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Efficient Crop Drying

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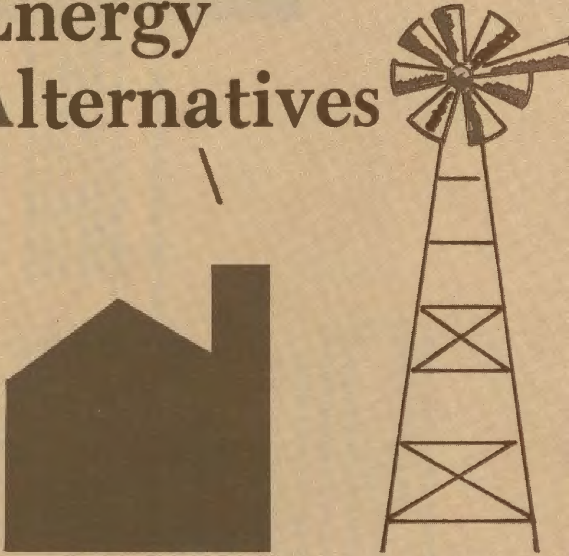
South Dakota Cooperative Extension Energy Information

Irrigation Energy Alternatives



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SOUTH DAKOTA
OFFICE OF ENERGY POLICY
ENERGY INFORMATION

Irrigation Energy Alternatives

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Agricultural production requires 3% of the total energy used in the U.S. Approximately 13% of that energy was used for irrigation in 1976.

Since energy consumption and conservation is of national interest, agriculture and other segments of the national economy have been summoned to review the utilization and related productivity of energy consumption.

Three things influence the amount of energy required to move water from a water supply to storage in the soil profile for crop use (Figure 1). These factors are volume, pressure and efficiency.

Total **volume** of water is determined by the number of irrigated acres and the total depth of water applied to the land. The size of the power unit is determined by the volume of water and pumping time. A properly sized pump and a 100-hp unit can pump a volume of water twice as fast as a 50-hp unit. Both units still require the same total kwh (kilowatt hours) of electricity, but the 100-hp unit would use the energy twice as fast as the 50-hp unit.

Pumping **pressure** is determined by three things: The vertical distance between the pump and the irrigation system, the water friction loss in the delivery pipe, and water pressure for the proper operation of the irrigation system. The greater the irrigation system pressure, the greater the pumping pressure has to be.

Pump and power unit **efficiency** represents the ability of the pumping plant to convert energy (diesel, electrical, or from some other source) to water energy for irrigation use.

Diesel and electric sources compared

Results of the 1976 irrigation questionnaire from the SD Department of Natural Resource Development indicate that electricity and diesel fuel are the two primary types of energy used to power irrigation pumping plants. Table 1 summarizes the results of the survey.

Energy cost and availability are two factors that influence the selection of an energy source. Assuming that two energy sources, diesel fuel and electricity, are available for irrigation, then you must examine their relative costs. We compared diesel and electric energy sources, first making a set of assumptions to determine yearly operational costs and pumping hours:

1. 100 horsepower power requirement.
2. 0.9 kilowatt (kw) = 1.0 horsepower (hp).
3. 18.0 horsepower hours per gallon (hp hr/gal) of diesel fuel.
4. Diesel maintenance costs = 25% of fuel costs.
5. Electric maintenance costs = $0.75 per horsepower every year.

The maintenance costs cover all grease, oil, labor, etc., for maintenance of the power unit.

Table 1. Types of energy used for irrigation in South Dakota during 1976.

Energy type	Percent of irrigated acres
Diesel	24.99
Electricity	55.15
Propane	11.09
Gasoline	3.14
Natural gas pipeline	0.86
Gravity	4.46
Flowing well pressure	0.31

