Case Study: West Sound Utility District

Introduction

Until now, hydropower as a distributed generation energy source hasn't made sense: dams are both too expensive and environmentally destructive, paddlewheels are inefficient, and propeller turbines require difficult construction to install. Hydrovolts has solved that challenge by approaching the problem from a new perspective. Hydrovolts is capturing hydrokinetic energy – the energy in moving water – in artificial waterways such as industrial outfalls, avoiding the environmental and technical challenges that have made small traditional hydropower too expensive.

Hydrovolts has patent-pending turbine innovations that make small scale hydrokinetic energy feasible. First, the turbines involve minimal permitting and are designed for easy installation at a range of heights and flow angles. Transported on the back of a pick-up truck and dropped into place with a simple boom crane, the turbine simply bolts onto the flume and hangs over the plant wall, requiring minimal site engineering. Second, customers can install multiple turbines side by side to increase total power output. Third and most importantly, power is a direct function of height and flow: Hydrovolts has designed a product that can accommodate the highly variable flows in waste water treatment plants.

In the fall of 2012, Hydrovolts installed a scale model of its new waterfall (WF) product line in the outfall at West Sound Utility District ("WSUD") treatment plant in Port Orchard, Washington. Port Orchard's 1.8 millions of gallons of water per day ("MGD") flows and generous subsidy for renewable energy solutions combined with strong community support to make WSUD an ideal testing location. This model serves as a reduced scale model of a larger commercial product with a 15kW nameplate that will be launched in early 2013, and also as a prototype for a smaller 3kW unit.

Site Selection Characteristics

This particular test location near Port Orchard is conveniently located to Hydrovolts' Seattle headquarters and exemplifies several characteristics common to many outfalls:

1. **Artificial Environment**. The site is wholly contained within the plant, eliminating environmental concerns and speeding up the permitting and permanent installation process.

2. **Accessible**. The site is readily accessible, facilitating installation and eventual maintenance.

3. **Local Load**. Electricity is one of the largest operating costs facing waste water treatment plants. As the turbine is on plant property, there is significant electrical load nearby. This allows the generated electricity to be easily interconnected to the grid via a net metering arrangement. The local power utility company is supportive of net metering projects. For demonstration purposes, however, this particular product is off-grid.

4. **Constant power**. The West Sound Utility District serves a population of 15,000 people and receives average flows of 1.8 MGD. While ideal for a small scale test, this plant has lower flows than the minimum required for our larger commercial product. At sites with average flows of 5 MGD or greater, Hydrovolts turbines will be able to produce constant power at almost any volume.

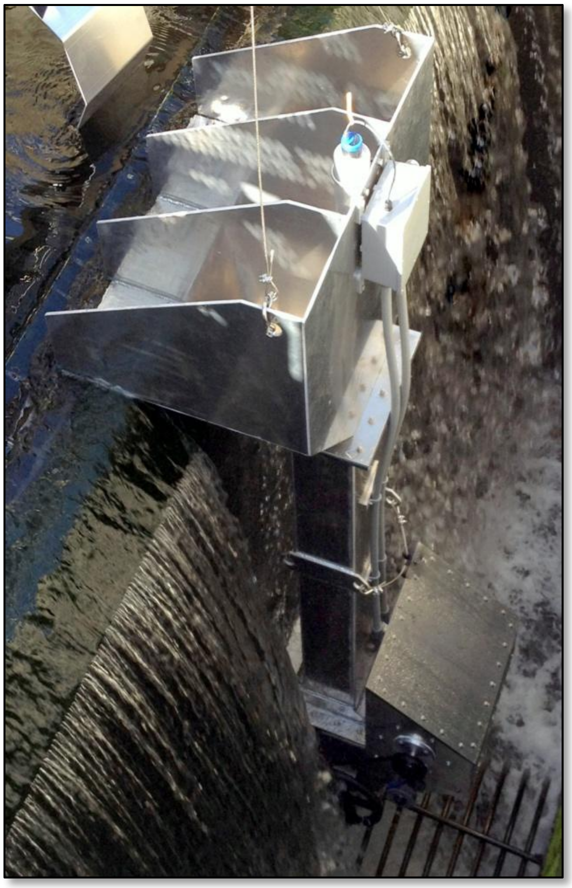
Turbine Description

- 27 blade stainless steel banki runner with automatic flow-controlled inlet valve
- Prototype turbine dimensions are 4 feet wide by 8 feet tall by 2 feet deep
    - Designed to produce 1.4 kW at maximum flow rate of 2.5 million gallons per day (MGD)
    - Operational down to 25% rated flow (.625 MGD)
    - Permanent magnet AC generator rated for 1500 watts at 500 RPM
    - Turbine dry weight 500 pounds.
- Operating description:

