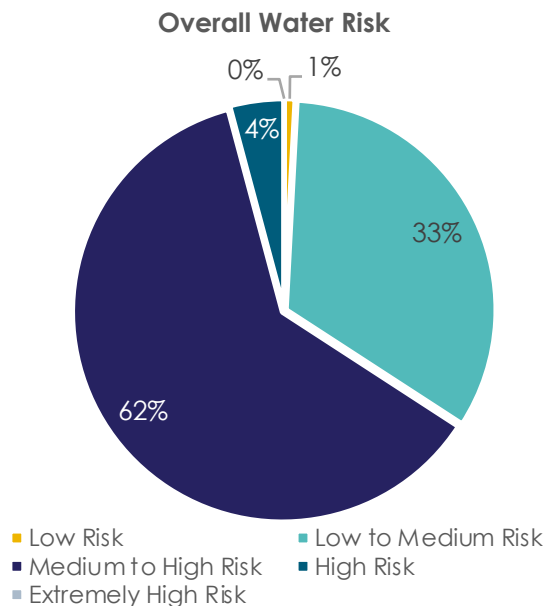
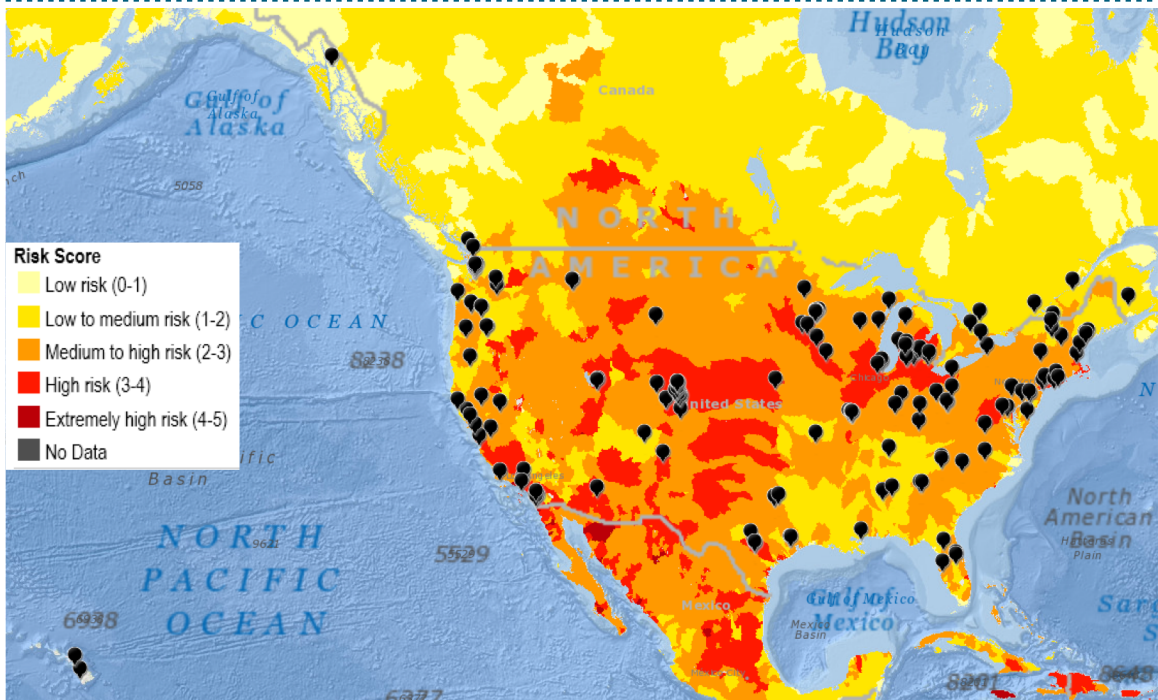
For additional information and to use the WRI Aqueduct Water Risk Atlas tool, visit: <http://bit.ly/2hxP9qv>.

