Hydroelectric

IN 2003, MINNESOTA HAS ABOUT 32 HYDROELECTRIC generating stations that produce slightly less than 150 megawatts of capacity. Most of these projects are smaller than four megawatts of capacity, although there are a few larger projects. About 3% of Minnesota's energy consumption is currently derived by hydroelectric power, but most of this comes from Manitoba Hydro, a large hydro project in Canada. Most of Minnesota's hydroelectric stations function as run-of-river operations. Manitoba Hydro and many of the hydroelectric stations in the Pacific Northwest operate in peaking or storage mode.

Minnesota communities may find the opportunity to develop hydroelectric power at formerly decommissioned dams.

The economics of hydropower development in Minnesota requires that the supporting infrastructure (i.e., transmission lines, site access, dam development) is either present or readily available for development. Suitable sites in Minnesota have limited capacity and most of the significant hydroelectric resources of the state have already been captured. There is not significant development potential for large hydropower projects, but a few small sites with the necessary infrastructure support do exist.

These sites could present potential small-scale electricity generation opportunities for rural areas. Indeed, the Idaho National Engineering Laboratory prepared a hydropower resource assessment for Minnesota in July 1996 that identified 40 sites with undeveloped hydropower potential.[1] Most of these sites are classified as small, in the range of kW of capacity, with 60% of the sites with capacities of 1 MW or less.

In Minnesota, communities may find the opportunity to develop hydroelectric power at formerly decommissioned dams that, in addition to storing water, could be used for electric generation. These sites hold the most promise for future hydroelectric power development in Minnesota.

HYDROPOWER BASICS

Hydroelectric power plants convert the potential energy in water pooled at a higher elevation into electricity by passing the water through a turbine and discharging it at a lower elevation. The water moving downhill turns the turbine to generate electricity. The elevation difference between the upper and lower reservoirs is called the "head". Hydroelectric power facilities are typically categorized as either low head (under 60 feet) or high head. Most of the facilities in Minnesota are low head, run-of-river operations.

OPERATIONAL MODES

Hydropower facilities operate via three primary operational modes. Many projects can function in more than one of these modes. The three types of hydropower operational modes include:

1. Run-of-River Mode uses the natural flow of the river by channeling a portion of the river to a canal to spin the turbine. This may or may not require the use of a dam, but technically requires that the flow in and out of the reservoir are equal.

2. Peaking Mode captures and releases water when the energy is needed.

3. Storage Mode captures and stores water during high-flow periods to augment the water available during low-flow periods, thus allowing power production to be more constant. Pumped storage mode allows hydropower facilities to store power by pumping water from a lower

CASE STUDY:

Byllesby Dam: Hydroelectric Power Revisited

THIS CASE STUDY IS A GREAT EXAMPLE of putting a decommissioned resource back to use. Construction of the Byllesby Dam was completed in 1911, and it generated electricity for Northern States Power Company (now Xcel Energy) until 1966. In 1968, the power company transferred ownership of the dam to Goodhue and Dakota Counties. The dam remained decommissioned until the mid-1980's when the two counties jointly decided to put it back into operation. In 1987, North American Hydro, a private firm, began to refit the dam for hydro production. The Byllesby Dam now provides 2.6 MW of renewable energy via three generators and a 56-foot head.

Dakota County manages the dam, but the generation itself, along with the paperwork and operation and maintenance details, are contracted out to North American Hydro. North American Hydro also provided the upfront capital to restart the project. The two counties and North American Hydro share the revenues from the electricity generation, which are generally put back toward dam maintenance costs. Although it does not generate a profit for the counties, it does help them cover their costs, while putting local, renewable energy back into the grid.

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Byllesby Dam on the Cannon River

Improves the environment

Works well with agriculture

Helps with reliability concerns

Recycles waste materials and waste heat

Offers community economic development

Improves energy independence, local control, and energy security

Promotes learning about energy

reservoir to an upper reservoir during periods of low-energy demand. During periods of high-energy demand the water can be re-released to the lower reservoir to spin the turbines and create electricity.

CURRENT TECHNOLOGY STATUS

Hydroelectric power generation is a well-developed technology and therefore is generally very reliable except during periods of sustained drought or in the presence of ice. Both limit the availability of water to turn the turbines. Hydroelectric plants boast an overall efficiency of about 80 percent, significantly higher than that of either coal or natural gas. The capital costs for constructing a hydropower facility are estimated to be in the range of $1,700 to $2,300 per kilowatt (1996 dollars). Operating costs of hydroelectric plants are often low in comparison to those of fossil fuel plants because the flowing river water generally has no direct cost associated with its use.

