Electricity Is Still The Cheapest Fuel For Irrigation

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Fuel costs do not look like they are going away, so irrigators will continue to shove out money in 2008 to keep pumps running in the southeast Missouri region (SEMO). The cost of energy going into the 2008 season is \$0.11/KWH, \$3.52/gal and \$1.97/gal for electricity, diesel, and propane, respectively. The cost for diesel and propane is fairly straightforward to obtain and is provided by calling local wholesalers. Diesel costs are based on a 500-gallon delivery; however, if it is purchased in tanker loads of 7,000 gallons the price is discounted by 6.5 percent. The "average" cost per KWH of electricity is more difficult to glean, since factors like being or not being in load management programs, hours of operation, size of motor, etc. will affect the price. However, a rate of \$0.11/kwh is probably fairly representative. Figure 1 shows current energy costs, as well as, what they have been the last several years.

Generally, the amount of BTU per energy unit divided by its unit cost is the major component of its energy price – especially in the case of diesel and propane. However, cost analysis must also include other pertinent factors. For example, combustible engines (e.g., diesel and propane power units) almost always require a driveshaft and gearhead. There is a 5% loss in energy here, so this must be factored into diesel and propane fuel costs. Likewise, there is about a 5 percent energy loss when phase-converters transform singlephase electricity to 3-Phase electricity; this too must be factored into costs when phase converters are utilized. Finally, initial investment costs need to be considered. These include purchase of the power unit, gearhead, driveshaft, etc. Investment costs for electric units also include any grower cost for bringing in new utility lines.

As will be seen, electricity is always cheaper then diesel or propane if electric lines are present, and even when you have to bring in utility lines, electricity often remains cheaper then either one. Both of these fossil fuels currently cost about the same, so diesel and propane (D/P) are lumped together in this analysis. The question that begs to be answered is how much one can afford to spend on these new power lines if they are currently not at your farm. Your annual hours of operation and the size of your pump greatly influence the answer to this probing question. Note that natural gas, which powers only 13 percent of Missouri's irrigation pumps, is also more expensive then electric, but it its cost is just 2/3 of D/P, assuming no gas line construction fees. Irrigators, who can't get electricity, may want to visit with their local natural gas provider.

The Analysis

This article evaluates costs encountered for a new pumping plant installation under a variety of energy source options. The analysis involves only electricity and D/P, since natural gas units are so few and far between in Missouri. For electricity, special factors (e.g., using 3-phase versus single-phase, need to build power lines, and the cost difference between bringing in 3-phase versus single-phase lines) can create several spinoff permutations that need investigating.

First, the analysis looks at 40-HP units on "typical" pivots, and then examines the same for a "typical" flood system. Although the HP requirement for the two systems is the same (i.e., 40 HP), there are two important differences. One is that pressurizing the water causes the water of the pivot to be 60 percent more expensive then flood water. Offsetting this however, is that a "typical" pivot has 800 GPM, waters 135 acres, and applies 8 inches. A "typical" flood system might have 2,000 GPM, waters 80 acres, and applies 10 inches. The end result is that the pivot system has three times the annual hours of operation as does the furrow system, in our analysis.

Simple Solution – Some Form of Electricity is Already on Site.

The most complicated factor in determining the overall most economic pumping method is what the cost of bringing in power lines is, if they are currently not at site. However, so as not to muddy the water, let's first do an analysis assuming some form of electricity is already there. Under this scenario, the analysis is straightforward, and the irrigator just needs to ask this set of questions and sub-questions:

- Is 3-phase already at the site?
- If not, is single-phase already at the site?
  - o Does the utility company allow the use of phase-converters?

If 3-phase is on site, and with current energy prices, using a 3-phase motor will always be the cheapest route. If 3-phase isn't there, but single-phase is present, using a phaseconverter and a 3-phase electric motor is most likely the next best choice. However, a utility company may not allow a phase-converter at some locations, and then one would need to resort to a Written-Pole motor that is more expensive (its outlay is about twice that of the phase-converter option), but this motor is not problematic to utility grid service. Table 1 shows the initial investment costs and annual cost (equipment amortization + energy costs) for the four options an irrigator has if electricity is on site. Situation 1: 3-phase exists on site; Situations 2 and 3: single-phase exists on site; and, Situation 4: ignore electricity and use diesel or propane. Note that the initial investment cost (top row) is the same for both the pivot and flood situations, since they are both built around 40-HP units. This investment cost only represent items involved in the power unit and does not include the actual pump, well costs, etc. as these are the same for all units. The annualized costs of amortized equipment and yearly fuel costs (bottom two rows) differ between the pivot and flood scenarios. Note that the annual flood costs are less then those of the pivot, due to pumping 35 percent fewer acre-inches even though the cost per acre-inch is higher due to the added pressure requirement.

