Case Study: Roza Canal

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 canals, avoiding the environmental and technical challenges that have made small traditional hydropower too expensive.

Hydrovolts has invented patent-pending turbine innovations that now make hydrokinetic energy feasible. First, the turbines are designed for easy installation. Transported on the back of a pick-up truck and dropped into place via a simple boom crane, the turbine simply tethers to either side of a waterway and floats or sits in place at the bottom of the canal, requiring little site engineering and minimal permitting. Second, the turbines are scalable. Customers can install turbines side by side, or chain them together along the length of a canal to increase power output. Finally, the modular turbines have a switchblade chassis that allows the customer to choose a rotor that will optimize power output. This is critical because the power in the water flow increases by the cube of velocity, so small changes in speed translate to exponentially larger increases in power.

A major feature of "canal power" is that it is controlled, continuous, and predictable, unlike other sources of distributed generation. Hydrovolts targets canals and other artificial waterways because they are not generally subject to floods or significant debris and actively monitored and controlled by engineers. Thus the turbines generate reliable renewable base load power.

Hydrovolts is the only hydrokinetic company in North America to have the opportunity to test its groundbreaking technology in a federal canal. In the fall of 2012, Hydrovolts received the first-ever License Agreement for hydrokinetic power issued by the US Bureau of Reclamation (USBR) to demonstrate its technology in the Roza Canal, near Yakima, Washington. It was in this canal that Hydrovolts conducted a six week demonstration of our prototype canal turbine, designed to produce five kilowatts (kW) in a flow of two meters per second.

Site Selection Characteristics

This particular test location near Yakima is conveniently located to the company's Seattle headquarters and serves as an ideal test site for several reasons:

1. **Concrete Lining → Fast Water**. Hydrovolts turbines work well in either earthen or concrete channels. Concrete is generally installed to prevent erosion from fast water and therefore signals good hydrokinetic potential. Further, preexisting concrete minimizes environmental concerns.

2. **Accessible**. The site is readily accessible by road, making installation and eventual maintenance easy.

3. **Local Load**. Electricity transmission poles run along the side of the canal, and several electric loads are within a half mile of the site. This allows the generated electricity to be easily interconnected to the

grid and subsidize those loads via a net metering arrangement. The local power utility company is supportive of net metering projects.

4. **Long Wet Season**. The longer the canal is wet, the more energy a site can produce and the faster the turbine's payback. This section of the Roza Canal feeds water to a hydroelectric power plant downstream and operates 11 months of the year.

Turbine Summary

- Hydrovolts' prototype was designed to produce 5 kW at 2 meters per second (m/s). The turbine was significantly more efficient than anticipated, and created up to 8 kW at 1.8 m/s.
- Prototype turbine dimensions were 14 feet wide by 8.5 feet tall by 8 feet deep.
  - Each modular rotor section was 5 foot long and 7.5 foot high. The turbine can accommodate up to four rotor sections.
  - Each end caps was 1.5 feet thick, creating a width of 14 feet (2 rotors and 2 end caps)
  - Though the prototype was designed to float, the turbine was mounted on a brace to limit any sideways swaying and damage to the canal. The brace added an extra foot of height.
- Turbine dry weight was 6,000 pounds.
- The turbine was tethered to bank via 3/8" thick wire cables.
- The submerged turbine raised the water level between 6-8 inches at a water velocity of 1.8 m/s.

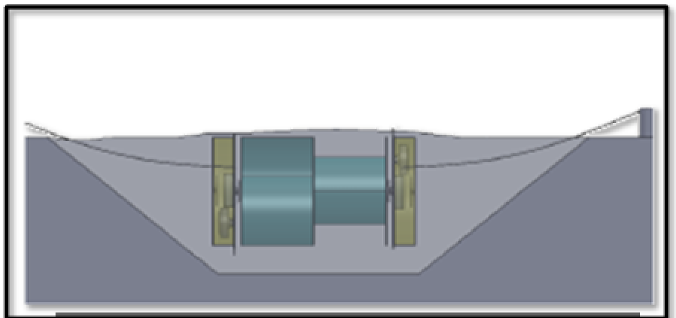
Chief Engineer Jim Styner conducting a dry run test install of the Hydrovolts turbine prototype in Roza canal.

Electrical Summary

- Electricity was generated using a permanent magnet generator, which is housed inside the turbine end caps. For the demonstration period, the power was routed to a resistive load bank to be dissipated as heat. In a typical installation, this power would be fed to a load optimizing inverter or charge controller that would enable a grid-tie connection or remote battery charging.
- The voltage range was between 4-500 volts. This can be stepped up or down depending on need.

Site Summary

- The canal operates from February through December: an 11-month power generation window.
- Maximum flow rate is about 2,100 cubic feet per second (cfs), translating into a swift maximum velocity of 2.1 m/s. At this speed, a single Hydrovolts turbine would generate more than 8 kW: enough electricity to power a subdivision.
- The turbine was installed early in the irrigation season when water demand is low. Flows varied from 1,100 – 1,900 cfs. As flow rate is directly correlated to velocity, power output was affected.
- The trapezoidal concrete canal has a bottom width of 14 feet, a maximum depth of 11 feet, and a 1½ :1 side ratio.



