F - 8 Sep 08
file - environment 1834
date 15 Sep 08
69 pages
many links and references

Handbook for Developing MICRO HYDRO In British Columbia

March 23, 2004

THE POWER IS YOURS

BC hydro

SMALL AND MICRO HYDRO ENERGY

Small and micro hydroelectric developments have significant potential for contributing to B.C.'s energy mix. For example, BC Hydro has signed electricity purchase agreements for 19 green small hydro projects to be owned, built and operated by independent power producers.

In addition to these new projects, a number of small hydroelectric generators have been supplying power to the BC Hydro grid for many years. These existing facilities operate with small dams or diversion structures to divert water from smaller rivers and streams through pipes to the generating station. There are also a number of micro hydro plants in areas where there is no access to the electric power grid. While these existing projects may be green, it's important to note that BC Hydro has not assessed them against green criteria.

Micro and small hydro developments are similar in terms of impacts and operation – the main difference is size. While definitions of the terms "micro" and "small hydro" vary significantly, Hydro considers micro hydro developments as ones with an installed capacity of less than 2 MW (2,000 kW). We apply the term small hydro to developments with installed capacities between 2 and 50 MW. By comparison, BC Hydro's largest facility, the G.M. Shrum Generating Station at the W.A.C. Bennett Dam has a capacity of 2,730 MW.

For small and micro hydro developments, 1 MW of installed capacity will supply enough power for about 550 homes. This assumes that the facility is able to generate, on average, about 65% of its full capacity. Generation is limited during periods of low streamflow, caused, for example, by low precipitation or temperatures low enough to freeze the stream.

PRINTER-FRIENDLY VERSION

Last Modified: September 23, 2005

IN THE SPOTLIGHT

Handbook for Developing Micro Hydro in British Columbia [PDF, 315 Kb] /69 pages plus links

Inventory of Undeveloped Opportunities at Potential Micro Hydro Sites in British Columbia [PDF, 509 Kb]

Green Energy Study for British Columbia Phase Two: Mainland

Small Hydro [PDF, 904 Kb]

INTERACTIVE MODEL

MICRO AND SMALL HYDRO

SEE ALSO

Green Criteria

INTERNET LINKS

RETScreen International

International Energy Agency - International Small Hydro Atlas

Notes on: Croockewit J (2004), Engineering Handbook for Developing Mico Hydro in British Columbia, prepared for BC Hydro, >F-8Sep08; file - environment1834, date 15Sep08, 69 pages. Has literature review.

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of 69

6	*Mico hydro usually less than 8,000* kW.	
9	Define purpose and vision — Is there appropriate stream? What will power needs be in 10 years? Who will you sell power to? What kind of licenses?	
10	Reasons for business plan – access to financing, accountability, control *benchmarks, big picture realism, times lines, licensing applications,*	
11	Preliminary cost estimates - initial for project development, construction, operational, taxes, repayments	
12	Net-metering is under revision	
13	Site requirements – over 10% slope in grid areas and 5% in diesel areas for run-of-river. Lots of water but watch for freezing. Close proximity to distribution. Connecting is only if 12 to 25 kV capacity - if larger connection is too expensive. Site accessibility for pipe, equipment, maintenance	
14 34	Power potential P = Q flow of water in cubic meters x head x 7.83 x 35.3 conversion to cfs. Power production is E = P with meters, x 8760 hours in a year x capacity factor as percentage. 60% of installed capacity is common.	
14	BC Hydro goal is 50% from clean energy in ten years — renewable, low environmental impact, socially responsible, licensable	
16	Considerations — water quality, access to site, licenses,	
20 25 28 30 35	Project evaluation — cash flow analysis, sources of funding, electricity repurchase agreements, duration of debt. Obtain Review Engineer Reports. Reporting requirements to finance sources. Approvals for transmission lines Liability insurance, Permits for project and use of electricity, if needed. Rights of way for transmission lines.	
37	Interconnection requirements. 12.5 to 25 kV	