The current price of water does not always justify the investment of large-scale water saving initiatives. The initial brewery focus tends to be on electricity and natural gas improvements as that is

where returns on investments are more readily apparent. However, many breweries see utility savings work in tandem; in essence, when there are energy savings, there are often water savings and vice versa. Appropriate water temperature is a crucial component of brewing beer, and thus a focus on attaining that optimal temperature for operations can often see savings across the board including water, which may be a large focus as water availability becomes more stressed in the future.

Overall Water Risk		
Physical Risk: Quality	Regulatory & Reputational Risk	Physical Risk: Quantity
Return Flow Ratio	Media Coverage	Baseline Water Stress
Upstream Protected Land	Access to Water	Inter-annual Variability
	Threatened Amphibians	Seasonal Variability
		Flood Occurrence
		Upstream Storage
		Groundwater Stress

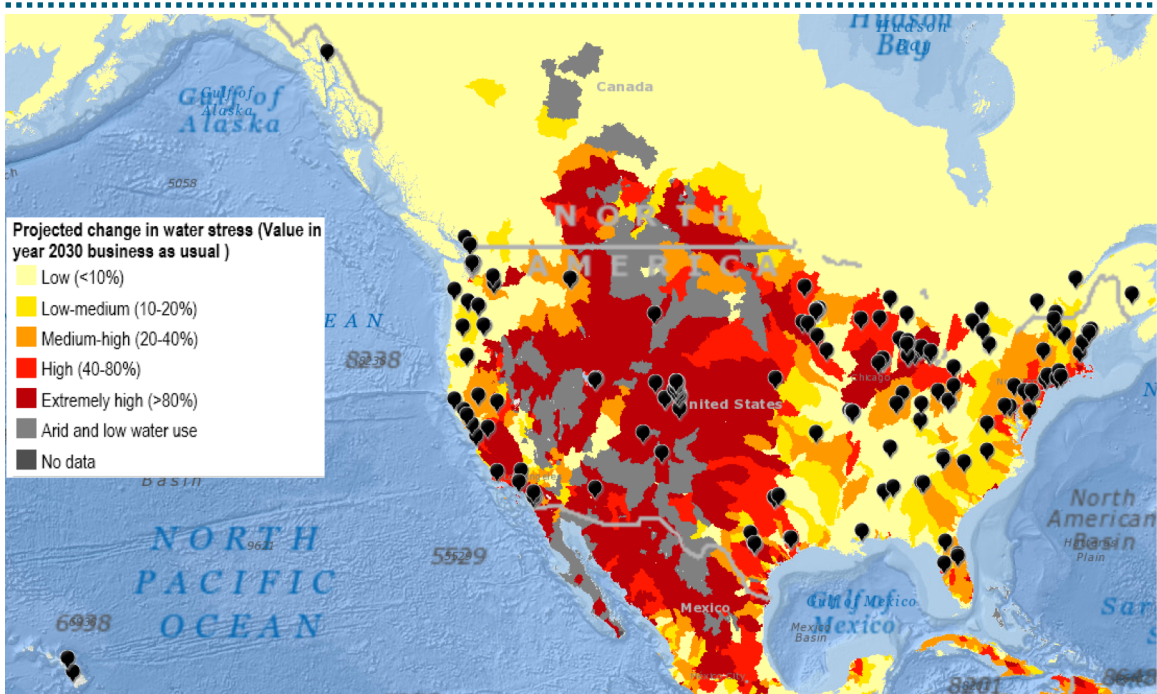
WRI Current Conditions Overall Water Risk



