

## The Next Era of New Hydropower Development

This Benchmark details several recent Kleinschmidt projects associated with new hydroelectric development. As we near the end of 2005 several trends fuel the increased growth potential of hydroelectric development in the United States.

The first trend is the significant and continued resurgence in energy prices over the last several years. For example, many locational market prices in the northeast United States are consistently double compared to three years ago. Also in some areas in the United States ancillary generation products such as capacity and area regulation are increasing in value.

A second trend is a growing societal awareness of the environmental benefit of hydropower's potential to produce clean renewable "green" energy that does not contribute to global warming. This is reflected in the Renewable Portfolio Standards (RPS) being implemented in many states that require minimum percentages of renewable energy. While the long term economic impact of this trend is not yet fully foreseeable, we believe that hydropower's proven technology offers an important advantage of a much lower risk exposure than other renewable technologies.

A third trend is a renewed interest in reducing our dependence on foreign oil.

These trends contributed to the recent passage of the Energy Policy Act of 2005. This legislation contains many important provisions that hydro owners have sought for over a decade. While the legislation provides important improvements for the relicensing process, the aspect that we see as most encouraging is the hydropower development financial incentives, particularly at existing projects or dams. The specific components of the bill that encourage hydropower development include:

- A 10-year, 0.9 cent per kilowatt-hour tax credit for efficiency increases and capacity additions placed into service before January 1, 2008
- Incentive payments of 1.8 cents per kilowatt-hour (up to \$750,000 per year per facility) for efficiency improvements and incremental hydropower
- Incentive payments of up to 10% of the capital costs for efficiency upgrades, up to \$750,000 one-time payment

Both incentive payments are subject to future congressional appropriations. There are also provisions for public power bonds and money for research and development that should benefit hydropower development.

Kleinschmidt has recently worked on several successful new hydropower generation developments that resulted in substantial economic and environmental benefits. Two of these projects have already been recognized as green power developments in New York and New Brunswick. Our ongoing new generation projects in their final engineering and construction phases include the installation of a new replacement turbine at Green Mountain Power's (GMP) Vergennes station, a new minimum flow turbine at GMP's Essex 19 project, preparation of the procurement documents and technical specifications for Brascan's Allens Falls replacement runner currently released for fabrication, and hydro-mechanical design and project review for the Crown Hydro project in Minneapolis, Minnesota.

Several of our clients are gearing up for an expedited licensing amendment process and subsequent design phase to get their proposed developments online by the 2008 tax credit deadline. Kleinschmidt is also currently working with other clients to determine the economic viability of an increasing number of potential hydropower development projects. For more information on how Kleinschmidt could assist you in any phase of hydroelectric generation development, please call Gary Liimatainen at (207) 487-3328, ext. 269.

## Higley Redevelopment Project Helps Meet New York's Green Energy RPS



The Higley Hydro Project, currently owned and operated by Brascan Power, is part of the Middle Raquette River Project, FERC No. 2320.

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The original project was constructed in 1911 and consisted of three horizontal Francis turbines with a total licensed capacity of 5.0 MW. The original units had reached the end of their service life. At the request of the previous owner, Reliant Energy, Kleinschmidt conducted feasibility studies for a new powerhouse. The selected alternative consisted of a new intake and powerhouse adjacent to the existing powerhouse, which was listed on the Historic Register.

Kleinschmidt conducted feasibility studies, assisted in procuring permits, prepared construction drawings and specifications, and provided technical support during construction. The existing units remained in service during construction of the new powerhouse. Construction started in April 2002 and the project was placed in service in September of 2003. Four new eight foot diameter penstocks connect the new intake to four new vertical propeller turbines, which have a total installed capacity of 6.1 MW. The new facility is expected to produce over 25 percent more energy compared with the average annual production for the original plant.

During the project's dedication ceremony, FERC's Chairman Pat Wood said, "I commend Reliant, federal and state resource agencies, and local interest groups for reaching a mutually satisfactory settlement of competing uses of the Raquette River that was used for relicensing of this project. This project provides benefits to water quality, fishery resources, recreation and economic development."

