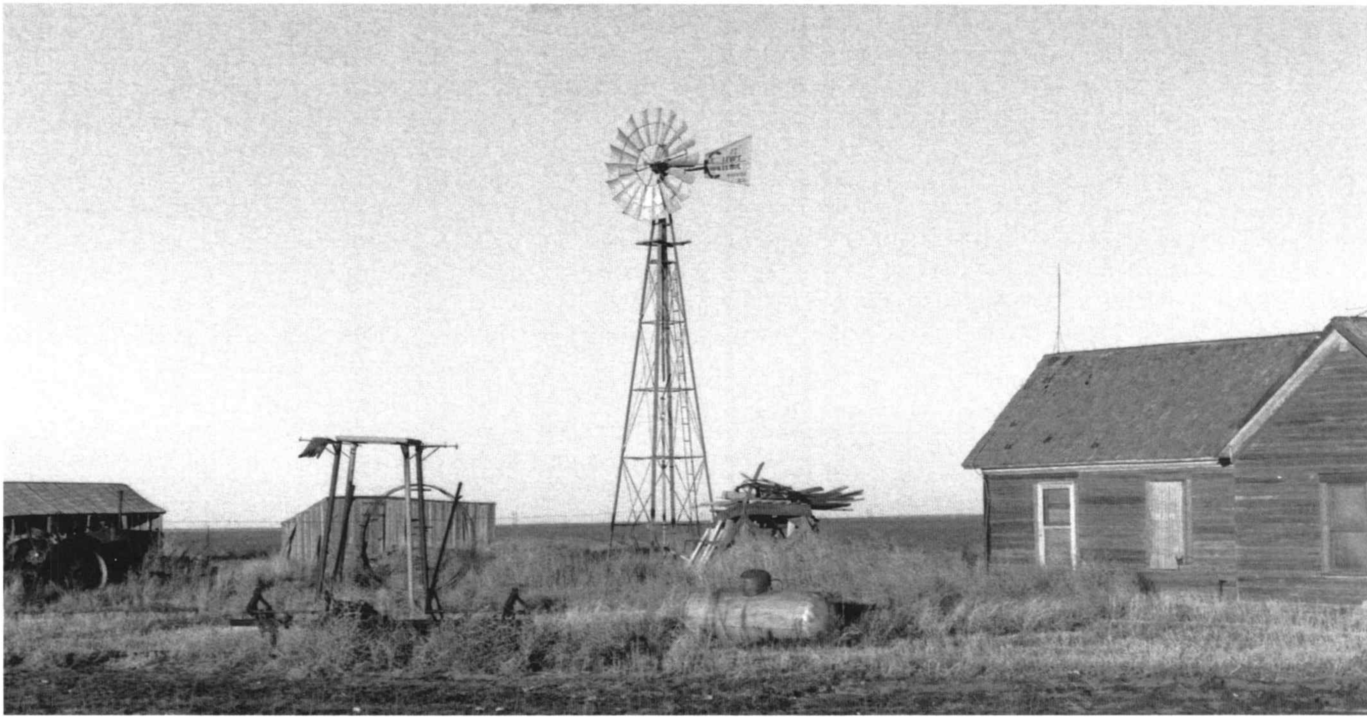


Windmills in use.

Windmills or Solar Watering Systems

M. Wade Polk and R. T. Ervin

In many parts of the American Southwest livestock producers are faced with an inadequate water supply on a regular basis. Ranchers are often faced with the decision of choosing a means of providing water in remote areas. Many have learned to depend on the windmill for supplying water. Although the electric submersible pump has also been used for watering livestock, this option is not always economical for isolated areas lacking a ready source of electrical power.

Windmills seen on many farms and ranches throughout the U.S. were developed in the 1860's (Torry 1976). These windmills have a horizontal-axis rotor, often called head-on machines, meaning that the axis of rotation is parallel to the direction of the wind. Railroads were one of the early users of windmills to fill water tanks for locomotives. Ranchers and homesteaders used them to irrigate. There are approximately 150,000 windmills in the United States, with the majority being located in western rangelands (Cheremisinoff 1978). A major problem associated with windmills is the variability of wind which causes some water needs to be unmet when the wind quits blowing.

An alternative source of power for water delivery is the newly developed solar powered watering system. The solar water system traps sunlight on a photovoltaic panel, converts the sunlight to electricity, which powers a submersible pump.

Windmills and solar water systems represent alternative means to pump ground water. However, given these 2 alternatives, the question remains, which is the most cost-effective means of delivering water to the livestock? One system, solar, may have a relatively low initial cost, and a relatively short expected life; the other system, windmills, may have a relatively high initial cash outlay, and a relatively long expected life.

Scenario

A representative farm or ranch watering scenario is assumed for the purpose of comparing the windmill to the solar water system. The depth of the well is 100 feet and both water systems are able to produce approximately 800 gal/day. The following assumptions are made: (1) the well is in place; (2) there is no electricity at the well site; (3) both systems will pump enough water to meet the needs of the producer; and (4) the producer wishes to minimize costs.

