Topic Hub: Craft Brewing

Pacific Northwest Pollution Prevention Resource Center
2101 Fourth Ave., Suite 1080
Seattle, WA 98121
Tel: 206.352.2050
Fax: 206.352.2049

Contents

Background and Overview

Craft brewers, brewpubs and microbreweries (as opposed to macrobreweries) are defined as those that brew less than six million barrels of beer (BBL) each year, are independently owned, and have distinctive, individualistic approaches to brewing and connecting with their customers. One required characteristic to earn the label of microbrewery is to not use adjunct ingredients or fillers, such as rice or other cereal grains.

Interestingly, the Craft Brewer's Alliance states that the majority of Americans live within 10 miles of a craft brewer.

Many craft or microbrewers also operate a restaurant and pub adjacent to their brewery. Craft brewers and brewpubs currently provide an estimated 115,000 jobs in the U.S., including serving staff in brewpubs. This is information from the **Brewers Association**. They also report growth of the craft brewing industry by 12.8% in 2015, and that the craft market is 12.2% of the marketshare of all beers, including domestic and export. There are 4,225 craft breweries (and brew pubs) in the U.S.

Operations

The Brewing Process

Brewing beer typically involves at least six steps: mashing, lautering, boiling, fermenting, conditioning, and packaging. Some breweries also filter their beers and thus have a filtering step prior to packaging. Some simplified or alternative brewing systems exist in craft brewing. Many craft or microbrewers also operate a restaurant and pub adjacent to their brewery, and offer tours of their breweries.

The process steps are described below, abbreviated from **Brew Hopping**.

Mashing is the process of combining a mix of milled grain, often malted barley, with water and heat until enzymes in the malt break down the starch into sugars. Mashing removes most of the proteins, starches and sugars from the grain.

Lautering separates the wort (liquid) from the spent grain. The liquid is removed via a mash tun outfitted with a false bottom, a lauter tun, a special-purpose wide vessel with a false bottom and rotating cutters to facilitate flow, a mash filter, or a plate-and-frame filter. Most separation processes have two stages: first wort run-off, during which the extract is separated in an undiluted state from the spent grains, then sparging, in which extract which remains with the grains is rinsed off with hot water. This process results in spent grain waste - which most brewers deliver to local ranchers as a feed supplement.

Boiling the malt extracts, called wort, and ensures its sterility. During the boiling process hops are added, which contribute bitterness, flavor, and aroma compounds to the beer, and, along with the heat of the boil, causes proteins in the wort to coagulate and the pH of the wort to fall. Finally, the vapors produced during the boil volatilize off unwanted flavors. The boil lasts between 50 and 120 minutes, depending on intensity, the hop and flavor addition schedule, and the volume of wort to be evaporated off.

Different boil kettles or tanks include direct-fired, with a burner underneath, and steam-fired, which uses an external boiler to deliver steam, under pressure, to the kettle or tank. At the end of the boil, the wort may be centrifuged to remove denser solids (coagulated proteins, vegetable matter from hops, etc.) The wort is then cooled with a heat exchanger and usually glycol chillers.

Fermentation begins after the wort is cooled and aerated and the yeast is added. The yeast "feeds" on the sugars, metabolizing them into alcohol and a significant amount of carbon dioxide (CO2).

Conditioning occurs after the sugars have been almost completely digested and the fermentation slows down. At this point, the yeast starts to settle. The beer is then cooled to around freezing in pressure-controlled tanks, which encourages further settling of the yeast, and causes proteins to coagulate and settle out with the yeast. Unpleasant flavors become insoluble in the cold beer, and the beer's flavor becomes smoother. Conditioning takes weeks for most beers, but as long as six months for others, especially lagers. This cold aging serves to reduce sulfur compounds produced by the bottom-fermenting yeast and to produce a cleaner tasting final product with fewer esters.

Filtering is an optional step, but stabilizes the flavor of the beer. Filtration processes vary - some use pre-made filtration media such as sheets or candles, while others use a fine powder made of, for example, diatomaceous earth which is introduced into the beer and recirculated past screens to form a filtration bed.

Packaging involves moving the beer to filling stations where it is put into kegs, bottles, cans, or growlers. For outbound shipment, additional packaging occurs - such as boxing, palletizing, and preparing or loading on for outbound shipment. Some of the beer produced will go straight to the pub for serving on tap to guests.

Inputs and Outputs

Typical inputs and raw materials to brewing include (but are not limited to):

- Energy
- Water (used in the product itself, but also non-brewing uses such as cleaning, heating and cooling)
- Grains
- Hops
- Other beer additives
- Bottling containers (cans, bottles, kegs, growlers)y
- Labels and adhesives
- Carbon dioxide (CO2) (and/or Nitrogen)
- Industrial cleaners and sanitizers
- Packaging products such as pallets, stretch wrap, banding, keg “collars” or other pallet stabilizing products

A handful of craft brewers grow hops for direct inclusion in their final product.

Typical wastes and emissions of brewing operations can include the following, depending on the scope and size of the specific brewing process:

- Yeast
- Spent grain
- Hop liquor
- CO2 gas (unless reclaimed). Even small breweries emit a large amount of CO2, one source being around 8-10 pounds per barrel of wort produced (**Energy Star)**, plus, there are losses of purchased CO2 during transportation, onsite storage, and distribution of CO2 to the specific brewing process.
- Spent filtration media
- Waste product (that is defective, spilled, etc.) - (statistics say it's 1-6% of production!)
- Defective, dented, or broken bottles, cans, growlers, or kegs
- Water and wastewater (BOD, COD, pH, TSS)
- Wastewater treatment chemicals
- Potentially recoverables: vapor/heat and carbon dioxide
- Packaging (from incoming shipments, or defect/unused packaging for outbound shipments), including keg collars, bottle labels, empty grain or yeast bags, pallet stretch wrap or banding
- Administrative operations – office wastes / paper

When pubs /restaurant operations are occurring adjacent to breweries, food & restaurant wastes must also be considered and managed, especially fats, oils, and grease (FOG).

