

## **SUSTAINABILITY AT SIERRA NEVADA**

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### **ABSTRACT**

Innovative and simple solutions that help reduce the environmental impact of brewery operations, will be discussed. Also under discussion will be the long-term financial savings possible from investment in environmentally friendly technology. Some practical examples will include: co-generation fuel cell units and a 1.4 megawatt solar array to supply electric power and heat to the brewery production process, wastewater treatment plants that reduce the impact on local water treatment facilities and allow for the beneficial recovery of methane from the anaerobic digestion of brewery wastewater, CO<sub>2</sub> recovery and energy balance.

**Keywords:** *sustainability, environment, Sierra Nevada, craft brewery, innovations*

### **INTRODUCTION**

From its humble beginnings in 1980, Sierra Nevada Brewing Co. has recognised the environmental importance and financial benefit of operating its business in a sustainable manner. Many efficiency and waste reduction projects are simple and cost effective. Communication, education and the participation of all employees have proven central to the success of Sierra Nevada's sustainability projects that have targeted brewing industry concerns such as wastewater, transportation, energy efficiency and recycling. While the growth of organisations that sell carbon credits may seem to present a simple solution, Sierra Nevada encourages breweries to do everything in their power to minimise their carbon footprint and environmental impact first and only then use credits to supplement efforts made at the brewery.

From malting and brewing to packaging and transportation, the brewing industry consumes a great deal of energy, raw materials and other natural resources. All aspects of the process need to be examined from start to finish determining how each step of the product life cycle impacts the environment. That knowledge - combined with a good understanding of the actual resources being consumed - represents the starting point for sustainability efforts. The brewing industry can probably never be entirely 'green' or 100% sustainable, but there is a great deal of room for improvement.

As every good employer knows, employees constitute a company's most important asset. The same holds true when it comes to sustainability. Minimising environmental impact is an important aspect of Sierra Nevada's company culture and employees are encouraged and empowered to contribute to those efforts. Companies that boast a workforce engaged in sustainability efforts will ultimately prove more successful than companies that do not foster awareness and participation. However, changing people's established habits can present one of the biggest challenges to a company's sustainability efforts.

With a relatively flat company structure, Sierra Nevada relies heavily on an open-door policy to ensure high employee productivity and high involvement in sustainability. With the company's sustainability co-ordinator spearheading efforts, all employees are encouraged to submit ideas and suggestions. Information about recycling and other sustainability projects is communicated to employees in a number of ways. Bulletin boards in central hallways show the amount of material recycled in the previous month and year, including the types of material. They also provide information about water and energy consumption, both compared to previous periods and relative to beer production. Company newsletters also contain information about sustainability projects. Articles highlight company successes and solicit additional participation from employees. Finally, onsite recycling and composting workshops offer ideas about how employees can incorporate these practices at their homes.

From simple measures to the creative re-use of byproducts, recycling has become a way of life at Sierra Nevada. Clearly labelled recycling bins for numerous materials are located in all workspaces, hallways, offices and break rooms. Making recycling convenient makes company-wide participation easier to achieve. The key to successful recycling is identifying a use for the product after its initial use. Ideally, a product would have no end, but would constantly be re-purposed into another product. While the byproduct may not prove useful to the company that generates it, other companies may have a use for it. Sierra Nevada has had success working with suppliers who are more familiar with their products' secondary uses and may be helpful in locating companies that want their recycled material. In some cases, co-operation with a supplier has resulted in the perpetual, direct re-use of material.

Sierra Nevada uses only 100%, two-row malted barley and whole-cone hops in its beers. The brewery is located in an agricultural area near many local farms and dairies, making it easy to recycle the approximately 120 000 pounds of spent brewing malt, hops and yeast as animal feed. The brewery also owns its own herd of cattle, naturally-raised and fed a ration of spent grain, hops and yeast in co-operation with a local university that has studied the benefits of utilising brewing byproducts to produce healthier beef. These cattle provide the beef served in the brewery's adjoining taproom and restaurant.

