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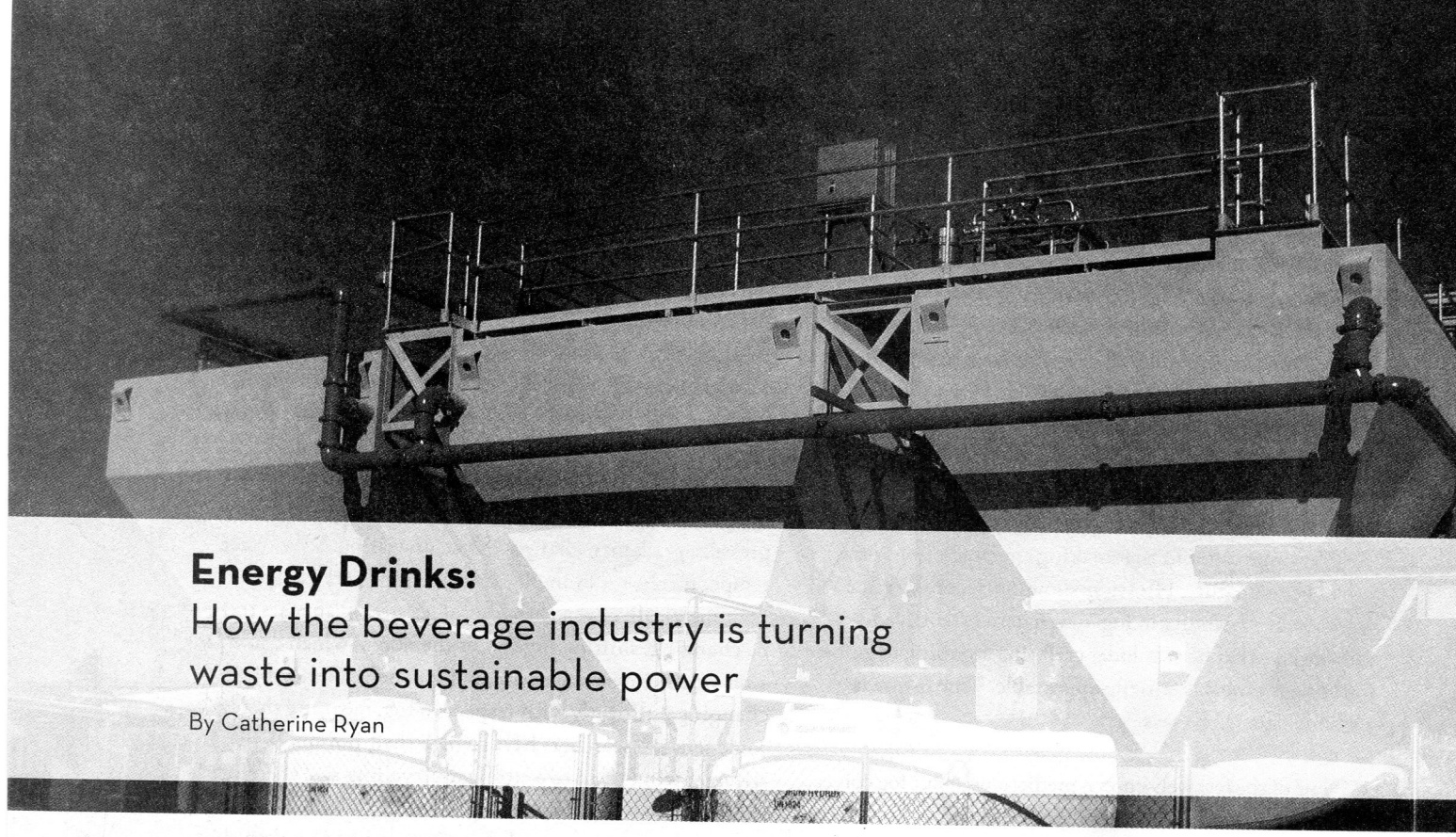
THE NEXT GENERATION

Forty years after the first Earth Day and the founding of Berkeley's Ecology Center, a look at where we've been and where we're going. Special fortieth birthday section begins on page 36.



Energy Drinks:
How the beverage industry is turning waste into sustainable power

By Catherine Ryan

Behind the tasting room at Oakville's Napa Wine Company, near the two-story-tall fermenting tanks, stands a chest-high white box festooned with a beaker-like cylinder, rubber piping, and myriad valves. Gas bubbles up through a glass tube on the container's surface. But the box, about the size of an industrial-grade refrigerator, is not a new way of processing wine—it's an attempt to deal with its waste. This microbial electrolysis cell, as the contraption is called, is Napa Wine's most recent effort to tread lightly on the Earth.