Reasons for Action

Why should the craft brewers take action to reduce their environmental footprint?

The craft/microbrew market serves a customer base that enjoys the culture and taste of unique beers, the ambiance of smaller, local brewers and pubs, and learning how the establishment is contributing to positive environmental and community efforts. Employing environmentally sound practices can attract more customers, both to the brewing or pub site, and in the retail purchase of beers. In addition to the market potential, there are many economic benefits of improving energy, water, and waste efficiencies.

Energy Efficiency efforts often offer a quick payback, especially when coupled with the energy incentives and tax breaks that are often available to businesses. Further, it provides opportunity to reduce greenhouse gas emissions.

Some recent, simple efforts that breweries have undertaken, which have paid off quickly, include compressed air optimization and leak repair, insulation of steam pipes, and lighting retrofits. An energy

study at an Oregon brewery found that just insulating steam pipes throughout the facility could reduce heat loss by 87%, and therefore decrease steam purchase or generation costs, giving it a 0.8 year payback after a tax rebate.

Larger brewers have capital to invest in some of the …. Technologies, such as Sierra Nevada Brewing Co. who has stretches of solar panels and fuel cells, has installed heat recovery units on boilers, has brew kettles in place to trap and recover energy, and a wastewater treatment system that recovers energy. These and other efforts have allowed the company has been able to reduce the energy costs per barrel of beer by almost $2 since 2007, creating savings of more than $1.5 million—all while increasing the total annual production volume by over 159,000 barrels of beer (read more **here**).

Water Consumption is an important aspect of brewing because production can be very water-intensive. However, there are lots of opportunities for reducing consumption. A common measure in the brewing sector is how many barrels of water it takes to make one barrel of beer. Some companies have been able to achieve a ratio of less than 4:1, while others report a figure as high as 7:1. Many have goals to achieve 3.5:1 in 2014 or by 2015. Water is often still considered a cheap commodity, and although this may be changing in the near future, water reduction projects are still sometimes difficult to justify based on the low cost of raw water.

However, if the total cost of water is included in the equation below, some water efficiency projects become more attractive.

Total cost of water = Price of incoming water

+ Sanitary Sewer Service Charge
+ Cost of energy and chemicals needed to process or heat the water
+ Labor and other costs associated with water processing and wastewater treatment
+ Wastewater Sewer service charges (including overage fines for BOD or TSS)
+ Administrative time for compliance activities.

A simple example of water reuse at Summit Brewing Company, where they capture rinse water for the inside of their bottles, filter it, then reuse it to rinse the outside of their bottles, has reduced their water consumption by about 2.7 million gallons annually.

Reducing Waste through minimization, reuse, and recycling is also important. Reusing pallets, keg collars, shipping materials, buckets and containers, saves money not only in disposal but in purchase costs.

Another way to minimize costs for disposal and purchase is to reduce defects in bottling or canning and the loss of beer during production. Recycling materials, including process wastes such as spent grains, yeast, and filtration media means avoiding landfill disposal costs. Some breweries have been able to compost their organic wastes onsite, for local use in gardens, farms, as livestock feed, or in hop fields. New technology allows breweries to use spent grain as fuel for biomass steam boilers, thus offsetting energy costs.

Finally, customers and brewery tour guests get very excited about innovative and sustainable business practices such as recycling, composting, and energy efficiency. Brewers have several venues in which to brag about their achievements, efforts, and certifications. This is a great way to appeal to clients while promoting environmental practices on their marketing literature and in their establishments. A few examples follow:

- Alaska Green Star Certification
- Salmon Safe certification of beer
- Salmon Safe – Urban Development (certification of an urban facility)
- B Corp Certification
- Institute for Environmental Research and Education (IERE) offers an Environmental Product Declaration Certification software specifically for brewers, allows a company to understand the life cycle impacts of their products, reduce that footprint, and place the eco-label Earthsure on their labels and marketing literature.
- Green Restaurant Association Certification
- Local environmental certification programs such as EnviroStars in King County, Washington, or the Bay Area Green Business program, or the City of Portland's Sustainability at Work program.

P2 Opportunities

Although there are many creative pollution prevention activities going on at more than 2,000 breweries nationwide, numerous opportunities are listed in Energy, Water, Wastewater, and Material & Solid Wastes.

Many of the recommendations below, especially under the capital investment sections, will require cost benefit analysis to ensure a good business case. Also, these are merely a sample of options and examples and many breweries and energy consultants have found other resource-saving opportunities.

PPRC has established a "sustainable listserv" of craft brewers that are interested in learning best practices from each other, and sharing ideas, successes, and challenges. Review the listserv format and please feel free to subscribe at **Yahoo Groups** if interested in joining this online discussion group.

Energy

There are many more energy efficiency improvement opportunities, which are feasible for craft brewers. Some may only be cost-effective for larger brewers.

First, a strategic energy management (SEM) plan or energy management system (EMS) can save thousands each year. For example, Widmer Brothers implemented an SEM, along with incentives available from a local energy service provider, and is now saving 800,000 kwh /year and $49k/year.