A variety of packaging materials are the inevitable byproduct of the brewing process. Fortunately, most can be re-used or recycled. At Sierra Nevada, cardboard is collected and processed in a cardboard compactor prior to being recycled. Shrinkwrap is similarly collected and compacted in a shrinkwrap baler. The bales are then sent to a company that melts them down to make new shrink wrap. A special chipper breaks down the strapping material that holds the bottles on the pallets into two-inch pieces that are returned to the supplier and used to make new straps. Additionally, the chips are collected and shipped in a super sack, which originally held malt shipped to Sierra Nevada.

As the world's largest consumer of whole-cone hops, the brewery makes every attempt to recycle the 200-pound bales' packaging. Mylar bale coverings are collected and sent to a company that melts them to make other products. Burlap bale covers are diverted to a local landscaping company and used to wrap tree roots. A relationship with local beekeepers also allows the brewery to supply excess burlap, which they burn in their

smokers to harvest honey. Finally, the sacks that arrive filled with specialty malts from overseas are returned on an export shipment to be refilled and returned to Sierra Nevada.

Glass is one of the most obvious targets for recycling efforts by the brewing industry. In Sierra Nevada's early days bottles were all returnable and the brewery used longneck bar bottles obtained from any available source. A deposit was charged for every returnable bottle with the intention of encouraging customers to return them. That system quickly broke down and eighty percent of the float was lost right away. Being such a small brewery at the time, Sierra Nevada did not produce sufficient volume to buy new bottles directly from the glass manufacturers. Unfortunately, the American consumer, retailer and distribution system did not embrace a returnable beer bottle at the time, forcing a switch to an available design of one-way glass. It was later adapted as a proprietary Sierra Nevada bottle that has been light-weighted and purchased in bulk to minimise transportation costs. California law mandates that 35% of all new glass be comprised of cullet from recycled glass obtained statewide through a fee-based recycling program. Sierra Nevada also employs an onsite crusher to process glass prior to recycling. Glass from the brewery is pure, making it an excellent candidate for re-use because it avoids the problems associated with stones, Pyrex and other materials typically found in recycled cullet.

Sierra Nevada has also proven successful in incorporating new innovations for other commonly used items. The wooden pallets that breweries traditionally use break and fray easily. Moreover, a 10 000 pound forklift can inflict a great deal of damage to a wooden pallet that then requires parts and labour to repair. Sierra Nevada has started using plastic pallets constructed in the same fashion as children's blocks. They are better able to withstand everyday wear and tear - and in the event that they are damaged, new pieces are easily snapped into place.

In addition to the remaining wooden pallets, near constant expansion for the last 28 years has generated a steady supply of scrap lumber. Concrete form boards are re-used until no longer functional; only then are they deemed scrap. Sierra Nevada works with a company that burns scrap wood for electrical production at a cogeneration plant. Scrap wood is also made available for employees' personal use. One employee completed part of his house expansion using only this recycled wood.

Aside from wood, growth and construction generate other materials that can be diverted. As existing systems are updated and retrofitted with new technologies, the resulting scrap metal and copper wire are collected and recycled at a local recycling centre. Rather than discarding old concrete, Sierra Nevada utilises a system that removes the rebar for recycling then uses a concrete grinder to break it down into aggregate for new construction. Not only does reusing concrete fit with company values, it costs less than removing old concrete and purchasing new aggregate.

While a facility's design certainly contributes to sustainability efforts, retrofitting an old plant with new, more energy-efficient technologies can prove expensive. Sierra Nevada has been fortunate that expansion has offered opportunities for improvement, but even without new construction there are simple things breweries can do to increase energy efficiency. Retrofitting incandescent (and even metal halide) fixtures with the newest generation fluorescents and using bulbs with the proper wattage helps increase

efficiency. Installing motion-detecting lights in low-traffic areas helps ensure that employees will have the light they need without incurring the cost of leaving lights on all the time. A more advanced option has been installed in the new bottle shop at Sierra Nevada. A lumen-sensing system registers ambient light and supplements it with T-5 fluorescent lights from five ballasts that turn on and off as needed for proper illumination throughout the day. Extra windows and skylights in the building complement the system and reduce the need for artificial light.

