

# Water audit expands reuse opportunities at brewery

A partnership between Lagunitas Brewing Company and Cambrian Innovation demonstrates how breweries and other industrial operations can decrease water consumption from onsite process water treatment and reuse strategies. **Matthew Silver, Mark Barosky, and Claire Aviles** of Cambrian Innovation collaborate with **Eppa Rixey** of Lagunitas Brewing Company to explain how an auditing process and its findings resulted in major benefits for Lagunitas.

As the number of breweries in the United States (US) continues to grow, concerns about access to freshwater resources become increasingly prevalent. Many breweries are implementing strategies around water consumption, including process water reuse, to avoid business interruption and mitigate supply concerns.

Faced with rising costs and logistical challenges in dealing with process water, and with an interest in reuse to hedge against capacity fees and scarcity, Lagunitas Brewing Company of Petaluma, California, USA, turned to Boston-based Cambrian Innovation® for a solution. Lagunitas implemented Cambrian's EcoVolt® treatment and reuse technology that, at full capacity, reduces the brewery's water consumption by 40 percent while generating renewable electricity and heat. The Lagunitas reuse installation consists of three EcoVolt Reactors, three EcoVolt MBRs (membrane bioreactors), and a reverse osmosis (RO) system. Cambrian's Water Audit, an analytical auditing process that provides strategies for facility-wide water recycling, established the framework for Lagunitas' various uses of recycled process water from its EcoVolt solution.

## Brewery water use

At many breweries, water is used once before it is discharged to a municipal treatment plant. A typical brewery discharges more than 70 percent of its incoming water as process water. Brewery process water is significantly higher

in strength than domestic process water – typically averaging 600 to 5,000 milligrams per liter (mg/L) of biochemical oxygen demand (BOD), according to the Brewers Association's *2017 Water and Wastewater: Treatment/Volume Reduction Manual*, and running as high as 20,000 mg/L. Because of its makeup, brewery process water can disrupt operations at small, municipal treatment plants. In some cases, it must be hauled to larger plants for disposal at high cost.

Though often viewed as an economic and environmental liability, this high-strength process water can be a valuable resource. Some breweries are taking advantage of treatment and reuse technologies that help transform process water into energy and recycled water, drastically reducing energy and water footprints, as well as their overall cost of operations.

## Exploring reuse strategies

Lagunitas Brewing Company is an example of a facility that had to discharge a portion of its process water off-site due to high BOD loading. Until 2016, the brewery was forced to haul 189,000 liters (50,000 gallons) per day of high-strength process water to East Bay Municipal Utility District (EBMUD) in Oakland, almost 80 kilometers away. This transport process required more than 3,000 trucks a year. The brewery was also paying municipal discharge fees for its lower strength process water and faced hefty capacity fees tied to any increases in process water discharge.

In order to mitigate these economic risks and secure water supply for current production and future growth, Lagunitas partnered with Cambrian Innovation to proactively investigate how to treat and reuse this critical commodity onsite. The first step in achieving this goal was to complete Cambrian's Water Audit at the Petaluma brewery and understand the impact of a water reuse system at Lagunitas. The Water Audit is a comprehensive analysis that generates sustainable strategies for facility-wide water reuse based on water usage, quality information and specifications, and site goals and constraints.

Following the Water Audit, Cambrian identified potential targets for recycled water with Lagunitas personnel and worked with Lagunitas to down-select strategic options for maximizing water reuse. The targeted options were presented with a complete financial and engineering analysis for comparison, with the ultimate goal of finalizing the scope and design of the EcoVolt treatment and reuse systems. In the summer of 2016, Cambrian installed the final system, which currently recycles more than 45.4 million liters (mL) (12 million gallons (gal)) per year, representing the tremendous economic and environmental benefits water reuse can have at industrial facilities.