In February 2005 the generation from the Higley station was included in the New York State Energy Research and Development Authority's (NYSERDA) selection of renewable green power projects that meet the recently enacted New York State Renewable Portfolio Standard (RPS) Program. Kleinschmidt assisted Brascan in preparing the competitive NYSERDA application.

The Higley Redevelopment is one of a growing trend of projects aimed at decreasing this country's dependence on foreign oil. As stated by Linda Church Ciocci, Executive Director of the National Hydropower Association, "We are delighted to see that Reliant has shown that we can expand hydropower capacity in a responsible manner while cooperating with various stakeholders. Considering our growing energy needs, it's refreshing to see companies interested in meeting those needs by further tapping into our nation's hydropower resource."

For more information contact Kleinschmidt's Project Manager, Paul Williams, P.E., at (207) 487-3328, ext. 235, or Paul.Williams@KleinschmidtUSA.com.

## **New Minimum Flow Unit Meets New License Requirements While Increasing Clean Renewable Energy Used At The IP Mill**

A new minimum flow unit at International Paper Company's Livermore Falls Hydroelectric Station went on-line in September, 2004. The new minimum flow unit provides the flow required in the lower bypass reach of the Livermore development which is located on Maine's Androscoggin River. Generation from the unit displaces more expensive energy used at International Paper Company's Androscoggin Mill energy with clean and renewable hydroelectric energy.

The new powerhouse houses a single vertical Kaplan turbine with a generator and required appurtenances and is located on the forebay structure upstream of the existing powerhouse. The new minimum flow unit has a design flow capacity of 450 cfs with an output capacity of 1,000 kw.

The FERC established the minimum flow discharge to the bypassed reach in a new license that was issued to International Paper following its collaborative relicensing effort. The license required two separate flow regimes for different parts of the bypassed reach. Along the upper section of the bypassed reach, a variable 100/150 cfs flow requirement is met by spillage. The lower section of the bypassed reach has an increased flow requirement that is met by spillage supplemented with discharge from the new minimum flow unit.

The new unit operates at 450 cfs at full output (full wicket gate opening) and the operating regime is monitored automatically by a PC-based system that receives input from water level transponders located at the dam, the south end of the existing forebay, and the intake of the new powerhouse. Kleinschmidt provided all the licensing and permitting services, conceptual, final design, and construction monitoring services for the project.

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**Exterior of new powerhouse nearing completion**

# Oswegatchie Project Adds Green Energy Power to the Grid

## Upgrade Increases the amount of 'green' power available to the state of New York

A major upgrade was recently completed for the Oswegatchie Power Plant, currently owned and operated by Brascan Power and located on the Oswegatchie River in St. Lawrence County, New York. The hydropower plant, originally built in 1913, consisted of a wooden power house and flume. The Plant had been out of service since 1992 when the flume wall collapsed. The \$3.3 million upgrade boosts the rated capacity of the plant to 2 MW and helps meet New York's twenty-five-year goal for green energy.

The upgrade required demolishing the original structures, constructing a new intake with fish-friendly trashracks, installing two 6 1/2-foot-diameter penstocks, and constructing a new powerhouse with two new hydro turbines.

The license amendment application was filed on June 29, 2001. The FERC issued an order amending the license on September 17, 2001, and construction began immediately as the project needed to be operational by September 2002. Cooperation among the project participants and stakeholders was critical to achieving this goal. Meeting this challenge required innovative approaches in the permitting, design, bidding and construction of the project.

"This project moved along at almost lightning speed," said Dave Youlen, Managing Director-Hydros. "The time span of the required FERC license amendment application to the finished plant may be a record, as it was completed in a period of only 13 months. Most hydro projects of this nature can be years in the making."



**Photograph of Oswegatchie dedication ceremony**



**The Oswegatchie Project generates clean renewable energy for NY State**

Although a number of conventional project approaches could have been applied, we found several alternatives were best suited to accomplishing the objective of completing the design, bidding and construction of the project within the scheduled fast-track time-frame. The entire process was reviewed to determine where time savings could be achieved without compromising quality or increasing the project cost. This approach and cooperation between all of the project participants resulted in the successful completion within the project schedule.

For more information about this project, contact Kleinschmidt's Project Manager, Paul Williams, P.E. at (207) 487-3328 ext. 235 or [Paul.Williams@KleinschmidtUSA.com](mailto:Paul.Williams@KleinschmidtUSA.com).



