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Water For Livestock Using Solar Generated Electricity[1]

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TRADITIONAL WATER SUPPLIES

Surface water is the usual livestock water supply source on Florida ranches. Since the early 1500s when Spanish explorers brought cattle to Florida, creeks, sloughs, lakes and rivers have provided the water needed for beef production. Since the invention of the dragline, dug-out ponds have also been used quite extensively as a surface water supply.

There are advantages and disadvantages to surface water supplies. One of the major advantages of natural surface water is that it has no installation or maintenance cost to the rancher. Disadvantages often include the distance to the natural water supply, such as a creek, from the grazing area. Surface water also can be unreliable during drought periods. It may often present a health hazard. Cattle infected with Leptospirosis can infect other members of the herd by urinating in the water supply. In addition certain areas of Florida have an aquatic snail which carries the cattle liver fluke organism. An advantage of dug-out water holes is that they can be placed where the rancher wants them in most of the "flat woods" pastures in Florida. However, in addition to a high initial installation cost, they present the same or bigger health problems as natural surface water sources. Dug-out water holes are generally muddy and unclean since there is no upstream source to refresh the water.

On some ranches only groundwater is available naturally for the livestock. Windmills used for pumping groundwater enjoyed a brief popularity in Florida. Few still remain, having been replaced by dug-out water holes where natural surface water sources are absent. Windmills are unreliable in Florida because of generally low wind speeds and occasional severe summer storms or hurricanes. Calm days may leave cattle without water and strong thunder storm or hurricane winds can destroy windmills. In addition windmills are expensive to purchase and maintain. New energy supplies for pumping groundwater, that are reliable and economical, are of great interest to Florida ranchers, because a good supply of clean water can eliminate many problems in livestock production.

ALTERNATIVE WATER SUPPLIES

Perhaps the most compelling reason for ranchers to consider alternative methods of supplying livestock water is the increasing environmental concern and legislation involving surface water. The Surface Water Improvement and Management (SWIM) legislation is currently being enforced in south Florida. Natural surface water has been fenced

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Table 1. Pump options for solar photovoltaic powered water pumping systems

PUMP TYPE	RATE (gal/min)	TDH (ft)	COMMENTS
positive displacement rotary vane	0.15 - 3.5	470	self - priming; not submersible; does not tolerate sand or silt; 25 ft lift
diaphragm	1.7 - 4.8	210	self - priming; can be run dry without damage
centrifugal jet	0.5 - 23	5 - 60	self-priming; motor must be kept dry
centrifugal	1 - 55	100	suction lift limited to 25 feet
centrifugal submersible	0.5 - 67	450	four - inch well required
diaphragm submersible	0.5 - 1.7	230	four - inch well required
jack	0.5 - 15	1,000	

off in some areas where phosphorous loads exceed the water management district's limits.

The cost of installing electric power lines for the purpose of pumping water in remote pasture areas is prohibitive. Using solar generated electricity to pump water for livestock can be a cost-effective and reliable method of placing the water supply where it is needed without producing the negative environmental effects of electricity generated from coal, oil or natural gas.

PHOTOVOLTAIC (PV): ELECTRICITY FROM SUNSHINE

Many PV cells are made from silicon, the same stuff as the sand at the beach. A PV cell has two sides; one side has extra electrons, and the other side lacks sufficient electrons. When sunshine hits a PV cell, the solar energy dislocates electrons from the side with too many. These dislocated electrons, which have a negative charge, are drawn to the other side of the PV cell which is short in electrons and has a positive charge. This sets up a flow of electrons in tiny wires connected to each PV cell. Electrons flowing from all the PV cells together generate the direct current eletricity which drives the motor. The only thing that moves in a PV cell is the electrons. PV cells can last twenty years because there are no moving parts to breakdown.

EVALUATING THE WELL

One of the most important phases in designing a solar water pumping system is evaluating the well. If the rancher is fortunate enough to have unused wells on his property, the expense of drilling a new well may be avoided by evaluating the well. If the well is found to be usable, installing the PV pumping system on-site can be a simple matter.

