Estimating Pumping Plants Performance

Producers can use Tables 2-4 and their past energy records to estimate the performance rating for their pumping plant and the amount of energy that could be saved if the pumping plant was repaired. For example, if a pivot was used on 130 acres to apply 15 inches of water the total volume of water applied would be (130 x 15) = 1950 acre-inches. If the lift was 150 feet and the pump discharge pressure was 60 psi, an efficient pumping plant would require about 5130 gallons of diesel fuel for the year. If a producer's records show that 6000 gallons were used, the performance rating would be (5130 / 6000) x 100 = 86% and 870 gallons of diesel fuel could be saved if the pumping plant performance was improved. The form below is an example for an electric system.

Pumping Cost Worksheet

Known Information:

Pumping Lift, feet	*150*
Pressure at pump discharge, psi	*60*
Size of the irrigated field, acres	*130*
Depth of irrigation applied, inches	*13.5*
Amount of energy used to irrigate the field for the year	*80000*
Type of energy source used to pump water	*Electric*

Results:

Diesel fuel needed to pump an acre-inch at 100% rating (Table 2) *2.63*

Volume of water pumped, acre-inches: *130* (acres) × *13.5* (depth) = *1755*

Gallons of diesel fuel needed for field if at 100% rating *4616*

Multiplier for energy source (Table 3) *14.12*

Energy used if at 100% pump rating: *4616* × *14.12* = *65178* *kWh*

If actual amount of energy used is known:

Performance Rating of Pump = 100 × *65178* (at 100%) / *80000* (actual) = *81*

Potential Energy Savings with Repair: *80000* (actual) - *65178* (at 100%) = *14822 kWh*

Cost Savings, $ *0.07 $/kWh* (cost of energy) × *14,822* (energy savings) = *$ 1038*

If actual energy is not known but you estimate the pumping plant rating:

Estimate performance rating *80*

Multiplier from Table 4 *1.25*

Energy Used at Estimated Rating: *1.25* × *65178* = *81472 kWh*

Potential Energy Savings: *81472* (actual) - *65178* (at 100%) = *16294 kWh*

Cost Savings, $ *0.07 $/kWh* (cost of energy) × *16294* (energy savings) = *$ 1140*

Paying for Repairs

Energy savings from repairing the pumping plant should be compared to the ability to pay for the repairs. The money that can be paid for repairs is determined by the length of the repayment period and the annual interest rate. These values are used to compute the capital recovery factor (Table 5). The breakeven investment that could be spent is the value of the annual energy savings divided by the capital recovery factor. The energy cost savings for the electric pump example was about $1140. If a 5-year period and 9% interest were used, the capital recovery factor would be 0.257. The breakeven repair cost would be $1140/0.257 = $4436 as shown in the example below. If repair costs were less than $4400 then repairs would be feasible. If costs were more than $4400 the repairs may not be advisable at this time.

Table 5. Capital Recovery Factor

Period,	Annual Interest Rate				
Years	7%	8%	9%	10%	11%
3	0.381	0.388	0.395	0.402	0.409
4	0.295	0.302	0.309	0.315	0.322
5	0.244	0.250	0.257	0.264	0.271
6	0.210	0.216	0.223	0.230	0.236
8	0.167	0.174	0.181	0.187	0.194
9	0.153	0.160	0.167	0.174	0.181
10	0.142	0.149	0.156	0.163	0.170
15	0.110	0.117	0.124	0.131	0.139
20	0.094	0.102	0.110	0.117	0.126
25	0.086	0.094	0.102	0.110	0.119

Example:

Annual Savings	$1,140
Interest, %	9
Recovery Period, years	5
Capital Recovery Factor	0.257
Maximum Improvement Cost	$4,436

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Know how. Know now.

Estimating the Savings from Improving Pumping Plant Performance

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Estimating Energy Savings

This document describes a method to estimate the cost of pumping water and to compare the amount of energy used to that for a well maintained and designed pumping plant. The results can help determine the feasibility of repairing the pumping plant.

Background

The cost of pumping water depends on the:

- distance water is lifted from the groundwater aquifer or surface water source,
- discharge pressure at the pump,
- work per unit of energy consumed by a well designed and managed pumping plant,
- performance rating of the pumping plant,
- depth of irrigation water pumped, and
- cost per unit of energy.

