PROFITS, WATER, AND ENERGY

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Abstract: Time-of-use (TOU) electric rates partition the day into on-peak and off-peak periods. The on-peak period has high energy charges and a penalty demand charge. Off-peak energy rates can be as low as $0.03 to $0.04 per kilowatt hour. TOU rates offer the potential of increasing profits by operating during the off-peak period only. Several analyses comparing the cost of operating off-peak with the benefits have shown that profits can be increased over operating 24 hours per day either on a TOU rate or on the flat rate.

Analyses of the benefits and costs of using diesel engines instead of electric motors have shown that profitability may also be increased by such a conversion.

Keywords: Electric rates, irrigation, diesel engines, profits

Water and energy conservation are benefits of improved management water and energy for irrigation. Other benefits include reduced adverse environmental impacts from irrigation return flows.

While benefits are frequently presented to encourage adoption of improvements, costs are generally not fully considered. Costs of improved management include capital costs of improved irrigation systems, increased labor and cultural costs, and increased management costs. If the cost of an improvement is less than the benefit, adoption by growers will increase profits, which should encourage adoption. If implementation reduces profits, adoption is unlikely.

Time-of-use electric rates (TOU) offer an opportunity to decrease electric energy costs. However, is profitability increased by these rates? Also, is conversion from electric motor to diesel engines profitable for pumping plant operators? These questions are addressed herein.

TIME-OF-USE ELECTRIC RATES

Time-of-use (TOU) electric rates partition the day into an off-peak period and a peak period (some rates also offer a partial peak period). The peak period normally is from noon to 6:00 p.m. during the weekdays. On-peak energy charges may be as high as $0.20 per kwhr, with a peak demand charge also. These high charges are designed to discourage pump operation during that time period. The off-peak period is from 6:00 p.m. to noon for most rates. Off-peak energy charges range from as low as $0.035 to $0.05 per kilowatt-hour.

The relatively low off-peak energy charges offer an opportunity for reducing pumping costs for irrigation. Off-peak irrigation, however, requires irrigating 18 hours per day instead of the usual 24 hours for many growers. Thus, a cost may be incurred for converting to the 18 hour operation. Costs may include capital costs for modifying an irrigation system to apply the same amount of water in 18 hours versus 24, increased labor costs, and/or yield reductions. Profitability will be increased with TOU rates only if the benefits, i.e. reduced pumping costs, exceed the costs of converting to TOU irrigation.

Options

Options available for growers include the following:

Operate 24 hours per day on the flat rate

2 Operate 24 hours per day on a TOU rate with no change to the irrigation system or pumping plant. On-peak penalty charges will occur for this option.

3 Operate 18 hours per day on a TOU rate with no change to the irrigation system or pumping plant. This option may reduce yields. For multiple-day sets, soil infiltration rates may be reduced.

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4 Operate 18 hours per day on a TOU rate. Modify the irrigation system and pumping plant to apply sufficient water in 18 hours to prevent yield reductions.

Use a TOU rate with a block of days designated as the off-peak period. During those days, pumps can be operated 24 hours per day without incurring penalty charges. Irrigation scheduling will be partially controlled by the timing of the off-peak block.

Case Studies

Several case studies were conducted to illustrate the effect of various options on profitability. The studies involved determining the modifications needed to implement an option, the cost of the option, and the savings in energy costs.

CASE 1--an alfalfa field (160 acres) irrigated with a wheel-line sprinkler system. Annual hours of operation were about 1608. Input horsepower was 100, pumping lift was 112 feet, and discharge pressure was 50 psi.

Options 1, 2, 3, and 4 were considered. The modification consisted of replacing the existing pump and motor with a larger size (137 HP) and increasing the nozzle size of the sprinklers. Input horsepower of the modified system was 137. Larger nozzles were used to reduce the pressure required to apply adequate water in 18 hours instead of 24.

The highest energy cost occurred under the flat rate, and the lowest operating 18 hours per day with no system modification (Table 1). However, converting from a flat rate to a TOU rate (24 hour per day operation) saved about $11 per acre per year even though on-peak penalty charges were incurred. The largest savings occurred by operating 18 hours per day (off-peak) with no modification. Revenue losses due to reduced yields, however, were about $36 per acre. The net return was about $6 per acre. The most profitable option was modifying the irrigation system and pumping plant to apply adequate water in 18 hours. The net return was about $22 per acre, even though the energy savings were less than that of option 3.

CASE 2--Eighty acres of alfalfa irrigated with a border irrigation system. Run length was 1245 feet, the border width was 60 feet, and the normal border flow rate was 350 gpm. Annual operating hours was 1490. Pump input horsepower was 64. Normal advance time of the water to the end of the border was about 19 hours, with an infiltration time of nearly four hours at the lower end of the field. Set time was about 24 hours.