Compressed air has many uses at a brewery, and after refrigeration, can be one of the more significant users of electricity. It is required for many different uses at Sierra Nevada, from opening valves to unloading malt utilising dense-phase conveying. Installation of high-efficiency, variable-speed compressors, staging several different-sized units to better match varying loads and lowering plant operating pressures to minimum values have resulted in significant savings. Walking air, water, steam and hot water lines to identify and correct leaks also contributes to energy efficiency. Finally, super-efficient motors used in new installations and to replace old motors also improve efficiency. Super-efficient motors are more expensive, but over the long-term their low energy inputs save money.

Beer making depends on a lot of energy for cooling during the cellaring process. Multiple options for cooling systems exist, allowing a brewery to consider the environmental efficacy of each. Ammonia-based refrigeration systems are considered an environmentally friendly option, but unfortunately, Sierra Nevada's proximity to a school would require extensive evacuation plans. The brewery employs flooded-plate screw chillers that have a relatively low-approach temperature (the difference between the temperature of the coolant and the target temperature) and require a minimal charge of refrigerant.

Sierra Nevada is fortunate to be located in California - a fairly environmentally conscious state that offers subsidies for projects aimed at sustainability. Making good use of those programs, the brewery has embarked on a variety of energy conservation and generation projects over the years - from boiler upgrades and heat recovery projects to fuel cells. For the last several years, the brewery has been focusing on solar power electrical generation and recently completed the last phase of one of the largest privately owned solar installations in the world. The first phase was a three-acre, 5 megawatt (2880-panel) -covered parking structure utilising an automatic tracking system that follows the sun to capture the maximum amount of energy possible. The following phases involved covering every available rooftop area with 1.4 megawatts (7688 panels). This completed system brings us closer to providing 100% of our electrical needs with onsite generation. The Company has already experienced some months where it produced more net electricity than was consumed. While the seven-year return on investment for this project may have deterred other companies, the combination of government incentives and company structure made it a worthwhile investment for Sierra Nevada. As a privately held company with no outside board of directors, that financial hurdle was cleared and with an average life of 27 years for the solar panels, the brewery anticipates approximately 20 years of free power.

Sierra Nevada also boasts an onsite, combination anaerobic/aerobic wastewater treatment facility. The advantage of an anaerobic waste water system is that the soluble organic material is converted into methane (74%), carbon dioxide (25%) and a

small amount of hydrogen sulphide (1%). It also has a relatively low solid production of only five to ten percent compared to approximately 60% in aerobic digestion, requiring less frequent disposal of solids. The anaerobic sludge-bed reactor works by passing wastewater through a granular sludge bed where the bacteria feed on the organic material and begin to digest it. During the digestion process the particles become buoyant due to gas production and float up into the settler, which separates the bacteria from the biogas collected for later use. At that point, the bacteria descend back to the bottom, having consumed 90%-95% of the wastewater's strength. The water is then transferred to the final aerobic digestion - or polishing step - where it is further broken down and clarified. Sierra Nevada's anaerobic digester can produce 15–70 standard cubic feet per minute (SCFM) of biogas. At peak loading it has produced 90 000 cubic feet per day of gas containing around 750–800 British thermal units (BTU). This peak load, however, would mean that a high BOD load was being processed, indicating that an unusually high amount of beer had entered the wastewater. Sierra Nevada's wastewater treatment facility can also process small amounts of waste yeast, but currently most of this is collected and used as a feed supplement. Yeast contains high solids and a very high BOD that can quickly overpower the bacteria.