## Water Audit

Cambrian Innovation's Water Audit is a comprehensive report developed by Cambrian engineers that is used to detail an industrial facility's water usage and the economic impact of different water reuse strategies. The Water Audit at Lagunitas included five major steps:

- 1. Concept planning and data collection:** Cambrian visited the facility over two days, meeting with head brewers, operations managers, and quality assurance personnel to understand brewery operations and obtain all necessary water data (including general facility data, water consumption, and quality data). Additionally, Cambrian and Lagunitas identified all of the site sustainability goals – specific water management goals, any relevant planned process changes – and process constraints, including volume limits, permit requirements, current infrastructure

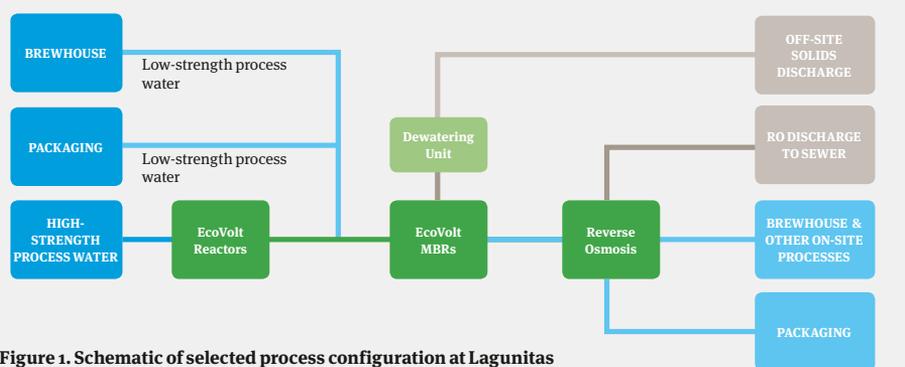


Figure 1. Schematic of selected process configuration at Lagunitas Brewing Company. Provided by Cambrian Innovation

**Table 1. Selected Water Reuse Processes**

Brewery Reuse Category	Water Using Process	Daily Water Consumption, Liters/Day
Brewhouse	Sample Chiller	3,028 (800 gal)
	Initial Vessel Rinses	27,940 (7,381gal)
	Chase Water	78,112 (20,635 gal)
Packaging	Vacuum Pump	54,510 (14,400 gal)
	External Bottle Rinsers	54,510 (14,400 gal)
CIP	Brewhouse Vessels	10,872 (2,872 gal)
	Fermentation Vessels	14,275 (3,771 gal)
	Packaging Vessels	27,986 (7,393 gal)
	Production/Filtration Equipment	4,542 (1,200 gal)
Production/Facilities	Filtration Vacuum Pump	5,451 (1,440 gal)
	Boiler Make-up	4,164 (1,100 gal)
<b>TOTAL</b>		<b>285,390 (75,392 gallons)</b>

**Table 2. Lagunitas' Water Consumption Breakdown**

Water Use Class	Daily Consumption (Liters/Day)
Product	159,407 (42,111gal)
Losses: evaporation, trub, spent yeast, packaging, filtration	68,319 (18,048 gal)
Non-recyclable Water*	122,061 (32,245 gal)
Recyclable Water	285,390 (75,392 gal)
Packaging	137,006 (36,193 gal)
Brewhouse	119,952 (31,688 gal)
Filtration/Production/Facilities	28,432 (7,511 gal)
<b>TOTAL</b>	<b>635,177 (167,796 gal)</b>

\*Includes water lost in spent grains

limitations, and cost structures.

**2. Generation of strategic options:** The data collected in the concept planning stage allowed Cambrian to construct a full water balance of the facility and identify water-using processes that could safely and reasonably use recycled water. Using this information along with the identified site goals and constraints as a guide, Cambrian developed five potential strategies for process water treatment and reuse at the facility, each with varying process configurations, unit operations, and different amounts of reuse water production.

**3. Facilitated down-selection of strategic options:** After presenting and discussing the proposed strategic options, Cambrian and Lagunitas conducted a facilitated review of the options, with the goal of down-selecting to two or three of the potential strategies.

**4. Water options analysis:** A comprehensive business case was presented to the Lagunitas executive team comparing the down-selected scenarios on quantitative criteria – water and process water savings, capital requirements, operational costs, and footprint – and qualitative criteria such as infrastructure complexity and risks associated with permitting and seasonality.

**5. Final process selection:** After final selection, Cambrian provided Lagunitas with a comprehensive report detailing the Water Audit's findings and recommendations for the installation of a strategic process water treatment and reuse system at the Petaluma brewery. Cambrian installed the system in the summer of 2016 and now operates the system full-time.

### Audit results

During the concept planning and data collection stage, Cambrian and Lagunitas were able to identify the site goals and constraints in addition to the water balance

of the brewery. These inputs were integral in the formation of broader strategies and processes for reusing water.

