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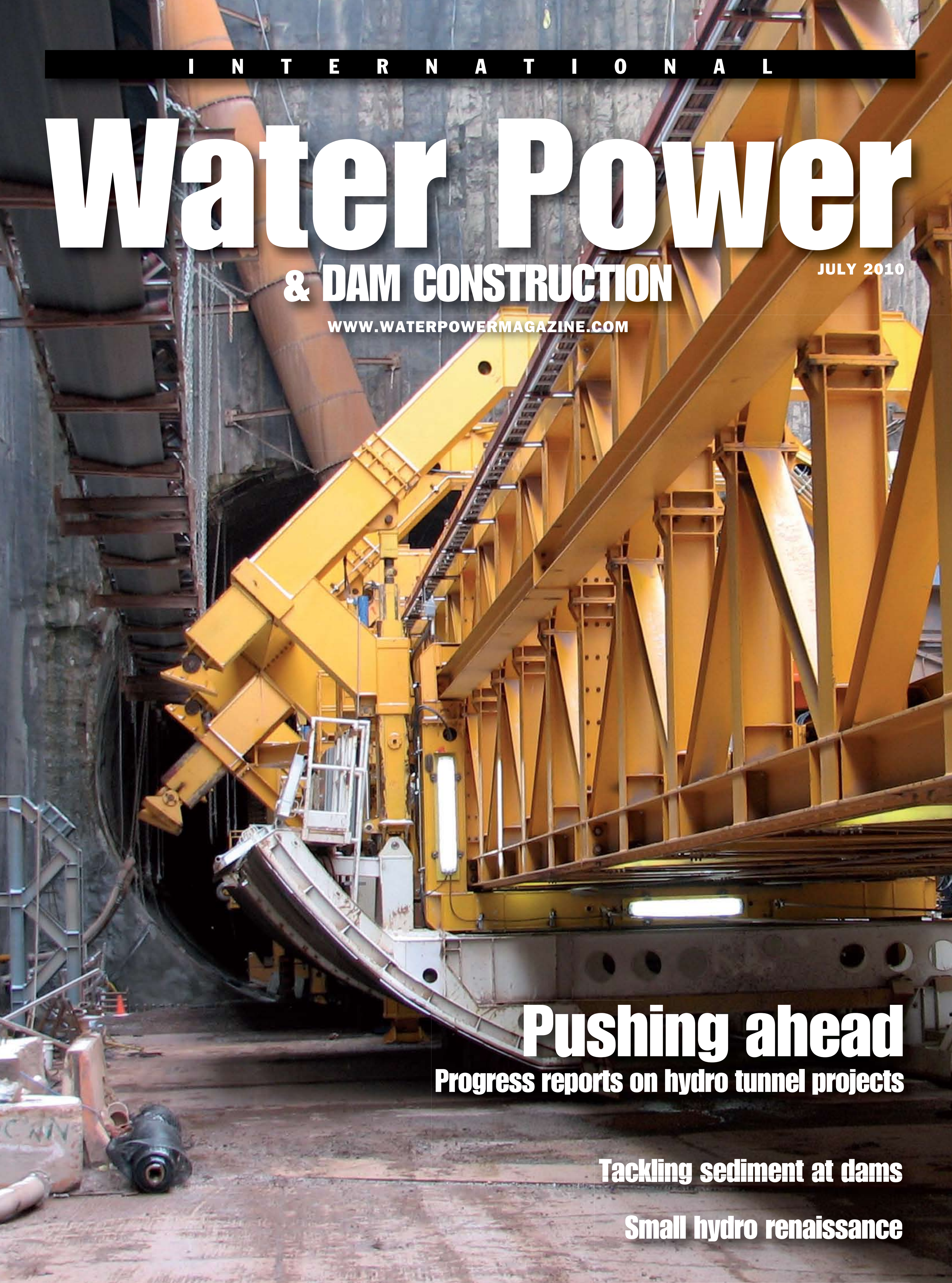