Sierra Nevada uses the biogas it captures for boiler feed gas to supplement the natural gas used in the fuel cells. The biogas goes through a cleanup process to remove moisture and hydrogen sulphide in a system that incorporates Sulfa Treat (which contains iron that reacts with the hydrogen sulphide to form iron sulphide), resulting in purified biogas that can then be used in the hydrogen fuel cells and boilers. The biogas can also be fed into a specially equipped, stainless steel burner train boiler. Those gases are captured and sent to Sierra Nevada's four cogeneration, 300-kilowatt, Direct Fuel Cells (DFC 300), making up approximately 9% of the gas needed to run the fuel cells (the other 91% comes from natural gas). These units are also fitted with heat recovery boilers to capture waste heat from the exothermic combination of oxygen and hydrogen. In the fuel cells, methane (or natural gas) is passed through a steam reformation system using high-temperature pressure and a catalyst to break apart the chemical bond. The high-direct electrical efficiency, heat recovery from cogeneration and lack of transmission line loss provides for almost double the usable energy efficiency of that of a typical fossil fuel plant.

Sierra Nevada also makes use of multiple heat recovery systems. Water is pumped through a boiler stack economiser where it absorbs the extra heat before returning it to boilers as pre-heated water that then requires less energy to heat to the proper temperature. A vapour condenser absorbs heat from the kettle stacks during the wort boiling process to preheat the brewery's hot service water. Advanced boiler stack monitoring controls combustion efficiency in the boiler and adjusts the oxygen load to create ideal combustion. A closed and slightly pressurised condensate recovery system was installed to capture more of the energy that would typically be vented to the atmosphere.

Transportation is another area where Sierra Nevada has explored options to improve sustainability. Ninety-five percent of the brewery's malt arrives by rail from Canada. Similarly, with rising transportation costs alternative means of shipping beer across the United States are being considered. Intermodal rail travel has proven the most appealing option. A full, refrigerated trailer is loaded onto a flatbed rail car and shipped to a distribution centre where it is unloaded and taken by truck to its destination.

Conveyance of goods over greater distances is accomplished much more effectively by rail than by truck and when considering the environmental impact of both methods intermodal transport promises improved energy efficiency.

Sierra Nevada management and employees closely monitor brewery sustainability projects. Sierra Nevada was the first brewery to join the California Climate Action Registry and voluntarily reports its annual greenhouse gas emissions for the Registry to track, report and certify. The brewery also purchases its gas and electricity under a program that offsets this purchased energy by funding organizations that perform reforestation, conservation and dairy methane capture projects that sequester the equivalent amount of carbon emissions.

Sustainability has been part of Sierra Nevada's vision and values from day one; receiving recognition for those efforts provides positive feedback about the importance of the brewery's projects. Sierra Nevada received the Governor's Environmental and Economic Leadership Award through the California Environmental Protection Agency in 2005. The brewery has also been a recipient of the WRAP (Waste Reduction Awards Program) for Sustainable Practices - Waste Reduction/Recycling for eight years in a row.

Sierra Nevada has made great strides in improving energy efficiency and waste reduction to reduce its carbon footprint. Much thought, time and effort have been invested in sustainability projects since the brewery's inception. From advanced lighting systems and an onsite wastewater treatment facility to simple measures like routine preventive maintenance and proper light bulbs, there are many avenues the brewing industry can explore in an effort to decrease its carbon footprint. The importance of including employees in these projects and empowering them to contribute ideas and solutions cannot be overstated. Now, between the photovoltaic solar panel installations and fuel cell technologies, Sierra Nevada produces between 70%-80% of its own electricity, with an ultimate goal of 100% of its needs throughout the year. Most importantly, rather than remain content with that figure, Sierra Nevada continues to expand its sustainability projects and improve efforts to reduce its environmental impact.

Through continuous self-evaluation, Sierra Nevada strives to remain on the vanguard of sustainable innovation while never losing sight of its heritage and the art of craft brewing.

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