Options considered were 1, 2, and 4. The modification consisted on increasing the border flow rate to 450 gpm, which advanced the water to the end of the run in 14 hours. Set time was 18 hours, thus allowing off-peak irrigation. The border flow rate was increased by reducing the number of borders irrigated per day from four to three. This increased the irrigation time from 11 days to 14 days, resulting in increased labor costs.

An analysis of benefits and costs, in Table 3, showed that nearly $36 per acre could be saved at no cost by converting from a flat rate to a TOU rate (24 hour per day operation). If the system is converted to an 18 hour per day operation providing adequate water, the net return would increase by about $24 per acre.

CASE 3--two furrow-irrigated tomato fields (52 and 70 acres each). Pumping lift was about 87 feet. Hours of operation were 587 (52 acres) and 835 (70 acres). Input horsepower of the pumps were 52 (52 acres) and 62 (70 acres). Multiple-day irrigations occurred, with the irrigation stopped each day between noon and 6:00 p.m. Pumping plants were not modified. However, flexible plastic gated pipe was used on the 52-acre field instead of ditches with siphons, and aluminum gated pipe was used on the other field. Gated pipe was used to reduce labor costs of restarting the irrigation after each peak period.

Results of this analysis revealed that where the aluminum gated pipe was used, the rental cost of the pipe exceeded the energy and labor savings, resulting in a loss of over $67 per acre (Table 4). Where the flexible plastic pipe was used, profitability was increased, but was very dependent on the life of the pipe. For this case, the net return was much less than for the other two cases, the primary reason being a smaller annual operating hours and smaller kilowatt hours. Converting from the flat rate to a TOU rate (24 hours operation) saved about $2.54 per acre (52 acres) and $4.64 per acre (70 acres).

Conclusions on TOU rates

Conclusions on the economics of TOU irrigation are:

Where pumps operate 24 hours per day, a TOU rate will be cheaper than the flat rate even though penalty costs are incurred for operating during the peak period.

Where pumping hours and pump kilowatt demand are relatively small, returns from irrigating on a TOU schedule may be small. Capital costs for modifying the irrigation system should be minimal.

3 Profitability can be increased substantially on a TOU schedule for relatively large operating hours and kilowatt-hours.

ELECTRIC MOTORS VERSUS DIESEL ENGINES

Recent declines in diesel fuel cost has generated interest in converting to diesel engines. The economics of such conversions depends, however, on capital costs of engines versus motors, maintenance costs, fuel or electrical energy costs, the economic life of engines versus motors, horsepower requirements, and annual operating hours. Because of these numerous factors, UC researchers developed a program to calculate the annual costs of diesel engines and electric motors given a set of operating conditions.

Results of several analysis using this program are shown in figures 1 and 2 for 25 and 100 horsepower pumps, respectively, for operating times of 500, 1000, and 2000 hours. These figures show the average electric cost, which include demand, meter, customer and energy charges, and the diesel fuel costs that provide the same annual costs. Annual costs include capital costs, maintenance and repair costs, insurance and taxes, and energy costs. In figure 1, we see that an electric cost of $0.065 per kilowatt hour provides the same annual cost as diesel fuel at about $0.50 per gallon for 500 annual operating hours. If the electric cost is $0.105 per kwhr, the fuel cost which provides the same annual cost is about $1.00 per gallon. For this case, if current fuel costs are less than $1.00 per gallon, diesel engines will be more economical than electric motors. For a 100 horsepower pump operated 1000 hours per year, electric costs at $0.065 per kwhr (incurred by operating off-peak only) will provide the same annual costs as diesel fuel at about $0.80 per gallon.

Fuel prices of $0.40 to $0.50 per gallon have been reported, suggesting that diesel engines are more economical than electric motors. Average electric costs would need to be $0.07 per kwhr and less to provide the same annual costs as diesel engines and diesel fuel at $0.50 per gallon. Table 5 shows the electric costs needed to provide the same annual cost as diesel fuel at $0.50 and $0.80 per gallon.

Other factors needed to be considered. These factors include uncertainty in future diesel fuel costs, convenience of operating motors, reliability of motors versus engines, decline of engine performance with wear, and cost of re-establishing electric service at some future time should diesel engines become less economical than motors.

One question asked is should one maintain their electric service after converting their pumping plant to diesel engines. Maintaining the electric service requires paying the fixed charges of customer, meter, and basic demand. Continuation of electric service is economical only if these fixed charges are less than the savings incurred by the conversion. For example, for a 25 HP pump operating 500 annual hours, the fixed electric charges will exceed the annual savings from the conversion. For a 100 HP pump operating 1000 annual hours, continuation of electric service would be economical, however, savings resulting from the conversion will be substantially reduced by the fixed charges.