Then, there are numerous tools, strategies, and higher efficiency equipment and facility options for consideration.

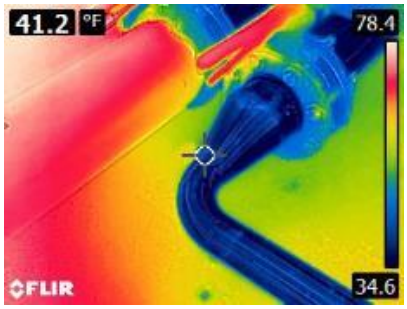
Start an energy efficiency effort by evaluating current performance.

Investigation/Evaluation

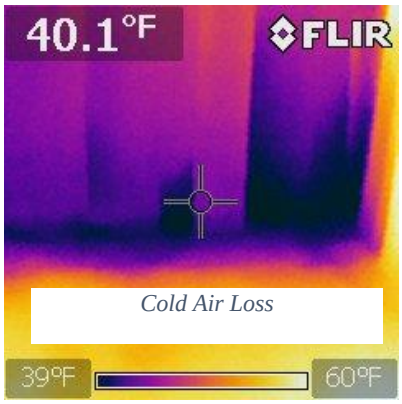
Perform an energy audit. Utilize local and regional resources such as utility companies to help in auditing. Determine the kWh, therms, and gallons used per BBL produced to track usage intensity and compare to industry benchmarks, find outliers, and find areas to concentrate on for savings.

Some steps can be taken by the brewery, but an in-depth audit with energy consumption measurement for specific devices and operations and full analysis of upgrade or efficiency opportunities may require energy professionals. A few simpler "do it yourself" audit ideas are:

Uninsulated Glycol Line



Uninsulated Steam Lines



Cold Air Loss

- Compile data from utility bills, or contact utility account managers who may already have the data collected.
- Rent an infrared (IR) digital camera to look for refrigeration and heat loss (see photo inserts).
    - Check exterior temperatures of various equipment throughout the facility in comparison to the surrounding ambient air temperature: steam pipes including insulation, tank exterior, tank exhaust vents, HVAC equipment, motors and pumps, the entrances of refrigerated spaces, the seals around doors, and fans.
- Identify and document current age and specs of refrigeration controls, fans, motors, and pumps. Compare the operating temperature specs for the devices to any temperature readings from the IR camera.
- Conduct a leak test of the compressed air system. Compressed air is not a "free resource"! (**Carbon Trust**).
- Determine the operating pressure of the compressed air system.
- Identify current age of facility lighting and type of lighting fixtures.
- Identify steam or condensate leaks in facility boiler or brewing tanks.
- Take pressure readings on steam lines and equipment. Higher than necessary pressure can result in heat loss during distribution and end use.

Lower Cost Opportunities (Based on Evaluation Findings Relevant to the facility)

- Heating and Insulation
    - Insulate steam, refrigerant, glycol, or cold water pipes, and any tanks that are not insulated already.
    - Minimize indoor summer heat load by diverting any sources of hot air (off compressors, boilers, kettles, etc.) to the exterior of the plant during summer months.
    - Minimize any heat sources (lights, tank vents, vapor release, etc.) contributing to higher indoor air temperatures, especially in hotter climates in summer months.

- Install weather stripping, especially in warehouse/cellar and cold storage areas.

- Lighting
  - Upgrade older lighting, especially incandescent and T12 lights, to LEDs and T5 bulbs.
  - Install natural lighting – such as windows and skylights – to reduce electrical lighting needs.
  - Install occupancy sensors, utility daylighting, and daylight sensors inside.
  - Install photocells for exterior lights
- Conserve and Prevent
  - Turn energy consuming devices off or to lower speed or temperature when not needed. Examples include: conveyors, compressed air systems, and unneeded chiller in winter and unneeded boiler(s) in summer.
  - Maintain regular and preventive maintenance on HVAC and brewing equipment, compressors, motors, pumps, refrigeration controls, etc.
  - Do not heat water for exterior keg or can/bottle washing, or for facility cleanup.
- Compressors and Air Flow
  - Analyze the benefit of redirecting compressor intake air to use outside air. (This will depend on current intake temperature, and average outdoor temperature.
  - Match the compressed air load to the pressure required. If pressure is higher than necessary, cutting pressure in half can result in energy savings of more than 50 percent **(Business Energy Advisor)**.
- Equipment
  - Install automated, high-speed doors on refrigerated spaces (in lieu of plastic curtains, or doors with poor seals, and/or operators forgetting to fully close doors).
  - Install motion sensors, ambient light sensors, and timers around the plant that function to adjust electric lighting based on occupancy, and/or the level of available natural light.
  - Motors are often more powerful than necessary, producing needlessly high energy consumption and peak power draw. If possible, consider replacing to right-size, variable speed, and higher efficiency.
  - Recover vapor and heat with heat recovery units on boilers, fuel cells, and brew kettles, trapping and recovering energy that otherwise would be vented. Adding heat recovery to a keg-washer system can reduce cleaning energy by 40 percent and recover 85 percent of the heat required to warm incoming water **(E Source)**.
  - Incentives or tax rebates may be available from energy service providers or utilities for more efficient equipment such as compressed air, equipment controls, direct contact

water heaters, dust collection systems, high-speed doors, HVLS fans, insulation, HVAC, hydraulic pump applications, hydraulic system improvements, refrigeration, VFDs, and welders.