As a result of trying to control water levels in Manitoba for maximum power generation, flooding occurs causing debris to line the shore and large amounts of sediment to be deposited in once clear waters.

ENVIRONMENTAL AND SOCIAL CONCERNS

Large hydroelectric projects can have severe impacts on surrounding communities and on ecosystems. Some of the impacts can include complete dislocation of communities and flooding of surrounding villages or restriction of fish movement and local extinctions.

Smaller scale projects, like those possible within Minnesota, tend to have fewer impacts. To address the potential environmental and social concerns, it is imperative that project developers do an environmental analysis on their site that includes an analysis of the potential impact to flora and fauna. For projects of less than 5 MW, a formal environmental assessment is not required, but the developer should address potential environmental issues to ensure community buy-in.

END NOTES

[1]Francfort, James. *U.S. Hydropower Resource Assessment for Minnesota.* Idaho National Engineering Laboratory, Boise, Idaho, July 1996. This report can be accessed from: http://hydropower.inel.gov/state/mn/mn.pdf.

PHOTOGRAPHS

page 31 – Eastern Waterfall Guide; page 32 – Bruce Blair/ Dakota County Park Service; page 33 – JustEnergy; page 34 – Park Rapids Enterprise Newspaper (left), LuAnn Hurd-Lof/ Park Rapids Enterprise Newspaper (right); page 35 – Minnesota Historical Society

CASE STUDY:

Park Rapids: A Study of Options to Retrofit a Former Structure

A STUDY OF USING THE FISH HOOK RIVER DAM in Park Rapids to again generate electricity began in 2000 as part of a University of Minnesota Central Regional Sustainable Development Partnership energy project on alternative community energy generation possibilities. The study looked at local renewable energy generation at five community sites, including the Fish Hook River dam. The dam was originally built with a hydropower facility in 1909 but was decommissioned in 1943, and has sat unused ever since.

Park Rapids saw a great opportunity at their underutilized dam. After all, they had both the dam and the plant already there. While the upfront capital costs would be high to install the new turbines that would be needed, the project would generate renewable energy for the community and would reduce the amount of coal needed to generate electricity in Park Rapids. Additionally, the project could draw upon a 1982 feasibility study that had evaluated the potential of reactivating the site but never came to fruition.

In nearly every sense, the project seemed well aligned. If successful, the project could serve as an example to other communities around the state with inactive power facilities at existing dams. Unfortunately, plans to reactivate the power facility on Fish Hook River were dropped in April 2002. The Park Rapids City Council decided that the expected generation of only 100 kWh/hour meant that the project was not economically feasible. They believed that at least 200 kWh/hour would have been necessary for the project to move forward.

In the end, it appears that delayed research findings may have stalled the project too long and swayed council members to pass up an opportunity without ever getting the full story. Project supporters are now considering applying for an Xcel Energy Renewable Development Fund grant that could provide partial funding and help make the project a reality.

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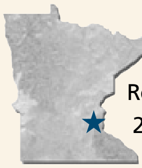
- *Improves the environment*
- *Works well with agriculture*
- *Helps with reliability concerns*
- *Recycles waste materials and waste heat*
- *Offers community economic development*
- *Improves energy independence, local control, and energy security*
- *Promotes learning about energy*

CASE STUDY:

Crown Hydro: Renewable Energy for Metro Markets



CROWN HYDRO received $5.1 million through Xcel's Renewable Development Fund in 2002 to renovate for hydropower production a section of the Minneapolis Mill Ruins located at the west end of St. Anthony Falls. The project will be a run of the river plant, consisting of a reconstructed upper canal and intake tunnel, a powerhouse room containing two Kaplan turbines with a total generating capacity of 3400 kW, an existing tailrace tunnel as well as a reconstructed tailrace tunnel, and an underground transmission line. The project will also improve a section of Minneapolis Park Board land with a new bridge, a boardwalk, landscaping, and public information structures featuring the hydro plant and history of the area.

As of January 2003 Crown achieved three major milestones: a completed 20 year power purchase agreement with Xcel, which awaits expected PUC approval this March; a settlement agreement with the Minnesota Department of Natural Resources for a fish restitution plan; and an agreement with the Federal Energy Regulatory Commission (FERC) for a cultural resources management plan affecting the historical site. A lease agreement with Minneapolis Park Board is under active negotiation. FERC intends to issue an order for construction in April, 2003, and Crown now expects to begin construction in June with start up projected for April, 2004.

