FROM CREAMERY TO BREWERY WITH GEOTHERMAL ENERGY: KLAMATH BASIN BREWING COMPANY

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INTRODUCTION

The Klamath Basin Brewing Company, located in Klamath Falls, Oregon, is the only known beer brewing company in the world that uses geothermal energy in their brewing process. The brewery opened in 2005 after renovating the historic Crater Lake Creamery Building, built in 1935. The building is now known as "The Creamery Brewpub and Grill". The brewery currently brews about 10 different beers.

THE GEOTHERMAL RESOURCE AND DISTRIBUTION SYSTEM

The City of Klamath Falls is located in a Known Geothermal Resource Area (KGRA) that has been used to heat homes, businesses, schools, and institutions since the early 1900s. The Creamery Brewpub and Grill is part of the Klamath Falls district geothermal heating system, which was originally constructed in 1981 to extend the benefits of geothermal heating to downtown Klamath Falls. This year (2006) marks the 25th anniversary of the district heating system, and after some difficult times in its development, the system now provides heat to 24 buildings totaling about 400,000 ft2 (37,200 m2), 150,000 ft2 (14,000 m2) of greenhouse space, 105,000 ft2 (9,750 m2) of sidewalk snow-melting area, and also provides process heat to the Klamath Falls wastewater treatment plant (WWTP).

The history and design of the Klamath Falls geothermal district heating system has been recently summarized by Brown (2006). The system is served by two geothermal production wells located about 1 mile (1.6 km) from the downtown area. Well #CW-1 is 367 ft (112 m) deep with a groundwater temperature of 226˚F (108˚C) and well #CW-2 is 900 ft (274 m) deep with a groundwater temperature of 216˚F (102˚C). Production well pumps, which are the vertical line shaft type each rated at 500 gpm (31.5 L/s) pumping capacity with a 50 hp (37 kW) motor, convey geothermal water through a transmission pipeline to a central heat exchange building. The transmission pipeline is 8-inch (203 mm) steel with polyurethane foam insulation protected by a fiber-wound FRP jacket. The pipeline is about 4,400 ft (1,340 m) long, with about one-third of the line being direct-buried and the remainder enclosed in a concrete tunnel.

At the heat exchange building, the geothermal water transfers heat to the closed downtown circulating heating loop via large stainless steel plate-type heat exchangers. The geothermal water is then injected back into the aquifer via a 1,200 ft (365 m) deep injection well adjacent to the heat exchange building. Hot water is provided to the downtown customers at approximately 180˚F (82˚C). Variable speed drives on well pumps and circulating pumps in the closed heating loop help the system to maintain the design supply temperature.

THE BREWERY GEOTHERMAL SYSTEM

The Creamery Brewpub and Grill uses geothermal energy from the Klamath Falls geothermal district heating system for all its heating purposes. Uses of geothermal energy include space heating of approximately 11,000 ft^2 (1,022 m^2) of restaurant/pub space, snow-melting of about 1,000 ft^2 (93 m^2) of sidewalks, and generation of hot water for the brewing process.

THE BREWING PROCESS

The brewing process is shown schematically in Figure 1. The process starts with malted barley stored in a silo outside