The amount of work that can be obtained from a unit of energy with a well designed and maintained pumping plant is represented in Table 1.

Table 1. Energy conversion factors for a well designed and maintained pumping plant.

Energy Source	Factor Value	Units of Factor
Diesel	12.5	whp hours / gallon
Gasoline	8.86	whp hours / gallon
Propane	6.89	whp hours / gallon
Natural Gas	61.7	whp hours / 1000 ft^3
Electricity	0.885	whp hours / kilowatt hour

where whp stands for water horsepower

Lift

The pumping lift depends on the location of the water source relative to the elevation of the pump discharge. For groundwater the lift depends on the distance from the pump base to the water level when not pumping (static water level) and the groundwater drawdown as shown in Figure 1. The lift may increase over time if the groundwater level declines.

Pressure

The discharge pressure depends on the pressure needed for the irrigation system, the elevation of the inlet to the irrigation system and the pressure loss due to friction in the piping between the pump and the irrigation system. It is best to measure the discharge pressure with a good gauge.

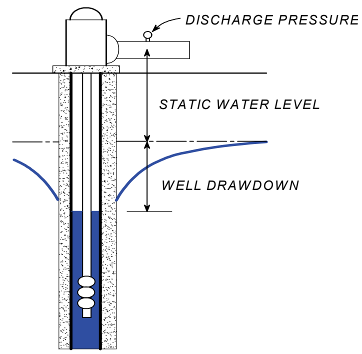

Figure 1. Pumping lift and location of discharge pressure.

Energy per unit of water

The amount of energy required for a properly designed and maintained pumping plant to pump an acre-inch of water can be determined from Tables 2 and 3. For example, a producer with who has a system with a pumping lift of 150 feet and operates at a pump discharge pressure of 60 psi, would use 2.63 gallons of diesel fuel to apply an acre-inch of water. If the producer uses electricity the value of 2.63 should be multiplied by the factor in Table 3 to convert energy units. So, for electricity (2.63 x 14.12) = 37 kilowatt-hours would be needed per acre inch of water.

Pumping Plant Efficiency

The amount of energy needed to pump a unit of water depends on the efficiency of the pump and power unit. If the pumping plant is not maintained, or if operating conditions changed since the system was installed, the pumping plant may not operate as efficiently as listed in Table 2. The energy needed for an actual system is accounted for in the performance rating of the pumping plant. Table 4 can be used to determine the impact of a performance rating less that 100%. For a performance rating of 80% the multiplier is 1.25 so the amount of energy used would be 25% more than for a system operating as shown in Table 2. The amount of diesel fuel for the previous example case would be (2.63 x 1.25) = 3.29 gallons per acre-inch of water.

Table 2. Gallons of diesel fuel required to pump an acre-inch at a pump performance rating of 100%.

Lift	Pressure at Pump, psi						
feet	10	20	30	40	50	60	80
0	0.21	0.42	0.63	0.84	1.05	1.26	1.69
25	0.44	0.65	0.86	1.07	1.28	1.49	1.91
50	0.67	0.88	1.09	1.30	1.51	1.72	2.14
75	0.89	1.11	1.32	1.53	1.74	1.95	2.37
100	1.12	1.33	1.54	1.75	1.97	2.18	2.60
125	1.35	1.56	1.77	1.98	2.19	2.40	2.83
150	1.58	1.79	2.00	2.21	2.42	2.63	3.05
200	2.03	2.25	2.46	2.67	2.88	3.09	3.51
250	2.49	2.70	2.91	3.12	3.33	3.54	3.97
300	2.95	3.16	3.37	3.58	3.79	4.00	4.42
350	3.40	3.61	3.82	4.03	4.25	4.46	4.88
400	3.86	4.07	4.28	4.49	4.70	4.91	5.33

Table 3. Conversions for other energy sources:

Energy Source	Units	Multiplier
Electricity	kilowatt-hours	14.12
Propane	gallons	1.814
Gasoline	gallons	1.443
Natural Gas	1000 cubic feet	0.2026

Table 4. Multiplier when pumping plant performance rating is less than 100%

Rating, %	100	90	80	70	50	30
Multiplier	1.00	1.11	1.25	1.43	2.00	3.33