Subsequently, Cambrian identified five treatment scenarios for further down-selection by Lagunitas. The first three options aimed to maximize the amount of water recycled onsite through different arrangements of treatment operations, while the final two options explored a combination of internal and off-site reuse. These options were presented and compared based on system performance, capital and operating costs, complexity, and risks associated with permitting and seasonality.

Based on insight gained from the Water Audit analysis, Lagunitas moved forward with an onsite Cambrian Innovation EcoVolt treatment and reuse system, designed to treat 100 percent of the brewery's process water in a small footprint and recycle 70 percent of it for immediate use onsite. The system consists of one headworks unit controlling three EcoVolt Reactors, three EcoVolt MBRs, and a reverse osmosis system. It is designed to treat more than 454,000 liters (120,000 gal) of process water and produce approximately 303,000 liters (80,000 gal) of industrial reuse-quality water per day.

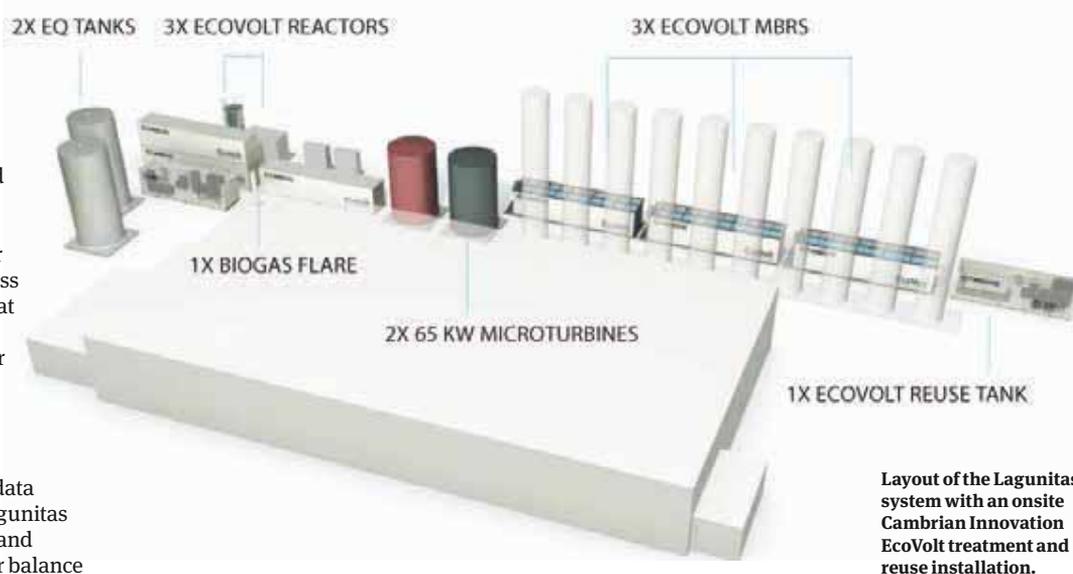
The process configuration can be seen in Figure 1, the notable benefits of this system compared to other reuse strategies include:

- Centralized, onsite treatment equipment that allows for cost-effective and efficient installation, lower infrastructure requirements, and simpler operation and maintenance
- Water security and independence critical for future operations
- A reduction in BOD of process water to below City of Petaluma discharge permit for the brewery and an eliminated need for trucking high-strength process water to EBMUD
- Better lifecycle economics when compared to other reuse strategies
- Eliminated dependency on outside variables (e.g., trucking costs, off-site discharge demands and regional regulations) significantly reduces seasonal and business risk.

The projections determined during the Water Audit can be seen in Table 3.

### System operation and performance

After it is treated with Cambrian's EcoVolt solution, the recycled water is sent to Lagunitas' reuse infrastructure. The brewery



**Layout of the Lagunitas system with an onsite Cambrian Innovation EcoVolt treatment and reuse installation.**



A bird's eye view of the Lagunitas Brewing Company facility in Petaluma, California, USA. Photo by Cambrian Innovation

has a 98,420-liter (26,000-gal) central reuse tank that receives recycled water. The tank also has a backup connection to city water in the event that the RO system cannot produce sufficient water to meet demand. From this central tank, the recycled water is split and conveyed to two 98,420-liter (26,000 gal) point-of-use tanks. From these tanks, the water is disinfected by UV lamps to eliminate risk of contamination. The recycled water is then distributed by dedicated lines that convey the water to the actual point of use.