- Alternative practices or technologies that reduce heated water use in cleaning and sanitation (see water section below)
- Automatic shut-offs for conveyors (or manual shut-off as policy)

- Brewing Areas and Boilers
  - Brew batches back to back instead of spreading the process out over several days to minimize wasted energy with equipment preparation and preheating.
  - Experiment with boiling and evaporation to see if wort boil times can be reduced and evaporating temperatures can be optimized, since many are set lower than necessary.
  - Adjust steam pressure if the audit found it to be too high.
  - Seal steam or condensate line leaks identified in the audit. Boiling wort is very energy-intensive. Fuels for boilers alone can account for 25 to 35 percent of a brewery's overall energy bill **(E Source)**, so leaks can be costly.
  - Consider insulated spaces and air flow controls for brewing areas or equipment that needs to be warmer vs. cooler. See **Summit Brewing** Company's example of their Glass Wall/ Heat Recovery Project, saving $20,000, 200,000 KWH, and 6000 therms of natural gas annually.
  - If the hot water tank is oversized, consider a new, more efficient water heater sized to the needed capacity. Hot water requires high energy to maintain temperature when the water is not needed. For lower-volume needs, such as restaurants, consider an on-demand water heater.
- Supplemental Energy Sources/Savings
  - If volumes of brewing wastes warrant, install an anaerobic digester to remove organics from wastewater and generate electricity onsite. (See Matt's Brewing Company story. Numerous other breweries have also installed units).
  - If operations are large enough, consider installing a biomass steam boiler and using spent grain as fuel.
  - Install solar panels to supplement water heating. Worthy Brewing installed 117 photovoltaic panels on their roof that generate roughly the equivalent of power for three large homes in Oregon (and avoiding 15 tons of CO_2 emissions).
  - Sustainable transit: e.g., bike-friendly space (for workplace and for customers) and support for carpools or local transit for employees.

Refer to the Brewers Association **Energy Usage, GHG Reduction, Efficiency and Load Management Manual** for additional energy efficiency recommendations and examples.

Water Consumption

Minimizing water is becoming a higher priority for many brewers, but also has the downstream benefit of reducing wastewater generation and management.

Investigation/Evaluation

Determine water pressure(s) for all lines and to incoming equipment, especially vacuum pumps and larger equipment.

- For facility cleaning, exterior keg cleaning, and exterior can or bottle cleaning, document the flow rate (if possible) and time spent cleaning these areas.
- Document other non-product uses of process water uses, such as interior keg cleaning, sanitizing, belt lubrication, can or bottle cleaning. Note any uses that require or currently use heated water.
- Install submeters on high-water use processes and collect the data to inform future decisions on water use.
- If a flow meter is available, take measurements on all water consuming processes.

Low Cost/No Cost Recommendations (Based on Evaluation Findings Relevant to the Facility)

- Conserve and Prevent
  - Minimize cleaning water flow and volume (by optimizing pressure, line diameter, upgrading spray jets/nozzles, and using brushes/squeegees to clean out fermenter to extent possible). For floors, use water-efficient commercial floor cleaning machines, or a water broom.

- **Use a water broom**. This device connects to a hose and is driven by standard water pressure. It can use 10% of the water of a hose alone. Some water broom attachments can be connected to a power washer for washing down large surface areas at commercial and industrial facilities.

(City of Portland Cleaning & Sanitation Factsheet)

  - Ensure all hoses and water sources are turned off when not in use, with automatic shut-off valves, or standard operating procedures.
  - Implement a standard procedure for cleaning floors (how often and how clean) - to eliminate unnecessary cleaning.
  - Make sure the heat exchangers are well maintained and regularly check the meter readings of the water flow. Pollution of the heat exchanger will negatively affect the heat transfer and cause an excess of water flow.
- Reclaim/Reuse Water
  - Capture water used at the filler for rinsing of bottles.

- Capture wort-cooling water: Midnight Sun Brewing Company purchased a 1500 gallon tank allowing reuse of almost all of their knockout water
- Capture and reuse sanitation water for floor cleaning or other uses: Summit Brewing Line Rinse Water Reclamation).

Equipment to Reduce Water Use

- Waterless vacuum pumps
- Lube-free conveyors for bottles: Redhook Brewery reports that initial adjustments are needed for full functionality, and these run better with certain bottle types than others, depending on the bottles' center of gravity.
- Ionized air "rinse" for can or bottle cleaning prior to fill.
- Clean-in-place (CIP) system(s). At Bells Brewery, a cellar CIP reduced the amount of water to clean tanks by about 65% **(Brewer's Association, pg. 22)**.
- Right-sized, high-efficiency filler vacuum pump. Bells Brewery installed a new pump design to reduce water that goes to drain, achieving a reduction from 57 liters per minute to 8 liters per minute, saving 20 million pints of water annually on filling operation **(Brewer's Association, pg. 22)**.
- Closed loop recycle system for fermenter cooling or chilling water.

A few interesting pilot projects are also underway to test performance of technologies that reduce chemicals and heated water needed for sanitation. PPRC can provide current information and contacts on these efforts (mgaither@pprc.org).

- Fog-In-Place sanitation (using paracetic acid) (@Widmer Brothers)
- Electrochemically Activated Water sanitation (@Merrimack Ales, in partnership with TURI)
- Electrostatic spray sanitation (using hypochlorus) (@Merrimack Ales, in partnership with TURI)
- UV Sanitation at Jackson Family Wineries

Refer to the Brewers Association **Water and Wastewater: Treatment/Volume Reduction Manual** for additional water efficiency recommendations and examples.

Wastewater

Reducing non-product water use will also reduce wastewater generation (refer to the Water Consumption section above).