One possible approach is to install a dual-drive pump head, and operate the pump with a tractor PTO during on-peak periods. The feasibility of this approach depends on the cost of the dual-drive pump head, as much as 2 to 3 times the cost of a standard gear head, diesel fuel costs, and on-peak electric energy charges, in addition to capital and maintenance costs of the tractor allocated to the pumping time.

An economic analysis of this option was conducted for a 25 and 100 horsepower pump operating 500 and 1000 hours per year. The analysis considers the cost of the dual-drive pump head, fuel costs, and on-peak electric costs. Capital and maintenance costs of the tractor were not included. Results for fuel costs of $0.50 per gallon in table 6 show considerable savings in energy costs except for relatively small use i.e. a 25 horsepower pump operating 500 hours per year. Actual savings will be somewhat less due to allocation of capital and maintenance costs of the tractor to pumping.

Table 1. Energy costs for various options, sprinkler irrigated field.

Option	HP	Yield loss	Annual Energy Cost ($/acre)	$/kwhr
1	100	No	77	0.1026
2	100	No	66	0.0885
3	100	Yes	35	0.0617
4	137	No	47	0.0612

Table 2. Benefits and costs, sprinkler irrigation.

Option Change	Annual Savings ($/acre)	Annual Cost ($/acre)	Return ($/acre)
1-2	11	0	11
2-3	42	36	6
3-4	30	8	22

Table 3. Benefits and costs, border irrigation.

Option Change	Annual Savings ($/acre)	Annual Cost ($/acre)	Return ($/acre)
1-2	36	0	36
2-4	30	6	24
TOTAL	66	6	60

Table 4. Benfits and costs, tomato fields ($/acre)

	52 acres (plastic)	70 acres (aluminum)	70 acres (plastic)*
Annual Benefit			
Energy savings	14	18	18
Labor savings	11	11	11
Total	25	29	29
Annual Costs			
One-year life	22		17
Two-year life	12		9
Annual Returns		-67	
One-year life	3		12
Two-year life	13		20

*Estimated for plastic gated pipe

Table 5. Electric rates needed to provide same annual cost as diesel fuel at $0.50 per gallon and at $0.80 per gallon.

Horsepower	Annual Operating Hours	Electric Cost $0.50/gallon	$0.80/gallon
25	500	0.070	0.085
25	1000	0.065	0.085
25	2000	0.060	0.078
50	500	0.065	0.085
50	1000	0.055	0.077
50	2000	0.052	0.073
100	500	0.055	0.069
100	1000	0.046	0.065
100	2000	0.043	0.064

Table 6. Annual savings ($) using a tractor PTO during on-peak period. Costs include cost of dual-drive pump head and fuel costs of $0.50 per gallon. On-peak electric costs were bsed on AG-VA for the 25 horsepower pump, and on AG-4B for the 100 horsepower pump.

	500 hours	100 hours
25 horsepower		
On-peak electric costs	653	1307
PTO costs		
Dual drive head	136	178
Fuel	84	168
Savings	433	961
100 horsepower		
On-peak electric costs	2391	3980
PTO costs		
Dual drive head	159	208
Fuel	296	592
Savings	1936	3180

