

Small Hyrdopower Case Study

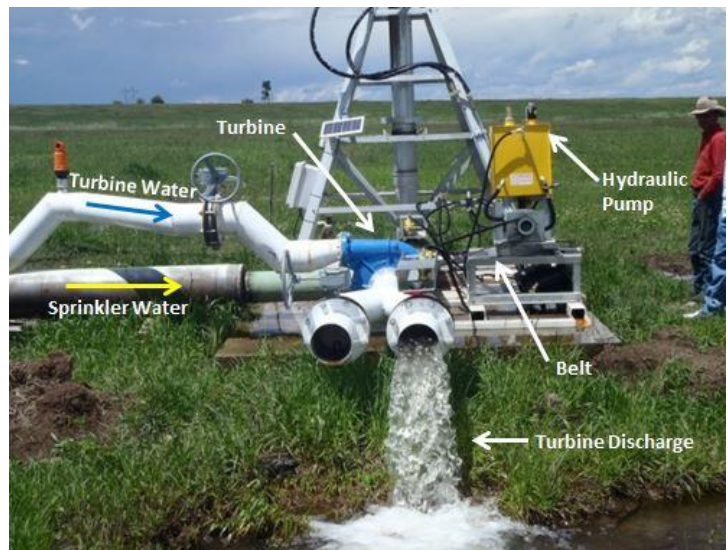
Bear River Ranch Hydro-Mechanical Center Pivot Irrigation Project

Summary

When confronted with rising water costs and low crop yields, Bear River Ranch, located near Steamboat Springs, installed a hydro-mechanical system to power its center-pivot irrigation system. This system uses the power of falling water to directly drive and pressurize the center pivot; this eliminates the need for electricity and significantly reduces operating expenses. The turbine uses 126 feet of head and 560 gpm to produce the equivalent of 5.2 kW of power which drives the center pivot. The \$13,000 project was funded through \$6000 in support from NRCS, yielding out of pocket cost to the ranch of \$7000 and an expected payback of slightly over 3 years.

Background

The Natural Resource Conservation Service (NRCS) encourages water conservation by supporting the conversion of flood irrigation to sprinklers and also supports renewable energy for on-farm applications. By working with the NRCS for project design and financial assistance, Bear River Ranch was able to achieve both NRCS goals. A center pivot sprinkler was chosen as the water conservation measure, which uses significantly less water than the previous method of flood irrigation. A hydro-mechanical system was installed to eliminate the energy required to power the center pivot.



Design and Technical Details

The photograph at right shows the key components of the system: a turbine that powers the hydraulic pump through use of a connecting belt, and water supply lines to power the turbine and provide water to the sprinklers. A single, supply pipeline originates from a settling pond at a point 150 feet higher in elevation. This elevation difference pressurizes the water in the pipeline. Just before reaching the center pivot, the pipeline splits into two smaller supply pipes as shown in Figure 1; the pressurized water powers the turbine (via the pipe denoted with a blue arrow) and supplies the sprinklers (via the pipe denoted with a yellow arrow). The turbine

is attached to a shaft which drives a belt connected to the hydraulic pump. The hydraulic pump powers the drive system that moves the center pivot wheels and turns the sprinkler system.

Hydro-mechanical systems are relatively simple, so complex safety and operational procedures are typically not necessary. Because the use of hydro-mechanical systems is relatively rare, a lack of institutional knowledge has prevented their widespread use to date.

The Bear River Ranch turbine produces an equivalent of 5.2 kW or 7 HP to power the hydraulic pump on the center pivot sprinkler system. The hydraulic pump powers the drive system that turns the sprinkler, and the sprinkler is pressurized through gravity. No pumps, motors or electrical connections are required, resulting in very low annual operational expenses and minimal maintenance. Because it does not produce electricity, the project is not regulated by the Federal Energy Regulatory Commission.

The center pivot is operated only during irrigation season, with operation dictated by the crop's water demand. A T-L Irrigation hydrostatic center pivot with manual speed control was selected for the sprinkler system and a Cornell Pump (5TR5) was selected as the turbine. Cornell pumps are easily obtainable due to their dual purpose. Most pumps can be used for both pumping and as a turbine without any modification.



Construction of the hydro-mechanical system was a fast and simple process, spanning only one non-irrigation season. The center pivot distributor, B&B Irrigation, consulted with Jordan Whittaker of Two Dot Irrigation to select the turbine and design the connection. Because the turbine and hydraulic pump are belted together, their power outputs are essentially equivalent. As such, the turbine was sized to provide 7 HP or 5.2 kW which corresponds to the power needed for proper operation of the hydraulic pump. The turbine uses a flow of 560 gpm at the available 126 feet of working head to provide the 7 HP to the hydraulic pump.

Maintenance of the system is very simple. The turbine will need to be maintained as a pump would, with occasional bearing greasing. The center pivot machinery and turbine are generally given a useful lifetime of 20 years, although with proper operation and maintenance, they can last much longer. Premature wear due to debris and sediment in the water is possible and

could reduce the expected lifespan of the turbine so care must be taken to adequately filter the water prior to its entry into the system.

Economics

NRCS support the project in both the design of the irrigation system and partial funding of the entire project through the Environmental Quality Incentives Program (EQIP) program. EQIP provides financial and technical assistance to farmers and ranchers for the planning and implementation of natural resource conservation efforts. During 2011, EQIP allocated over \$26 million for nearly 800 projects in Colorado. For Bear River Ranch, the NRCS grant lowered installation costs enough to make NRCS the only outside source of funding needed.

The only cost incurred which varied from that of a traditional, electricity-driven center pivot is that of the turbine; the center pivot sprinkler and pipeline costs were equivalent to traditional center pivot installations. The purchase of the turbine amounted to \$13,000 to which the NRCS contributed \$6,000, making the out-of-pocket expense for the system \$7,000. The system saves estimated annual energy costs of approximately \$2,100. Power to spin to the center pivot could alternatively have been obtained through either a diesel generator or grid interconnection if Bear River Ranch had opted for a traditional center pivot irrigation system, but this would result in annual fuel/electricity expenses. If electricity had been extended to the center pivot location, it would have cost \$22,000. Center pivot systems using diesel or electricity would have higher installation costs and would have resulted in higher annual expenses. With the hydro-mechanical system, the initial investment by the ranch of \$7,000 will be recaptured in 3.3 years of energy savings.

Lessons Learned

The project ran successfully through the 2012 irrigation season with no problems reported and increased crop yields using less water than had historically been used with flood irrigation. Many of the ranchers in the area are expressing an interest in installing the same type of system. Some have submitted applications to the local NRCS office, which is hoping to offer design services for this type of system. Such a system can potentially be replicated throughout Colorado in areas where sufficient pressure can be generated using at least 100 to 150 feet of fall.