



Potable Water Distribution System - In-Conduit Hydropower Case Study for the Anchorage Water and Wastewater Utility Anchorage, Alaska



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 in water distribution infrastructure downstream of a water treatment facility. This finished drinking water, which is required to meet water quality standards such as NSF-61/372, is delivered to commercial and residential customers by cities, municipalities and coops. Pressure regulating valves (PRV) control pressure in the system to accommodate changes in topography, supplemental storage facilities and emergent demands. Sites where PRVs are located represent excellent opportunities to deploy a in-conduit hydropower system. In-conduit hydropower systems behave like a PRV (reduces pressure and manages flow), therefore can be deployed either in lieu of or in concert with the PRV depending on hydraulic conditions. Controlling the In-conduit hydropower system in an optimized fashion allows for seamless operation and servicing of the entity's primary mission; namely to deliver safe, reliable drinking water on demand to its customers.



Rentricity's also supplies its Sustainable Energy Management System™ (SEMS) which is compatible with and can be 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 approximately 350-megawatt potential for in-conduit hydropower clean energy recovery. In addition to water utilities, 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 this case study of the Hydropower Project with Anchorage Water and Wastewater Utilities at one of its distribution sites controlled by a PRV.

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 preliminary and final design was completed in 2020 and major hydropower equipment procured in the front half of 2021 and construction and startup completed in the 3rd Quarter 2021.

1. Introduction

Anchorage is the largest city in Alaska with a population of more than 300,000 residents. The Municipality of Anchorage owns and operates the Anchorage Water & Wastewater Utility(AWWU) for the core purpose of safeguarding the health and welfare of the public. Its mission is to provide safe and reliable water and wastewater services.

Reliable Infrastructure is the Backbone of AWWU Operations

- 1,600 miles of underground pipeline (4-inch to 78-inch in diameter)
- Three wastewater facilities (Asplund, Eagle River and Girdwood)
- Two surface drinking water treatment plants (Eklutna and Ship Creek) that produce on average 22 MGD
- 14 active wells, 22 water reservoirs that serve primarily as backup to the main water treatment facilities
- 34 Booster stations, 7,200 fire hydrants
- 38 wastewater pump/lift stations
- 2 septage receiving stations
- 17,000 pieces of rotating equipment.



AWWU conducted a preliminary assessment to identify potential pressure reducing valve (PRV) sites in its distribution infrastructure in the previous decade. A target PRV site was selected (referred to as 92nd Avenue) which has an AWWU facility in proximity. AWWU's plan was to back-feed the clean power generated at 92nd Ave to defray power costs from Chugach Utility at one of AWWU's maintenance and operating facilities.

2. Previous "Is" Condition

One of AWWU's distribution vaults is the 92nd Avenue pressure regulating facility which provides high volumes of water to flow from the Hydraulic Grade Line (HGL) 347 pressure zone into the HGL 260 pressure zone to meet customer demands and fill the 5.5 million-gallon Kincaid Reservoir. This station establishes the HGL 347/260 zone



boundary, from its prior location at 88th and Lake Otis Pkwy. The facility, with a finished floor elevation of 118 feet, provides stable water pressure and flow through the 36-inch water transmission main running east to west along the 88th and 92nd Avenue corridor.

The pressure regulating facility has full SCADA system provisions providing for local and remote monitoring and control. All but one isolation valve are manually operated butterfly valves. Two relief valves release entrapped air when required and ensure a vacuum condition does not occur when system pressures fall below normal. An HVAC system provides two types of heat while a ventilation system will monitor and control humidity. A jib crane is in place to facilitate mechanical repairs and a floor drain connected to a dry well will collect residual water on the floor.

3. Flow-to-Wire In-Conduit Hydropower Energy Recovery System

The Rentricity Flow-to-Wire System (F2W) consists of a turbine generator, inlet control valve and electrical/control panel. The turbine is an NSF-certified Cornell 10TR2 unit, close coupled to and vertically mounted with a US Motors generator. The generator is a three phase 460V, 1200 rpm unit with a full load rating of 45 kW (60 horsepower).

This turbine has been optimally selected to pass 5 million gallons a day (MGD). The clean energy power output is estimated to be approximately 33kW and 39kW for variable diurnal and seasonal flow and pressure conditions. The F2W System retains the capability to control downstream conditions to either a pre-programmed pressure or flow condition. After careful review of



AWWU's subsystem future plans, it was determined that this vault would require programming to manage flows under most scenarios with a backup capability to manage pressure. Both conditions would occur with the parallel PRV in standby.