Pushing ahead

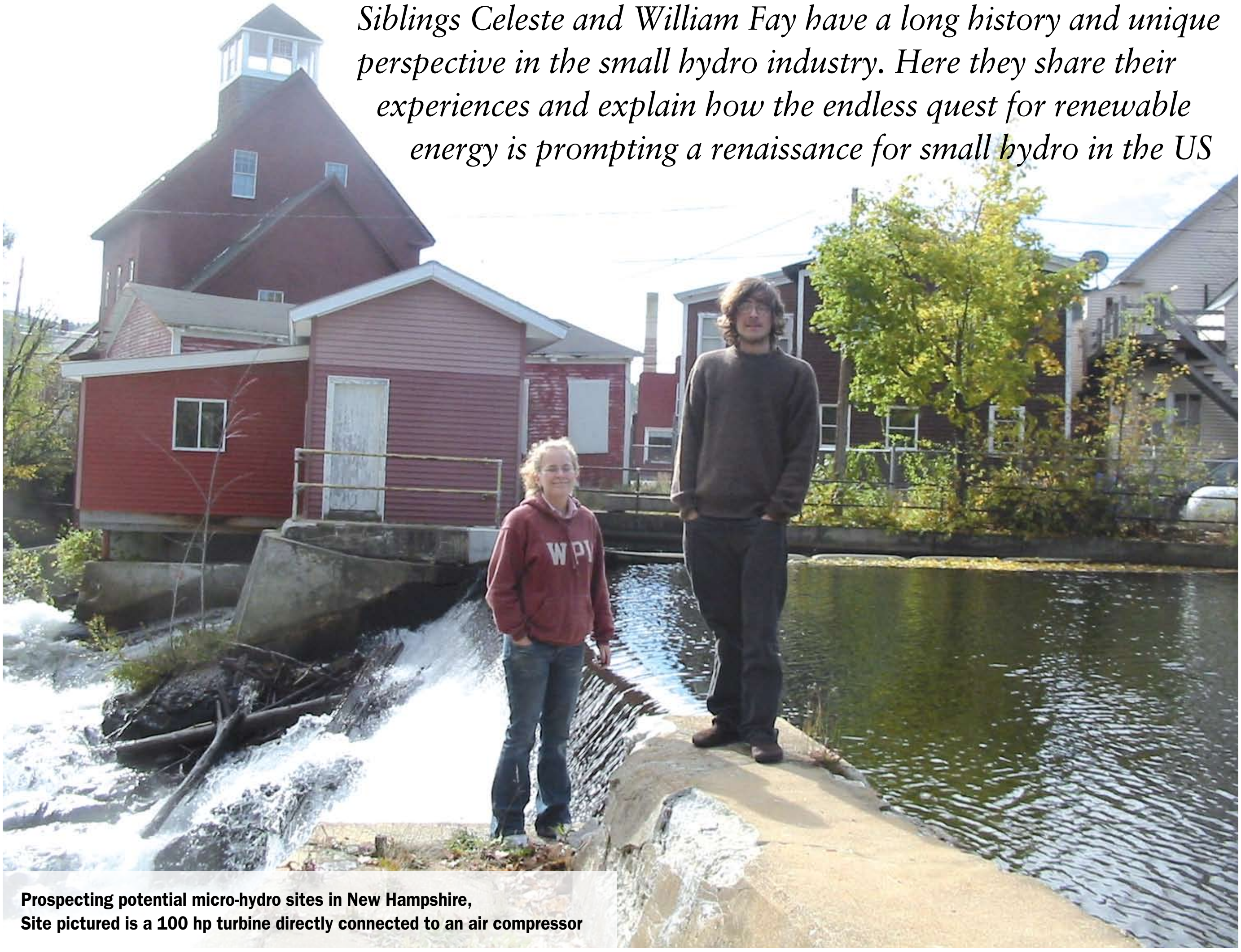
Progress reports on hydro tunnel projects

Tackling sediment at dams

Small hydro renaissance

Serving the hydro industry for over 60 years

Siblings Celeste and William Fay have a long history and unique perspective in the small hydro industry. Here they share their experiences and explain how the endless quest for renewable energy is prompting a renaissance for small hydro in the US



Prospecting potential micro-hydro sites in New Hampshire, Site pictured is a 100 hp turbine directly connected to an air compressor

Small hydro renaissance

A SIMPLIFIED history of hydropower in the New England area begins hundreds of years ago as small mill owners harnessed the energy available in falling water and converted it to usable mechanical power. Later, this energy was converted to electricity and by 1940 approximately 40% of the US' electrical demand was met through hydroelectric generation. With the increased use of inexpensive fossil fuels, the majority of these smaller hydropower facilities were eventually left to ruin. Today in a seemingly endless quest for renewable energy, we have returned to our roots and the hydropower boom has once again begun.

There are many challenges associated with small hydropower development. For those involved in the industry it will be no surprise to see regulation discussed first. However, there are other important challenges such as acquiring the initial capital investment, overcoming market instabilities, and for now let's say finding some 'Yankee Ingenuity'.

Regulations

With few exceptions, new hydropower is heavily regulated under the Federal Energy Regulatory Commission (FERC). The process of obtaining permission to construct, maintain and operate a hydroelectric plant through the means of a licence or exemption document is typically a lengthy and expensive process. Pursuant to 18 CFR 4.38 and 5.1 (d), and 16.8, an applicant seeking an exemption or licence must consult with relevant federal, state, and interstate resource agencies, Indian tribes, and non-governmental agencies.

