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Energy and irrigation system planning

Most irrigators are concerned with the spiraling costs and threatened shortages of energy for irrigation pumping. Energy costs are expected to continue increasing and, in some areas, limited energy supplies may restrict irrigation development.

Irrigation systems are normally based on a least cost design. With low energy costs, for example, it has been more economical to use smaller pipes than would be used for minimum-energy designs. Future systems may require a minimum-energy design to minimize energy inputs. As energy costs increase, this also may be the least cost design.

Energy costs should be considered when evaluating alternative systems. Most economic analyses and comparisons of energy requirements assume that surface irrigation will remain less efficient than sprinkler irrigation. This assumption could lead to selecting a system today that in the long run may be the most costly. Studies conducted at the University of Nebraska with automatic surface systems using gated pipe and a reuse system indicate that irrigation efficiencies as high as 90% can be achieved. Similar results have been obtained in Idaho using an automatic buried lateral system. Without a reuse system, efficiencies in the 70% range have been obtained with automated systems.

Surface systems are not suited to all soil and topographic conditions. However, where labor requirements are not excessive, surface irrigation will usually be the most economical system where soils are erosion resistant, have moderate to low intake rates, have less than 1½% slopes and are otherwise well suited for surface irrigation. Many surface systems have been converted to sprinklers to reduce labor and to increase irrigation efficiency. Both of these objectives can usually be met at a much lower cost by using automated surface irrigation where field conditions are suitable.

The irrigation industry is becoming more interested in automatic surface irrigation and some valves and controls are now available commercially. Additional systems and components will be available in the near future. The development of laser-beam-controlled equipment has made precision land leveling for surface irrigation easier and less costly, especially for level basins.

Annual operating energy cost can be an important consideration in selecting an irrigation system. A graph for estimating pumping costs for different irrigation efficiencies and pumping heads is presented. For example, if the net annual consumptive irrigation requirement is 25 inches, 36 inches must be pumped with a 70% efficient irrigation system. Electrical energy to pump this amount for a surface system operating at 10 psi at the pump would be 108 kilowatt-hours (kWh) per acre and cost $2.16 at 2 cents per kWh, assuming 65% pumping plant efficiency (motor and pump).

Comparative costs for a wheel line sprinkler requiring 65 psi (150-foot head) would be $14 for 700 kWh. With a circular sprinkling system operating at 90 psi (208-foot head) and achieving 75% irrigation efficiency, 33 inches of water would be required and would cost $18.18 for 909 kWh. The above comparisons assume that water is available at ground elevation and the pumping plant is in good condition. Costs would be proportionately greater for an older system or one operating at less than 65% efficiency. An additional 468 and 437 kWh, respectively, for the two different volumes of water pumped would be needed for *each 100 feet* of lift to ground elevation.

Erroneous conclusions can be reached in long-range planning by assuming that surface irrigation will always be less efficient than sprinkler irrigation. For example, at 50% surface irrigation efficiency, 50 inches of water must be pumped to meet a consumptive irrigation requirement of 25 inches, which would require 151 kWh. At 85% irrigation efficiency, attainable with an automated surface system with reuse, 29 inches of water would be needed, requiring 89 kWh plus 30 kWh to repump approximately one-third of the water by the reuse system. Many surface systems require only about 10 ft of head (4.3 psi) instead of the 3 feet (10 psi) used in this example.

As the pumping lift increases, irrigation efficiency has a larger effect on the energy cost. The cost of

Annualized Cost Factors For 9% Annual Energy Cost Escalation

Interest Rate	Useful Life — Years 10	15	20	25	30
Percent					
10	1.420	1.683	1.961	2.249	2.542
12	1.403	1.637	1.870	2.094	2.304
15	1.378	1.575	1.751	1.903	2.030

electrical energy (at 2 cents per kWh) to lift the required amount of water to satisfy a 25-inch net consumptive irrigation requirement 400 feet, in addition to the pressure energy cost, for surface and sprinkler systems having different irrigation efficiencies, would be:

Surface	
50% efficient (50 in. water)	85% efficient (29 in. water)
$55.52	$33.25

Sprinkler	
Wheel Move 70% efficient (36 in. water)	Circular 75% efficient (33 in. water)
$51.54	$53.14

Thus, by assuming that surface irrigation systems will always be inefficient, a person may invest in a system having a higher operating cost than if an alternative system were used. These figures represent only the energy costs. The amortization cost of the initial investment, maintenance and other related costs must be added to obtain the total annual cost of owning and operating the system.

By using conversion factors, one can also use the graph to estimate pumping costs with natural gas and diesel. The equivalent amounts of fuel used will vary with the heat value of the specific fuel and the efficiency of the engine. For estimating purposes, the kWh values from the graph can be multiplied by 13 to convert to cubic feet of gas and by .09 to convert to gallons of diesel fuel. Thus, 100 kWh from the graph will be equivalent to approximately 1300 cubic feet of natural gas and 9 gallons of diesel fuel. The equivalent cost can then be determined by multiplying these values by the respective local fuel costs.

