*Cooperative Extension, University of California*

# *Ag Water & Land Resource Manager*

**TEHAMA, GLENN, COLUSA, AND SHASTA COUNTIES**
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***A newsletter from the University of California Cooperative Extension seeking to support wise and judicious use of limited water and land resources in the Northern Sacramento Valley.***

## In This Issue



***Welcome to the April/May 2001 issue of the "Ag Water and Land Resource Manager" Newsletter. Due to the critical situation of California's electricity and natural gas supplies and high prices of other fossil fuels, this newsletter outlines steps for agricultural water users to cut energy demands for irrigation and reduce expenses.***

***Thank you, Allan Fulton***

**Irrigation/Water Resource Advisor**
**Tehama, Shasta, Glenn and Colusa Counties**

## Short-term Opportunities to Cut Energy Costs for Irrigation

### Evaluate Three Parts of the Irrigation System to Save:

Three parts of the irrigation system should be evaluated to realize savings: 1) the pumping plant; 2) the irrigation system performance; and 3) management decisions of when to irrigate and how much water to apply. Adjustments to any of these three parts of the irrigation system may lead to energy savings. However, failure to evaluate all three parts of the irrigation system together may result in missed opportunities to reduce energy costs.

### Electric Motor Driven Pumping Plant Checklist:

☐ ***Best time of use electrical rate schedule for your needs***

A variety of ***electrical rate schedules*** have been available to PG&E customers for years and most agricultural consumers have already selected the rate that best fits their needs. However, check the rate schedule on your bill to be certain your electrical pumping plant is on the most economical rate. Off-peak electrical rate schedules encourage off-peak pumping (minimal pumping from 12:00 noon to 6:00 p.m. weekdays) by offering lower electricity rates. The potential cost savings is over 50 percent reduction in the average cents per kilowatt-hour charge (13.5 cents per kw-hr versus 6.0 cents kw-hr, at present). The rate schedule AG-4 is among the most commonly used rate schedules by agricultural pumpers. AG-5 and AG-R rate schedules may also fit specific needs.

The AG-1 rate schedule is least suitable for most agricultural pumpers. For a free rate analysis call 1-800-743-5000.

### ☐ *Electric pumping plant efficiency*

Chart 1 below shows the factors that determine pumping plant efficiency. Pump discharge capacity (gpm), total pumping lift, and input horsepower are the key components. Higher pumping plant efficiency results in reduced power demand (kw-hr) to lift each acre-foot of water and translates to lower electricity costs per acre-foot of water.

Pumping plant efficiency can range from less than 50 percent to greater than 60 percent (see chart 2). A pumping plant efficiency greater than 60 percent indicates a high performing pump where no repair is necessary. Chart 2 outlines the types of corrective actions that are often appropriate for pump efficiency levels below 60 percent. Common causes for poor pumping plant efficiency are:

- worn impellers and pump housing commonly due to sand
- pump is mismatched for groundwater conditions
- pump capacity insufficient for irrigation system expansion
- incorrectly changing nozzle sizes in sprinklers and microsprinklers

For years, the utilities evaluated pumping plant efficiency as a free service. This service has been discontinued and evaluation of pumping plant efficiency is now the responsibility of the pump operator. So, how can a grower evaluate pumping plant efficiency?

**CHART 1. WHAT IS ELECTRICAL PUMPING PLANT EFFICIENCY ?**

$$E = \frac{Q \times H}{3960 \times IHP}$$

E = Pumping Plant Efficiency (%)
Q = Capacity (gpm)
H = Total Head (Pump Lift + Pressure Discharge Head)
IHP = Input Horsepower to motor
3960 = Constant

WHY IS ELECTRICAL PUMPING PLANT EFFICIENCY IMPORTANT?

↑ Efficiency ↓ Kw-hr per Ac-ft

**CHART 2. WHAT ARE COMMON ELECTRICAL PUMPING PLANT EFFICIENCY RANGES?**

| Efficiency Range | Corrective Action |
|---|---|
| Greater than 60 % | No action |
| 55 to 60 % | Consider adjusting impeller ($100 - $200 expense) |
| 50 to 55 percent | Adjust impeller first, repair or replace pump if adjustment has no effect |
| Less than 50 percent | Consider repairing or replacing pump |

Interpreting pumping plant efficiency of a pump in use is more effective when the manufacturer's performance curve for the pump in new condition is available.