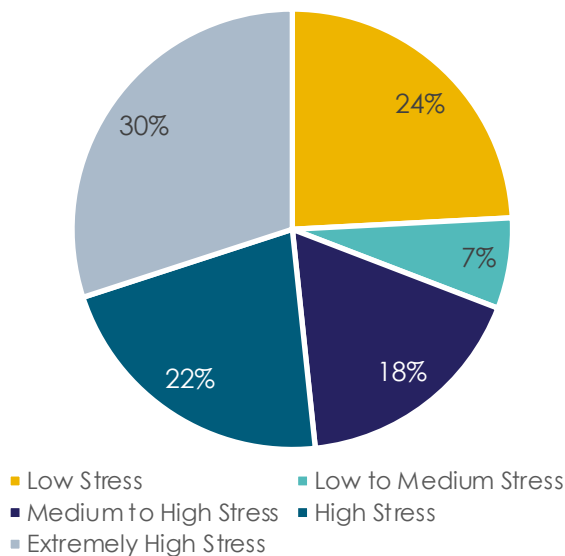
As seen in the figure to the left, almost two-thirds of participating breweries currently operate in areas that possess at least a medium overall water risk. Overall water risk accounts for physical risks, including quality and quantity, as well as regulatory and reputational risks. These risks are outlined in the table on the preceding page.

The high risk breweries do not exhibit specific trends in terms of water use efficiency; however, they do fall within the middle 50% of their peer category benchmarking for water use in terms of bbl/bbl.