Another factor to consider in long-range planning of irrigation systems is the escalating cost of energy. The cost of most forms of energy has recently been increasing at about 9% per year. At this rate, the cost of energy will double approximately every 8 years.

An escalation factor can be used to evaluate the increasing cost of energy over the useful life of the system. With the annualized cost method, the accumulated energy cost over the useful life of the system is determined in terms of the first-year energy cost. The total accumulated energy cost is then distributed over the useful life as an annualized cost which can be added directly to the annual fixed amortization cost in determining the total annual cost of the system. Multiplying factors are shown in the table for different interest rates and useful life.

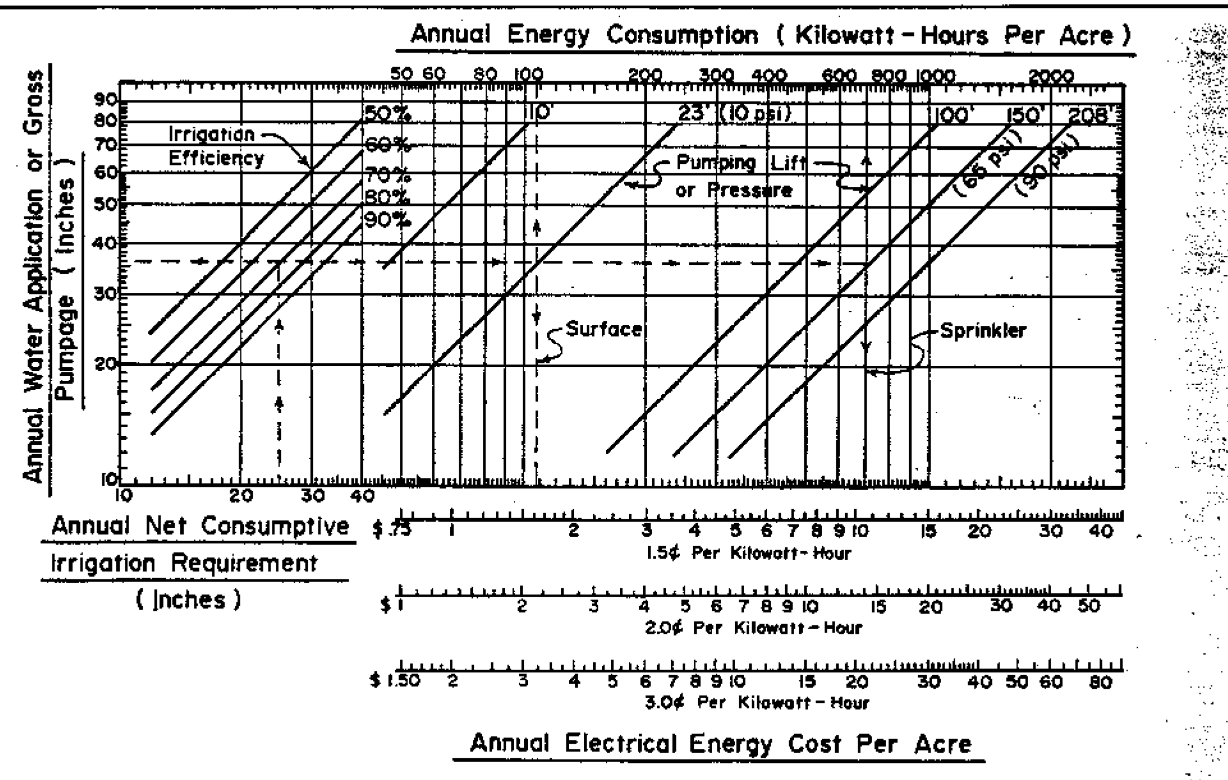
The first-year energy cost, such as that determined from the graph, is multiplied by the appropriate factor to determine the equivalent annualized cost. Most of the escalated energy cost occurs in the later portion of the useful life; however, this method distributes the increased cost over the entire useful life to give an equivalent annual cost as a basis of comparison between alternative systems.

For example, with a 12% interest rate and a system useful life of 15 years, the equivalent annualized energy cost each year would be 1.637 times the first-year energy cost. This factor applied to the first-year energy costs in the previous 400-foot-lift example would result in the following equivalent annual energy costs:

Surface	
50% efficient	85% efficient
$90.89	$54.43

Sprinkler	
Wheel move	Circular
$84.37	$86.99

Energy is one more complicating factor to be reckoned with by the irrigator in making present and long range plans and decisions.



Annual Energy Consumption And Cost For Different Irrigation Efficiencies And Pumping Lifts With A Pumping Plant Efficiency of 65%