The turbine portion of the turbine-generator (all water facing components) is certified by WQA as fully meeting the requirements of NSF-61 and 372 for drinking/finished water applications. The unit is listed on WQA's website and certification is provided to AWWU that the specific unit has been fabricated utilizing the proper materials and specifications.

The inlet flow control valve to the turbine is a 10" butterfly valve with a Rotork electric actuator that provides full modulating capability. The motor-operated valve (MOV) provides isolation when the turbine is not operating and modulates to regulate

discharge pressure and flow from the turbine for certain flow conditions. The MOV closes in a controlled fashion following any system alarm, loss of normal power following an emergency or manually induced trip of the system.

Rentricity's Sustainable Energy Management System (SEMS™) provides all monitoring and control of power generation and distribution while preserving the safe and reliable operation of the System. The main features of the panel include a multi-function relay (MFR) Beckwith M3410 A, Allen Bradley Programmable Logic Controller (PLC) – Micro 850 w 48 I/O, circuit breakers, safety lockout, I/O and 7 inch color front panel display for quick status and interrogation.



SEMS is designed and fabricated to the appropriate portions of the NEC and UL508A and is rated NEMA type 12; operating in a controlled environment inside the vault. The PLC monitors the condition of the F2W System and determines the operational readiness and provides control of the F2W in real time. An interface with SCADA includes faulted condition signals if any of a variety of abnormal conditions or actions exist.



An operator will be able to view and check on the condition of the F2W via the flat panel display/operator's module on the front of the panel or real time through SCADA. The operator is able to reset or re-start the System from the control panel if a faulted condition exists that trips the multi-function relay (MFR). The MFR is automatically tripped when one or more of the unit's function limits are exceeded; e.g. voltage, frequency, etc.

The operator is required to clear any MFR trip conditions and resolve any other issues at the SEMS control panel prior to attempting a re-start of the system.

4. Results

Rentricity's in-conduit hydropower solution permits AWWU to recover clean energy that would normally be dissipated during normal water delivery between different distribution zones. The excess pressure is converted to electricity that in turn offsets essentially all of the consumptive electric load and a portion of the demand load of a nearby AWWU facility normally assessed by Chugach Electric. This big offset substantially reduces a major operating cost for the facility and lowers the AWWU's and Chugach's carbon footprint.

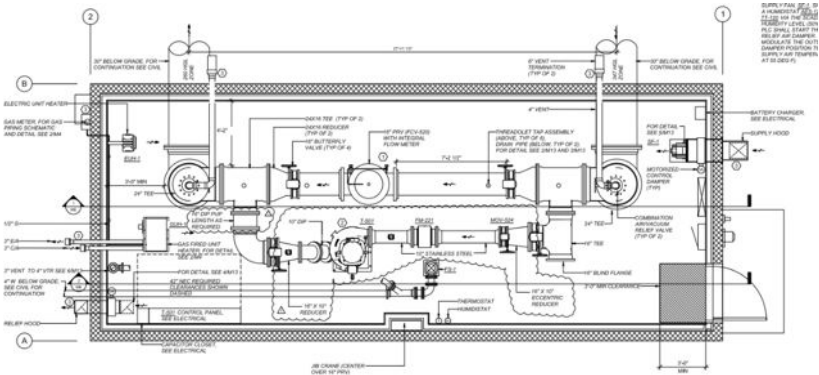
The performance of the F2W in-conduit hydropower energy recovery system has exceeded expectations for power output and reliability. The system has had 100% availability since beginning commercial

operation in January 2022. For the baseline flow condition of 5 MGD, the energy recovery system has consistently generated power at or exceeding 40 kW; slightly above projected performance.

Incorporating flexibility in the control scheme and programming in the SEMS PLC allows for maximum flexibility for AWWU 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. Also, AWWU has the flexibility to move from flow to pressure regulating regimes.

5. Conclusions

Drinking water flows being conveyed in conduit infrastructure can be used to generate clean renewable energy. This means that entities which process and distributes large amounts of water potentially offset a significant portion of its annual electric charges. When upgrading water infrastructure, “energy recovery ready designs” will help create smart and sustainable water infrastructure.



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