The Washington Post

Energy and Environment

Alaska’s quest to power remote villages — and how it could spread clean energy worldwide

By Chris Mooney August 14

On the Tanana River off Nenana, Alaska, researchers with the Alaska Center for Energy and Power and Oceana Energy test a river-based hydrokinetic energy system, which draws power from the river’s flow. (University of Alaska Fairbanks photo by Todd Paris)

NENANA, Alaska — This village of 600, an hour's drive beyond Alaska's northernmost city of Fairbanks, has long depended on the Tanana River. Along the banks, huge fish wheels use the river's flow to catch salmon. On a July day, a barge was loaded up with supplies, perhaps to transport to even more remote communities — atop the stack of bulk goods was an all-terrain vehicle.

Even when it's frozen, the residents use the river to hunt, traveling by dog sled or snowmobile. "I have to use the river to trap beaver in the wintertime," says Victor Lord, the second chief of the Nenana tribe, which runs the town alongside a city government. "It's a third highway for us."

And one day, maybe, the river will serve as a kind of power line, too. This summer, researchers with the Alaska Center for Energy and Power, a research institute at the University of Alaska at Fairbanks, have come here with Oceana Energy, a small private energy firm, to test a "hydrokinetic" turbine that draws energy from the flow of the river. From a barge held in the water by a three-ton anchor, they lower the white, doughnut-shaped device (with short blades on the inside and out) through a moon door — and it starts to turn when water hits it. It kicks up a spray — at least until the turbine is submerged.

Anticipation is high — renewable energy from rivers holds promise beyond traditional sources such as wind and solar, even if it's far from clear whether the current technology will rise above competition or succeed in the marketplace.

"Everybody uses the analogy of where wind was 15 years ago," the university's Jeremy Kasper, who is leading the research at Nenana, says of river power. "Everybody's trying to come up with a good design and drive down the cost of production."

Researchers test the turbine in the river’s flow. (Todd Paris/University of Alaska Fairbanks)

Alaska, a vast landmass with harsh winters and many remote native towns and villages facing dramatic electricity costs, has become an important and unique innovator in renewable energy. The implications extend far beyond the state. From Africa to small Pacific island chains, successfully powering grid-less, remote or underdeveloped communities with renewable energy, and easing their reliance on fossil fuels, is one of the biggest energy challenges of the century.

“We prove up the technology, we prove up the economics, and then maybe it has application in Africa or the Canadian Arctic,” says Gene Therriault, director of policy and outreach at the Alaska Energy Authority, the state agency that has put over $1 million into the testing of the Oceana Energy turbine at the Tanana River test site.

President Obama will visit Alaska this month. And while his full itinerary hasn’t been disclosed, the president has said that he’ll “be the first American president to visit the Alaskan Arctic, where our fellow Americans have already seen their communities devastated by melting ice and rising oceans."

In Kivalina, for instance, far to the northwest of Nenana and vastly more remote, 400 people live on a Chukchi Sea barrier island that is hammered by storms and intense erosion, threats accelerated by declining sea ice offshore.

But as the president may see if he visits one of these communities, a changing climate isn't their only challenge. Additional problems include sanitation (Kivalina lacks running water in most of its buildings) and what's primarily driving energy innovation in the state: dramatically high energy costs.

For a long time, Alaska's rural communities, living off the grid and in many cases not accessible by road, have overwhelmingly turned to diesel generators for power — and, when temperatures drop well below zero, simply to ensure safety. But transporting their fuel — by barge like the one moored at Nenana or by plane — is very expensive.

Diesel fuel and heating fuel costs in remote villages can be as much as $10 per gallon, according to the Environmental Protection Agency. Alaskans overall paid an average price of 18.12 cents per kilowatt hour of electricity in 2013, according to federal data — second only to New York and Hawaii. In some remote villages, costs can be more than 40 cents per kilowatt hour — and that's after contributions from a state program designed to equalize energy costs.

Even though Alaska is traditionally known as an oil state, "remember that we're paying more for hydrocarbon energy than anybody," says Mead Treadwell, a former lieutenant governor. "The last thing people who live in a place known for cold, dark and distance need is higher energy prices."

Clearly, renewable energy would be a great benefit to Alaska's small villages — but there are also unique hurdles to deploying it. For one thing, renewable power solutions that are coming on strong in the lower 48 states don't necessarily work as well up here.

Solar, for instance, is less useful in the long dark night of the northern winter. And that's when electricity costs, due to home heating, are highest. Large batteries are also problematic, says Brent Sheets, of the university's Alaska Center for Energy and Power, which is operating the Tanana River test site. When they are past their working life, they can become a form of bulk waste, difficult and expensive to transport back and dispose of safely.

But Alaska has experimented successfully with microgrids — small electric distribution systems that can operate connected to or apart from a larger grid. A microgrid, for example, could be set up to provide power to a small community, an island or a military installation. Precisely because of its many remote villages and its weather extremes, Alaska hosts more than 200 of them, more than any other state, according to Navigant Research.

For now, diesel remains the dominant provider of energy to these remote grids. Of over 200 microgrids, just over 70 have integrated renewable power into the mix, according to the Alaska Center for Energy and Power.