Wastewater containers at Sierra Nevada Brewing Company use microbes to generate methane power.

The cell is not only cleaning the winery's effluent, it is creating a new alternative fuel. Bacteria inside digest organic waste from water used to rinse barrels and wash grapes. While cleaning the runoff, the cell produces hydrogen, a gas that emits water vapor when it's burned, rather than air-dirtying carbon dioxide. Although still in the research stage, this project hints at a future in which sustainable energy can be farmed from the agricultural byproducts of Northern California's wineries, breweries, and distilleries.

It takes an astounding amount of energy to produce a glass of pinot grigio or a bottle of ale, and the process also creates a deep and fast-flowing waste stream. It can take up to seventeen gallons of water to make a single gallon of wine, which is formidable considering that California—perennially in drought—annually produces 580 million gallons of vino. And even mid-size breweries can generate tens of thousands of tons of solid waste each year. Turning effluent and solid waste into a fuel source, though, could help producers solve the problems of limited power and seemingly unlimited byproducts. No wonder, then, that the state's alcoholic beverage industry is hoping to turn its trash into energy-rich treasure.

"Have you seen *The Matrix*?" asks Bruce Logan, director of the Environmental Engineering Institute at Penn State. Designer of the microbial electrolysis cell, Logan is working with Napa Wine to put his thinking into action. "In the movie, they hooked up humans in this goo to make energy," he says. "That's science fiction, but what we're doing is not. We're using microbes to break down glucose, alcohol, and other traces in the wastewater to make an electrical current and hydrogen."

Electromicrobiology, the use of bacteria to generate electricity, may offer an alternative to expensive, scarce, and climate-damaging petroleum and coal. This plan for turning waste into renewable energy appealed to Andrew Hoxsey, the managing partner of Napa Wine and a fourth-generation winegrower who refuses to be yoked by operating conventions, such as spraying pesticides. Under his direction, the company's 635 acres of vines were certified organic in the 1980s, long before "sustainable" was a buzzword. "My grandparents didn't use many chemicals, basically just some Roundup, and learning to live without those few chemicals was pretty easy. We don't know how

else to do it," Hoxsey says. "We're focused on doing things with less impact environmentally."

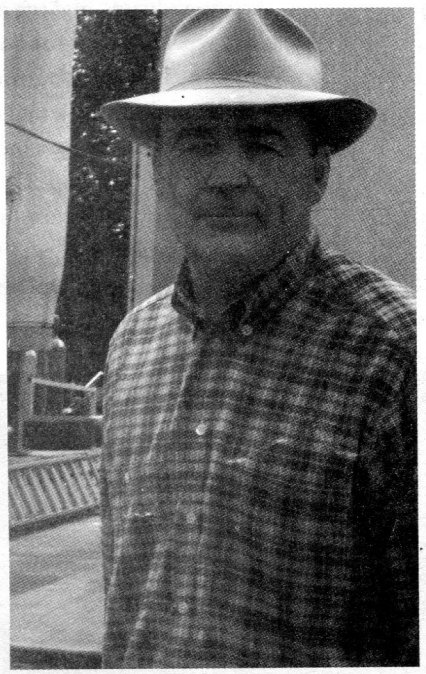
Hoxsey also keeps tabs on the hydrogen industry ("I'm adamant that hydrogen should be looked at more closely as a power source," he explains), so when he learned of Logan's studies in Pennsylvania, he offered his winery as a site for a pilot project. Researchers from Penn State installed the device last September; today, despite the overcast skies, Hoxsey stands in a lot behind the winery's tasting room, unshivering before the box. Wearing a cowboy hat pulled low over his eyes, he gestures towards the fuel cell. "Microbes—we call them 'bugs'—are present in the soil, in wine barrels and in water treatment ponds," he says. "You can't see them and the concept of them is way out there, but they're there. We're using these bugs to produce electricity."