The brewery's current recycled water usage is nominally 142,000 liters (37,500 gal) per day, differing from the 285,390 liters (75,392 gal) per day capability projected by Cambrian's Water Audit in Table 2. The current main reuse points are the vacuum pump (52,996 liters or 14,000 gal per day) and external bottle rinsers (52,996 liters or 14,000 gal per day), which come close to the expected water consumption determined by the Water Audit. Other uses include the packaging clean-in-place (CIP) system (26,498 liters or 7,000 gal per day), the five-vessel CIP system for production and filtration equipment for initial rinses (3,785 liters or 1,000 gal per day), and the initial rinses on the packaging and five-vessel CIP systems (3,785 liters or 1,000 gal per day).

The main reason for deviation from the Water Audit projections is risk of contact with product. One of the processes selected during the Water Audit, "Chase Water" (water used to keep piping full between product transfers, projected to use 78,112 liters or 20,635 gal per day), and certain production and filtration processes do not use

recycled water due to the risk that it would come in contact with product. Additionally, the sample chiller was not incorporated into the reuse strategy, as it is a low-impact point of use.

Lagunitas has plans to incorporate several water reuse measures by the end of 2017 and may explore additional points of use in 2018. However, no points of use that could come in contact with product will be installed or set up. The plans for 2017 include:

- Use 37,854 liters (10,000 gal) per day for initial rinses of the brewhouse vessels and whirlpool
- Use 18,927 liters (5,000 gal) per day for cooling towers for cold storage, boiler make-up water, and the filtration vacuum pump.

**Conclusions**

While the opportunities for process water reuse are expansive, breweries and other food and beverage facilities face a number of associated challenges. Lagunitas' current recycled water consumption, for example, is at half of the projected capacity. This result is primarily due to requirements involving infrastructure and operation as well as the need to maintain quality assurance of the product.

There are standard rules and regulations in place, such as California's Title 22 regulations, for recycling treated domestic process water. The same cannot be said for industrial process water, due to its variability and complexity. The lack of widespread industrial process water reuse suggests that this gray area of policy obfuscates and discourages industrial facilities. Efforts like the one at Lagunitas are

Increased adoption of industrial treatment and reuse projects may help to change consumer perception.

critical in generating data, experience, and awareness around industrial process water reuse to help further protocols of safe water recycling and inform future regulations for industrial facilities.

Facilities also face challenges around overcoming consumer perception, particularly in the US. Despite increasing water scarcity, a negative connotation remains around recycling process water even for breweries, whose process water is solely made up of organics from the brewing process. The need to ensure that recycled water does not come in contact with final product eliminates several high-impact points of use and requires additional infrastructure; at Lagunitas, the team has separate distribution lines dedicated to input water from the city and recycled water from the EcoVolt solution.

Increased adoption of industrial treatment and reuse projects, along with education, may help to change consumer perception. These steps, along with clear regulations and the optimization of technology for process water treatment and reuse, will allow breweries and other industrial businesses to increase recycled water consumption. The partnership between Cambrian Innovation and Lagunitas Brewing Company is a step in this direction –and a major milestone in sustainable brewery water and process water management.

**Authors' Note**

Cambrian Innovation Founder and CEO Matthew Silver, Mark Barosky, and Claire Aviles collaborated with Eppa Rixey, the strategic planning manager of Lagunitas Brewing Company, in writing this article. Cambrian is headquartered in Watertown, Massachusetts, USA.

Table 3. Cambrian Innovation's Water Audit Projections for Lagunitas Brewing Company

Key Performance Indicators	Current*	Theoretical Max Efficiency
Annual Beer Production (barrels/year)	463,305	487,953
Total Water Usage (liters/day)	660,785 (174,561 gal)	63,177 (167,796 gal)
Recyclable Water	110,523 (29,197 gal)	285,390 (75,392 gal)
City Water	550,262 (145,364 gal)	349,787 (92,404 gal)
City Water/Beer Ratio	3.64	2.19
Reduction from Baseline Water Usage	17%	45%

\*Annualized based on February & March 2017 operational data