Investigation/Evaluation

- Determine pathways and sources of wastewater to sewer and/or treatment systems.
- Review sewer records for volumes of wastewater and overage fees for biological oxygen demand (BOD), total suspended solids (TSS), or other constituents.
- Sample and analyze different wastewater streams to determine which have high BOD or high TSS), or other contaminants of concern to the brewery or wastewater treatment utility.

Streams that may be higher in BOD include:

- spent grain: last running, washing cellulose, and nitrogenous matter
- whirlpool rinsing of spent hops and hot trub
- fermenters rinsing yeast
- storage tanks rinsing beer, yeast, and protein
- filtration cleaning: start up, during, and end

Streams that may be highest in TSS include:

- spent grain: last running and washing cellulose, nitrogenous matter
- whirlpool rinsing spent hops and hot trub
- filtration cleaning: start up, during, and end

Low Cost/No Cost Recommendations (Based on Evaluation Findings Relevant to the facility).

- Conserve water by decreasing the amount used to remove spent grain from the lauter tun
- Use more water-efficient cleaning hoses or reuse sanitation water for facility and conveyors (See water consumption section above).
- Maintain water hoses, connectors, and nozzles, checking routinely for leaks.
- Fit fine mesh baskets in the floor drains to collect and prevent grains from entering the drainage system.
- Reduce beer losses by addressing spillage, overflows, losses during filtration, losses during filling startup or shutdown, or leaks. For instance, JW Lees & Co.'s Manchester brewery installed float operated valves at a low level in the hot liquor tank which minimized both the overflow of hot liquor to drain and the quality of cold top-up liquor. The payback was about five months **(Brewers Association, pg. 24)**.
- Implement policies and prevention methods to ensure no spent beer, destroyed product, or spent grain/hops, diatomaceous earth, or yeast is dumped to any drain.
- Review analysis of different streams that were found to have high BOD or TSS, and work with staff to make behavioral or existing equipment changes to reduce concentration.

Equipment to Reduce or Better Manage Wastewater

- Determine if cost effective to treat wastewater or effluent onsite for energy or reuse, or simply to remove wastewater constituents that are over regulatory limits, such as Biological Oxygen Demand (BOD). Systems may range from simple filtration, to internal measurement of high BOD to be able to remove that portion of high strength water only, or for larger breweries, an anaerobic digester.

- Reduce beer losses with equipment
    - Centrifuge
    - Malt press
- Filtration/solids removal
    - Mash filter (e.g., roto screens)
    - Solids interceptor or other solids straining
    - Holding or settling vault with flocculation

Refer to the Brewers Association **Water and Wastewater: Treatment/Volume Reduction Manual** for additional wastewater reduction recommendations and examples.

Materials, CO2, and Wastes

Packaging Waste Prevention

- Reusable pallet covers or minimal strapping in lieu of stretch wrap.
- Reusable keg collars (with small removable stickers or temporary adhesives to provide the lot and product identification)
- Repair pallets.
- Use minimum amount of stretch wrap necessary.

Carbon Dioxide

- Address leaks and losses in lines and storage. CO2 is subject to volume loss during transport and storage
- Pinpoint carbonator: Installed at Hopworks Urban Brewery, saves $5k /year.
- Change to hard CO2 lines instead of flexible/soft tubing and clamps, which are more subject to leaks and friction loss.
- Even small breweries emit a large amount of carbon dioxide (CO2) during fermentation CO2 at around 8-10 lbs. per barrel of wort produced, according to **Energy Star**. Onsite CO2 recovery systems may be feasible for larger breweries, and can make breweries CO2 self-sufficient. . The **Alaskan Brewing Company** describes their system here, which also helps them prevent over a million pounds of CO2, a greenhouse gas. Several manufacturers sell CO2 recovery systems, some of which can be customized to the operation, which have various payback periods and initial capital costs.
- Consider replacing CO2 use with an onsite nitrogen extractor. PPRC can assist with a cost benefit analysis. Two breweries installed in 2016 and are reporting excellent results and reduced CO2 uses and losses. Mac & Jack's, Midnight Sun Brewing Company). Uses for the nitrogen include:
    - Covering headspace of stored ingredients, tanks

- Purging kegs, cans, bottles
- Reducing fobbing when discharging beer from storage to filtration
- Purging equipment and pipelines
- Tap

Recycle

- Used multi-layer hops bags can be shipped to TerraCycle for recycling, at the expense of the end user (brewers). There are efforts however, by a few packaging suppliers, to design and test new material that is more recyclable. Contact PPRC for more info.
- If not already happening, find local beneficial uses for spent grains, hop fluid, yeast, and diatomaceous earth -- **PPRC** can assist in finding potential end users. This includes local ranchers and growers, and possibly bioenergy facilities for certain organic streams.
- Spent grain can also be used for cooking and baking, if dried properly, which **Craft Beer** showcases.
- New technology uses spent grain as a fuel in onsite biomass steam boilers, which offsets energy consumption. The **Alaskan Brewing Company** was one of the first to employ this machinery. Biomass boilers are more feasible in areas where transport of heavy material (spent grains, etc.) is cost-prohibitive. Otherwise, the highly nutritious material is a great feed source and many companies exist around purchasing this byproduct.
- Recycle stretch banding, defect cans or bottles, woven or paper grain bags, pallets, cardboard, and glass. If quantities warrant, bale the material.
- In rural areas where recycling is less prevalent or inclusive, consider partnering with other businesses to generate sufficient quantities for recycling haulers. The **Boulevard Brewing Company** brought glass recycling to Kansas City to meet its needs, which subsequently generated 100 million recycled glass bottles in 2011.
- Recycle restaurant grease and cooking oil, which can be used in biofuels.

