

PUMPS AND PUMPING COSTS

Introduction.....1.3-1
[Required Pumping Power](#)1.3-2

INTRODUCTION

Many times, Growers think in terms of unit costs. They know about how many dollars per acre to cultivate, how many dollars per acre to harvest, how many tons per acre of production to expect (hopefully), etc. It is also good to know unit-costs for water pressure. That is, the costs to pump one acre-foot of water through a sprinkler system, or back up a tailwater reuse system.

A handy unit-cost is the money required to pressure water to 10 pounds-per-square-inch (PSI). (This is only the direct power costs. Capital costs for the engine/motor and maintenance are not considered.) Since we are talking about unit costs, we already know how much water we have to move, one acre-foot.

There are only three (four if using diesels) additional numbers needed to calculate the cost to pump it. For electric-powered pumping plants these are the amount of pressure you need, the pump efficiency, and the unit cost of electric power. The equation to use for electric power is . . .

$$UC = 2.36 * H * UCE / PE$$

where:

UC = unit pumping cost, \$/acre-foot

H = pumping head, pounds per square inch

UCE = unit electric power costs, \$/KWH (this is an average cost based on power and demand charges).

PE = pumping plant efficiency, a decimal normally in the .5 to .7 range

For example, to determine an example 10 psi unit-cost, assume that the average electric power cost is \$.07/KWH. The pumping plant efficiency is estimated at .6. Thus, . . .

$$UC = 2.36 * H * UCE / PE$$

$$UC = 2.36 * 10 * .07 / .6 = \$2.75$$

$$10 \text{ PSI} = \$2.75/\text{AF}$$

10 PSI is the unit-cost to pressure one AF of water 10 PSI.

10 PSI Electric Unit Cost /AF			
KWH Cost	50% Eff.	60% Eff.	70% Eff.
\$.05	\$2.36	\$1.97	\$1.69
\$.10	\$4.72	\$3.93	\$3.37
\$.15	\$7.08	\$5.90	\$5.06

If you were thinking about a field sprinkler system that required about 70 psi, just multiply the unit cost by 70 PSI /10. . .

$$\text{COST} = 70 \text{ PSI}/10 * \$2.75/\text{AF}$$

$$10 \text{ PSI COST} = \$19.25/\text{AF}$$

At 70 PSI, each AF pumped costs \$19.25 for power alone.

Determining pumping costs for diesel engines requires one more number, which indicates how efficient the engine is in converting diesel fuel into energy. It has been called the "energy-conversion constant" and for modern turbocharged diesels is around 15-17 brake-

horsepower hours/gallon of diesel burned. The equation for diesel engines is . . .

$$UC = 3.16 * H * UCD / (EC * PE)$$

where:

UC = the unit power costs

H = pumping head, in PSI

UCD = the unit cost of diesel fuel (delivered to the engine) in \$/gallon

EC = the energy conversion constant, brake-horsepower hours per gallon of fuel burned

PE = pumping plant efficiency, a decimal normally in the .5 to .7 range

For example, figuring the unit cost to pressure water to 10 PSI, assume that diesel fuel is about \$.65/gallon delivered to the pump. The engine is relatively old and the EC is only 15 BHP-hours/gallon. Then, the cost of pressuring water to 10 PSI is,

$$UC = 3.16 * H * UCD / (EC * PE)$$

$$UC = 3.16 * 10 * .65 / (15 * .60)$$

$$UC = \$2.28/AF$$

The unit-cost for pressuring one-acre foot of water to 10 PSI is \$2.28 with a diesel engine and fuel costing \$.65/gallon delivered.

10 PSI Diesel Unit Cost / AF			
Cost/Gallon	50% Eff.	60% Eff.	70% Eff.
\$.60	\$2.37	\$1.98	\$1.69
\$.80	\$3.16	\$2.63	\$2.26
\$1.00	\$3.95	\$3.29	\$2.82
\$1.20	\$4.74	\$3.95	\$3.39
Note: Assumes 16 BHP-hours/gallon			

Note that diesel prices have been much higher in past years. Doubling the price of diesel would double the unit pumping cost.

Important!!! The unit-costs developed above do not consider annual maintenance or the capital costs of the pumping plant. They are only the direct power costs.

REQUIRED PUMPING POWER

Questions that come up many times in field situations are "How big a pump, and what type, is needed? They are critical questions because one pump might throw enough water, but not at the right pressure. And another pump might build up enough pressure, but not enough flow. And, if using electricity as the power source, you may or may not have enough power where you need the pump.

Here is an easy equation to use in answering the power question . . .

$$HP = (FLOW * HEAD) / (1714 * PE)$$

where:

HP = gross horsepower rating of the pump

FLOW = flow of water from the pump in gallons per minute (GPM).

HEAD = pressure built up by the pump in pounds per square inch PE is the pumping efficiency of the unit

1714 is what is known as a conversion constant, it matches up the various measurement units

For example, assume that you are thinking about going to sprinklers for a preirrigation. You usually take a 4 cubic-feet-second (CFS) head of water (flow from the delivery). You also know that the sprinklers need to run at about 50 PSI. The field is relatively smooth

ground and sits next to the canal. Thus, there are no large elevation changes and you don't have to pump the water for long distances.

Four CFS is about 1800 GPM (1 CFS = about 450 GPM). We need to add about 15 PSI for pipe friction, thus, we need about 65 PSI total pumping pressure. Assuming a 65 percent pumping efficiency, the equation then says that . .

$$HP = (\text{FLOW} * \text{HEAD}) / (1714 * PE)$$

$$HP = (1800 * 65) / (1714 * .65)$$

$$HP = 105 \text{ horsepower}$$

Pumps do not operate at the same efficiency at every combination of flow/pressure. For example, a sprinkler pump may operate at 70 percent efficiency when pumping 1400 gpm at 80 PSI. It may operate at only 60 percent efficiency when pumping 1100 gpm at 100 PSI. That drop of 10 percent is money out of your pocket. (60 percent efficiency means that 60 percent of the power delivered to the pumping plant, power that you paid for, is used to pump the 1100 gpm of water at 100 psi.)

The other 40 percent is used up in overcoming friction within the pump and motor. Always consult an experienced pump engineer when buying or rebuilding a pump. Match the pump design and type to the job. Also, make sure you follow a regular maintenance schedule to keep your pumps working at top efficiency. If using electricity for power, consider a design that will allow using the off-peak power rates offered by PG&E.

[energy use and conservation](http://www.wcc.nrcs.usda.gov/nrcsirrig/irrig-handbooks-part652-chapter12.html) (http://www.wcc.nrcs.usda.gov/nrcsirrig/irrig-handbooks-part652-chapter12.html). An article describing [pump testing](http://www.krcd.org/13series/13-1/13-1.pdf) (http://www.krcd.org/13series/13-1/13-1.pdf) was published by KRCDD.

Additional sources of [basic irrigation energy information](#) include: (http://www.wateright.org/site2/advisories/energy.asp) or