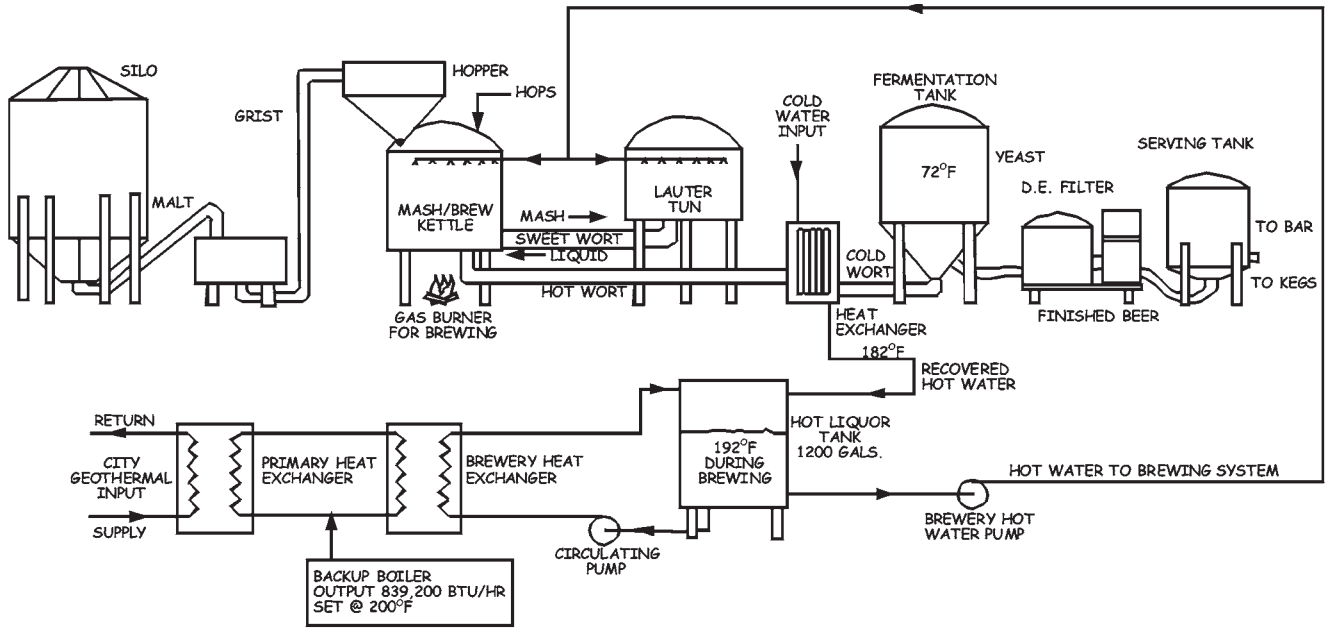

Figure 1. Brewing process schematic.

the building (Figure 2). The blend of malts required for a particular recipe is cracked in a roller mill. The milled malt or "grist" is transported by an auger to the grist hopper above the brewhouse.

The grist is mixed with hot water generated from the geothermal source in the mash tank (Figure 3), which starts the process of "mashing". As shown in Figure 3, the hot water provided by the City geothermal system exchanges heat with a heating loop, which includes a backup/supplemental boiler. The heat exchanger between the primary geothermal water and secondary heating loop is shown in Figure 4.

Figure 2. Photograph of the malted barley silo.

This secondary loop provides heat through another plate-type heat exchanger to the pure water stream used in the brewing process. The desirable temperature of the mash is about 154˚F (68˚C), and depending on the temperature of the grist (which enters the building near ambient outdoor temperatures) , hot water up to 192˚F (89˚C) must be supplied. After a few hours, mashing converts starches in the malt to sugars, and then the mash and the sweet liquid called "wort" are transferred to another tank called the "lauter tun".

Once the mash and wort are transferred to the "lauter tun", the wort is pumped back to the mash tank which now becomes the brew kettle. During this step, the "lautering" process is started, which is done by rinsing the mash with clean hot water at a temperature of about 172˚F (78˚C), generated from the geothermal source. The temperature of the water will shut down the conversion process of starch to sugar so that the wort will not become astringent tasting.

Once the brew kettle is full, the wort is brought to a boil for about two hours using a gas burner. Bittering hops are added at the beginning of the boil, while hops used for aroma and flavor are added toward the end. After the boiling process, the wort is "whirlpooled", where the centrifugal force separates the hops from the wort and helps clarify the wort.

The wort is then cooled as it passes through a heat exchanger on its way to temperature-controlled fermentation tanks kept at 72˚F (22˚C).

The initially cold water on the cold side of the heat exchanger is recovered at about 182˚F (83˚C) and is pumped to the hot liquor storage tank. During the transfer of the wort, yeast is added which ingests the sugars to produce alcohol and carbon dioxide. Many different strains of yeast are used to give many different flavors of the finished beer. Fermentation takes 3 to 4 days for ales and 1 to 2 months for lagers.

The Klamath Basin Brewing Company does not filter their beer, as it is believed that using "fines" to help clarify the

Figure 3. Photograph of the mash tank/brew kettle.

Figure 4. Photograph of the heat exchanger between the City geothermal district heating system and the brewery secondary heating loop.

beer results in a more full-flavored beer. The finished beer is carbonated and stored in serving tanks in a walk-in cooler, where it is either kegged or served to customers.

ENERGY CONSUMPTION AND OPERATING COST

City metering of geothermal energy usage by the Creamery Brewpub and Grill has just begun in March 2006, so documented geothermal energy use history is limited. During March 2006 when a significant amount of space heating and snow-melting were required, the Creamery Brewpub and Grill used about 1,700 therms (179 GJ) of geothermal energy, which cost about $1,360. The avoided cost of natural gas at 80% efficiency and $1.20/therm would be about $2,550. Therefore, the Creamery Brewpub and Grill saved about $1,190 during the month of March 2006 with geothermal energy.

During the month of June 2006 when most of the geothermal energy would be used for beer brewing, the Creamery Brewpub and Grill used about 430 therms (45 GJ) of geothermal energy, which cost about $344. The avoided cost of natural gas at 80% efficiency and $1.20/therm would be about $645.

Therefore, the Creamery Brewpub and Grill saved about $300 during the month of June 2006, with geothermal energy. It should be noted however, that the geothermal system was shut down sometime in June 2006, so these values may not be representative of a full month's energy useage.

ACKNOWLEDGEMENTS

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REFERENCES

Brown, B. 2006. "Klamath Falls Geothermal District Heating System at 25 years", *Geothermal Resources Council Transactions Vol. 30*, pg. 185-190.