39	☐ Conditions Precedent – events that must occur before the contract is deemed valid ☐ Condition Subsequent – events that must occur to ensure the contract remains valid ☐ Commercial Operation Date – the date on which the project is operational and capable of making deliveries under the terms of the contract ☐ Seller's Plant – a description of the plant ☐ Suspension Conditions – conditions that allow suspension of certain terms of the contract ☐ Termination conditions – reasons for early termination resulting from a default in the agreement ☐ Purchase and Sale terms – the commercial terms of the contract including term and price *as well as conditions that determine who bears risk for certain events.* ☐ Statements and Payments – administrative requirements ☐ Insurance conditions – minimum insurance conditions ☐ Assignment – notice and consent of sale may be required ☐ Force Majeure – an event over which neither party has control and which may cause delay prior to the Commercial Operation Date ☐ Dispute Resolution – defining how to settle any dispute fairly and at minimum cost	
42	Environmental management [Section 404 permits]	
66	Interconnection requirements	
end		

F - 3 May 08
f:6-wwdr2-ch-9.pdf
32 pages
date - 29 July 08

CHAPTER 9

Water and Energy

By

UNIDO

(United Nations Industrial Development Organization)

Colorado River dam in Arizona, United States

Gun City Council - Work Session
Two Head hydro - 16 Sep 08 : 3:30

Taylor R 60" and 72" penstocks dam
Span, Sewer, plant, Private

Pillager

Engineer -
Taylor - Head 150' Maximize. 1 MW machine could be handled
for 1000 homes 25 kV line is line
180 primary amp. Non-consumptive -
Van Tyle - North Bridge to Twin Bridge 300' - impact 3.5 - 42" diameter
~~2.5 MW~~ for 100 CFS instream. 2. Meg

Tanks - Water Tanks - losing need
Sewage Treatment Plant not enough drop.
Water Park - not enough.
Carbon tax - REC credits.
10 KW enough for 10 homes.
Blue Mesa - upper reservoir in dry ravine for wind
Gunnison 12 MW peaker.
Use of Kinetics - address instream.
Velocity of water.

Manual
Aspinall
- EIS planning.
WAPA
EIS - volumes

gether to form a film that has one oil-avoiding side and one water-avoiding side. They wrap themselves around oily substances suspended in water, and keep them in suspense.

This is similar to the way that all surfactants work. The trick is that the spirals come undone when the zinc is removed. That is achieved by adding a small amount of a chemical called a chelating agent, which scoops up the zinc atoms, or an acid, which bumps them out of the way. As the spirals unfold, the films disintegrate. The oily and watery components of the mix then return to their tense, separate relationship. The process is reversible and happens in a few seconds.

Adding a dash of Pepfactants to laundry detergent seems to confer this switching ability on the whole mixture. It should then be possible to switch off the films that give rise to soap bubbles between the washing and rinsing cycles, so that less water is needed to remove the suds. Pepfactants are biodegradable, so they could also be useful in pharmaceuticals and cosmetics.

But their main use may be in the oil industry. Even after an oil well has been pumped dry, a substantial fraction of its contents remains tucked away in the nooks and crannies of the rock. One way to gather and extract that oil is to inject water laced with a surfactant into the well, creating an oil-rich mixture which is drawn to the surface. Once there, though, the mixture must be separated—a process that involves further chemical treatment. Pepfactants might be able to make that process considerably easier. ■

End of a dammed nuisance

Energy: A new generation of free-standing turbines promises to liberate hydroelectric power from its dependence on dams

EVEN in today's more environmentally conscious times, hydroelectric dams are often unwelcome. Although the power they generate is renewable and appears not to produce greenhouse-gas emissions, there are lots of bad things about them. Blocking a river with a dam blocks the movement both of fish upstream to spawn and of silt downstream to fertilise fields. The vegetation overwhelmed by the rising waters decays to form methane—a far worse greenhouse gas than carbon dioxide. The capital cost is huge. And people are often displaced to make way for the new lake. The question, therefore, is whether there is a way to get the advantages of hydropower without the drawbacks. And the answer is that there may be.

