

$$kWh = \left[\left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3,960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746 \right] \times h$$

Where:

kW = Input to the system to produce the flow and head.

h = Hours of operation.

$Flow$ = Flow rate in gallons per minute. Generally speaking, we try to use a pump test for at least one condition for this. If that is not available we will use a value from a tab report. Lacking that we will use a design number from the original drawings or an equipment submittal.

$Head$ = The pump head in ft.w.c. water column, which we usually try to identify from field measurements and pump test data. Lacking those measurements we will use a value derived from a TAB report or the design value.

3,960 = A units conversion constant that is good for water between 40°F and 220°F.

η_{Pump} = Pump efficiency. We usually try to get this number from the pump curve or from the pump's rated brake horsepower (bhp), flow and head. Lacking that, we will make a geometrically similar pump selection (same flow rate, impeller diameter, and speed) using manufacturer's software and use that efficiency. Lacking that is is not possible, we will assume that for a pump rated for 300 gpm or less the efficiency might be in the range of 45-60%. For pumps between 300 gpm and 1,500 gpm, efficiencies might range from 60% to 75%. For pumps over 1,500 gpm, efficiencies might range from 75% to as high as 87%. Generally, efficiency will improve with pump size.

η_{Motor} = Motor efficiency. We usually try to get the motor performance curve and select the efficiency from the curve at the bhp that the pump impeller is extracting from it. If we can't get the motor curve, we use a similar motor from MotorMasterTM International. In all cases we adjust the efficiency for the motor operating point to match the motor's rated nameplate efficiency. Lacking anything else, it is reasonable to assume that the motor efficiency will improve by 1-2% over the nameplate efficiency when the pump is at 65-85% of its rated load, drop to 80% nameplate efficiency at around 50% load, and then drop sharply towards 0 at 20-30% of rated load.

η_{VSD} = Variable speed drive efficiency. Where possible, we try to get the manufacturer's data for this. But this is often difficult to obtain and not consistent in its development. Lacking manufacture specific data, we use general data as published by the Department of Energy on their Industrial Best Practices web site. Lacking any other data, it is reasonable to assume there will be at least 4-6% loss in the drive with it at full speed with a gradual drop to 80% efficiency at about 20% load.

.746 = Horsepower to kW conversion constant.