Materials

- Find safer alternatives for supplemental chemicals, such as spray aerosol glue, stainless steel cleaners, and other custodial products. For product ideas, see **GreenSeal Products** and the EPA's **Design for the Environment**.
- If diatomaceous earth is used as a filtration media, use proper PPE when working with the dry material, as it contains crystalline silica.
- Use washable cups and dishes, or purchase recycled-content or compostable dishware for special events.

Where to go for Pollution Prevention Help

Sustainable Craft Brew Listserv

Join a growing list of Craft Brewers that are able to discuss, share, and learn about environmental opportunities from each other.

To join: send email to craftbrewenvirolistserv-subscribe@yahoogroups.com

---

Brewer's Association

Technical information, resources and tools to reduce environmental impacts and improve productivity in the craft brew industry.

Contact: John Stier, Sustainability Mentor

Craft Brew Alliance

Craft Brew Alliance was formed with the merger of leading Pacific Northwest craft brewers – Widmer Brothers Brewing and Redhook Ale Brewery in 2008, which were then joined by Kona Brewing Company (and produced the Omission brand in 2012). The alliance is committed to sustainable and socially just business practices. CBA is a family rooted in passion, creativity and uniqueness with a shared conviction: craft brew.

Contact: Julia Person

Idaho Department of Environmental Quality

Idaho DEQ's Pollution Prevention Program works with Idaho's businesses, communities, and citizens to prevent pollution and conserve resources through technical assistance, research services, and community outreach activities.

Contact: Ben Jarvis

Impact Washington

Impact Washington (formerly Washington Manufacturing Services) is a non-profit organization that strengthens Washington manufacturers to make them more globally competitive. With our manufacturing experts and our network of industry resources, we provide the change that makes the difference between surviving and thriving.

Oregon State University - Energy | Efficiency Center

The primary objective of the Industrial Assessment Center is to identify and evaluate opportunities for increased productivity, energy, conservation and waste minimization through visits to industrial sites. The Oregon IAC is one of 26 centers supported by the U.S. Department of Energy at universities across the country. It provides no cost energy, waste and productivity assessments to small and medium-sized manufacturers.

Contact: Joe Junker

Pacific Northwest Pollution Prevention Resource Center (PPRC)

PPRC is a non-profit organization that provides high quality, unbiased pollution prevention (P2) information. PPRC works collaboratively to promote environmental protection through pollution prevention. A few of PPRC's technical assistance offerings include safer chemical alternatives, lean and environment, spray paint efficiency, P2 measurement, and pharmaceutical takeback.

Contact: Michelle Gaither

TechHelp of Idaho

A non-profit organization partnered with the universities of Idaho, Idaho State and Boise State. Affiliated with the national network of Manufacturers Extension Partnership Centers.

Contact: Dave O'Connell

Energy Trust of Oregon

(Oregon only) Energy efficiency assistance, including application for incentives and rebates for improvements.

Contact: Christian Bernard

Sustainable Connections

(Northwest Washington). Business, economic, and environmental assistance for small businesses.

Oregon Department of Environmental Quality

Non-regulatory environmental assistance to businesses.

Contact: Dave Kunz

Manufacturing Matters

Lean & productivity consulting.

Contact: Charlie Martin

Washington State Department of Ecology - TREE

Free, non-regulatory assistance to Washington businesses through the TREE program, focusing on waste, energy, water, wastewater, and toxics reduction.

Contact: Tony Cooper

Alaska Forum
(Alaska only). Environmental technical assistance to businesses, especially focusing on energy efficiency.
Contact: Doug Huntman

Your Local Utilities & City or County Wastewater Staff

Center for Advanced Energy Studies (CAES) Energy Efficiency Research Institute (CEERI)

The mission of the CAES Energy Efficiency Research Institute (CEERI) is to promote the effective and efficient use of energy resources through cutting-edge research, effective outreach and accessible education. CEERI's goals include developing energy efficiency concepts through research in applied technology and consumer behavior; providing specialized education for energy efficiency technicians, engineers and architects; evaluating existing energy-saving technologies; and creating infrastructure for the accelerated transfer of ideas from the institute to the marketplace.

References

Articles/Reports

America's Favorite Sustainable Craft Breweries
The 6 breweries in American with the best sustainable practices, as selected from the top 50 craft breweries based on sales volume.
Source: Inhabitat

Anaerobic Digestion of Brewery By-Products
Brewery bi-products can become fuel using anaerobic digestion of the methane released during fermentation. This resource recovery reduces waste while generating energy.
Source: Water Pollution Control Federation

Anheuser-Busch: How We Conserve Water From 'Seed to Sip'
Description of Anheuser-Busch's sustainability efforts to conserve water through their participation in Agrimet and improve efficiency with their SmartBarley program.
Source: GreenBiz.com

Brewery Filter Applications
Article detailing the types and stages of filtration, including a sustainability index rating for the different methods.
Source: Pro Brewer

Brewery's Anaerobic Digester System Reduces Loading to Municipal Wastewater Treatment Plant
The Matt Brewing Company of New York is employing an anaerobic digester system that will remove 80% of organic material from its wastewater while generating at least 35% of their energy needs from the methane produced.
Source: Treatment Plant Operator

Brewhouse Innovation
The Alaskan Brewing Co. has implemented several sustainable practices, such as a CO2 recovery system, a spent grain steam boiler, and a mash filter-press, which reduced water usage by 2 million gallons in one year.
Source: Alaskan Brewing Co.