WRI Projected Change Water Stress 2030



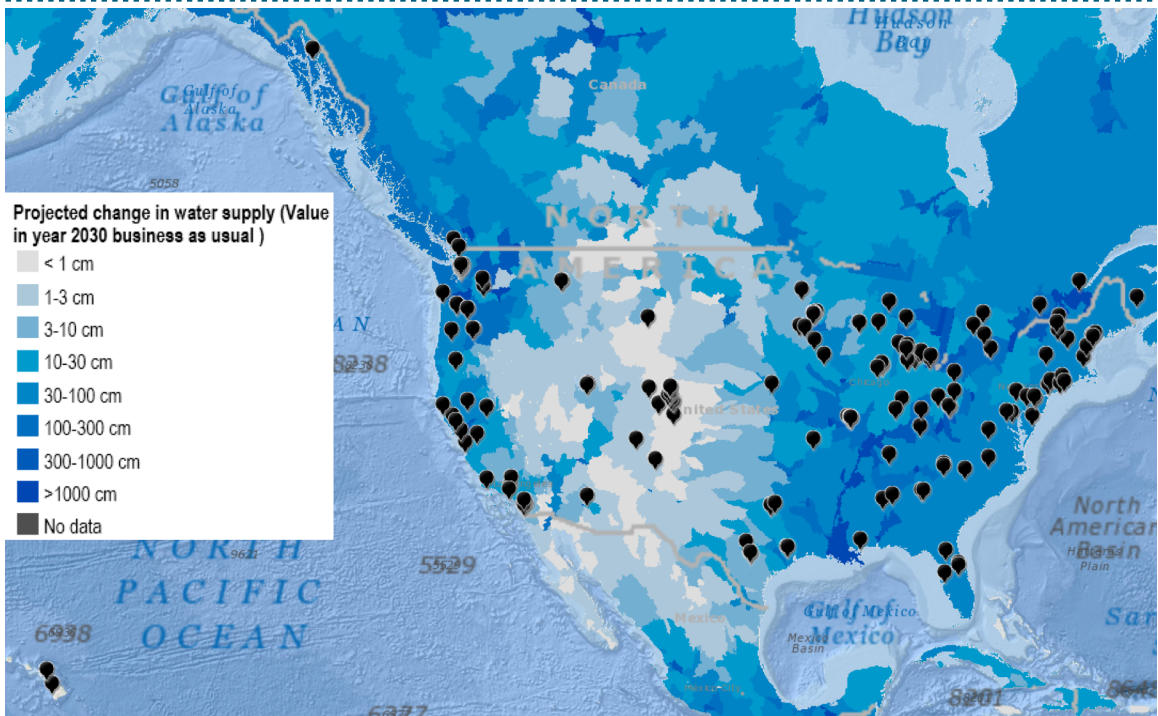
Future Water Stress, 2030



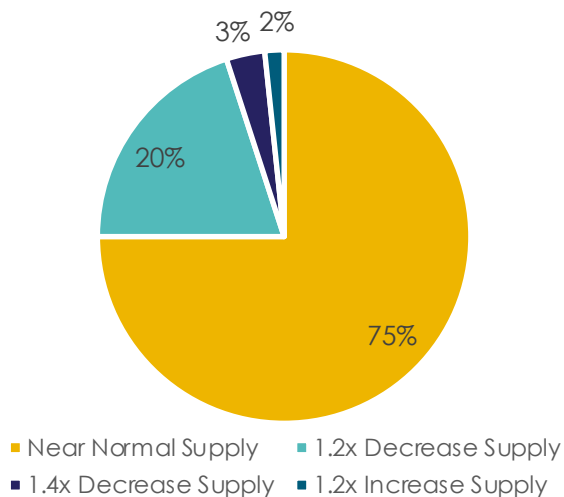
Facilities were analyzed for projected water stress in 2030. As shown in the figure to the left, "business-as-usual" models project that over 40% of breweries are expected to operate under medium or high risk for water stress. WRI Aqueduct's future water stress models account for freshwater availability as well as competition for available water based on the following variables:

- Area equipped for irrigation & irrigation efficiency
- Agricultural land area
- Industrial & domestic water withdrawals
- Gross domestic product per capita
- Urbanization
- Baseline water stress
- Population density & world population

WRI Projected Change Water Supply 2030



Projected Change in Water Supply, 2030



Additional analyses were conducted to determine if efficiency improvements were occurring in areas expected to increase in water stress per 2030 "business-as-usual" projections. As shown in the figure to the left, 23% of breweries are expected to see a decrease in water supply.

Breweries in Decreasing Water Supply Regions	Breweries in Decreasing Water Supply Regions with Improving Water Use Ratios
28	12

appendix e – sustainability resources

BA Sustainability Resources

The BA has published multiple resources to help craft brewers, including sustainability benchmarking reports and manuals on a variety of topics. Through the benchmarking work and sustainability manuals, the BA and Sustainability Subcommittee encourage conscientious brewing practices that will ensure the long-term success of the craft beer industry. The following are links to all of the sustainability materials published by the BA to date.



2015 Benchmarking Report:
<https://s3-us-west-2.amazonaws.com/brewersassoc/wp-content/uploads/2017/04/2015-Brewers-Association-Benchmarking-Report.pdf>

2016 Benchmarking Update:
https://s3-us-west-2.amazonaws.com/brewersassoc/wp-content/uploads/2016/10/2016_Brewers_Association_Sustainability_Benchmarking_Update.pdf

Manual Publication Webpages



Energy Sustainability:
<https://www.brewersassociation.org/educational-publications/energy-sustainability-manual/>



Solid Waste Sustainability:
<https://www.brewersassociation.org/educational-publications/solid-waste-sustainability-manual/>



Water & Wastewater Sustainability:
<https://www.brewersassociation.org/educational-publications/water-wastewater-sustainability-manual/>