It requires three pieces of information:

- Input horsepower to the electric motor
- Pump capacity in gallons per minute
- Total head (pumping lift + pressure head)

**Input horsepower** can be measured at the meter mounted on the service pole. Simply record the time (t) in seconds that it takes the meter to complete 10 revolutions and note the meter constant (Kh). Then calculate the input horsepower using the following equation:

$$\text{Input Horsepower} = \frac{4.81 \times 10 \times Kh}{T}$$

**Pump capacity** can be more easily measured for pressurized irrigation systems. Measure the output of several individual sprinklers in gallons per minute and calculate an average sprinkler discharge rate. Multiply the average discharge value for a sprinkler by the number of sprinklers per acre to determine the pump flow rate. Flood and furrow systems are more challenging to measure flow rate. Some of the simpler and reasonably accurate methods of measurement include: 1) trajectory methods that measure the distance and angle of discharge from an open pipe; 2) Flow velocity and cross-section measurements in an open ditch; and 3) measuring head differences for siphon pipe of certain diameters and counting siphons per irrigation set. More precise methods of measurement but more expensive include flumes, weirs, velocity gages, and propeller meters. UC Division of Agricultural Sciences leaflet #2956, Measuring Irrigation Water describes several methods of measuring irrigation water.

**Total pumping lift (feet)** involves measuring the depth to water while a well is pumping and calculating the pressure head of the irrigation system. Pressure head is usually very low and not a factor for flood and furrow systems, whereas, it is very important to pressurized irrigation systems. To determine pressure head in feet for drip, microsprinkler, and sprinkler systems multiply the system operating pressure measured with a gage in psi by a factor of 2.31 (1.0 psi pressure equals 2.31 feet of water head).

Measuring pumping lift may be the most difficult task in evaluating pumping plant efficiency. One common method of measuring pumping lift is an electric well sounding device. It is simply a continuity device. An electric wire connected to a small battery is lowered down the well. The other lead is grounded and connected to some sort of a detection device such as a ammeter or a light bulb. When the wire that is being lowered downed the well touches the water the circuit is closed and continuity should be detected. The length of cable lowered down the well is then noted as the pumping lift to the top of the well column. Additional pumping lift must be added to account for the height of any standpipe or discharge pipe. This is the pumping lift. Adding the pumping lift to the pressure head gives the total pumping lift. Electric well sounding devices can be purchased for a cost of about $200 or more. As an alternative, contact UC Cooperative Extension in Tehama County for a publication written by Bill Richardson on how to construct a homemade electric well sounding device.

Another method is an airline with pressure pump and gage. It also requires carefully dropping a line down inside the well between the casing and the pumping column. It may be more accurate if cascading water inside the well is suspected to be a problem.

## ☐ *Be alert to a "Power Factor" adjustment to your electrical costs*

A power factor adjustment is calculated for larger customers, over 400 kw. Most private pumpers do not require these high loads so this adjustment may not affect electricity costs, but there are agricultural situations such as large pumping plants, cooling facilities, and other processes where the power factor is applied.

All power distributed by PG&E is three-phase alternating current (AC). Electrical power in an AC circuit has three components. The component we pay for is called "real power" and is typically measured in kilowatt-hours (kw-hr). Real power is the work-producing component. The second component is "reactive power". It does not do work, but it must be present in a utility's transmission and distribution system to keep current and voltage in phase. Reactive power is measured in kilovolt-amperes-reactive-hours (kvarh). It is required to operate motors and transformers. The third component is "apparent power" which comprises both "real" and "reactive" power. The power factor is the ratio of the "real power" compared to the "apparent power" and is expressed as a percent. So for pumps driven by electric motors, the power factor is the ratio of "real" power consumed by the motor to the "apparent" power supplied by the utility provider to the site.

A power factor indicates how far a customer's electrical motor causes the electrical current delivered at the customer's site to be out of phase with the voltage. Usually, electrical motors cause current to lag behind voltage resulting in a lagging power factor. A power factor of 60 to 90 percent is typical for electric motors. Lower power factors indicate the use of greater amounts of reactive power that must be replaced by the utility. Monthly bills are reduced or increased according to how much the power factor deviates from 85 percent. At one point (it may be different now), the total utility bill was reduced by 0.06 percent for each 1.0 percent the power factor was above 85 percent or increased by 0.06 percent for each 1.0 percent the power factor was below 85 percent. Customers may be able to bring a lagging power factor closer to 100 percent by installing capacitor banks on their service poles. Contact your utility provider if explore the opportunity to reduce costs by improving the power factor for a specific site.

Other related considerations include checking for phase balance. Three-phase motors operate most efficiently when the power load on each phase is balanced. Also, recognize that electric motors require significantly more current during start-up. It is not unusual for the start-up current to be six times the normal running current. Generally loads over 50 kW/HP are of concern and require corrective action that may reduce electricity costs.