He outlines the process: The bacteria, living on bottle brush-like fibers inside the box, eat the sugary leftovers of grapes and exhale clean water. Meanwhile, a small amount of energy pumped in unites protons and electrons to form hydrogen. On a good day, the box produces the equivalent of five gallons of diesel—not much in the grand scheme of winery operations, but Hoxsey is unfazed. For now, the project uses just a fraction of the winery's effluent because scientists are working out glitches in the cell's design. (The vast majority of the winery's wastewater is currently diverted to ponds, where other kinds of bacteria clean it before it irrigates the vineyards.) "We're learning a lot," Hoxsey says. "Eventually we'll store the hydrogen in a battery or cell, but for now we're testing the feasibility. You could run a car with the hydrogen it makes or generate energy to power our winery. Hydrogen gives more alternatives than electricity."

Although Logan estimates it will be another three to five years before the technology is used on a larger scale, a project like this is a tantalizing taste of what the alcoholic beverage industry could do to harvest its own energy. The idea of eco-friendly wine-making is certainly growing: Membership in the California Sustainable Winegrowing Alliance, which Hoxsey chaired in 2008 and 2009, has nearly tripled in the last five years, to 1,237 vineyards and 329 wineries statewide. While Hoxsey's hydrogen cell may be unique, throughout the state other beverage companies are brewing up similarly innovative solutions.

The view from atop Chico, California's Sierra Nevada Brewing Company roof is breathtaking. Blue skies and sun—the first clear day the region has seen in weeks—shine on a dizzying quilt of 10,000 rectangular solar panels. The brewery's 200,000 square feet of blue silicon plates make it one of the country's largest private solar arrays, but a row of large silos off to the left offers another glimpse of the company's attempts to operate off the grid.

Each of those silos contains almost 25,000 gallons of beer. To craft that beer, brewers boil the grains, filter out the solids, cool the product, then add yeast to the liquid. That slurry sits in fermenters—the silos—for ten to fourteen days. Yeast, a single-celled organism, eats sugars from the malt and hops. As it digests its food, the yeast exhales carbon dioxide and produces alcohol. But instead of releasing the greenhouse gas into the air, Sierra Nevada diverts it to a storage tank, where it is cleaned and pressurized. It later plays a vital role in the brewery's operations, adding carbonation to some of the brews and pushing beer from one boiler to another via a labyrinthine series of tubes and pipes. "Our philosophy is a closed-loop approach," says Cheri Chastain, Sierra Nevada's sustainability coordinator. "We take the byproducts of brewing and use them for something we need."



Napa Wine's Andrew Hoxsey

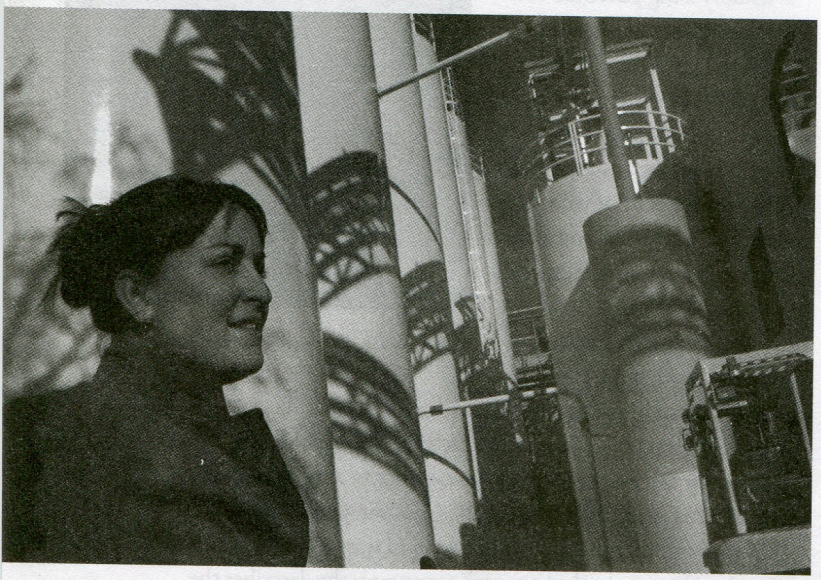
This both saves money and reduces greenhouse gasses, she says. "Carbon dioxide is usually a big purchase for carbonation and dispensing," Chastain explains. "With the recovery system in place, we're not releasing carbon dioxide and we're supplying a hundred percent of what we need. It's a free fuel source and we have it on-site, so we might as well use it."

Sierra Nevada employs mindful production elsewhere. Chastain walks nearly the entire loop of the twelve-acre facility, which exudes the sticky-sour smell of yeast and hops familiar to anyone who has visited a fraternity after a keg party. Chastain points out the silos that store spent barley until it's fed to steers destined to end up as hamburgers in the brewery's restaurant; she describes the ultra-efficiencies of the boilers, lighting, and bottling line. After all, she says, "You can create all the green energy you want, but if you're not using it efficiently, it defeats the purpose."

