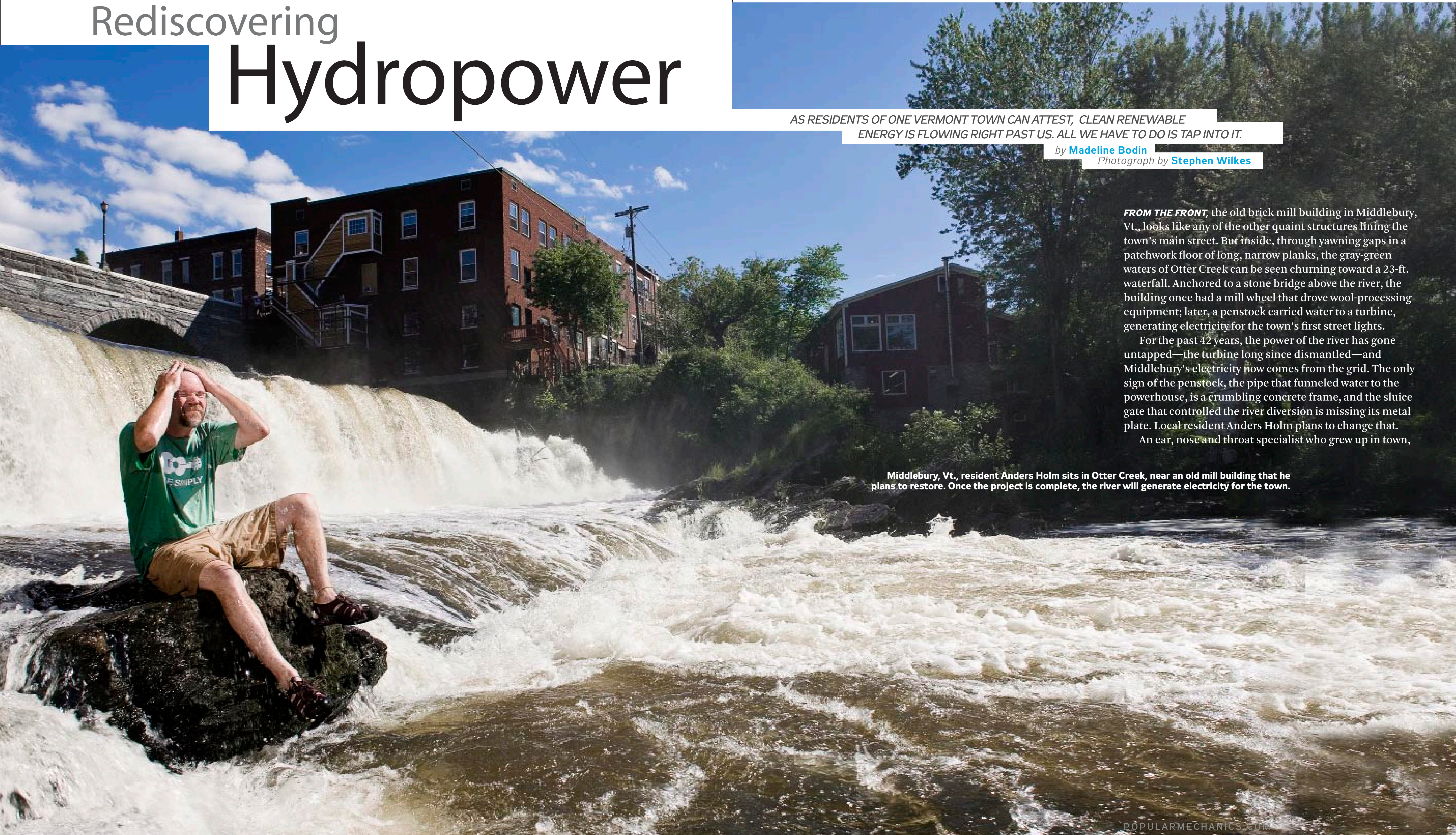
Rediscovering Hydropower

AS RESIDENTS OF ONE VERMONT TOWN CAN ATTEST, CLEAN RENEWABLE ENERGY IS FLOWING RIGHT PAST US. ALL WE HAVE TO DO IS TAP INTO IT.

by **Madeline Bodin**
Photograph by **Stephen Wilkes**



Middlebury, Vt., resident Anders Holm sits in Otter Creek, near an old mill building that he plans to restore. Once the project is complete, the river will generate electricity for the town.