The purpose of a dam is twofold: to house the turbines that create the electricity and to provide a sufficient head of water pressure to drive them efficiently. If it were possible to develop a turbine that did not need such a water-head to operate, and that could sit in the riverbed, then a dam would be unnecessary. Such turbines could also be put in places that could not be dammed—the bottom of the sea, for example. And that is what is starting to happen, with the deployment of free-standing underwater turbines.

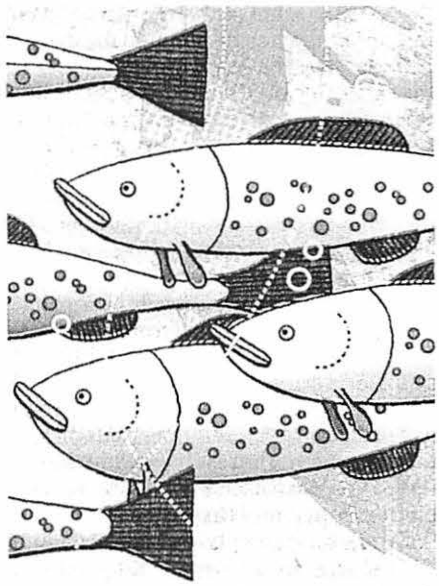
The big disadvantage of free-standing turbines is that they are less efficient than turbines in dams at turning the kinetic energy of moving water into electricity. They are also subject to more wear and tear than turbines protected by huge amounts of concrete. They can be hard to reach for repairs and maintenance. And their generators, being electrical machines, must be protected from the water that surrounds the rest of the turbine.

A discouraging list. But in the past three decades computing power has become cheaper, helping developers to simulate the behaviour of water and turbine blades—something that is hard to do with paper, pen and formulas. Moreover, prototypes can be built directly from the computer models. All this has helped scientists and industry to solve the inherent problems of free-standing turbines.

The first new design was by Alexander Gorlov, a Russian civil engineer who worked on the Aswan High Dam in Egypt. He later moved to America where, with the financial assistance of the Department of Energy, he produced the first prototype of a turbine that could extract power from free-flowing currents "without building any dam". The Gorlov Helical Turbine, as it is known, allows you to use any stream, whatever the direction of its flow. The vertical helical structure, which gives the device its name, provides a stability that previous designs lacked. It is also relatively efficient, extracting 35% of the energy from a stream. In addition, since the shaft is vertical, the electric generator can be installed at the top, above the water—so there is no need for any waterproof boxes.

In 2001 Mr Gorlov won the Edison patent award for his invention, and his turbines have now been commercialised by Lucid Energy Technologies, an American company. They are being tested in pilot projects in both South Korea and North America.

A second design is by Philippe Vauthier, another immigrant to America, who was originally a Swiss jeweller. The tur-



bines made by his company, UEK, are anchored on a submerged platform. They are able to align themselves in the current like windsocks at an aerodrome, so that they find the best position for power generation. Being easy to install and maintain, they are being used in remote areas of developing countries.

Finally, a design by OpenHydro, an Irish company, is not just a new kind of turbine but also a new design of underwater electric generator. Generators (roughly speaking) consist of magnets moving relative to coils. So why not attach the magnets directly to the external, rotating parts of the turbine? The coils are then housed in an outer rim that encloses the rotating blades. And there is a large circular gap at the centre of the blades, which is safer for marine life. In addition, OpenHydro's generators do not need lubricant, which considerably reduces the need for maintenance.

These new designs, combined with growing interest in renewable-energy technologies among investors, mean that funding is now flowing into a previously neglected field. According to New Energy Finance, a specialist consultancy, investments in companies planning to build or deploy free-standing turbines have increased from $13m in 2004 to $156m in 2007. Projects already under way include the installation by American Verdant Power of a tidal turbine in the East River in New York, and UEK, OpenHydro and Canadian Clean Current are operating pilot projects in Nova Scotia.

