In-Conduit Hydropower Case Study City of Manitou Springs Water Treatment Plant Manitou Springs, Colorado

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1. ABSTRACT

Rentricity Inc. works with regional and municipal water utilities to recover in-conduit renewable energy in pressurized water transmission systems. Rentricity approaches each project and creates custom designs for each facility which include one or more micro turbines (called Flow-to-Wire™), each coupled to a generator, sensors, processors, electronic controls and communication equipment.

One excellent application for in-conduit hydropower energy recovery is at the front end of a water treatment facility whose source water originates in a penstock miles upstream. Normally, a water treatment facility processes water for drinking purposes at very low pressure. Source water miles upstream results in significant pressure which typically is reduced by a Pressure Reduction Valve (PRV) at the front end of the facility. This makes it an excellent location to situate one or more turbines in parallel with the PRV.

Rentricity's supplies its Flow-to-Wire (F2W) systems that is compatible with and can be readily integrated to commercial Supervisory Control and Data Acquisition (SCADA) systems, assuring real time monitoring and control. The Oak Ridge National Laboratory estimates more that 1.4 gigawatts of clean renewable energy available from solid pipe conduits in the United States from drinking, agricultural and industrial water usage. Municipal drinking water accounts for close to 350 megawatts of potential for clean energy recovery. Rentricity's technology is also applicable to irrigation conduits, industrial inflow, low head, high flow wastewater treatment systems, mandated small dam releases, and water transfer stations. Rentricity presents a case study of the Hydropower Project with the City of Manitou Springs at its main Water Treatment Plant.

Rentricity's scope for this project included all hydropower system and site design, supply of the hydropower system equipment including controls, permitting, startup and training. The final design was completed and with all in-conduit hydropower equipment procured in 2020 and construction and startup completed in the 3rd Quarter 2021.

2. INTRODUCTION

Manitou Springs is a resort city in Colorado, just outside Colorado Springs. It's known for its mineral springs and mountain landscapes, dominated by soaring Pikes Peak. The population is approximately 5,000. It sits more than 6,000 feet above sea level.

The City supplies water to industrial, commercial and private/homeowner customers. The City has multiple sources of supply but its primary source is the output of its main Water Treatment Plant (WTP). The daily output of the WTP varies from approximately 500 to 1500 gallons per minute.

In 2016 the City initiated a design and construction project to replace and upgrade the main supply penstock from the source supply several miles in the mountains to the primary Storage Tank. This new penstock has a nominal pipe diameter of 16".

To complement this project, Rentricity was engaged in 2016 to conduct a preliminary design and capital cost projection. This effort was completed in early 2017 and determined that 10 to 70 kilowatts (kW) of clean electricity would be generated depending on the daily processing flow.

An important aspect of the preliminary design and assessment was the evaluation of the electric utility invoices and how the rate of generation would offset the WTP's power costs. It was determined that peak demand charges made up more than 50% of total invoices for an annual period. These peak demand charges occurred during a six (6) hour period each day from late afternoon to late evening in the Fall and Winter months. Further, it was determined that the consumptive charges made up no more than 25% of the total annual charges.

Since the peak demand charges occurred during periods of very low water processing, only small amounts of power would be generated. This would severely impact the payback analysis. An operational strategy needed to be developed that would combine adjustments in the timing of water processing to more closely match the periods of peak demand charge while optimizing the output of the Flow-to-Wire system. The ability to integrate these incremental changes would improve the economics and provide for a much more favorable payback.

3. PREVIOUS "IS" CONDITION

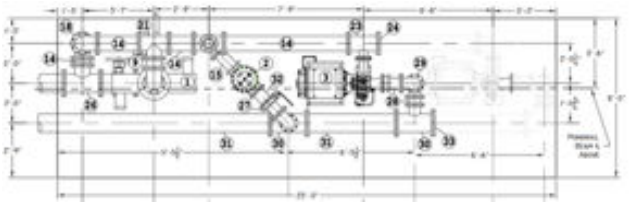
The City of Manitou Springs, Colorado has its main Water Treatment Plant (WTP) at the end of a six-mile pipeline. This pipeline originates high in the mountains at a large pond. The dynamic pressure developed through the pipeline's vertical drop less friction losses results in an inlet pressure of ~ 250 psi. Reserving for approximately 15 psi for movement of the water into the WTP's main storage tank yielded approximately 235 psi that could be put to work with a F2W turbine generator.