Crown will take advantage of an existing untapped resource to provide additional capacity to the surrounding metro-area and provide clean, renewable energy to a highly populated, energy demanding community.

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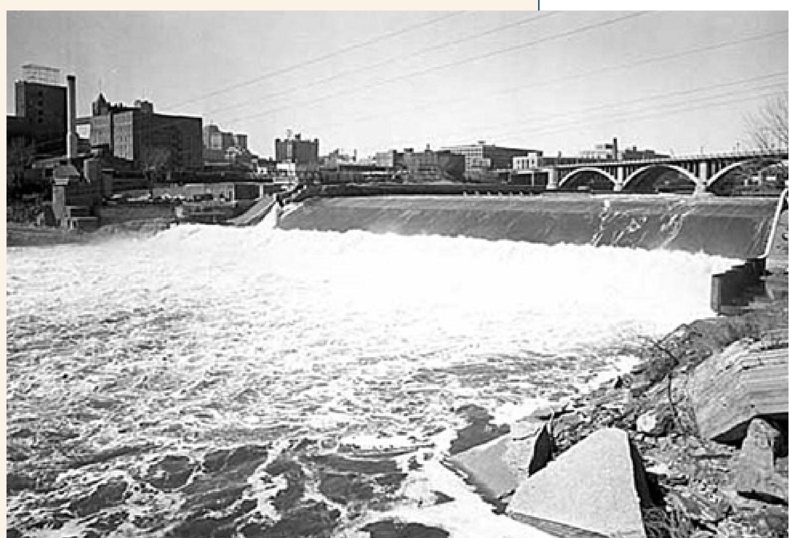
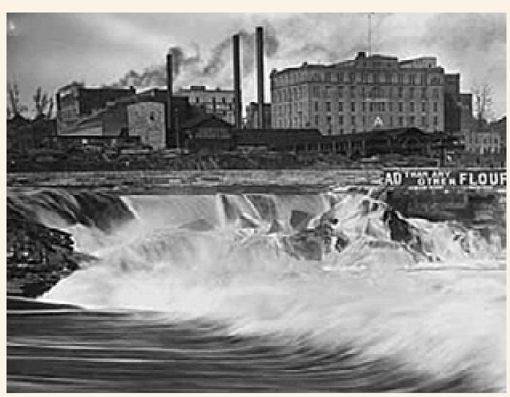


Crown Hydro facility will be located on the east end of St. Anthony Falls



Pillsbury Mill and St. Anthony Falls, circa 1897

HELPFUL RESOURCES FOR COMMUNITIES

All web links listed here are available (and updated if necessary) at www.mnproject.org (click on "publications")

Office of Energy Efficiency and Renewable Energy: Hydropower Topics and Hydropower Basics. Sites include basic hydropower information and descriptions of types of turbines. (www.eren.doe.gov/RE/hydropower) and (www.eren.doe.gov/RE/hydro_basics.html)

U.S. Hydropower Resource Assessment for Minnesota, James E. Francfort, Idaho National Engineering Laboratory for the US DOE, July 1996. Outlines sites available in Minnesota with undeveloped hydroelectric potential by dam status group and by river basin. (http://hydropower.inel.gov/state/mn/mn.pdf)

Minnesota Department of Commerce 2001 Energy Planning Report. Includes basic information regarding hydropower projects in Minnesota and the potential associated environmental and social costs. (www.commerce.state.mn.us)

St. Anthony Falls Laboratory. Provides information, research and publications available from this University of Minnesota research laboratory. John Thene, Associate Director, Contract Research and Engineering, 612-627-4609, email thene@tc.umn.edu. (www1.umn.edu/safl/index.html)

Minnesota Department of Natural Resources Hydropower webpage. Provides links to pertinent licensing organizations, information about potential environmental impacts, and listings of Minnesota's hydropower facilities. (www.dnr.state.mn.us/waters/surfacewater_section/stream_hydro/hydropower.html)

Federal Energy Regulatory Commission: Hydropower. Outlines the preliminary and final permitting requirements as well as permit conditions reviewed (including environmental and safety issues) and parties that must be involved in any permitting process for a hydroelectric facility. (www.ferc.gov/hydro/docs/waterpwr.htm)

University of Minnesota, Department of Civil Engineering. John S. Gulliver, author of *Hydropower Engineering Handbook,* has worked on the feasibility of small hydropower, on hydraulic design, hydrologic studies, and water quality impacts of hydropower. 612-625-4080, email: gulli003@tc.umn.edu.