FROM THE FRONT, the old brick mill building in Middlebury, Vt., looks like any of the other quaint structures lining the town's main street. But inside, through yawning gaps in a patchwork floor of long, narrow planks, the gray-green waters of Otter Creek can be seen churning toward a 23-ft. waterfall. Anchored to a stone bridge above the river, the building once had a mill wheel that drove wool-processing equipment; later, a penstock carried water to a turbine, generating electricity for the town's first street lights.

For the past 42 years, the power of the river has gone untapped—the turbine long since dismantled—and Middlebury's electricity now comes from the grid. The only sign of the penstock, the pipe that funneled water to the powerhouse, is a crumbling concrete frame, and the sluice gate that controlled the river diversion is missing its metal plate. Local resident Anders Holm plans to change that.

An ear, nose and throat specialist who grew up in town, *The new system will take advantage of every inch of head–the water pressure exerted by gravity. Under ideal conditions, it will generate enough electricity for about 1000 homes, or most of downtown Middlebury.*

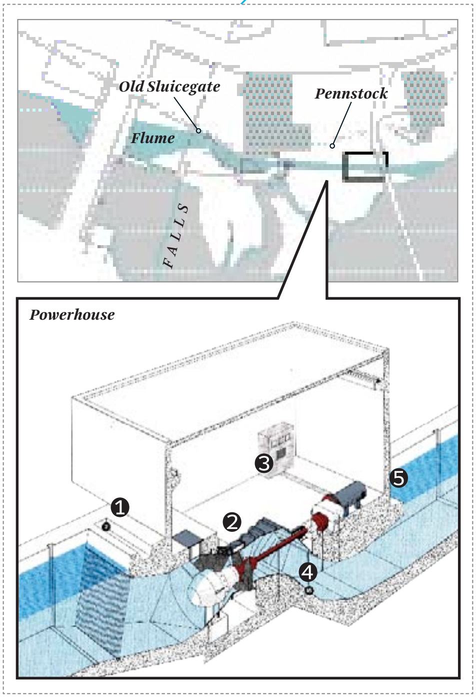
Holm was born a few years after the hydropower system was retired. His father purchased the mill in the 1980s and rented it out as commercial space. But changing times—particularly the events of September 11, 2001—convinced Holm that he should reduce his dependence on foreign oil. He covered his home with solar panels. Then he and his brother, Erik, decided to restore both the mill building and the hydropower.

"Our original plan was to make power for our own property," Holm says. "We didn't intend to sell it. But then we realized the enormous power potential, and knew we had to do more." Unlike the old system, the new one will take advantage of every inch of head—the water pressure exerted by gravity—and will use a modern 1-megawatt turbine. Under ideal conditions, it will generate enough electricity for about 1000 homes, or most of downtown Middlebury.

Of course, reviving aging infrastructure is no small task. Holm, who recently decided to build a mahogany deck using only hand tools, didn't shy from the challenge. Instead he took two months off from his surgical practice to work on the project full-time. His first task: Reduce the flow of the river under the northwest corner of the building to a mere gurgle, so that the foundation could be repaired.

But even with the river diversion fully restored, Holm expects it will be three years before the turbine goes in. It's already been four years since he enlisted the assistance of lawyers and engineers. The protracted timeline reflects a regulatory process that governs even small renewable energy projects. But Holm is looking at it "with a surgeon's mentality," he says. "No matter how long it takes, it has got to get fixed."

When the equipment is finally in place, the rushing water of Otter Creek will provide Middlebury with a reliable source of renewable power, just as it did in 1890.



Restoring Hydropower to Middlebury

Water from Otter Creek will be diverted into a concrete flume under the mill building, then enters a penstock that runs parallel to the river. At the powerhouse, the water flows through adjustable wicket gates (1) and releases its energy in the runner (2) of a Kaplan S-turbine. A generator (3), connected to the runner by a shaft (4), converts the mechanical energy to electricity. Water exits the turbine through the draft tube elbow (5) and rejoins the river downstream.

"Once it's up and running, it will be a carbon-free source of power," Holm says. In contrast, if the same amount of energy were generated in a coal-fired electric plant, it would produce 10,000 tons of carbon dioxide emissions annually. Because there's no dam on site, just the natural waterfall, fish can bypass the hydropower system and move freely downriver. And because the turbine is an innovative water-lubricated design, the water will be as clean coming out as it was going in.