## Engine Driven Pumping Plant Checklist:

☐ ***Diesel Pumping Plant Efficiency***

Evaluation of Diesel pumping plant efficiency is similar to that for electric motors. Both motor and engine driven pumps require flow rate (gpm) and total pump lift (feet) to measure efficiency. However, with engines water horsepower must be determined instead of input horsepower. Water Horsepower is a simple calculation using the flow rate and pumping lift information.

$$\text{Water Horsepower} = \frac{\text{gpm} \times \text{Total pump Lift (feet)}}{3960}$$

One method of evaluating diesel pumping plant performance is by dividing the working horsepower by the gallons of fuel consumption per hour. A rating of 12.5 or higher is considered good. A rating of below 12.5 indicates that the pump, engine, or both are performing inefficiently. Like motor driven pumps, an overall pumping plant efficiency above 60 percent is considered very good. Efficiencies between 55 and 60 percent are reasonable for older pumps, and efficiencies less than 50 percent indicate room for improvement. The overall pumping plant efficiency for engine driven pumps can be calculated by using the same equation shown in Chart 1 on page 3, except use Water Horsepower (for engine driven pumps) instead of Input Horsepower (for motor driven pumps).

### ☐ ***Electric motors versus diesel engines, and other energy sources***

Conversion from electric motors to diesel engines is perhaps the single most common step being taken to reduce irrigation costs, to overcome time of use restrictions, and to avoid rolling blackouts that are expected during the present electricity shortage.

If you are considering making a conversion, two simple equations are provided below to compare the energy costs for electric motors and diesel engines. These equations are not intended to assess the total cost of converting from a motor to an engine because they do not consider capital costs, costs associated with engine emissions control, or standby charges for electric motors. However, they may suggest whether converting from a motor to an engine is worthy of more investigation.

**Electricity Cost : $/Ac-ft = 1.58 x Total Pump Lift x $/Kw-hr**
**Diesel Cost: $/Ac-ft = 0.139 x Total Pump Lift x $/gallon**

If you are interested in a thorough comparison of capital, maintenance, and energy costs between electric motors and diesel engines or some other energy source such as propane or natural gas, UC Cooperative Extension has developed a user-friendly computer program that makes this comparison. This program will be demonstrated at the May 15, 2001 meeting in Corning or a copy can be obtained by calling UC Cooperative Extension in Tehama County at (530)-527-3101. Presently, the software runs on MS-DOS but efforts are underway to upgrade it to a MS Windows version.

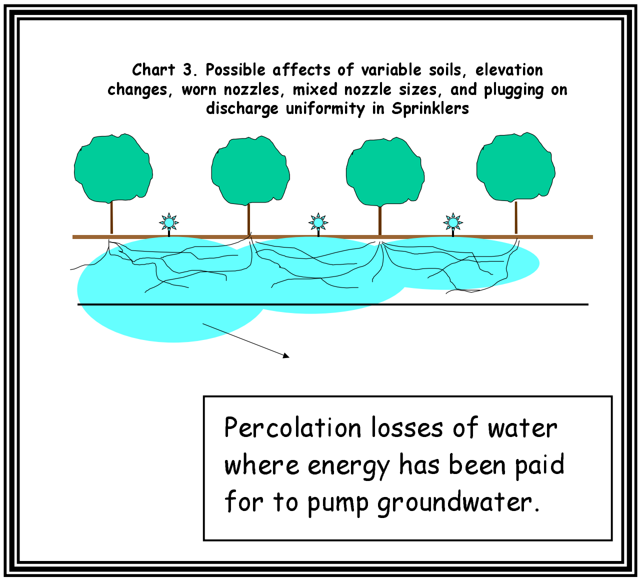
Costs for control of diesel engine emissions from stationary motors is a growing concern. The Tehama County Air Pollution Control District is initiating a program to encourage volunteer reduction of emissions and maintain engine driven pumps as an affordable option to manage energy costs for irrigation. **Beginning June 1, 2001 they will offer grants of up to $25,000 to towards replacement of older, high use, stationary diesel engines. Grants are being distributed on a first-come, first-serve basis to qualifying applicants.** A total of $230,000 is available to support this program. Contact the Tehama County Air Pollution Control District at 527-3717 for information.

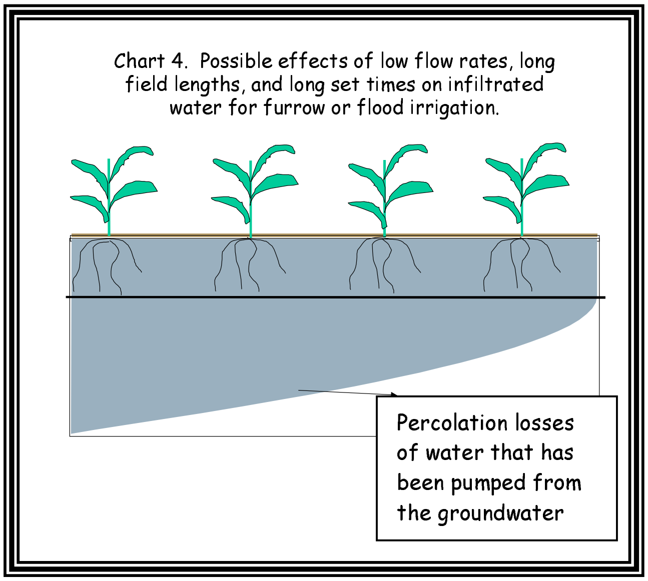
## What Can Be Expected by Improving Pumping Plant Efficiency?