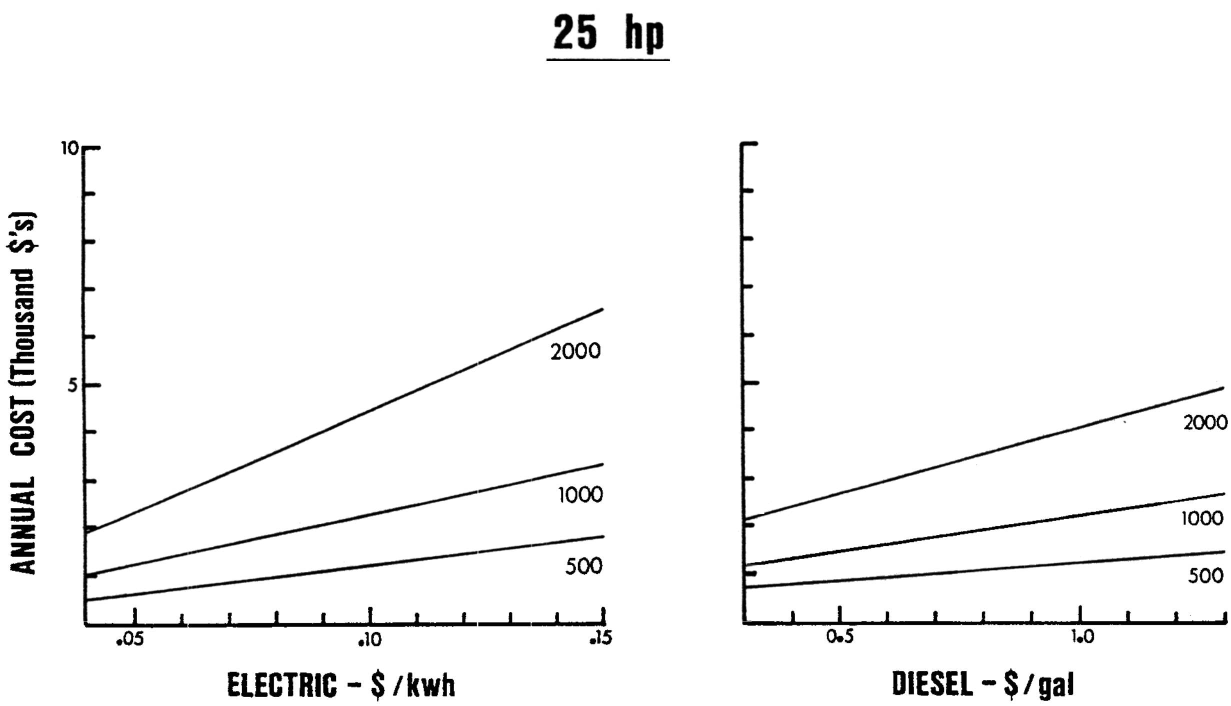

Figure 1. Annual costs for electric motors and diesel engines for a 25 horsepower pump operating 500, 1000, and 2000 hours per year.

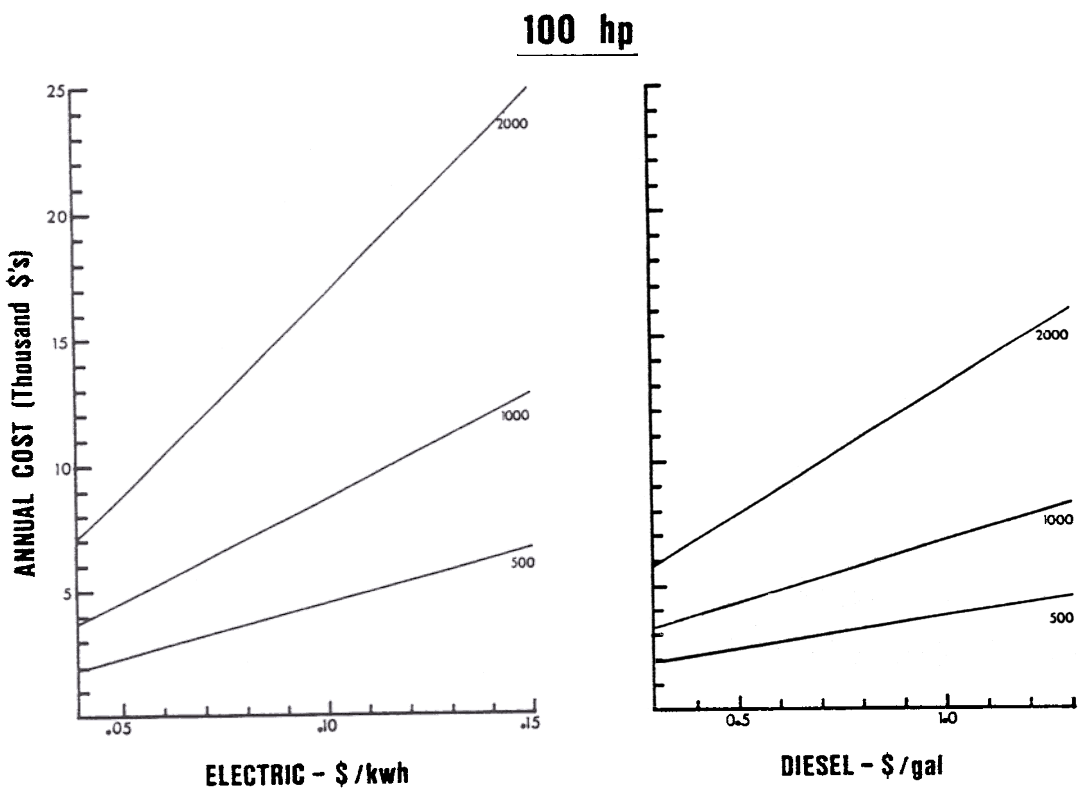

Figure 2. Annual costs for electric motors and diesel engines for a 100 horsepower pump operating 500, 1000, and 2000 hours per year.