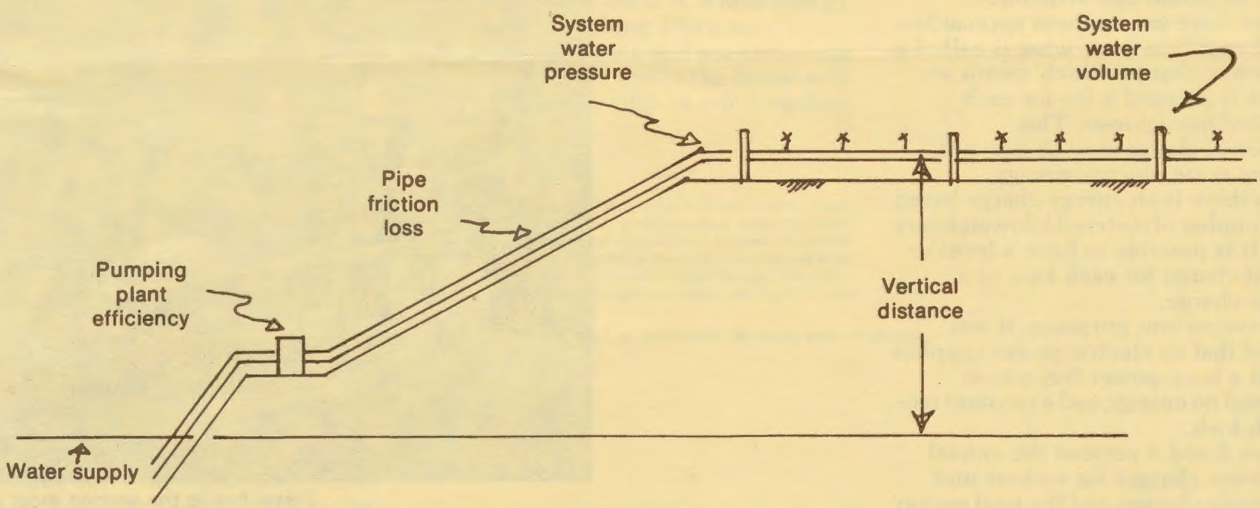


Figure 1. Factors that determine energy requirements for irrigation.

Electric powered irrigation pumps are used on over twice as many acres as diesels. Each electrical power supplier has its own peculiar characteristics you must know.

Table 3. Horsepower charge for a 100-horsepower electric powered irrigation pumping plant.

Unit charge	Annual charge
5.00	500
10.00	1000
15.00	1500

Table 4. Energy costs of a 100-horsepower electric powered irrigation pumping plant with a $0.00/horsepower charge.

Electric cost/kwh	Hours of operation 500	750	1000	1250
$0.02	$ 975	$1425	$1875	$2325
0.03	1425	2100	2775	3450
0.04	1875	2775	3675	4575
0.05	2325	3450	4575	5700

Values in Table 2 do not reflect the initial cost of the diesel unit or ownership (fixed) cost, only those costs involving operation of the unit. If you pumped for 750 hours on a 130-acre field and purchased $0.50 diesel fuel, your pumping cost would be $2604/130 A, or $20.03/A.

Table 2. Operational costs of a 100-horsepower diesel powered irrigation pumping plant.

Fuel cost/gal	Hours of operation per year 500	750	1000	1250
$0.40	$1380	$2083	$2778	$347[illegible]
0.50	1736	2604	3472	4340
0.60	2083	3125	4166	5208
0.70	2430	3646	4861	6076

Each electric power supplier has unique irrigation rate schedules, however there are common approaches. Several suppliers have what is called a horsepower charge, which means an irrigator is charged a fee for each connected horsepower. This horsepower charge may or may not purchase some electric energy.

Then there is an energy charge based on the number of metered kilowatt hours (kwh). It is possible to have a level or constant charge for each kwh or a variable charge.

For comparison purposes, it was assumed that an electric power supplier charged a horsepower fee, which purchased no energy, and a constant rate for each kwh.

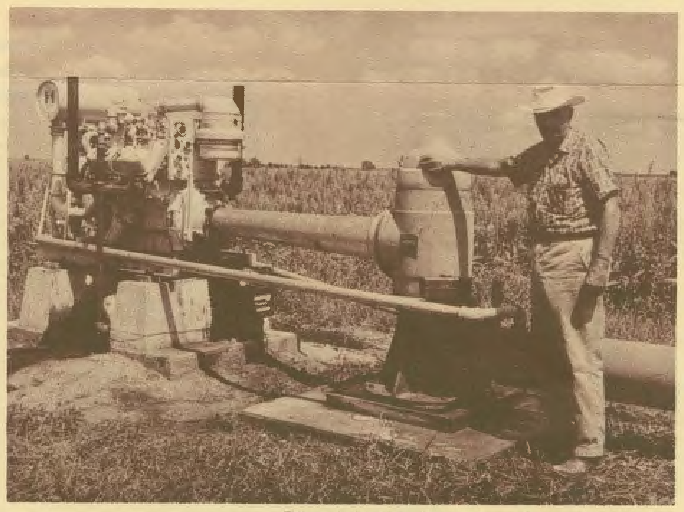
Tables 3 and 4 present the annual horsepower charges for various unit horsepower charges and the total energy costs for various electric costs and hours of pumping. The sum of the two appropriate numbers from Tables 3 and 4 gives the annual operational costs for an electric powered irrigation pumping plant. For example, 750 hours of pumping with a $5.00/hp horsepower charge and $0.03 electricity gives a total cost of ($500 + $2100) $2600 for the year or about the same total cost used in the previous diesel example. No costs of ownership are included in the values.

Another way to compare electric and diesel energy costs is to determine the equivalent cost of one energy source where the cost of a second source is given. The sum of the values in Tables 5 and 6 gives the diesel fuel cost per gallon where the cost of operation of diesel and electric power units are equal. For example, if an irrigator pumps water for 1000 hours in a season and has a $5.00 horsepower charge and $0.03 electricity, then ($0.40 + $0.07) $0.47 diesel fuel would produce the same annual operating costs as the electricity. If diesel fuel was $0.45, diesel operating costs would be less than electricity.