The initial investment and maintenance costs of the 2 systems were obtained from distributors of the systems

(Table 1). The initial cost of the windmill system represents the windmill motor, tower, cylinder, drop pipe and sucker rod. The initial cost of the solar water system represents the photovoltaic cell, stand, wires, submersible pump and drop pipe. The expected useful life of the windmill ranges from 30 to 70 years, while the solar water systems are expected to last 10 years. Prices for new windmill equipment range from approximately $4,000 to $5,000, and the solar water systems range from $2,500 to $3,000. Thus, while one system offers a relatively long expected useful life the other system offers a reduction in initial cash outlay.

Table 1. Costs of watering systems[a]

WINDMILLS: Projected Annual Maintenance Expense is $34.14

New Price	Used Price	Useful Life
$4,708.00[B]	$3,132.00	up to 70 yrs
$4,033.00	N/A	30 to 50 yrs
$4,968.00	$3,868.00	50 to 70 yrs

SOLAR WATERING SYSTEMS: Projected Annual Maintenance Expense is $32.76

New Price	Useful Life
$,2,500.00 to $3,000	10 yrs

[a]Sources:
Aermotor Windmill Corporation, P.O. Box 5110, San Angelo, Texas. (915)651-4951
Allen Pump Hwy. 82 E., Ralls, Texas. (806) 253-3656
Dempster Industries Inc., 4709 Clovis Hwy., Lubbock, Texas. (806) 765-9393
Robinson Solar Systems, Canton, Okla. (405) 886-3529
Topper Co. 1508 Beacon, San Angelo, Texas. 1-800-775-3277
[B]Two sources reported this price.

The projected annual maintenance expense of the windmill was estimated as the sum of the oil required for annual maintenance, and the annualized cost of replacing the leathers every 5 years. One quart of oil is required for annual maintenance, $4.25/quart. It is assumed that it takes approximately 30 minutes to replace the oil, $4.25/hour. The total annual cost of replacing the oil is $6.38/year. It is assumed that it will take 3 hours to pull the well to replace the leathers costing $52.50/hour for the well pulling rig and labor. It is also assumed that there are 4 leathers requiring replacement which cost approximately $3.00/leather. The total cost of replacing the leathers every 5 years is estimated to be $169.50. Windmill owners expecting to spend $169.50 every 5 years to replace the leathers could accumulate this amount if they were to save $27.76/year at 10% annual interest. This value is estimated as the annuity required to build a future value of $169.50 at 10% interest rate for a period of 5 years (Barry et al. 1979). Therefore, the annual estimated maintenance expense for the windmill is estimated to be $34.14.

In the solar system, the pump will require replacement every 5 years at a projected cost of $200.00. The pump owner would expect to spend $200.00 after the first 5 years of service to replace the pump. After the second 5 year period the producer replaces the entire solar water system, so replacement of the pump is not considered during this period. Producers could accumulate this amount if they were to save $32.76/year during the first 5 years of service at 10% annual interest. This value is estimated as the annuity required to build a future value of $200.00 at 10% interest rate for a period of 5 years (Barry et al. 1979). Therefore, the annual estimated maintenance expense during the first 5 years of service for the solar water system is estimated to be $32.76.

Comparing Investments with Different Economic Lives

When evaluating investment alternatives with different economic lives, it is necessary to (a) estimate the present value of cash flows over the respective economic lives; and (b) convert the present values to annuity equivalents. Because the economic lives differ between the water systems, the present values of cash flows are not comparable. The annuity equivalents allow for a comparison between the systems by determining the size of the annual annuity required for the economic life of the investment that should be provided to be equal to the present value of its projected cash-flow stream, given the cost of capital. An annual discount rate of 10% is assumed.

The Equation used to estimate the present value of the cost of the systems is:

$$V = \textit{Initial Cost} + \textit{Annual Cash Outflows}\left[\frac{[1-(1+i)^{-T}]}{i}\right]$$

where
V = present value of the cost of the systems
i = annual discount rate assumed to be 10%
T = number of years the annual cash outflows are considered