Test section only 14" wide at bottom

Test Installation: Power in Mere Hours

One of the key benefits of Hydrovolts' turbine technology is its ease of installation: with minimal site preparation, the turbine can be easily installed within a single day. Hydrovolts engineers worked with the Federal Bureau of Reclamation 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:

- Hydrovolts prefers to drive earth anchors into the ground upstream of the target turbine location and subject them to proof loading to ensure they can handle the drag loads before the turbine arrives at the site. Once the anchors are located, then cable lengths are defined and manufactured.
- Due to unexpectedly rocky terrain at this particular test site, however, it was prohibitively difficult to drive the earth anchors to the prescribed depths. Hydrovolts thus instead poured concrete anchors in lieu of earth anchors to ensure proper stability.
- An electrical disconnect was installed adjacent to the canal at the target turbine location and underground 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:

- A local crane company drove a boom crane to the site in preparation for turbine arrival.
- Hydrovolts transported the turbine to the site using a flatbed truck.
- Personnel reviewed the installation plan and confirmed roles and safety gear.

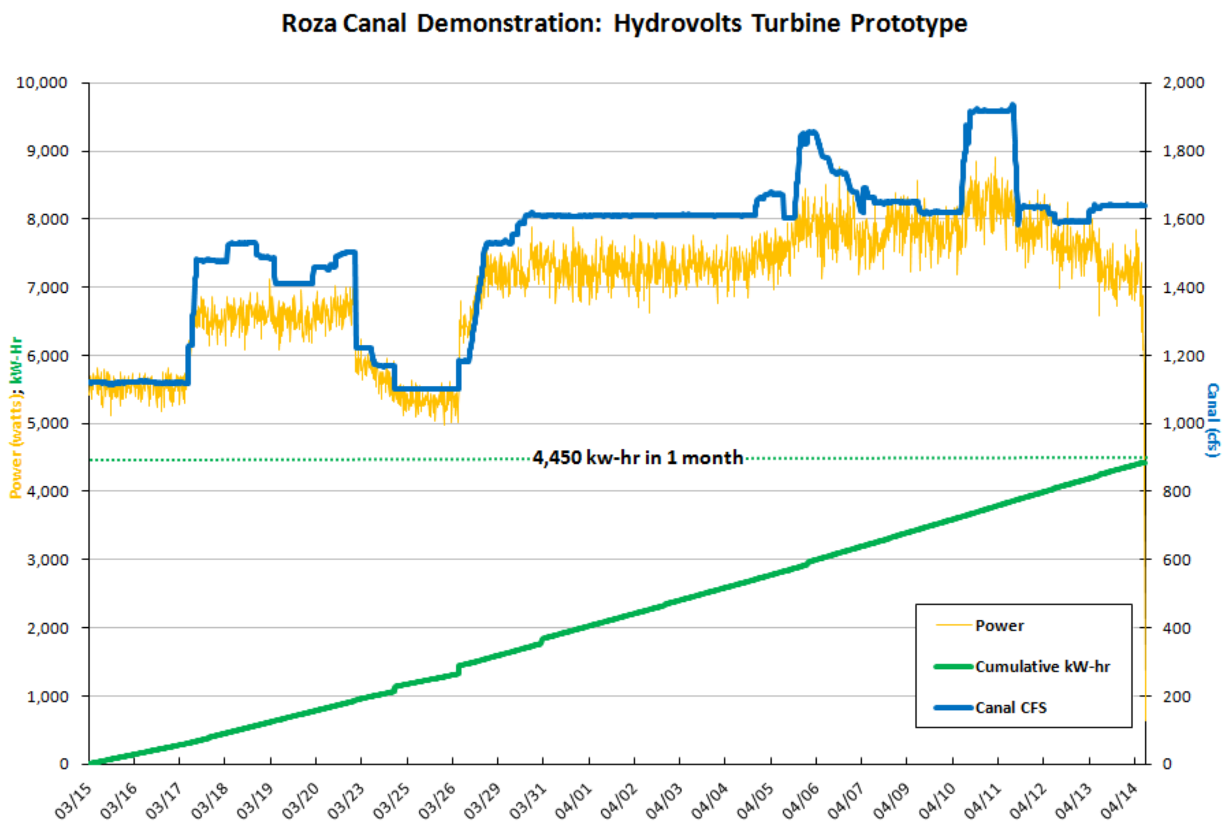
The installation:

A flatbed pick-up truck arrived with the prototype turbine. The boom crane lifted the turbine from the truck and positioned it over the water. As the turbine was being lowered, personnel on both sides attached lines from the turbine to the pre-installed anchors and connected the power output to the load bank. Once the lines were attached, the crane continued lowering the turbine into the water. This entire process took less than four hours, start to finish.

Turbine Installation Pictures

Power Output

The Hydrovolts turbine rotors started turning immediately upon partial submersion, generating power to the load bank. When fully submerged, the turbine exceeded expectations, generating over 7 kW in a 1600 cfs flow 24 hours per day, seven days per week – the most reliable renewable distributed power source installed in the country. A sample month-long power output chart:



- As expected, power output closely tracked the volume of water in the canal.
- The turbine produced 4,450 kWh in one month. At a value of $.11/kWh (average cost of electricity in US, per 2011 EIA data), this translates to a *monthly* revenue of just under $490.

Media Coverage

The successful install has created demonstrable proof of the hydrokinetic power that can now be profitably harnessed from the canals throughout the country. The most notable report includes a featured segment on Seattle's King 5 news, available here.

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.