Other power sources

South Dakota is blessed with two forms of energy (wind and solar) which have the potential to be used as sources of irrigation energy. A few experimental prototype solar powered irrigation power units are being studied in the U.S. The economics of the situation is not favorable at this time.

Solar generated electricity is approximately $15.00 per peak watt, while new coal fired generating plants produce electricity at about $0.75 per peak watt. The availability of solar generated electricity also depends on the level of solar radiation which varies during a 24-hour period. Coal or water generated electricity is available during all periods of the day.



Diesel fuel is the second most popular energy source in South Dakota. To find best source for you, compare relative fixed and operating costs and availability.

Table 5. Equivalent diesel fuel costs for specified electricity costs and $0.00 horsepower charge.

Electric cost/kwh	Diesel fuel cost/gal
$0.02	$0.27
0.03	0.40
0.04	0.53
0.05	0.66

Table 6. Extra equivalent diesel fuel costs for specified horsepower charges and hours of operation.

Horsepower charge dollars/ horsepower	Hours of operation			
	500	750	1000	1250
$0.00	$0.00	$0.00	$0.00	$0.00
5.00	0.16	0.10	0.07	0.06
10.00	0.20	0.20	0.14	0.11
15.00	0.44	0.29	0.21	0.17

The National Aeronautics and Space Administration is investigating the feasibility of using wind energy to generate electricity. A potential experimental site is located near Huron. Since wind velocities are not uniform throughout the growing season, wind energy will probably be used in conjunction with another energy source, such as electricity, to satisfy peak energy demands for irrigation pumping.

No one knows the relative economic feasibility of various energy sources in the future. One thing we can count on is that energy costs will increase. That means energy management will be a critical factor in the success or failure of irrigated agriculture.

Ownership (fixed) costs

The annual cost of ownership of a pumping plant is probably more important to an irrigator than the purchase price, because most equipment is paid for over several years. This makes the cost flow a concern.

Capital recovery factors are used to determine annual costs. Table 7 gives values which can be used for planning purposes.

Table 7. Capital recovery factors.

Time period, year	Compound interest rate			
	6	8	10	12
5	0.237	0.250	0.264	0.277
10	0.136	0.149	0.163	0.177
15	0.103	0.117	0.132	0.147
20	0.087	0.102	0.118	0.134

Capital recovery factors can be used for planning and evaluation purposes in two ways. The first consideration may be the annual payment that must be made to a lending agency and the second may be the average cost of ownership for the life of the equipment.

For example, an electric motor may cost $4000 and have a useful life of 20 years; however, the motor must be purchased during a 10-year period at 8% interest. The average annual cost of ownership during the life of the motor would be 0.102 (20 yrs @ 8%, Table 7) times $4000 or $408/year. The yearly payment to the lending agency would be 0.149 times $4000 or $596/yr. If the repayment period and the life of the machine are the same, then the annual payment and cost of ownership values will also be equal.

The application of this concept to power units for irrigation pumping plants is very simple. The value which represents the difference in purchase price can be used with the values in Table 7 to obtain the annual fixed cost difference for the power units. The difference in operating or energy costs must be added to the fixed cost difference to obtain the total cost difference for the two power units.

Irrigation energy represents a significant part of production costs. Irrigated corn cost data for an expected situation in South Dakota are presented in Table 8.

Table 8. Estimated production costs for irrigated corn grain.

	Cost/acre
Field costs (including land)	$150
Irrigation system	45
Power or energy	20
Total	$215

Energy costs are going up

The energy charge is about 10% of the total dollar figure cost of production. If energy charges double and all other costs remain the same, then the energy charge would be about 17% of the total cost. There are areas in the U.S. where energy costs are approaching $50/acre.

How efficiently we and our nation use energy this season and in the future will have a big part to play in our irrigation profitability. □

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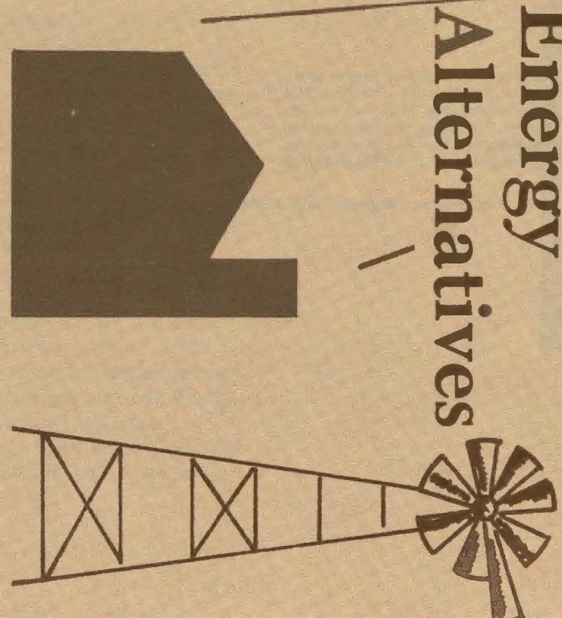

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