And that, proponents of the technology believe, will just be the beginning. Soon, they hope, many more investors will be searching for treasures buried on the sea bed—or, to be precise, in the water flowing just above it. ■

GCEA News

INSIDE...

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With expectations that electricity costs will continue to increase, the question as to the potential for developing a Taylor Park Reservoir Dam hydropower project has resurfaced.

Got Water? Need Power? Hydropower May Be for You

BY VICKI SPENCER, ENERGY USE AND COMMUNICATIONS SPECIALIST

Vicki Spencer

The concept of generating electricity from water has been around for a long time, but most hydropower projects in the United States have focused on large-scale facilities. It has only been within the past few years, with greater interest in renewable energy sources, that people have begun investigating the potential for developing smaller hydropower projects.

One such renewable energy project could be located at the Taylor Park Reservoir Dam. Even though the potential for generating power from the Taylor River existed when Gunnison County Electric Association's founders organized to bring electricity to the area, the feasibility of delivering that electricity to co-op members was questionable. The costs were high back in 1937, and even with government loan fund assistance through the Rural Electrification Act, only a few ranch, resort and dairy owners were in a financial position to pay the electric rates required to serve a membership of less than two households per mile, according to a letter from Ralph Allen to Walter Wolf at the Rural Electrification Administration dated July 9, 1937.

But times have changed. Today, more homes are located along the Taylor River corridor and, with expectations that electricity costs will continue to increase, the question as to the potential for developing a Taylor Park hydropower project has resurfaced. Recently, GCEA partnered with the Upper Gunnison Water Conservancy District and the Uncompahgre Valley Water Users Association to submit a grant proposal to the Colorado Water Resources and Power Development Authority for matching funds to conduct a feasibility study. If the proposal is funded, the partners will hire a consulting engineer to conduct the study. Whether the partners actually develop a hydropower project at the Taylor Park dam will depend upon the results of the feasibility study.

In addition to small-scale projects like the Taylor Park dam, which could generate more than 3,000 kilowatts of electricity during high-flow *[continued on page 8]*

Got Water? Need Power? Hydropower May Be Right for You

[continued from page 7] months, there has been a growing interest in "micro" hydropower projects. Micro hydropower refers to even smaller projects that generate between 1 and 5 kilowatts of electricity a month – enough to power a typical American household.

How does micro hydropower work?

Like larger hydropower plants, micro hydropower projects capture the energy of falling water to generate electricity. A turbine converts the energy of falling water into mechanical energy. Then a generator converts the mechanical energy from the turbine into electrical energy. The amount of electricity that a micro hydropower project can produce depends on two key factors: the amount of head and the amount of flow.

Members with an interest in developing a micro hydropower project can assess a project's viability by analyzing those key factors. First, you need to determine the amount of head, or the vertical distance the water falls. The distance the water falls depends on the steepness of the terrain the water moves across or the height of a dam behind which the water is stored. The farther the water drops, the more power it has. Generally, the difference in elevation should be a minimum of 10 feet, and the greater the difference, the more feasible the project would be.

Second, you need to determine the amount of water available for the project. More water falling through the turbine means that more power will be generated. Power is directly proportional to the stream flow. Therefore, a stream with twice the amount of flowing water as another stream can produce twice as much energy as the stream with less water.

Are there any other considerations in developing micro hydropower projects?

When determining the amount of water available you must consider both the physical and legal availability. In Colorado, water rights are based on the doctrine of prior appropriation, or "first in time, first in right," and the priority date is established by the date the water was first put to beneficial use. Appropriations of water are made when an individual physically takes the water from a stream and transports it to another location for beneficial use. But just because you may have a right to divert water for one beneficial use, such as irrigation for agricultural purposes, it does not mean that you automatically have the right to divert water to produce power. If you are contemplating a micro hydropower project, you might need to apply for a conditional water right, or you might need to apply for a change of water right. Since water rights are established through a water courts system, you might have to hire an attorney for adjudication of the water right, and this can be a lengthy process.