Using compressed air, the well driller can determine water yield and draw-down level and remove some accumulated trash from an old well. The water will almost certainly be dirty at first but can clear up after prolonged pumping if the original screen and casing are intact.

An experienced well driller can have a good idea of the well depth needed for a good water supply in his working area. In many cases artisan pressure pushes water close to the ground level. If this is the case and the well yield is adequate, a centrifugal pump can be used. Otherwise, submersible positive displacement type pumps must be used to push the water up and out of the well (Table 1).

The theoretical pumping limit for a suction pump is approximately thirty-four feet. That is the limit regardless of the motor size connected to the pump because suction is limited to one atmosphere of negative pressure. The practical limit for a centrifugal pump is about twenty-feet because of pipe friction, non-perfect seals, etc.

When evaluating an existing well for conversion to a solar pumping system, the following questions must be answered:

What is the size of the well casing?
Is the casing in good condition with no pin hole leaks?
How deep is the well?
What is the depth to the water surface?
How much water will the well produce?
What is the draw-down level during water flow?
Is the water free of silt and sand?
How many gallons of water will the livestock need each day?

SYSTEM DESIGN

PV cells generate electricity at their maximum rate under clear, sunny skies. They don't generate electricity at night or on extremely cloudy days. Under partially cloudy central Florida August skies, PV systems turn off and on as clouds pass over head. The certainty of clouds passing overhead and the occasional overcast day are factors in designing the PV system.

There are two things which increase the power output of a PV system: a larger area covered by PV cells, or a high level of sunshine all day long. While the first is easily controlled by design, nature alone controls how much sunshine falls on any particular day.

The PV array needs to be large enough to deliver enough power to work the pump on partially cloudy days, but oversizing the PV array adds unnecessary expense.

The DC motor and pump assembly must be sized correctly also. The voltage and amperage requirements of the motor need to match the voltage and amperage output of the PV system. This must be checked carefully. Direct current motors are designed to work at varying or reduced power levels without overheating as alternating current motors do when power levels fluctuate. If the entire capacity of the pump is desired under full sun, the voltage produced by the solar array should exceed the pump model wattage specifications by at least fifteen percent. County Extension Agents, The Florida Energy Extension Service, the Florida Solar Energy Center and system manufacturers can provide assistance in system design.

OPERATING EXPERIENCE

The well used in the Osceola County demonstration was an abandoned two-inch windmill well. The well was one hundred feet deep with seven feet to the water surface. An experienced well driller gauged the well yield at thirty gallons per minute with draw-down not more than eight feet. With this information, it was determined that a 36 DC volt 15 amp motor and centrifugal pump would deliver the needed water.

The PV array in the Osceloa County solar pumping demonstration was almost 27 square feet (4.2 ft x 6.4 ft) and cost about $2,000 (Table 2). The six-panel photovoltaic array was sized to produce 270 watts of DC electricity from 2,700 watts of solar radiation (full sun) under perfect operating conditions. The actual power delivered to the motor was about 240 watts under full sun due to factors such as line resistance and length of run of the electricity. The system needed a minimum of 900 watts of solar power (energy arriving from the sun) to pump water into the tank. The system yielded up to 10 gallons per minute under peak sunshine (Figure 1).

Table 2. 1992 prices for various livestock water supply options

SYSTEM	COSTS (approx.)
wind generators (windmills)	$4,500
photovoltaic (270 peak watts)	Panels: $2,000; Motor & Pump: $600
electricity from a utility company	Power line: $10,000 per mile; Motor & Pump: $300
dug out pond	$3,000 for 0.5 acre pond

Water was pumped into a five-hundred gallon water tank. The float switch turned the pump off when the tank was full, and allowed the pump to resume operation when the water level receded six inches. This conserved water and kept the ground around the water tank from becoming muddy as it did when the windmill was in operation.