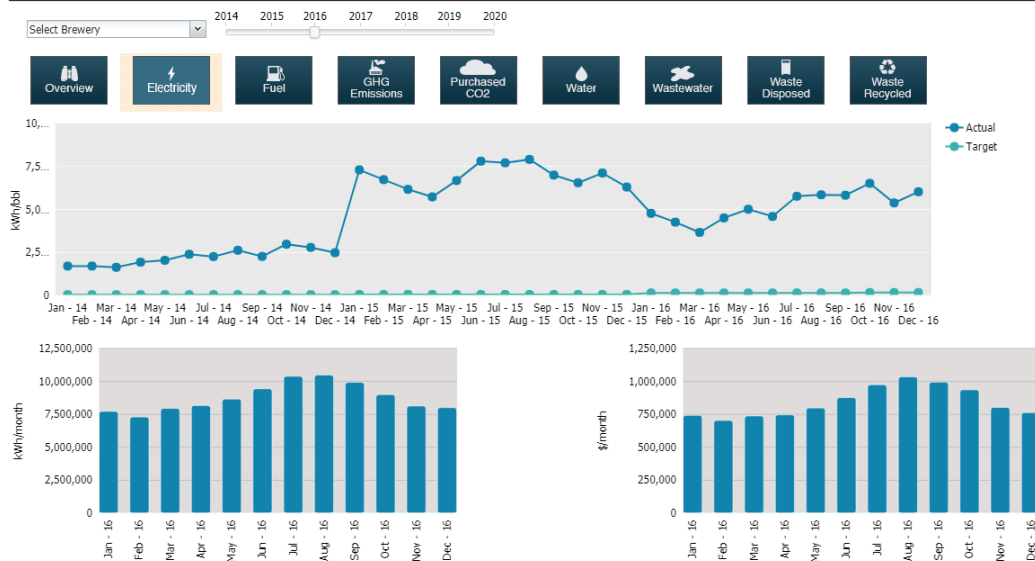
Wastewater Management Guidance:
<https://www.brewersassociation.org/educational-publications/wastewater-management-guidance-manual/>



Sustainable Design and Build Strategies for Craft Brewers:
<https://www.brewersassociation.org/educational-publications/sustainable-brewery-design/>



Sustainability Progress to Targets Report



Benchmarking Tool Example Progress to Target Report

BA Sustainability Benchmarking Tools

Determine the success of your sustainability initiatives by utilizing the online tools to record and track your efforts. Your participation will benefit your brewery and provide details to the BA and other stakeholders regarding the sector's environmental performance.

No individual brewery is identified in the benchmarking dashboard as all data submitted is kept confidential.

Access to the sustainability dashboard provides the opportunity for both peer benchmarking and measuring internal progress to targets. The ability to track progress against goals can help inform sustainability strategies.

Monetary Savings

Craft breweries that participated in the 2014 pilot benchmarking study and target setting exercise identified the potential for significant cost savings. These savings ranged from \$35,000 to \$235,000 annually for small to large craft breweries.

Access the Benchmarking Tools here:

<https://www.brewersassociation.org/best-practices/sustainability/sustainability-benchmarking-tools/>

appendix f – reporting breweries

10 Barrel Brewing Co. (OR)

14th Star Brewing Co. (VT)

Alamo Beer Company (TX)

Alaskan Brewing Co. (AK)

★ Allagash Brewing Co. (ME)

★ Arbor Brewing Company (MI)

Aslan Brewing Company (WA)

August Schell Brewing Co. (MN)

Avery Brewing Co. (CO)

Bale Breaker Brewing Company (WA)

Bathtub Row Brewing Co-op (NM)

★ Bear Republic Brewing Co. (CA)

Bell's Brewery, Inc. - Comstock (MI)

Beltway Brewing Company (VA)

Bent Brewstillery (MN)

Birdsong Brewing Co. (NC)

Black Warrior Brewing Company (AL)

Blue Point Brewing Co. (NY)

Breckenridge Brewery (CO)

BrewDog PLC – Ellon (UK)

★ Brewery Vivant (MI)

Broken Compass Brewing (CO)

★ Brooklyn Brewery (NY)

Buffalo Bayou Brewing Company (TX)

Burning Brothers Brewing (MN)

Butcherknife Brewing Company (CO)

Craft Brew Alliance - Kona (HI)

★ Craft Brew Alliance - Portland (OR)

★ Craft Brew Alliance - Portsmouth (NH)

★ Craft Brew Alliance - Woodinville (WA)

★ Chestnut Brew Works (WV)

Cigar City Brewing (FL)

Creemore Springs Brewery (Canada)

Dangerous Man Brewing Co. (MN)

Dark Horse Brewing Co. (MI)

Denver Beer Co. – Canworks (CO)