Comments and suggestions by these stakeholders can be in reference to fish and wildlife mitigations but also extend to historic concerns, recreational issues, and the aesthetic impact of the project on the surrounding area. Furthermore, there are provisions that licences for hydroelectric projects must include conditions to protect, mitigate damages to, and enhance fish and wildlife resources.

Specific project conditions required for a hydro plant are determined through a stakeholder consultation process, which typically includes a series of costly studies. The results may not only indicate measures to reduce impacts during construction but also permanent operations measures that may reduce the overall annual energy generation of the project.

In general the small hydropower community in New England is a tight group of hard working folks who are environmentally conscious. They support fair-minded measures which assist them in constructing and operating their sites in a manner that is environmentally friendly. The heart of the issue is very simple. Why does a proposed 50kW hydroelectric project at an existing dam site, with minimal additional environmental consequences, go through the same lengthy and expensive process as a new 5MW site? Why isn't there a streamlined process for non controversial projects or low impact projects?

To be fair, FERC itself held a workshop in December 2009 on small non federal HEPs where these same questions were asked. The cumulative results were summarised in a FERC press release from April 2010 which stated that the commission is working to ease the regulatory burden of small hydro regulations through developing new online resources, creating simplified licence/exemption application templates and improving coordination with resource agencies.

Finance issues

Acquiring the initial capital investment and overcoming market instabilities to be able to develop small hydropower are intertwined issues. Sometimes it is possible to obtain a fixed power sales contract. However, more likely than not, the energy generated is sold to a larger electric company based upon ISO New England open market rates. In other words, the value of the energy is based upon supply and demand, which is subject to wild fluctuation and can be difficult to predict.

French River Land Co (FRLC) in Ware, Massachusetts owns the Tannery Pond HEP that sells energy to National Grid for open market rates. FRLC receives a spreadsheet on a monthly basis that details, on an hourly basis, the amount of energy generated and the corresponding rate. It is not unusual to see the value of energy reach a high of US$300/MWh but a low of US$0MWh. As an example, for the ISO New England central/western Massachusetts zonal area, the average value of energy for this year to date (June 2010) is around US$48/MWh. However, having a potential value of US$0/MWh does not typically make a financial institution feel comfortable lending a developer the funding required to get the project off the ground.

Renewable energy certificates (RECs) have assisted in this area. Typically, a fixed value contract for the RECs is signed for a year or more. However the average value in the New England area is only around US$20-30/MWh for financing purposes.

Yankee ingenuity

Now we come to the Yankee Ingenuity. Large hydropower producers have the luxury of additional monetary resources, which means that there is more room for outsourcing of engineering and construction services. The small hydro producer must be more careful in this respect, be able to evaluate available resources and make them work to their advantage. If we look at sites that are making an average annual energy generation between 100MWh/yr and 2000MWh/yr and assume an average energy value of US$50/MWh with an additional US$30/MWh in RECs, the average annual value of the site's energy is approximately US$16,000 and US$160,000.

Some costs such as environmental studies, engineering, and construction materials are more or less fixed; therefore, others must be minimised to the extent possible for a small project to be financially viable. Depending on how one looks at it, the opportunity or challenge here is in planning and designing a site to use existing structures and equipment.

In New England, a new dam is very difficult to construct and really is not a necessary requirement. With tools such as Google Earth and GIS data, the ability to find existing, unused dams has been greatly enhanced. Many old mill sites still have extensive civil works such as penstocks, powerhouses or tailrace structures. Of course, it is rare to find these structures in a state such that they do not require some rehabilitation. Yet often, a simple economic analysis will show that using these structures will drastically increase the economic viability of small hydro.

Additionally, many hydroelectric facilities today are generating using equipment that is almost 100 years old and with a surprisingly high efficiency. Whether it is the equipment found on-site or procured from somewhere else, used equipment is not something that the small hydro developer should overlook even if it requires rehabilitation. A small hydro site does not necessarily require all the bells and whistles and will likely not be economically successful if anything other than the bare minimum is installed.

For example, a colleague of ours uses a simple mechanism consisting of a rope, pulley, telephone repeater, and weighted paint bucket as a regulating mechanism for the governor on his turbine and it works great. This approach is not for everyone but if the average annual generation of a site is below a certain threshold, this kind of plan of attack is critical to success. It should be noted that the primary goals of some developers is not to generate an income stream. Companies may be looking to meet green goals or to preserve their long-term sustainability by offsetting their electrical demand with renewable energy. These folks will still find benefit in using Yankee Ingenuity but it may not be quite as critical.

