

How to estimate long-term pumping plant performance

The performance of a pumping plant can be estimated using water meter readings and fuel use records over extended periods of time (weeks, months, irrigation season). Once the performance is known, the potential energy savings from improving the pumping plant's efficiency can be estimated, based on the following: volume pumped (acre-inches), lift (pumping water level), pressure at the pump discharge head (psi) and energy consumed over the period corresponding to the water meter readings.

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1. $\text{whp-h} = \text{acre-inches pumped} \times \text{total head (ft)} / 8.75$ whp-h / ac-in x ft

Where:

- whp-h = water horsepower hours (useful work performed by the pump over a period of time).
 - acre-inches = volume of water necessary to cover an acre one inch deep.
 - total head (ft) = lift (ft) + system pressure (ft)
 - lift = distance (feet) from the water level inside the well casing to the soil surface while pumping.
 - system pressure (ft) = psi x 2.31 ft/psi
2. Performance = whp-h for the test period (*from Step 1*) / fuel used for the test period
 3. Performance rating = (Performance (*from Step 2*) / NPC for the energy source) x 100%
 4. Potential fuel savings = ((100% - %NPC (*from Step 3*)) / 100) x fuel used for the test period

Example:

- Test period = entire irrigation season
 - Center pivot sprinkler system with a diesel engine.
 - Pumping water level = 140 feet
 - Pressure at the discharge head = 40 psi
 - Ac-in of water pumped (from water meter)^f = 1,415
 - Total fuel used for test period = 3,571 gallons of diesel
1. $\text{whp-h} = \text{acre-inches pumped} \times \text{total head (ft)} / 8.75$
 $= 1415 \times (140 + (40 \times 2.31)) / 8.75$
 $= 1415 \times (140 + 92.4) / 8.75$
 $= 1415 \times (232.4) / 8.75$
 $= 37,518$
 2. Performance = whp-h for the test period (*from Step 1*) / fuel used for the test period
 $= 37,518 \text{ whp-h} / 3,571 \text{ gallons}$
 $= 10.5 \text{ whp-h} / \text{gallon}$
 3. Performance rating = (Performance (*from Step 2*) / NPC for the energy source) x 100%
 $= (10.5 \text{ whp-h} / \text{gallon} / 12.5 \text{ whp-h} / \text{gallon of diesel}) \times 100\%$
 $= 84\%$
 4. Potential fuel savings = ((100% - %NPC (*from Step 3*)) / 100) x fuel used for the test period
 $= ((100\% - 84\%) / 100) \times 3,571 \text{ gallons of diesel}$
 $= 0.16 \times 3,571 \text{ gallons}$
 $= 571 \text{ gallons}$

Table 1. The Nebraska Pumping Plant Performance Criteria (NPC)

Energy Source	hp•h ^a (energy unit)	whp-h ^b (energy unit)	Energy units ^c
Diesel	16.66	12.5	gallon
Gasoline	11.50	8.66	gallon
Propane	9.20	6.89	gallon
Natural gas ^d	82.20	61.7	1000 ft ³ (MCF)
Electricity ^e	1.18	0.885	kW•h

^a hp•h (horsepower hours) is the work accomplished by the power unit with drive losses considered.

^b whp-h (water horsepower hours) is the work accomplished by the pumping plant (power unit and pump) at the Nebraska Pumping Plant Performance Criteria.

^c Based on 75% pump efficiency

^d Assumes an energy content of 925 BTU/cubic foot

^e Assumes 88% electric motor efficiency

^f Water meter volume conversion to acre-inch equivalents:

- If the water meter totalizer registers in gallons, divide gallons by 27,154.
- If the water meter totalizer registers in acre-feet, multiply acre-feet by 12.
- If the water meter totalizer registers in cubic feet, divide cubic feet by 3,630.