**New powerhouse interior showing controls**

## New Configuration at St. George Hydroelectric Station

**Increases generation by 100 percent and becomes  
New Brunswick's first certified green power project**

The new 15 MW St. George Hydroelectric Station is located in St. George, New Brunswick at the confluence of the Magaguadavic River and a tidal estuary of the Bay of Fundy. This new facility replaces a 3 MW hydroelectric station that had been originally constructed in 1902 as part of the St. George Pulp and Paper mill, and was subsequently converted to a hydroelectric generation station when the pulp and paper mill was abandoned in 1967. The new hydroelectric station is owned and operated by Saint George Pulp and Paper (SGPP), which is a subsidiary of the J.D. Irving Corporation of Saint John, New Brunswick.

Due to the station's age and the original equipment's physical deterioration, SGPP began investigating upgrade alternatives in the 1980s. The evolution of various studies lead to a new station configuration consisting of a new forebay dam with a gated spillway, a new intake, two new penstocks, and a new underground powerhouse with two 7.5 MW horizontal Kaplan turbines discharging into the tidal estuary through a 400 foot long rock tunnel. The new configuration made it possible to increase average annual energy generation at the project from 20,000 MWh/year to 44,000 MWh/year. This was accomplished by maximizing the site's head by hydraulically connecting the headpond directly to the Magaguadavic River's tidal bay estuary. This change increased the hydraulic capacity to reduce spring spillage, replaced the 60% efficient existing turbines with new 92% efficient equipment, and increased the station's hydraulic capacity to more efficiently manage the upstream storage and concentrate the available flow during low tide, which offered maximum head.



**Construction of intake and penstocks**



**One of the project's 7.5 MW horizontal Kaplan turbines**

Kleinschmidt began working with SGPP in June 2001 to address the project schedule and cost uncertainties of governmental approval, rock tunnel design conditions, and water to wire equipment selection. After working with SGPP and the Canadian firm of Jacques Whitford, SGPP presented the project's Environmental Overview to the New Brunswick Department of the Environment and Local Government in September 2001.

The project subsequently received provincial approval in December 2001. Concurrently, Kleinschmidt engaged the geotechnical firm Haley and Aldrich of Cambridge, Massachusetts to begin the project's lithographic and geological mapping as well as the site borings. The rock cores and project mapping indicated that the proposed tunnel route was composed of unfractured diabase rock with low water permeability; this allowed the project to proceed with a significantly less costly unlined tunnel. Bids for the water-to-wire generation equipment were also solicited in October and firm prices within the conceptual budgets were received in December 2001.

In February of 2002, SGPP authorized Kleinschmidt to begin the final design of the complete new facility including all civil, structural, hydraulic, mechanical, electrical, and control features.

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*St. George, continued from pg. 4*



### **The underground powerhouse features two 7.5 MW horizontal Kaplan turbines**

The civil/structural features of the new facility includes a new post-tensioned forebay dam and gated spillway, a downstream fish sampling and passage system, an intake with a mechanical trashrack raker, and two 11 foot diameter buried steel penstocks. The water-to-wire equipment was housed in a 66 foot wide by 84 foot long reinforced concrete powerhouse set 124 feet below grade with the discharge through a 22 foot diameter by 425 foot long bifurcated rock tailrace tunnel. The buried powerhouse walls were designed to resist excessive rock pressures of 1,000 psf and hydrostatic pressures exceeding 4,000 psf.

The project's tunnel construction costs were dramatically reduced by utilizing a unique rock grouting and reinforcement dowel system. This system permitted the use of the intact tunnel exit section as a rock plug in lieu of an expensive cofferdam in the tidal gorge. Such a cofferdam would have required an intricate arrangement of struts and braces to conform to the irregular gorge profile. Before final commissioning, the tunnel rock plug was displaced into a rock trap by a sequence of progressive charges over fifteen seconds.