The next step lies in microgrids that integrate multiple power sources, piling diverse renewables on top of diesel. After all, the latter isn't just pricey. It has many negative environmental consequences. It has been tied to emissions of black carbon, or soot, which can increase the warming of the Arctic by darkening ice when it falls upon it — thus decreasing its ability to bounce sunlight back into space and accelerating melt.

So what can displace diesel? It turns out the Alaskan landscape offers several potential energy sources — wind, tidal or river power, and geothermal energy. The trick, though, is making sure they work, getting the costs down, and then successfully integrating them into remote energy systems, where every time you add a power source to the mix, you also add complexity.

River power holds significant hope in this home to the Yukon, one of the world's great river systems.

Alaska has 17.1 percent of the United States' total hydrokinetic energy potential, according to a recent estimate, and 200 off-the-grid villages, many of which are located near rivers or other bodies of water. And that's just Alaska.

"With 7.2 billion people in the world, a lot of them are not on the grid, a lot of them tend to live near water, and so we think that there's a tremendous potential all around the world for a river turbine," says Dan Power, president of Oceana Energy, which holds the patent on the turbine system.

Humans have drawn power from rivers, going back to ancient water mills that used the energy of flowing water to grind grain or perform other tasks. Huge hydroelectric dams operate on the same basic principle – drawing on the energy of flowing water to turn a turbine and generate electricity. So do Nenana's fish wheels — they use the river's flow to turn a wheel that's attached to nets that catch fish.

But dams are controversial because of their environmental consequences — so a new generation of water-based research focuses on tapping the energy of tides, waves and undammed river flows. Oceana is a contender in the final space — trying to capture the kinetic energy of a free-flowing river through turbines. And it's also bucking a trend toward devices that resemble underwater windmills — Oceana thinks they're too fragile in an environment in which water is hundreds of times denser than air — in favor of a more compact, doughnut-shaped turbine with relatively short and thin blades.

But other companies such as Ocean Renewable Power Company of Portland, Maine, have a different technological approach. Its RivGen Power System, which has two turbines, has also been tested in Alaska.

Researchers Jack Schmid, left, and Dominque Pride drill through the ice on the Tanana River near Nenana to determine its potential for placement of a hydrokenetic generator in this Feb. 26, 2010, file photo. (Todd Paris/University of Alaska Fairbanks)

River power has its advantages — a steady flow, able to provide a reliable form of baseline power — but also unique challenges.

Perhaps the biggest one is that riverine debris, especially floating logs and tree branches, can clog or damage turbines. Indeed, debris problems arose quickly at attempted river power installations at the Alaska towns of Eagle and Ruby.

“Surviving in any water-based environment for a 20-year design life is very difficult,” says Jose Zayas, who heads the Energy Department’s Wind and Water Power Technologies Office, which has supported hydrokinetic research through a partnership with several universities, including the University of Alaska at Fairbanks.

To deal with debris at the site on the Tanana River near Nenana, Kasper’s team built a device — essentially, a large V-shaped structure with a rotating cylinder at the front — to shunt debris around the barge.

A critical factor in generating river power involves the speed of the water – anything less than 1 1/2 knots can't get the turbine running, and to generate significant power, you need speeds of at least 3 knots. At 7-knot flow speeds, the turbine can power about 10 homes, says Ned Hansen, the chief technology officer at Oceana Energy. For greater energy loads, larger turbines might be deployed or rows of turbines might be used.

Another problem involves getting the power to shore — without running cables underwater in such a way that they could also be damaged by debris. For now, researchers are running tests to measure how much power is generated and how much that varies, and are working to ensure that fish are not harmed. (Nets at the back of the barge sample whether any fish have come through and been injured.)

And then comes the problem of integrating a new power source into a small village grid or microgrid. Recently, the Alaska Center for Energy and Power took the turbine out of the river to run it at a tank at the university in Fairbanks, where its power output will be studied as part of a "test bed" that closely emulates the power demands of an actual village — a key step toward merging a new energy source with a system that has, as its backbone, a fleet of diesel generators.

"In small power grids, the changes in demand from second to second are much greater relative to total demand than they are in larger grids," says Marc Mueller-Stoffels, a professor at the University of Alaska at Fairbanks who heads the Power Systems Integration Lab at ACEP, which is studying how to safely and reliably add new sources of energy to these small grids.

So when you add more sources to these grids, "the complexity of the control task does not simply increase linearly with the number of new devices added," he says.

But if all of these challenges are met, Sheets says, river energy holds great potential. For three months of the summer when rivers are flowing, he says, his team's research suggests that turbines could fully power villages.

“That three months, there’s enough density in the water coming through, that that could equal or be greater than 12 months of wind power,” he says. So when the technology is fully developed, “we ought to be able to go diesels off in the summer.”

Back in Nenana, the village seems to welcome the experiment. While Nenana does get power from the grid — it is close enough to Fairbanks for that — the research project has extended transmission lines along a new stretch of the river, says Victor Lord, the Nenana tribe’s second chief.

“That was one big benefit to get that power line put in, so I can subdivide the land out to people,” Lord said. The village has also benefited from research on the river’s fishery, which has been conducted to make sure the turbine isn’t having any ecological costs, Lord says.

So would Nenana ever want to be powered by the very river that lies just outside people’s doors? Lord thinks so. The town could “maybe put it into our power grid, and lower our prices to run our offices up here, and our council, where we run our celebration,” he says.

“Yeah, I’m sure down the line it could help out a lot.”