Squinting against the sun, she gestures toward a set of metal containers shaped like upside-down pyramids. The three giraffe-height vessels hold 300,000 gallons of wastewater that's been used to rinse fermenters and bottles, along with billions of bacteria that are busy chomping sugars and cleaning the detritus-laden water. These microbes generate methane as they eat, and instead of being released into the air, the gas—more than twenty times more cor-

rosive to the atmosphere than carbon dioxide—is pumped back to the plant to power boilers. Although methane isn't innocuous (it releases carbon dioxide when used), it offsets the brewery's need to buy natural gas, a finite source of energy that expels its own atmosphere-altering compounds. And while Sierra Nevada does buy some natural gas, it generates 84 percent of its own energy through its combination of solar arrays, gas reclamation and fuel cells—up from 65 percent in 2008.

The brewery also takes a cue from iconoclasts who power their cars on deep fryer oil. Sierra Nevada recently purchased a biodiesel processor designed by Chico State University graduates, and the machine converts its restaurant's dirty vegetable oil into about a hundred gallons of biodiesel a month. That clean-burning fuel powers trucks delivering beer around town. Sierra Nevada is also investigating other alternative fuel sources, including distilled ethanol from spent grains. "We hope that not just the brewing industry, but all industries, follow suit and work to make their operations more efficient," Chastain says. "We believe that all manufacturing should be done in the most sustainable manner possible."



Sierra Nevada Brewing Company's sustainability coordinator Cheri Chastain

Six hours' drive south of Chico, Sun-Maid embraces an "ecosystem" approach to operations, turning its waste into products that help the environment and the company's bottom line, says Vaughn Kiligan, Sun-Maid's director of corporate sustainability. Although better known for its raisins, Sun-Maid also produces alcohol from sub-par grapes that is later turned into brandy and sherry. At the company's distillery in Orange Cove, just southeast of Fresno, grape juice is transformed into toast-worthy spirits via a method largely powered by biofuel.

To make alcohol, heat is applied to fermented fruit juice in a still. As the liquid evaporates, it produces concentrated alcohol and leaves behind a mush of sugars and grape solids. For the last twenty years, Sun-Maid, run as a cooperative of grower-owners, has taken those "slops" and run them through a methane digester, a state-of-the-art device when it was installed in the 1980s. Just as in Sierra Nevada's water treatment, microbes eat the leftovers and exude methane. That gas is harnessed and burned to heat the still that will produce alcohol and more waste for the digester. The repurposed byproducts provide sixty percent of the energy needed to power the still, slashing the company's natural gas consumption.

"We're not opposed to saving money, and we wanted to deal with the waste in a way that gives maximum returns to the co-op members," Charles Feaver, vice president of the distillery at Sun-Maid, says of the company's decision to install the methane digester years ago. "We're also concerned with sustainability, and it's a win-win on both accounts. Farmers are not interested in wasting water, contaminating land, or anything else other than the health of the land and making a profit. After all, growers and farmers were the first environmentalists."

Microbe-powered boilers, repurposed waste products and recovered greenhouse gases all seem like logical ideas in an era of dwindling resources. Yet creating alternative energy within a company can be capital-intensive. For example, Sierra Nevada's Chastain estimates it will take another nine years for the brewery's solar array to pay for itself. The hydrogen cell at Napa Wine is so experimental it probably won't even have a price tag for years, but like methane digesters, solar arrays, and other industrial-sized energy conversion technologies, it likely won't come cheap. As a result, it is often fiscally impossible for small producers to hop on the waste-to-energy bandwagon.

Ryan Donnelly, co-founder of Miracle One Wine, a Napa County producer of chardonnays and pinot noirs, wanted to craft impressive wines "at the least cost to the environment," he says. Yet being part of a small start-up meant that he couldn't try the energy-saving projects that Napa Wine Company, Sun-Maid, and Sierra Nevada champion. "We're just getting started and don't have the capital to do our own solar power or wastewater treatment," he says. Remaining committed to eco-friendly practices, though, Donnelly and Miracle One moved in with Sonoma Wine Company, a co-op style warehouse for small producers. "We chose to make our wine at their facility because of

their sustainability efforts," Donnelly explains. "One of the interesting things they do for us is save our wine waste for Green Energy Network to produce ethanol."