One wrinkle in this initial analysis is that, in situations where single-phase electricity may already exists on site, but 3-phase does not (Situations 2 & 3), and it may be cheaper to pay to bring in 3-phase service. In the following analysis it was found that if the new 3phase line charge is more then \$2,100 for pivots and \$1,600 for flood it is best to stick with the single-phase + phase-converter (Situation 2), contingent on the utility allowing the phase-converter. However, should the utility not allow a phase-converter and you would have to resort to the more expensive Written-Pole motor on the single-phase service (Situation 3), you could afford to invest more on the 3-phase service, and so \$2,600 for pivots and \$2,200 for flood become the break-even points. If the new line cost is greater then these values, use the Written-Pole motor, otherwise, bring in the 3-phase line.

Obviously, results vary depending on several key inputs, one big one being the timeframe used in the investment cost recovery. The input values used to derive the results shown in Tables 1 are seen below in Table 2. Irrigation equipment costs were provided by a local irrigation company.

More Involved Solution – No Form of Electricity Currently at the Site.

As already mentioned, the cheapest source of pumping for SEMO irrigators always will be the situation where 3-phase electricity is already present and a 3-phase electric motor is used. Thus, D/P becomes the card to play in situations where (a) it is not possible to bring in electric lines, or (b) the cost for doing so is very expensive (due to high initial cost and/or short return period). So assuming 3- or single-phase service is not currently at site, the proper set of questions and sub-questions an irrigator must ask are:

- How much would it cost to bring in 3-phase power?
- How much would it cost to bring in single-phase power?
  - o Does your utility allow a phase-converter to be used?

As example, let us use a recent real world situation from Mississippi County, MO where five farmers banded together this spring to pay \$35,000 for 1 1/2 mile of 3-phase service they could tap into, making the average cost per investor \$7,000. Let's assume that it would have cost \$3,000 to bring in single-phase. The return period used for the new line investment is 7 years. The results are seen in Table 3. For the pivot scenario, the savings from bringing in the 3-phase instead of using the diesel option will be about \$ 1,600 per year per investor, or about \$12/acre/year. In actuality, the utility company had agreed to provide about \$17,000 in rebates to the group later on, so their real savings is about \$2000 per year or \$15/ac/yr.

It is interesting to note that for pivots using the scenarios of \$7,000 and \$3,000 to bring in 3-phase and single-phases service, respectively, the single-phase options become more economical then the 3-phase option. This shows the powerful effect that return period has on results. Since the new line costs were set up to be evaluated on a fairly short scale (7 years) investments in improvements, like bringing in 3-phase versus bringing in single-phase electric lines, are harder to show a profit. Figure 2 shows the per-acre irrigation costs for pivot and flood for the various options (other then Written pole, which is similar to the phase converter); these costs include the capital recovery and fuel costs, but not maintenance and labor. When 3-phase electricity is on hand, pivot and flood costs are just a few dollars apart. If one uses D/P there will be about \$10 difference per acre in cost between the two systems.

When do you go with diesel instead of paying for new electric line? To make diesel or propane profitable, the line cost for the 3-phase would have to exceed \$ 20,500 for the pivot or \$ 8,900 for the flood situation.

In summary, the rules for choosing the most economic type of power unit on a new pumping plant are:

- 3-Phase motor (where this service is already at hand) is always the cheapest.
- If single-phase is to be used, and the utility allows it, a phase-converter is more economical then a Written-Pole motor.
- Many factors determine the most economical type of pumping unit, but, in general, there will be more money saved using electricity over diesel for pivots then for flood, therefore, more can be spent on bringing in power lines for pivots.
- Diesel only becomes a viable option for pivots if the cost to bring in the electric lines is around \$20,500 or greater; for flood, about \$8,900 or greater.
- The period of return for both new power lines plus equipment have tremendous impact on final results.
- This analysis is only for new equipment and doesn't include any salvage value options (e.g., using the proceeds from the sell of a diesel engine to help pay for an electric motor).
- The number of acres involved affects the results since more acres increases the hours of pump operation per year. As an illustration, the flood example assumed 80 acres to be irrigated, if it was only 40 acres then \$8,900 amount one could profitably invest to bring in 3-phase, reduces to just \$5,800
- The future increases in fuel and electricity costs are not dealt with here.
- The cost for new line service may be hard to quantify since rebates for part of the installation costs may occur if new customers tie in on the line you have paid for, or, as in the case from Mississippi County farmers, the utility company provides future price reductions on KWHs based on the line investment costs.