Deschutes Brewery (OR)

Discretion Brewing (CA)

Dry Dock Brewing Co. - North (CO)

Dry Dock Brewing Co. - South (CO)

★ Elliott Bay Brewhouse & Pub - Burien (WA)

★ Elliott Bay Public House & Brewery - Lake City (WA)

★ Elliott Bay Brewery & Pub - West Seattle (WA)

Elysian Brewing Co. (WA)

Epic Brewing Company (CO)

Falling Sky Brewing (OR)

FiftyFifty Brewing Co. (CA)

Figueroa Mountain Brewing Co. (CA)

Flying Fish Brewing Co. (NJ)

★ Fort George Brewery & Public House (OR)

Four Peaks Brewing Co. (AZ)

Fremont Brewing Co. - East (WA)

★ Fullsteam Brewery (NC)

Fulton Beer (MN)

Goose Island Beer Co. (IL)

★ Grand Rapids Brewing Company (MI)

Great Divide Brewing Co. (CO)

Great Lakes Brewing Co. (OH)

★ Hopworks Urban Brewery (OR)

★ Horse & Dragon Brewing Company (CO)

Iron Horse Brewery (WA)

★ Ironwood Brewing Co. (IN)

Jack Pine Brewery (MN)

★ Jackie O's Taproom Brewery - Campbell St. (OH)

★ Jackie O's Public House & Brewpub - West Union St. (OH)

Karl Strauss Brewing Company (CA)

KettleHouse Brewing Co. – Northside (MT)

KettleHouse Brewing Co. – Southside (MT)

★ Indicates breweries that reported three years of data

appendix f – reporting breweries

Kinetic Brewing Company (CA)	Stillmank Brewing Company (WI)
Land-Grant Brewing Company (OH)	Stone Brewing (CA)
Lazy Magnolia Brewing Co. (MS)	Switchback Brewing Co. (VT)
Left Hand Brewing Company (CO)	Three Taverns Craft Brewery (GA)
MadTree Brewing (OH)	Town In City Brewing Co. (TX)
★ Maine Beer Co. (ME)	Uinta Brewing Co. (UT)
Mankato Brewery (MN)	★ Upland Brewing Co. (IN)
Maui Brewing Co. - Kihei (HI)	Upslope Brewing Company - Flatiron Park (CO)
Mike Hess Brewing (CA)	Upslope Brewing Company - Lee Hill (CO)
★ Mother's Brewing Co. (MO)	Urban Chestnut Brewing Co. - Grove (MO)
Mount Hood Brewing Co. (OR)	★ Urban Chestnut Brewing Co. - Midtown (MO)
Nebraska Brewing Company (NE)	Walking Man Brewing (WA)
★ New Belgium Brewing Co. (CO)	Witch's Hat Brewing Co. (MI)
★ North Coast Brewing Co. (CA)	Worth Brewing Company (IA)
O'Fallon Brewery (MO)	Yards Brewing Co. (PA)
★ Odell Brewing Co. (CO)	★ Zipline Brewing Co. (NE)
One Well Brewing (MI)	
Orlando Brewing Partners, Inc. (FL)	
Oskar Blues Brewery (CO)	
Pigeon Hill Brewing Co. (MI)	
Potosi Brewing (WI)	
★ Revolution Brewing - Kedzie (IL)	
★ Rising Tide Brewing Co. (ME)	
Rockford Brewing Company (MI)	
★ Sierra Nevada Brewing Co. - Chico (CA)	
Sierra Nevada Brewing Co. - Mills River (NC)	
Silver City Brewery (WA)	
★ Ska Brewing Company (CO)	
The Pike Brewing Co. (WA)	
★ The Saint Louis Brewery, LLC - Bottleworks (MO)	
★ The Saint Louis Brewery, LLC - Taproom (MO)	
Standing Stone Brewing Company (OR)	
Steel Toe Brewing (MN)	

★ Indicates breweries that reported three consecutive years of complete data