Solar Powered Water Pumping
for Rotational Grazing in Pennsylvania

ABSTRACT: Solar power can be a viable alternative to conventional power sources for water pumping in remote areas if it is properly designed, installed, and maintained. This was the conclusion drawn from a two-year demonstration and evaluation project conducted on twenty-seven livestock farms across Pennsylvania. The primary objective aside from demonstrating photovoltaic (PV) and direct current (DC) pump technology was to advance the concept of intensive rotational grazing and thus reduce the need for mechanical harvesting and its inherent consumption of fossil fuels. Since water supply is one of the critical components in establishing rotational grazing systems, a reliable cost-effective means of moving water to and from remote locations was needed. On most Pennsylvania farms, water is available but it is seldom located where it will support properly designed and managed grazing systems, therefore it must be moved via pipelines using either gravity or mechanical means. Since water is typically found at lower elevations than is practical for use in most rotational grazing systems it generally needs to be pumped. In addition most under-utilized grazing lands are often very remote and at great distances from grid-power sources, therefore alternative energy sources must be used to power the pumps. Solar power with its inherent non-polluting characteristic appears to be a very acceptable and practical choice for powering water pumps in these rotational grazing systems.

The conventional wisdom on the use of solar energy in Pennsylvania assumes that there are too many overcast days to make it practical. This was a major consideration in the design and implementation of this project. Therefore it was essential to utilize every available ray of solar energy and convert it into stored water. This was accomplished by proper sizing of the solar arrays and by using large water storage tanks that were positioned high on hills. These tanks which were either buried or set in cool wooded areas needed to be large enough to hold three or more days water requirement for the given livestock operation. This allowed the pump to operate continuously during the daylight hours without shutting off. They also provided a water reserve for the cloudy days when less water would be pumped. The larger tanks also eliminated the need for the shut off switches and wiring that are otherwise necessary to prevent overflow of the smaller tanks. The solar arrays and pumps need to be sized to convey at least a one-day water requirement to the storage tank. Where finances and available water supply allows, a higher delivery rate is recommended. This will help avoid the need to supplement water during extended periods of overcast skies.

The placement of the water storage tanks high on hills provided gravity flow via pipelines to portable drinking troughs located through out the pasture system. Typically these were portable plastic tubs that were connected to the water supply pipeline with hoses and quick connect adapters. The supply lines were buried or laid on the surface along fence lines. For year-around use they must be installed below the frost line and be fitted with frost-free hydrants. Most livestock pipeline watering systems, however, were installed for seasonal use and drained before winter. A few of these were installed on grade and buried approximately one foot under the surface to provide cooler water. The plastic tubs as pictured above are manufactured in a wide range of sizes and configurations. They are the recommended types of drinking trough for the pipeline watering systems. Precast concrete troughs were used where only one or two water access areas were provided. They typically were sized at 500 or more gallons and often served as both the storage tank and drinking trough. This, however, is <u>not</u> a recommended design practice.

SOLAR ARRAYS: The solar panels were wired to match the voltage requirement of the selected pump. Typically DC water pumps that would be used for livestock water systems require 12, 24, 36, or 48-volts with 24-volts being the norm. Each solar panel is manufactured to produce 12-volts DC. For 24-volt systems, two panels wired in series are required. Two series pairs combined in parallel on four panel arrays provides additional power. The arrays are mounted on specially designed racks and are typically supported by a single metal pole. Tracker type racks can be used to maximize power by enabling the array to follow the sun's movement across the sky. Most installations, however, used stationary arrays that were oriented due south. The arrays were sized to provide the wattage required by the selected pump plus twenty-five percent extra to aid in kick-starting the pump. It was found that this 25% was critical for the installations due to the common occurrence of overcast skies. Extra array capacity beyond the 25% allows the pumps to operate even more efficiently under the overcast skies. The individual solar panels were wired with 12-guage braided wire. The solar electric current was wired into a disconnect box that included a lightning arrestor and then to the pump controller. Most systems were wired PV-Direct (without batteries) for maximum power efficiency. Wire size ranged from #10 AUW up to #4 AUW depending on the distance between the solar array and the pump.

PUMP CONTROLLERS: The most fragile component in a solar powered watering system was found to be the pump controller. It is an essential component that controls the voltage and amperage that is delivered to the pump. It converts excess voltage from the solar array to amperage to kick-start the pump motor early in the day and it keeps the pump running longer in the evening. It protects the pump from high or low voltage conditions by matching the peak power of the array with the voltage requirement of the loaded motor. The problem most often encountered was controller burn out which we could only attribute to possible stray voltage from near-by electric fences. This primarily occurred where the motor shut-off float switches were used with connecting wires buried along the fence line. If such switching is necessary then only 18-guage shielded wire should be used and it along with the controller should not be installed near an electric fence. Proper grounding is essential, as is strict adherence to the polarity of the controller terminals. Reverse polarity will also burn out a controller.

PUMPS: Two primary types of pumps were determined to be the best suited for solar water pumping installations on livestock farms although several types were demonstrated. Since most water utilized in grazing systems comes from streams, springs, and ponds, the surface piston pump (pictured on the left) was found to be the most durable and dependable. It is tolerant of dirty water and uses the least power per gallon of water delivered. Its suction limit is 25 feet with a water delivery rate of 4.5 to 9 gallons per minute and a lift capacity of approximately 150 feet. A submersible piston pump is available for wells as deep as 600 feet. The diaphragm type submersible pumps are significantly less expensive than the pistons but require more maintenance and pure water. They, however, proved to be very cost effective and very suitable for smaller livestock watering installations.

WHEN IS SOLAR WATER PUMPING THE RIGHT CHOICE?
It was determined that the cost-effective break-even distance from conventional power and domestic water sources is approximately one-quarter mile. For greater distances solar would be the less expensive alternative based on the cost of installation. From an environmental protection stand point, solar water pumping is naturally the right choice because it consumes no fossil fuels and allows you to set up grazing systems almost anywhere without adversely impacting the waters of the Commonwealth.

This project was funded through a grant from the Pennsylvania Department of Environmental Protection
Office of Pollution Prevention and Compliance Assistance

Technical Assistance was provided by the USDA Natural Resources Conservation Service
In cooperation with the Pennsylvania Resource Conservation and Development (RC&D) Councils

For more information, visit us on the Web at www.parcd.org