Additionally, many streams in our basin have in-stream flow rights associated with them. These are water rights held by the Colorado Water Conservation Board (CWCB) for the purpose of preserving the natural environment to a reasonable degree. The CWCB typically acts to protect streams that support fisheries, with the result that many of the streams in our area have in-stream flow rights. Since in-stream flow rights restrict the amount of water legally available to be diverted from the stream, they could have an impact on the feasibility of your project.

Anytime you deal with water rights, it can be confusing. If you are contemplating the potential for developing a micro hydropower project, the Upper Gunnison River Water Conservancy District can help. Please call UGRWCD General Manager Frank Kugel at 970-641-6065 and he can assist you with a preliminary feasibility estimate by determining the elevation head and water availability.

Another necessary step in developing micro hydropower projects is to obtain a permit from the Federal Energy Regulatory Commission. While the majority of micro hydropower projects (less than one megawatt capacity) would be exempt from full FERC regulations, it may take up to a year to obtain such an exemption.

Once you have estimated the potential for water availability, you will need to consider how you will put the electricity generated from the water to good use. When the electricity is generated in your turbine, it will need a place to go. In a balanced situation, all the electricity generated by the hydropower turbine will be consumed by your electrical loads and possibly recharging a battery. But if you generate excess electricity, you may want to consider selling that excess electricity to GCEA through its net metering program. For more information about net metering, you may contact GCEA at 970-641-3520 or 800-726-3523.

GCEA EMPLOYEE ANNIVERSARIES FOR DECEMBER

Mike Young, GIS technician, 29 years
Melba French, administrative assistant, 29 years

GCEA's IDEA CONTEST

Play to win $25. We will send you a check for $25 if we use your idea for an article. All you have to do is send your GCEA News insert article or photo idea to Melba French. If Communications Specialist Vicki Spencer picks your idea to include in next month's GCEA News insert to the *Colorado Country Life* magazine, you win. Please submit ideas relating to the electric industry, Gunnison County Electric Association, electricity use or energy conservation. Send, deliver or call your idea in to:

CONTEST: c/o Melba French
Administrative Assistant
Gunnison County Electric Association
P.O. Box 180, Gunnison, CO 81230
800-726-3523 • 970-641-7342
mrfrench@gcea.coop

CURRE

Deep in the Wilderness, Po

Small Hydroelectric Dams Catch On in Remote Spots; Critics Fear E

Sultan, Wash.