Craft Brew Alliance 2013 Sustainability Report **[PDF]**
The full 2013 sustainability report from the Craft Brew Alliance reporting $600,00 annual savings, 9 million gallons of water offset, and almost 3,000 tons of CO2 eliminated, all from green initiatives.
Source: Craft Brew Alliance

Craft Brew Alliance Releases 2013 Sustainability Highlights; Celebrates Earth Day With Water Restoration Pledge
Sustainability highlights of the Craft Brew Alliance for 2013 include reducing therms of natural gas per barrel by 6.5%, using innovative water reclamation technology, getting Green Restaurant certifications, and providing 50% of electricity by solar panels in the Kona brewery.
Source: Craft Brew Alliance

Craft Brewing Statistics
Facts on craft brewing and other industry statistics.
Source: Brewers Association

Full Sail Brewing Co. Sustainability
Full Sail Brewing Co. is one of the frontrunners in sustainable brewing practices, using a mash filter-press to save millions of gallons of water, local ingredients, recycling and reusing materials, and implementing high-efficiency technology.
Source: Full Sail Brewing Co.

Guide to Breweries and Brewpubs
Interactive directory of breweries and brewpubs.
Source: Brew Hopping North American Breweries and Brewpubs

How to brew beer better: Less water, less energy, more innovation
Best practice examples throughout the craft industry, for energy, water, and waste reduction.
Source: Greenbiz.com

Improving Efficiency to Brew Better Beer with a Better Bottom Line
Efforts described at Woodinville Brewery to reduce energy, waste, and BOD in wastewater.
Source: Washington Dept. of Ecology/Craft Brew Alliance

Industry Info, Standards, Statistics and Conversion Factors
Information on energy and water usage in brewery operations, as well as market values, standard grains and fuel properties,
Source: Sound Brewing Systems, Inc.

Optimizing Compressed Air Systems
A guide to identifying leaks and inefficiencies in air compression systems, and information on how to improve these.
Source: Business Energy Advisor

Sierra Nevada harnesses 'beer power' to reduce its energy costs
FuelCell Energy announced upgrade of 1-megawatt Direct Fuel Cell power plant at Sierra Nevada Brewing Company to use fuel created from a waste byproduct of the brewing process.
Source: Sierra Nevada Brewery

Sustainability and Hops: Green Energy and Craft Breweries
A brief overview of the practices in some of the most sustainable brewing companies in the nation -- Sierra Nevada and Full Sail.

Source: Innovation and Technology Today

Sustainability: Brewing a Better Future
The brewery's sustainability efforts include zero-landfill goals, glass recycling, a green roof, passive heating and cooling, and natural lighting.
Source: Boulevard Brewing Co.

Sustainable Uses of Spent Grain
A description of breweries using spent grain as livestock feed, for use in cooking and baking, or as a fertilizer. Moreover, spent grain can be used as fuel for an innovative new biomass steam boiler, which can provide more than half of the power needs of the brewery using only its own bi-product.
Source: Craft Beer

Technical Pollution Prevention Guide for Brewery and Winery Operations in the Lower Fraser Basin [PDF]
Report detailing the pollution occurring as a result of brewery operations and the associated environmental concerns. It includes strategies to mitigate these effects and best management practices for water and energy use, waste, and pollution prevention.
Source: Environment Canada

The Carbon Footprint of Fat Tire (R) Amber Ale [PDF]
Detailed report of greenhouse gas emission sources as a result of producing and distributing craft brew.
Source: New Belgium Brewing

The Ecological Creed of Craft Beer
Craft brewing seems to have a built-in environmental code, to which many successful companies adhere. This is part of a commitment to stewardship, as well as simply good business sense.
Source: Conservation Magazine

TOP 4 Sustainable Breweries in Celebration of American Craft Beer Week
An overview of sustainable practices in some of the greenest breweries in the country.
Source: Opportunity Green

Top 8 Green U.S. Breweries
A listing of the most sustainable brewery operations.
Source: Huffington Post

Wastewater in the Brewery -- Are You Sending Money Down the Drain?
Guide to evaluating the reasons and costs of wastewater generated in breweries and defining terminology.

Source: Birko Corp

Water Smart Guide for Process Water **[PDF]**
Report describing the uses of water in the beverage industry and opportunities for water efficiency and use reduction.
Source: Alliance for Water Efficiency

What's Up: Downtown Brewery Looks to the Sky for Energy
A Wisconsin brewery uses solar panels to heat its water and reduce its greenhouse gas emissions by 8.5 metric tons annually.
Source: Central Wisconsin Business

Case studies/Success Stories

California Microbrewery Takes Efficiency to the Max
Sierra Nevada craft brewing company has reduced the energy cost per barrel by $2 while increasing overall production outputs, for savings of $1.5 million. Its methods include extensive solar systems, using natural lighting, improved refrigeration seals, and heat recycling.
Source: Business Energy Advisor

Waste Minimization and Pollution Prevention **[PDF]**
A study to investigate in-plant modifications to reduce water and energy consumption that have a one-year payback period.
Source: EWATEC

Waste Reduction and Diversrion Successes
Success story of the brewery's waste diversion strategies and expanded recycling programs.
Source: New Belgium Brewing Co.