Ethanol, the once-lauded alternative to gasoline, has been criticized as a fuel source, because some farmers now prefer to grow corn for fuel production, rather than the edible crops needed to sustain their communities. Green Energy Network's solution circumvents these criticisms by distilling unsalable wine—an already-existing product—into ethanol. "Wineries in our area have to dispose of some wines for one reason or another. They don't dump it—that's wasteful and it causes environmental problems," explains Damon Knutson, co-founder of Green Energy Network. As he walks around the yard outside his Sebastopol home, sheep bleat noisily in the background, occasionally interrupting his train of thought. "The waste has to be dealt with, and what we do is take their wine and distill it to 190-proof alcohol to blend with gasoline," he says. Knutson and his brother Durrell run the business mostly as a hobby, he concedes; it remains secondary to his career in construction.

If their operation looks somewhat makeshift, that's because it is: The Knutson brothers have cobbled together their experience in construction, solar technology, plumbing and alternative energy promotion to create a self-powered distillery. Their homemade still is twelve feet high; wrapped in silver insulation and looking like a prop from a campy space-age movie, it stands alongside dark gray tanks holding wine outside a friend's furniture store. Trucks from Sonoma Wine Company periodically crunch over the gravel lot to drop off pallets of reds and whites that can't be sold, either because they're too old or mislabeled. Damon Knutson distills all the alcohol from the wine, pours the finished product back into the original bottles and sells the biofuel to members of the Green Energy Network, who add it to their tanks with regular gasoline. At $3.80 a gallon, it may seem cheaper to simply fill up at a nearby Chevron, especially because adding ethanol can reduce a car's efficiency. "But you're still increasing your mileage per gallon of gas, and our product is essentially carbon-neutral because it's made by converting a waste product in a low-energy process," Knutson explains.

The Green Energy Network is small—Knutson can't keep up with the wine that arrives from the co-op members at Sonoma Wine Company and has had to start storing it—but he plans to more than double his current output of a hundred gallons of ethanol a week. Yet the point he wants to prove is clear: By pooling resources—or rather their waste—minor wineries such as Miracle One can outsource the waste-to-energy procedure. The partnership benefits the wineries (which would otherwise have to pay to dispose of their waste), the innovator (Green Energy Network turns a free material into a salable product) and consumers (individuals reduce the impact of driving a car with a local substitute for gas). The symbiosis between Green Energy Network and Sonoma Wine Company demonstrates that even the little guys can get in on the alternative fuel game.

Back in his office, Hoxsey reflects on the future of the Napa Wine Company and, by extension, the agricultural industry at large. He leafs through the phonebook-thick sustainability workbook he helped design as the chair of the California Sustainable Winegrower's Alliance and steers the conversation away from hydrogen to the potential of other processes he'd like to incorporate into the winery's operations.

Hoxsey pulls a piece of what looks like burnt wood from behind his desk. Gesturing with the charcoal-like chunk, he explains how his winery burns forty acres of vines a year. Instead of emitting all those greenhouse gases released during combustion, Hoxsey is experimenting with a practice called pyrolysis. Pyrolysis, he explains, heats organic material—in this case, vines—to separate methane from the material while keeping its carbon dioxide sequestered. Hoxsey proposes a closed-loop process of heating the vines, harnessing the methane produced, and using that gas to heat more vines. The result—the "agrichar" he holds in his hand—could be added to the vineyard's soil to improve its fertility and increase water retention. He is already practicing pyrolysis on a small scale, using the agrichar in his home vegetable garden.

Reducing Napa Wine's environmental impact ranks high on Hoxsey's priorities. "It's a matter of not only benefiting the company—with decreased costs and improved quality—but benefiting the environment, too," he says. He strives to support what he calls "Mother Nature's equilibrium" by acknowledging that sometimes the Earth manages itself better than any pesticides or weed killers could. And rather than advocate stricter government controls of agricultural practices, Hoxsey wants producers to voluntarily change how they treat the environment. He thinks they'll follow his company's lead not only because it's the ethical thing to do, but because he believes it will ensure the industry's long-term existence. "There is no one solution to be self-sufficient," Hoxsey says. "That means looking at all resources, not just the ability to harvest hydrogen from wastewater. I'm the first to agree that the cost could be immense, more than our underlying assets are worth. But compared to what we already do, and the costs of our current operations, these alternatives could be self-sustaining."

Hoxsey pauses and wipes up the black dust littered on his desk. "What will come?" he muses. "We don't know. It's a matter of one step at a time."