Processing flows at the WTP are dictated by daily usage in the City. These flows typically range from 500 to 1500 gallons per minute.

The flow in the penstock to the main Storage Tank was controlled by a 16" control valve, three (3) miles from the WTP to match the processing rate. The City typically operated the WTP to maintain a processing rate to meet the demand.

4. Flow-to-Wire (F2W) Application

Following an 18-month period which involved securing some of the necessary funds from public sources, Rentricity initiated the final design effort in 2019. The design approach created a turnout near the WTP in the supply to the main Storage Tank to divert water to the lower level of the WTP. The diverted supply would penetrate the WTP where a parallel piping loop would have a Pressure Reduction Valve (PRV) in parallel with an inlet control valve and turbine generator. Downstream of the turbine generator or through the PRV (if the turbine generator was out of service), the fresh water would return to the main penstock piping and move into the Storage Tank. A schematic of the mechanical design is shown below.



Control and Monitoring

Rentricity deploys its specialized Sustainable Energy Management System (SEMS™). SEMS is designed with the versatility to control operation of the hydropower system either in the pressure or flow control modes. Pressure mode would maintain level in the Storage Tank within a normal operating band. Flow Control mode delivers a defined flow rate to the Storage Tank.

The City operates a remote monitoring or Supervisory Control and Data Acquisition (SCADA) system. This system interfaces with the microprocessor in the SEMS control system. Data ported to the SCADA enables operators to monitor statuses, power production, and be alerted to alarms in real time. In addition, the capability for future remote (on/off) control of the turbine generators.

The F2W system has two modes for start up and shut down which are determined by the position of the HAND/OFF/AUTO selector switch. There is also a manual start and shut down sequence. Safety and protective relay functions run throughout each mode selection as well.

Figure: Main Control Panel & Control Interface

5. RESULTS

Rentricity's in-pipe hydro energy recovery solution permits the City to recover energy that would normally be dissipated during normal fresh water delivery to the WTP. The excess pressure is converted to electricity that in turn offsets essentially all of the consumptive electric load of the WTP as well as offsets much of the peak demand charges imposed by the electric utility – Colorado Springs Utilities. This offset substantially reduces a major operating cost for the WTP and lowers the City's and Colorado Springs carbon footprint.

Flexibility in the control scheme and programming the F2W system with the SEMS control system allows for maximum flexibility by the City in operating the system. This flexibility allows for adjustments in a variety of pressure, flow and level setpoints and permissives; all from the Operator's SCADA. This helps assure maximum generation during periods of maximum benefit; i.e. peak demand periods.

6. Financial

The Manitou Springs WTP In-conduit hydropower system is expected to continue generating in excess of 300,000 kWh per year based upon historical hydraulics and operating demand. The City's Flow-to-Wire system is designed for durability and a long life (40-50 years) with minimal maintenance limited to servicing the generator stator every 15-20 years.

All of the energy generated at the WTP is used to offset the consumptive and peak demand charges the City would normally incur for supply of power by Colorado Springs Utilities. Payback on the capital funds used for the project is expected to occur within 12-14 years.

As the City continues to fine tune its water processing operations and adds storage capacity, it is expected the WTP will truly become a net-zero energy facility.

7. CONCLUSION

Fresh water flows being conveyed in conduit infrastructure can be used to generate clean renewable energy. This means that facilities which process large amounts of water (such as a water treatment facility) could potentially become a net-zero energy facility. When upgrading water infrastructure, "energy recovery ready" designs will help create smart and sustainable water infrastructure.

Photos: Manitou Spring F2W Turbine Generator

Figure: Main Control Panel & Control Interface