Factsheets/Checklists

Certification Standards For All Foodservice Operations
Certification program for restaurants with a detailed checklist of sustainability requirements including continual improvement after receiving the certification.
Source: Green Restaurant Association

T8 versus T5 Fluorescent: A Brief Analysis
General information on T8 and T5 fluorescent lighting: costs, performance, endurance, and the meaning

of the codes differentiating the lighting types.
Source: Lighting Solutions

The Zero Discharge Brewery [PDF]
Zero waste breweries are feasible using new technology. Methods include recapturing CO2 released during fermentation, converting spent grain to lactic acid, and treating wastewater through anaerobic digestion.
Source: Virginia Tech

Labeled Products and our Partners
An EPA list of green products recommended as suitable alternatives to other products for businesses to improve their environmental impacts.
Source: EPA Design for the Environment

Manuals/handbooks

Compressed Air
Guide for improving efficiency of compressed air systems to save energy.
Source: Carbon Trust

Energy Efficiency Improvement and Cost Saving Opportunities for Breweries [PDF]
Manual on methods of improving efficiency in the brewing process, saving money, and reducing the use or waste of water and energy.
Source: ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

Guide to Energy Efficiency Opportunities in the Canadian Brewing Industry [PDF]
Manual detailing brewing practices in Canada, approaches to energy management and auditing, implementing efficiency opportunities, and technical considerations and methods.
Source: Natural Resources Canada

Heat Recovery
A guide on how heat recovery systems can help businesses reuse heat and reduce energy consumption.
Source: Carbon Trust

Managing Energy Costs in Microbreweries [PDF]
This guide informs microbreweries, which have a slim profit margin and higher rates of waste than larger enterprises, on how to make operations more efficient with a quick payout. Techniques include identifying leaks, insulating pipes, adjusting steam pressures, air compression, and refrigeration temperatures, and upgrading motors and equipment to high-efficiency models.

Source: E Source Customer Direct

New Belgium Brewing Company, Inc.Sustainability Management System Version 2009 [PDF]
A comprehensive guide to the New Belgium Brewing Co.'s sustainable practices, initiatives, community work, operations, and management plans.
Source: New Belgium Brewing Co.

Water and Wastewater: Treatment/Volume Reduction Manual [PDF]
Comprehensive manual on water usage in brewing, including best practices for reducing consumption, improving operations, and several brewery case studies on water reduction, wastewater pre-treatment and community outreach.
Source: Brewers Association

Other:

Advantages of Earthsure Brewers Software
Institute for Environmental Research and Education (IERE) offers an Environmental Product Declaration certification software specifically for brewers, allows a company to understand the life cycle impacts of their products, reduce that footprint, and place the eco-label Earthsure on their labels and marketing literature.
Source: Institute for Environmental Research and Education

Alaskan Brewing Company: A Positive Cycle
The brewery's sustainability page, with links to some of their energy efficiency projects.
Source: Alaskan Brewing Company

Being Green (and we don't mean adding dye to our beer)
Summit Brewing Co. describes some of the ways in which it strives to be green in its operations, such as reclaiming water from the bottling process, replacing the air compressor with a multi-stage and variable speed one, and heat recovery. They reduced water by 85% per case of beer and spared 200,000 KWH and 6000 therms of natural gas annually.
Source: Summit Brewing Co.

Brewing a Better Future:The HEINEKEN Company Sustainability Elearning
Heineken has set a goal for itself of becoming the World's Greenest Brewer by 2020. It is starting an ELearning initiative to educate all levels of its employees on its sustainability efforts.
Source: Heineken

Energy Efficiency is Brewing!
Shows promotional efforts undertaken by several Alaska breweries and a winery, to promote energy efficiency on their bottle labels.
Source: Green Star

EnviroStars: Certifying Environmentally Responsible Business Practices
A collaboration between local government and businesses to reduce environmental and health impacts in Jefferson, King, Kitsap, Pierce, Skagit, and Whatcom counties.
Source: EnviroStars

FOG Prevention Training for Rural Communities
Information on trainings for FOG prevention in rural communities - preventing the build-up of fats, oils, and grease that damage water infrastructure.
Source: Pollution Prevention Resource Center

Interior Alaska Green Star
Green Star is a nonprofit that works with households and businesses towards energy conservation, waste reduction, and pollution prevention.
Source: Interior Alaska Green Star

Odell Brewing Co: Sustainability
A description of the brewery's sustainable business practices, such as heat exchangers, solar panels, and high-efficiency technology.
Source: Odell Brewing Co

Sustainability at Work
This program matches businesses and non-profits with sustainability advisors. Offers a green certification and provides resources.
Source: City of Portland

Sustainability: Triple Bottom Line
A summary of Great Lakes Brewing's philosophy of the triple bottom line: economic, social, and environmental business practices.
Source: Great Lakes Brewing Co.

The Bay Area Green Business Program
A partnership between local environmental agencies and utilities to offer incentives to participating businesses to minimize their environmental impacts.
Source: The Bay Area Green Business Program

The Green Brewery Project

A non-profit consultant for breweries seeking to make their operations more efficient and sustainable.
Source: The Green Brewery Project

Waste Reduction

As Bill Coors once said, "Waste is a resource out of place," and accordingly, MillerCoors set itself a goal of 50% waste reduction by 2015. As of 2013, five of its eight breweries were succeeded in sending zero waste to a landfill.
Source: Miller Coors

Water and Wastewater

Includes links to water/wastewater treatment volume reduction manual, with guidance on water usage, leaks, audits, efficiency opportunities, and cost analysis.
Source: Brewers Association

Merrimack Ales Tests Less Hazardous Cleaning and Sanitizing Technology

Describes the performance testing of electrochemical activation (ECA), a safer alternative for using caustic sodium hydroxide for cleaning and the follow on acids for sanitization.
Source: TURI