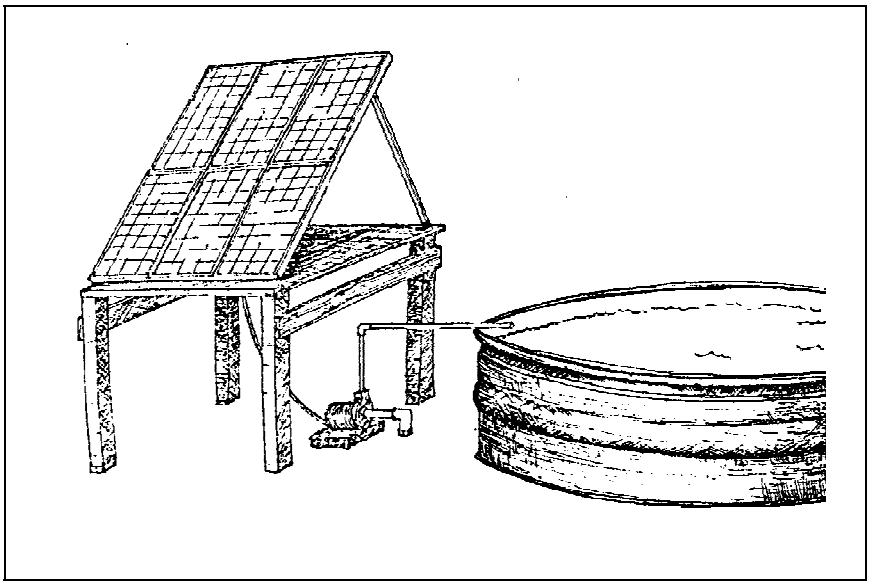

Figure 1. Solar photovoltaic (PV) powered water pumping demonstration for livestock

The herd used for the demonstration consisted of thirty pregnant cows. The water supplied by the PV pumping system was more than adequate, so the installed float switch was used almost daily to turn the pump off when the tank was filled, preventing waste.

WHAT ABOUT CLOUDY DAYS?

Just as there are days without wind to power a windmill, there are days without sunshine. There are two ways around the cloudy day problem. One is to install a power controller, a battery charger and a battery to supply energy to the pump on demand. The other solution is to simply store the energy, i.e., the water above ground in a large water tank, or in several smaller tanks.

Storage batteries increase the cost, complexity and maintenance of a PV pumping system. Solar pumping system manufacturers recommend using the above groundwater tank storage method whenever possible.

WHAT ABOUT TRACKING SYSTEMS?

The PV array at the Osceola County solar water pumping demonstration did not track the sun. It was pointed due south with a tilt angle of forty-five degrees and mounted on a stationary wooden platform. On a typical August morning, it began supplying enough electricity to pump water at about 9:30 a.m., usually before the summer day rain clouds began developing. The water tank would fill in the morning and keep the cattle supplied until the next day.

Solar trackers which tilt the PV array towards the sun and follow its movement during the day, increase the amount of electricity generated and the amount of water pumped. However, this adds considerable expense and the rancher may prefer the less expensive, more dependable stationary PV array.

CONCLUSION

Solar pumps require no fuel and are low maintenance. There are no moving parts in the PV cells and most manufacturers guarantee them for a long lifetime.

DC pumps can be selected to fit the existing conditions. Even if the well water level is one-hundred feet or more deep, solar-powered positive displacement pumps can push it to the surface. And, if a well produces only two gallons per minute, a PV powered pump can deliver seven hundred and twenty gallons of water with only six hours of good sunshine.

Solar energy is there where you need it. You do not need to truck it or pump it or pipeline it to your pasture. When the sun is shining brightly, making the cattle more thirsty, the PV system is also pumping more water for them. When it is overcast and rainy, the PV system will not pump as much water, but the cattle will not need as much drinking water during cooler, cloudy weather. Therefore, using solar photovoltaic-generated electricity to pump water for livestock can be cost-effective and reliable.