Right: Will moving the Tannery Pond turbine; Below: 18 Inch Rodney Hunt Type 60 being rehabilitated for the Tannery Pond HEP Grant; Below right: Celeste rigging a 640kW generator into a rehabilitated HEP

Technical data on the FRLC projects

	Tannery Pond	Ashland
Dam type	Gravity Dam	Gravity Dam
Dam material	Laid fieldstones	Concrete capped granite blocks
Dam length	125ft	80ft
Dam height	6ft	12ft
Spillway type	Overflow weir w/ flashboards	Overflow weir w/ flashboards
Year constructed	1913	1925
Impoundment surface area	8 acres	12 acres
River	Millers	Squam
Drainage area	49 square miles	67 square miles
Average flow	92 cfs	88 cfs
Average annual minimum flow	4 cfs	15cfs
Bypass reach length	760 ft	320 ft
Minimum bypass flow	21 cfs	32 cfs
Installed capacity	189kW	84kW
Turbine type	Unit 1 – 38" Rodney Hunt Type 80, Unit 2 – 48" Leroy Somners Semi-Kaplan	Unit 1 – 36" Leroy Somners Semi-Kaplan
Generator type	Unit 1 – 1800 rpm induction generator, Unit 2 – 900rpm induction generator	Unit 1 – 1800 rpm induction generator
Hydraulic capacity	230 cfs	79 cfs
Average annual generation	510,000kWh/yr	420,000kWh/yr
Regulatory status	FERC exemption from licensing	FERC exemption from licensing

Repowering sites

This is the business model that we have built as a result of our limited economic resources and our abundance of hydropower knowledge. We became involved in hydropower at a young age because we grew up in and around hydroelectric power plants. When we were children, our father would bring us to various HEPs and we would do small tasks to assist with both engineering and hands-on site rehabilitation tasks. As we gained more of a grasp on exactly what it was that we were doing, we gained more interest and enthusiasm for the hydroelectric field.

Towards the end of our high school careers, our father and his partner had acquired larger power plants in the 1200kW to 4000kW range. The Tannery Pond hydropower station in Winchendon, Massachusetts was originally licensed for 189kW and it was quickly becoming obsolete in comparison to a 4000kW project. We wanted to become more involved in hydropower and eventually took over French River Land Company and the Tannery Pond HEP. The Tannery Pond facility had not produced electricity prior to us taking over the project. The station posed many challenges but we persevered and were able to repower the site.

When we took over the Tannery Pond project, the station had a FERC exception, an interconnection, two non-operational turbine-generating units and all the necessary civil works such as the dam, intake, trash racks, and powerhouse. The first unit was a Rodney Hunt 96cm diameter runner, type 80 Francis turbine, coupled through a 200hp Paramax 90 degree gearbox, to a 150hp-1800rpm induction generator, which had the potential to produce 80kW on the 3.4m of available head. The second unit was originally a homemade

View of Ashland hydroelectric project

turbine that had poor design characteristics. The turbine could not operate efficiently and was removed.

In 2009, FRLC obtained a US$461,000 grant through the Massachusetts Technology Collaborative to install two remanufactured Francis turbine-generating sets and computer controls in the Tannery Pond plant. This work will be completed by the end of 2010.

Around the same time, we removed a Leroy-Somners, Hydrolec, semi-kaplan turbine from a mill in New Hampshire. The turbine, helical gearbox, and generator are located within an oil-pressurised bulb, in a flanged pipe section, mounted on a penstock. The unit was thoroughly dilapidated and required a full rehabilitation. Unfortunately, parts and mechanical specifications for the unit were not available. It took almost a year of part-time work to rebuild the unit with new roller bearings, gears, and various other parts. The rehabilitation was completed in 2005 and the site successfully produced electricity.

Searching for small hydro

During the same period we were looking for other small hydroelectric projects. Our limited financial resources restricted us. However, we located a potential project on the Squam river in Ashland, New Hampshire, which we were able to purchase through the graces of owner financing in 2005. The Ashland hydroelectric project is an 84kW FERC licensed project constructed in 1984. The station had originally been under a generous power sales contract from the 1980s that set the value of energy at about US$20/MWh; but this had expired previous to our purchase.

We were fortunate though to negotiate a power and sales contract with the Ashland Light Department, which included provisions for the department to conduct limited operations. The station has a Leroy Somners, Hydrolec tube turbine, rated at 84kW on 5.5m of net head. The unit had been struck by lightning, disassembled, and left in a field for almost five years.

Our 18-month part-time rehabilitation of the turbine included the replacement of just about every mechanical and electrical component in the unit. A fair amount of guesswork was involved since no parts, plans, or specifications were available from the original equipment manufacturer. But with the use of our father's machine shop, we were able to repair the unit and it began generation in November of 2007.

Enjoying the challenge

As our skills and knowledge expanded, our involvement in the engineering portion of hydroelectric power plants also expanded. We both enjoy the challenge and joy of sharing our hydroelectric knowledge with others by finding economical solutions for the development of small hydropower throughout New England. There is once again a small hydro renaissance occurring not only in New England but also throughout the county and it is an exciting time to be involved in the industry. IWP & DC

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