POWER SHIFT
By Jim Carlton

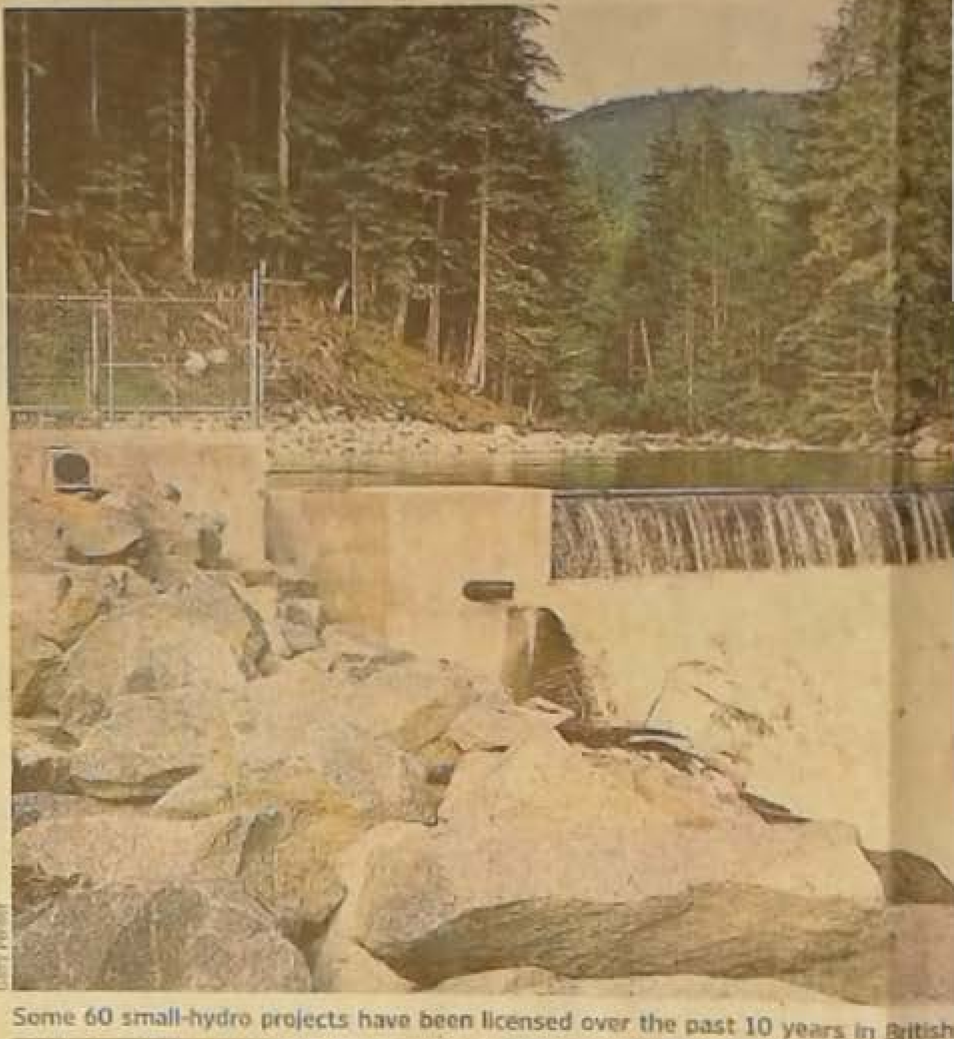
A big public utility is on the cusp of building a hydroelectric-power plant on a picture-perfect stream in the Pacific Northwest, but the plan has yet to draw the usual opposition.

That is in part because the approved project, which involves building a dam on a tributary called Youngs Creek, is so small and remote that it has attracted little notice. It will generate only about 7.5 megawatts of power at its peak, enough electricity to power between 3,500 and 7,500 homes. By contrast, the much bigger Henry M. Jackson Hydroelectric Project on the nearby Sultan River can produce up to 112 megawatts, or enough power for 56,000 to 112,000 homes.

So-called small hydro plants like Youngs Creek are sprouting up across the country, with around 500 potential sites identified by a federal study in Washington state alone. Power managers are seeking ways to meet the growing demand for electricity without turning to sources like coal plants that are widely thought to contribute to global warming. Generating power from streams and rivers, while often controversial, produces few emissions.

"We're in a situation where we're doing what our customers and society want," says Steve Klein, general manager of the Snohomish County Public Utility District north of Seattle, which is spearheading Youngs Creek and plans as many as 10 more.

But the small-hydro trend is beginning to raise eyebrows in environmental and recreation circles, especially in the West where much of the activity is taking place. The concern is that dozens, if not hundreds of dams and small power plants could industrialize vast reaches of spectacular backcountry, while providing relatively little power. Aside from ruining prized whitewater rafting runs, the projects



Some 60 small-hydro projects have been licensed over the past 10 years in British

could kill fish, critics say, while carving up habitat for other wildlife, such as for bears and eagles, with roads, transmission lines and other infrastructure.

According to the U.S. Hydropower Resource Assessment for Washington state in 1997, more than 2,500 megawatts of power could be added by simply improving efficiencies at existing hydroelectric plants and adding hydro to non-generating dams, such as those used for reservoirs or agricultural irrigation. By contrast, the report estimated that developing all the state's potential hydro sites, including small ones, would add only 762 megawatts.

"One plant here, one there, maybe we would support that," says Thomas O'Keefe, Northwest regional coordinator of American Whitewater, a rafters' group. "But with so many on the drawing board this really gets to be an issue of cumulative impacts."

Already, about 60 small-hydro projects have been licensed over the past 10 years in British Columbia, with at least one big U.S. utility, San Francisco-based Pacific Gas and Electric Co., saying it is considering using the power to add to its portfolio.