Kleinschmidt's engineering responsibilities included final design of all aspects of the project, including new dam, spillway, intake powerhouse, and tailrace tunnel. Kleinschmidt also assisted SGPP through all stages of the equipment procurement, from the selection through detailed shop drawing review. The water to wire equipment included two identical 7.5 MW horizontal double-regulated turbines that were purchased from GE Hydro. Kleinschmidt's final design of the station's mechanical systems also included the powerhouse dewatering system, turbine and generator bearing cooling water system, and the HVAC system.

To reduce the capital costs and facilitate future maintenance, SGPP elected to remove the switchgear and station controls equipment from GE's scope of supply and instead purchase the material from a local supplier. As a result, Kleinschmidt

designed the integrated turbine and station service logic which governs the inter-related gates, alarms, and turbine equipment. Kleinschmidt also designed the project's new substation and electrical power relay, metering, and control systems including the lighting, grounding, and station service.

Project construction began in April 2002 and reached a significant milestone when the powerhouse excavation and tunnel of more than 60,000 cubic yards was completed in February 2003. As scheduled, the completed station successfully began its commercial operation in March 2004 enabling the station to capture the energy generation during the high spring river flows of 2004. In September 2004 this project was certified as New Brunswick's first certified Green (electrical) Power Project.

For more information about this project, contact Kleinschmidt's Project Manager, Tom Kahl, P.E. (207) 487-3328 ext. 280 or Tom.Kahl@KleinschmidtUSA.com



**Interior of powerhouse looking down on unit**

## **Marshfield Unit 6 Overhauled**

### **Rehabilitation leads to increased generation**

Green Mountain Power Corp. (GMP) recently completed a major overhaul on its Marshfield No. 6 Hydroelectric Plant. The 350 foot head plant, located on Molly's Brook in Marshfield, Vermont, has an 8,300 foot long 6 foot diameter penstock leading to a 1927 vintage powerhouse. The station operates as a peaking station from the Marshfield Reservoir with ordinarily very limited reservoir spillage. In June of 2003 the single unit 5 MW station shut down due to extreme turbine vibration. Kleinschmidt responded to GMP's request for technical assistance.

A dewatered inspection revealed that the lower seal ring had become detached allowing high pressure water to bypass the runner, thus creating excessive cavitation damage. The loss of the seal ring, blade material, and balancing weights from the 1977 reconditioned bronze Francis runner contributed to the equipment vibration. Due to the condition of the existing runner and auxiliary equipment GMP elected to replace the runner.

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Kleinschmidt subsequently prepared the work-scope and technical specifications for a complete turbine overhaul. GMP awarded the new runner fabrication and installation contract in October 2003, scheduling installation before the spring runoff. During the winter rehab, the wood stave penstock needed to be full to prevent wood stave shrinkage. Kleinschmidt calculated the bypass flow and thermal conditions required to prevent the stagnant penstock water from freezing.

The rehabilitation effort encountered an unpredictable schedule delay upon finding that the original generator shaft was bent. This forced the installation to be postponed, which presented a serious challenge: how to bypass the spring runoff collecting in the headpond without discharging the full inflow through Molly's Brook, which could have caused significant flooding. A conventional purchased Multiple Orifice Valve, required to dissipate the full 350 foot of head, required an unacceptable lead time of several months. GMP and Kleinschmidt located a surplus ball valve and designed an energy diffusing chamber capable of reducing the potential free discharge velocity from approximately 95 fps to 30 fps. This design, including a finite element vibration analysis and detailed flow calculations, provided a safe and successful remedy to the problem within a few weeks.

GMP was able to successfully return the Marshfield No. 6 turbine to operation in June of 2004 with a new stainless steel runner, wicket gates, bearings, and lubrication system. The equipment is currently operating smoothly, and with a higher efficiency than the previous runner, increasing the total generation from the available reservoir water supply.

For more information about this project, contact Kleinschmidt's Project Manager, Tom Kahl, P.E. (207) 487-3328 ext. 280 or [Tom.Kahl@KleinschmidtUSA.com](mailto:Tom.Kahl@KleinschmidtUSA.com) or this project's mechanical engineer, Matt Dunlap, (207) 487-3328 ext. 279 or [Matt.Dunlap@KleinschmidtUSA.com](mailto:Matt.Dunlap@KleinschmidtUSA.com).



**GMP realizes increased energy benefits from unit overhaul**

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