With so many factors involved, having a computer program to crunch the numbers helps. Anyone interested in more information on choosing a new power unit can call Dr. Joe Henggeler at the University of Missouri Delta Center (573-379-5431). Δ

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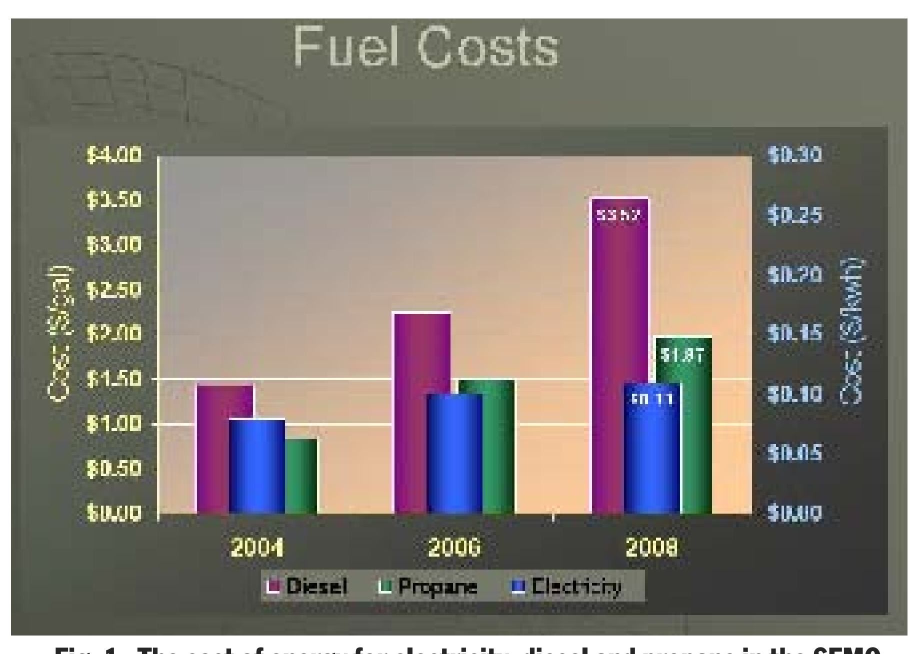

Fig. 1 - The cost of energy for electricity, diesel and propane in the SEMO region over the last four years.

Table 1. Initial investment costs and annualized equipment plus energy costs for various energy source options when *electricity is already on site* for pivot and flood.

	Situation 1	Situation 2	Situation 3	Situation 4
	3-Phase motor + 3-Phase already on site	3-Phase motor + phase-converter + single-phase already on site	Written-Pole motor + single-phase already on site	Diesel / Propane [a]
Initial Investment Cost	$ 3, 859	$ 7, 359	$ 13, 038	$ 9, 458
Annualized Cost of Equipment & Energy: PIVOT	$ 1, 906	$ 2, 159	$ 2, 221	$ 4, 351
Annualized Cost of Equipment & Energy: FLOOD	$ 830	$ 1, 021	$ 1, 089	$ 1, 880

[a] Diesel equipment is more expensive then propane equipment, but the pumping costs for propane are lower, making overall costs about equal.

Table 2. Parameters Used in the Analysis

	PIVOT	FLOOD
Area (acres)	135	80
Irrigation Depth (inches)	8	10
Flow Rate (gpm)	800	2,000
Pumping Water Level (ft)	20	25
Operating Pressure (psi)	35	5
Pump Set at (ft)	75	
Column Pipe Size (in)	10	
Diesel Engine Efficiency (hp-hr/gal)	13	
Electric Motor Efficiency (hp-hr/kwh)	18	
Pump Efficiency, diesel (%)	50	50
Pump Efficiency, electric (%)	50	45
Drive Train Efficiency, electric (%)	100	
Drive Train Efficiency, diesel (%)	95	
Phase Converter Efficiency (%)	95	
Cost of water, ELECTRIC ($/ac-in) *	$1.70	$0.95
Cost of water, DIESEL ($/ac-in) *	$3.47	$1.75
Investment Recovery	System life for components ** and 7 years for power lines	
Interest (%)	6 %	
Gear head energy loss (%)	5 %	
Phase-converter energy loss (%)	5 %	

* These costs do not include effect of drive train efficiency, as they are accounted for later.
** Drive shafts, gear heads, engines, and phase-converters: 15 years; 3-phase and Written Pole motors: 25 years.