In Colorado, Gov. Bill Ritter's energy office is working to get "10 to 15" small-hydro projects built out of about 200 potential sites federal officials have identified in the Rocky Mountain state, says Todd Hartman, a spokesman for the office. The sites the governor's office is pushing would use existing infrastructure like dams or irrigation ditches, and so wouldn't entail as much stream disruption as other places, Mr. Hartman says.

The Federal Energy Regulatory Commission, which oversees the plants, has applications

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RENTS

Power Companies Wade In

ear Environmental Toll and See More-Efficient Options Elsewhere

Debating Small Hydro

Pros

- Has less environmental impact than larger hydroelectric plants.
- Cheaper to build and can use existing infrastructure such as irrigation canals.
- Often located on remote creeks and streams, they are less likely to disrupt popular recreation areas.

Cons

- Putting power stations and access roads in the backcountry can cause environmental damage.
- Fish can die from water diversions and from colliding with infrastructure.
- Many small streams dry up or have so little flow in dry months that power generation falls off or stops.

years in British Columbia. Above, the Furry Creek plant near Squamish, B.C.

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pending for about 14,000 megawatts, enough electricity for roughly seven million to 14 million homes, from mostly small-hydro projects nationwide, says Andrew Munro, president of the National Hydropower Association trade group. That is a more-than-20% increase from two years ago, he says.

In some cases, small-hydro plants have met fierce resistance. In 2008, a clean-energy company called Principle Power Hydro of San Francisco unveiled plans for nine small-hydro plants along a 34-mile stretch of Oregon's McKenzie River that would generate a combined 83 megawatts of power. But environmentalists and recreation enthusiasts complained the hydro plants would despoil a popular whitewater river in Oregon, and FERC officials ended up denying the company's request for a preliminary permit.

And in Montana, American Whitewater has joined some other groups in protesting plans by Hydrodynamics Inc. to build a small-hydro plant on the famed Madison River outside Yellowstone National Park. The groups say diversion of water for the plant would harm fish and other wildlife on the river. Ben Singer, project engineer for the Bozeman, Mont., builder of small-hydro plants, says the company believes it can design a project that would have no impact. Federal officials are still considering the company's request for preliminary permit to explore building a plant there.

But often, plants like Youngs Creek are meeting little, if any, opposition in part because of their sheer remoteness. Youngs Creek, the place where the Snohomish utility wants to build a small-hydro plant, is situated in the Cascades foothills about five miles from the nearest town. Like most similar projects being considered, this would be built above where salmon and other threatened migratory fish go, and so can't be challenged on those grounds. The utility purchased property and rights for the hydro facility in 2008 for $745,000 from a private firm.

"We decided not to oppose Youngs Creek because we couldn't find anyone who really used it, and it would just take too much of our resources for such a small project," says Rich Bowers, Northwest coordinator of the Hydropower Reform Coalition, which represents about 140 environmental, recreation and other groups.

But Mr. Bowers added he still questions the viability of the project, which utility officials say is expected to cost $30 million and be completed in 2011 after a construction bid is issued in a few weeks. The project originally had been issued a federal license 20 years ago, but wasn't built then because the market for alternative energy projects generally foundered after oil prices declined. FERC officials reauthorized the project in February.

One issue these plants face, Mr. Bowers says, is that the creeks they depend on are often seasonal, with sharply reduced flows in late summer.

Snohomish officials say that when flows are low, they won't be generating electricity from the plant. Although the utility, like many around the West, is drawing ever more power from wind farms, they say creeks and small rivers are an important backup source much of the year.

"We have a lot of wind, but the problem is when it turns off," says Barry Chrisman, plant superintendent of the Jackson Hydroelectric Project, where officials plan to remotely control both Youngs Creek and another small-hydro plant, Woods Creek. The utility bought that existing 500,000-kilowatt plant from a private company for $1.1 million in 2008. "That's why low-impact hydro is important, to pick up the slack."