HYDROPOWER GENERATION has tripled since 1949, when it produced a third of the country's electricity—yet today it meets just 7 percent of demand. In the rush to keep up with ravenous consumption, legions of small, distributed resources have been overlooked. A Department of Energy study found 130,000 sites that could provide small-scale hydropower, some in every state. Many have the potential to produce 1 megawatt of electricity or less. While that's couch-cushion change in a world of behemoth energy projects, it adds up—to 30,000 megawatts of average annual power. The Electric Power Research Institute (EPRI) estimates that 2700 megawatts could be brought online by 2025—the equivalent of TK nuclear power plants or TK coal-fired ones.

Developing these small hydropower systems keeps money in the local economy, says Lori Barg, founder of the Vermont-based consulting firm Community Hydro. And because they produce power where it's being consumed, they both deliver electricity more efficiently and help stabilize the grid.

Most of the 2500 existing hydroelectric dams in the United States are also small-scale—85 percent have a rated capacity of less than 30 megawatts. Another 76,500 dams don't currently produce power. Installing or upgrading turbines in these could supply another 7300 megawatts by 2025, according to EPRI. Even the biggest sites have room for improvement: Ten turbines

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at the Wanapum Dam on Washington's Columbia River—each of which is capable of generating 100 times more electricity than the Middlebury project—are now being replaced with turbines that are 2 percent more efficient and also less injurious to fish.

Using tools such as three-dimensional computer modeling and computational fluid dynamics, engineers have been able to pinpoint how turbines can be refined. For example, contouring the blade where it connects to the hub minimizes the gap where fish get caught, as well as smooths the flow of water, improving efficiency.

On the other end of the spectrum, even extremely small infrastructure can generate hydropower—including the systems that deliver water to homes or subsequently scrub it of pollutants. "Anywhere there is excess energy in a water treatment plant you can generate electricity," says Michael Mahoney, principle of SOAR Technologies.

Maloney invented a turbine that can be installed parallel to the pressure-reducing valves found throughout municipal water systems. Rather than overcoming the resistance of a valve's spring-loaded diaphragm, the energy of the water drives the turbine. Two 45-kilowatt models were recently installed at the County of Hawaii water department, where one feeds power into the local grid and the other helps run a water pump.

Electricity from Water Treatment

This 45-kilowatt turbine, installed at the County of Hawaii Department of Water, generates electricity while reducing water pressure in pipes leading from higher elevations to a 2-million-gal. storage tank.

THE TECHNICAL BARRIERS to eking power out of overlooked water resources are slowly disappearing. Fred Ayer, executive director of the Maine-based Low-Impact Hydropower Institute, says it is becoming less difficult to get off-the-shelf turbines for small projects. "I'm excited," he says. "There are entrepreneurs developing in-stream technologies that don't require damming."

It has also become easier to assess a resource's potential. The 500,000 stream reaches evaluated by the DOE, including the 130,000 sites considered hydropower-worthy, can be viewed using the online Virtual Hydropower Prospector developed by Idaho National Laboratory. "The power of this medium is that it doesn't just show symbols on a map," says Doug Hall, manager of the lab's Water Energy Program, "it provides important attribute information." The sites can be displayed in the context of existing power and transportation infrastructure, nearby populations, political boundaries and federal land control.

But there are still significant financial obstacles. Small hydro projects are subject to the same federal regulations as large ones, meaning small project owners get less energy for each dollar they invest in federal licensing and other regulations. Community Hydro's Lori Barg is particularly frustrated with the red tape involved in installing turbines in the pipes of municipal water systems. "It's plumbing!" she says—but it's still subject to the Federal Energy Regulatory Commission (FERC) licensing process.

Ensuring that the project remains environmentally friendly can pose another hurdle. If the site has been dammed, it may require building fish passages, which add significant costs, and optimizing water flow, which may result in fewer watts generated and an equivalent reduction in profits.

Because Holm's project is less than 5 megawatts, he may be eligible for a fast-track FERC licensing. And his decision not to dam, but to use the river's natural flow, won't hurt the project's profitability. "We are not going forward with a project that doesn't make financial sense," Holm says. "There is an altruistic passion behind this, but there is also a bottom line."

Across the waterfall from the Holm's project is another hydroelectric site—a grist mill converted for power in the 1800s and later abandoned. Its crumbling stone walls and graffiti-covered relics, including an old Francis turbine, have been overtaken by weeds. The owners of this site, and representatives of several other Vermont towns, have contacted Holm about revitalizing their own languishing hydropower systems. They are watching his project closely, waiting for him to demonstrate it can succeed. "It's a small project," Holm says. "But we hope it will serve as a beacon to other communities, to show what can be done."