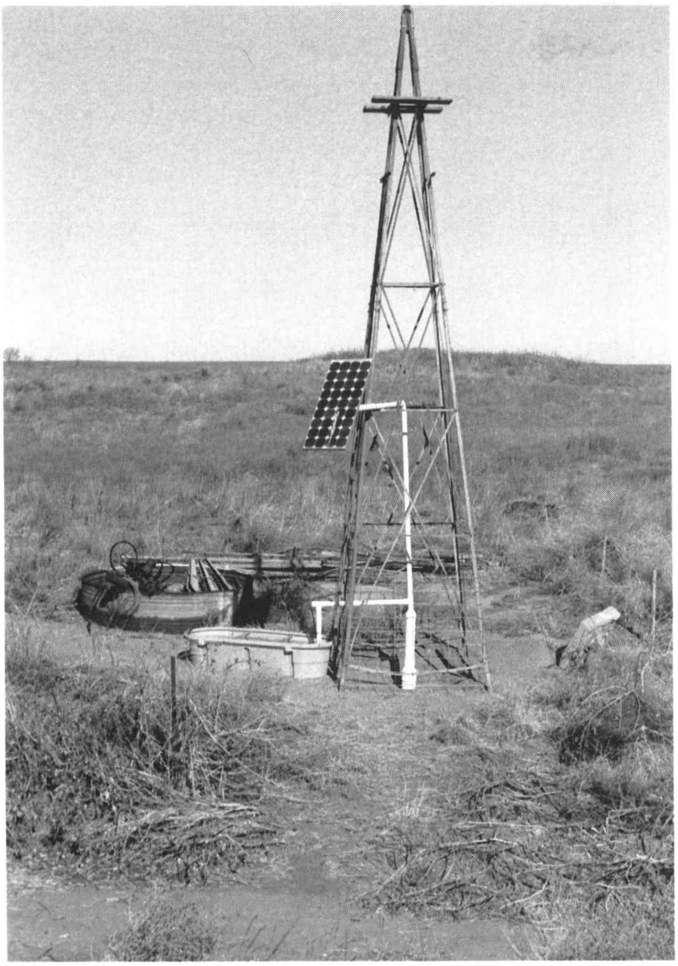
Present Value of Solar Water Systems: Assuming the initial cost of $3,000.00, the present value of the cost for the solar water system is estimated to be $3,124.19. This value includes the present value of the cost of establishing the solar water system with an expected economic life of 10 years plus annual maintenance of $32.76 during the first 5 years of service.

Present Value of Windmills: Assuming the initial cost of $4,708.00, the present value for the windmill water system is estimated to be $5,046.49. This value includes the present value of the cost of establishing the windmill with an expected economic life of 50 years plus annual maintenance of $34.14.

Because the economic lives differ between water systems the present value of cash flows is not comparable necessitating the annuity equivalents. The equation used to estimate the annuity equivalents for the above present values is:

$$V = A\,\frac{[1-(1+i)^{-N}]}{i}$$

where
A = annuity equivalent
N = number of years the system is expected to work.



Windmills converted to solar water systems.

Thus, the annual value of the annuity equivalent for the solar water system is $508.45 and for the windmill water system is $508.98. Given the assumptions made for this analysis and the difference in the annual annuity the cost of the systems is essentially equal.

Sensitivity of Results:

The above results may be dependent upon the values of the components initially considered. Thus, in an effort to determine whether the results may change if the initial values were to change, the following scenarios are constructed and estimated: (1) base scenario representing those values used to develop the above results: all succeeding scenarios reflect changes to the base, (2) reduce initial cost, (3) increase annual maintenance cost, (4) increase the discount rate, (5) decrease the discount rate, and (6) reduce the expected working life of the respective water system by 40%.

Changing the initial cost of the systems to the lowest reported costs causes the solar water system to be $13.83/year less costly than the windmill. When the cost of annual maintenance is increased to $50 for each system, the advantage ($5.76) remains with the solar water system. Increasing the discount rate to 12%, results in the advantage again being held by the solar water system by $49.21/year for the life of the system, while decreasing the discount rate to 8%, results in the advantage shifting to the windmill by $47.59/year. Finally, reducing the expected working life of both systems by 40%, results in an annualized equivalence value of the solar water systems costing $25.11/year less than the windmill.

Comparing the 2 net-present values coupled with the economic lives of each system, using the annuity-equivalent method, the discount rate and expected useful lives of the systems found which system is the most cost effective investment. However, ranchers and livestock producers should evaluate their circumstances before choosing one of these watering systems. The windmill is a trademark of western rangelands and may represent romantic and/or nostalgic value to some people. Many replacement parts for windmills are readily available, with installation relatively simple (Hayes and Allen 1983). Generally the windmill is permanently placed and not easily moved, while many solar water systems are capable of easily being moved from one well to another. On the other hand, lightning strikes will effect the two water systems differently. A windmill struck by lightning will generally continue to pump water whereas a solar water system would be expected to need repair.

Whether the discount rate is above or below 10% is anyone's guess. If the rancher is pessimistic on the direction of the economy and expects the discount rate to be above 10%, then the solar water system would be the most economical investment. The optimistic rancher, expecting the discount rate to be at or below 10% might choose the windmill. However, producers must seek the best system for their specific needs.

References

Barry, P.J., J.A. Hopkin, and C.B. Baker. 1979. *Financial Management in Agriculture* Second ed., The Interstate Printers & Publishers, Inc., Danville, Illinois.

Cheremisinoff, N.P. 1978. *Fundamentals of Wind Energy*; Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan.

Hayes, D., and B. Allen. 1983. *Windmills and Pumps of the Southwest.* Eakin Press, Austin, Texas.

Torry, V. 1976. *Wind-Catchers: American Windmills of Yesterday and Tomorrow*; The Stephen Greene Press, Brattleboro, Vermont, N.H.

Authors are undergraduate student and Associate Professor, Department of Agricultural Economics, Texas Tech University, Lubbock, Texas. Publication number T-1-425 of the College of Agricultural Sciences and Natural Resources, Texas Tech University.