Table 3. Initial investment costs and annualized equipment plus energy costs for various energy source options involving *bringing in power lines* for pivot and flood.

	Situation 1	Situation 2	Situation 3	Situation 4
	3-Phase motor + Bring in 3-phase	3-Phase motor + phase-converter + Bring in single-phase	Written-Pole motor + Bring in single-phase	Diesel
Initial Investment Cost	$ 10, 859	$ 10, 359	$ 16, 038	$ 9, 458
Annualized Cost of Equipment & Energy: PIVOT	$ 2, 740	$ 1, 993	$ 1, 993	$ 4, 351
Annualized Cost of Equipment & Energy: FLOOD	$ 1, 664	$ 1, 378	$ 1, 446	$ 1, 880

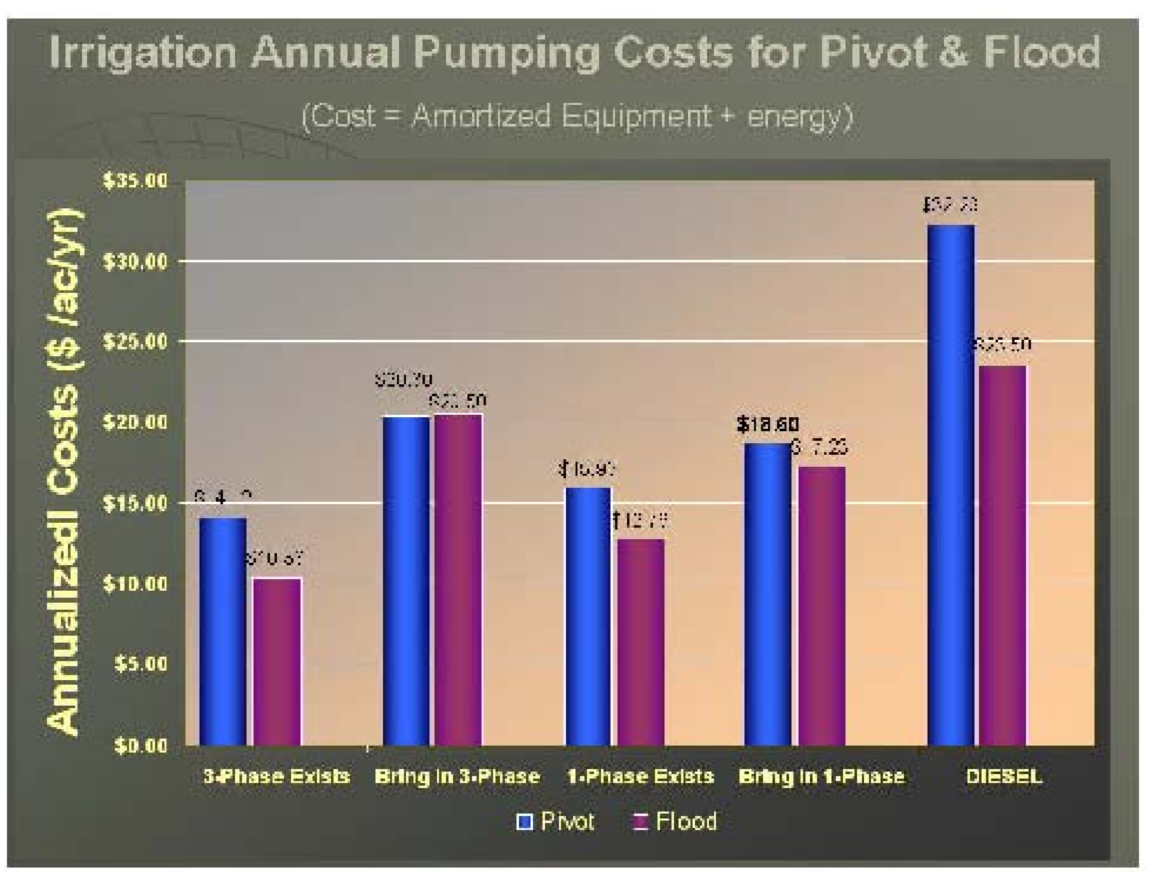

Fig. 2. – Annualized per-acre costs (equipment amortization + yearly energy costs) for a variety of energy options to pump irrigation water, the SEMO region over the last four years. The analysis used \$7,000 and \$3,000 to bring in 3-phase and single-phase, respectively. The least expensive option would have been using 3-phase if it existed.