The waterfall turbine is designed to harness the potential energy of treated water as it falls through the elevation change in an industrial outfall. This potential energy is converted into electricity for use by the plant electrical system to reduce the plant's energy footprint. The water in the outfall is funneled into a penstock that leads the water to a nozzle and valve assembly that both keeps the penstock full and directs the water to impact the turbine runner in a controlled manner. The valve is adjusted by a linear actuator that receives a control signal based upon a level input from an ultrasonic sensor at the top of the penstock. The turbine runner is connected to a speed increaser driving an electrical generator that sends electricity to the electronic equipment regulating the power to a usable form.

When the valve in the nozzle assembly is fully open, the turbine passes 100% of the design flow rate through the penstock and runner. If the actual flow rate continues to increase above the design flow rate, the water will spill over the penstock intake and cascade over the wall or weir just as it did before the turbine was installed. This is a passive action as the vertical height of the penstock intake is sized to correspond with the depth of water falling over the wall or weir without the turbine present.

If the flow rate of the site exceeds the maximum flow rate of the turbine, then the possibility exists to analyze the frequency distribution of the site for the feasibility of a 2nd turbine to capture the extra power available. For example, if the site averages 5 MGD, then two 2.5 MGD turbines could possibly be used to capture the full flow rate.



The prototype being installed at WSUD in Port Orchard, WA

Electrical Output

- Electricity is generated using a permanent magnet generator, housed within the turbine. For the demonstration, output power is routed to a resistive load bank. In a typical installation, the power will be fed to a load-optimizing inverter or charge controller that enables a grid-tie connection or remote battery charging.
- Output voltage is 75-230 VAC 3-phase. This can be stepped up or down depending on need.

Site Characteristics

- The outfall drop is 7 feet (2.1 meters), with net effective head of 75 inches (1.9 meters).
- The water treatment plant operates year round, with annual average flows of 1.8 MGD and peak flows of 5-6 MGD. As flow volume directly correlates to power output, plant variations affect the overall electricity production.

Test Installation: Power in Hours

One of the key benefits of Hydrovolts' turbine technology is its ease of installation: with minimal site preparation, a turbine can be easily installed within a few hours. Hydrovolts engineers worked with the WSUD engineers to create a detailed project and safety plan. This plan included both installation procedures and thorough safety protocols and emergency measures. The following outline of the installation sequence will be typical of most turbine installations.

The week before:

- An electrical disconnect was installed adjacent to the weir and conduit run to the nearby control center. The control center houses the electrical controls, dissipative loads, data collection, and remote data monitoring equipment.

The morning of:

- Hydrovolts transported the turbine to the site using a pickup truck.
- Plant personnel reviewed the installation plan and confirmed roles and safety gear.
- The first step was the installation of weir blocks that funnel the flow into the turbine. The height was sized to match the depth of the water flowing over the weir at 100% design flow rate. This ensures that when the plant flow exceeds the design flow rate through the turbines, the excess water is still able to fall over the weir without affecting plant operations.

The day-of installation:

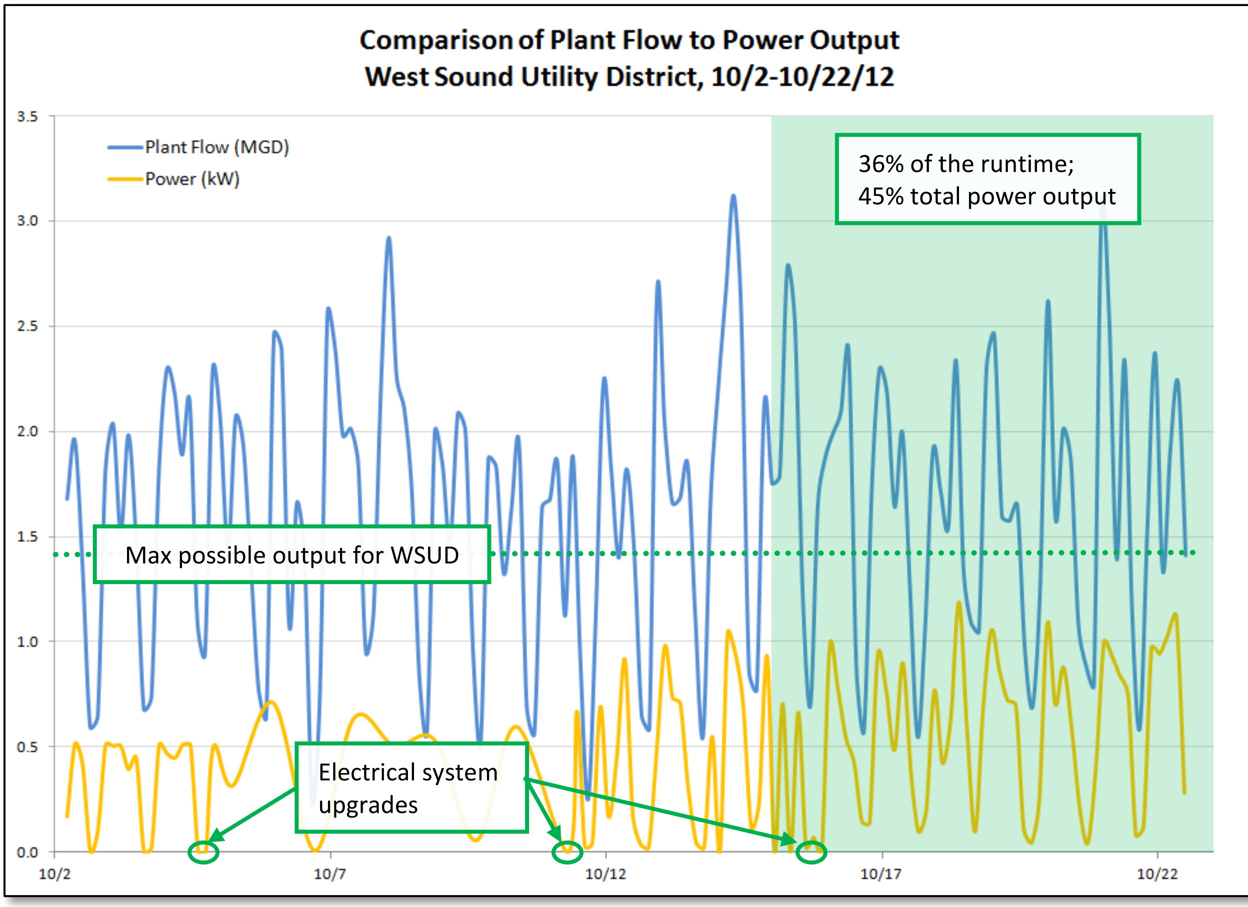
The plant's gantry crane lifted the turbine from the truck and positioned it over the outfall. As the turbine was being lowered, personnel on both sides connected the power output to the load bank. Following the electrical connection, the crane continued lowering the turbine into the water. Both the weir blocks and turbine hooked over the weir wall with no modification to plant structure. Power began flowing as soon as the penstock began to fill up. This entire process took less than four hours, start to finish.

Turbine Installation Pictures

Pictures (clockwise):
- Weir block installation to maximize water flow through turbine;
- Turbine being transported through plant on pallets;
- In-house gantry crane lifting turbine and positioning over outfall

Power Output

The Hydrovolts turbine rotor started turning immediately upon installation, generating power to the load bank. Estimated power output ranged from 50 watts to 1.4 kW in ideal conditions at peak plant flow; power generation directly correlates to plant flow. A power output chart from its first three weeks:



- As expected, power output closely tracked the flow of water in the plant.
- The turbine produced 238 kWh in three weeks (520 hours total).
- The final week benefitted from the accumulated adjustments to both the electrical and mechanical system, and the turbine produced 45% of the power (109 kWh) in the final 36% of the run (the final 192 hours in this sample). This average of 560 watts per hour indicates the turbine's vastly increased efficiency in the latter third of its run.

The West Sound Utility District has agreed to a long-term pilot-to-purchase program and operational data will be updated with longer-term production data as available.

More Information

To learn more about the full range of Hydrovolts products, please visit our website at www.hydrovolts.com, email us at info@hydrovolts.com, or call us at 206.658.4380.