Recall from Chart 1 (page 3), improved pumping plant efficiency means the cost to lift each acre-foot of irrigation water to the surface will be lowered. This does not necessarily assure that the cost per irrigated acre of land will be reduced because it depends on how much irrigation water is applied over a season. Often, when impeller adjustments are made to improve the pumping plant efficiency, the pump flow rate, the input horsepower, and the total head all increase. So under these conditions, to save energy costs, the total hours of pumping for the season must be reduced. Otherwise, in the end, the owner of the repaired pump may be disappointed that he/she did not save on energy costs or actually experienced higher costs. In the case where a new pump with the same pump capacity but with a higher pumping plant efficiency has replaced an old, worn pump a direct energy savings may be realized due to reduced input horsepower.

## Irrigation System Performance Affects Energy Costs

Charts 3 and 4 below illustrate the concept of irrigation uniformity for both pressurized and gravity irrigation systems, respectively. Irrigation systems that apply water uniformly across an orchard or field retain most of the applied water in the crop rootzone and will minimize the total irrigation time and maximize the benefit of improved pumping plant efficiency.




### *Tips to Improve Irrigation Application Uniformity:*

*Hand Move and Solid Set Sprinklers*

- **Check nozzles.** Since it is early, hand lines may be stacked nearby a shop, now is a good time to check for different nozzle sizes, worn nozzles, and plugged or corroded nozzles.

- **Check gaskets** in the collars of the pipe. Replace missing gaskets and cracked or broken gaskets.

- **Inspect sprinkler heads for bent, missing or broken parts** (any thing that might interfere with proper sprinkler rotation or throw pattern) and replace them.

*Minisprinkler, Microsprinkler, and Drip Systems:*

- **Check sand media in filter tanks**. Check media level and cleanliness (look for oil films, accumulation of silt and clay like layers, or evidence of precipitates). Depending upon what you see, you may want to replace the media or simply mix it around and perform several repeated backflush cycles and re-examine the media. Plugged filters require more pressure and cutback flow to the lateral lines.

- **Check disc and screen filters for cleanliness and repairs.** Disc filters are not usually self cleaning unless you are using a more elaborate spin type disc filter. Plugged filters require more pressure and cutback flow to the lateral lines.

- **Manually operate the backflush system.** Make sure the backflush controller is working and that proper flush times and dwell times are set. Tanks should flush in proper sequence. Flush valves should open and close completely.

- **Check for accurate pressure gages.** There should be a pressure gage located at a point before water flows through the filters and a gage after the water flows through the filter. Pressure losses exceeding 4-6 psi indicate dirty filters.

- **Manually test flow control valves.** Some microsprinkler and drip systems will have control valves so the system can irrigate more than one block. Make sure these valves are in good working condition.

- **Check pressure regulators and in-line screen filters.** Some systems might have regulators. Make sure they are in good condition and set to correct pressures for the microsprinkler or drip products in use. Some systems may have in-line screen filters. See that they are clean.

- **Walk lateral lines or drip lines.** Look for physical damage to hoses, external emitters, risers, and sprinkler nozzles. Most minisprinkler and microsprinkler nozzles are color coded by size to assist in checking uniform nozzle sizes. Inspect drip emitters and sprinkler nozzles for clogging. You may want to check for uniformity of flow from several individual sprinkler or drip emitters.

- **Consider chlorination or acidification** emitter plugging appears to be a problem. Chlorination is most appropriate to control plugging from algae and moss. Acidification is more appropriate to control plugging when calcium carbonate build-up appears around the emitter.

- **Flush lines.** Rid the system of sediments that may have built up during past use. Be sure to have sufficient flow velocity to achieve effective flushing.

*Furrow and Flood Systems:*

The first step in managing irrigation uniformity of furrow and flood systems is to identify fields or irrigation events that do not irrigate efficiently. One technique to judge irrigation uniformity and identify problem fields involves comparing the total irrigation set time to the time required to advance water from the head of the field to the tail end of the field but before much water has been stored in the furrows or basin. If more than one-half of the total irrigation set time is required to advance water from the head to the tail end of the field before the furrows or basin begin to fill with water, it is an indicator of lower irrigation uniformity. These conditions are likely to result in higher energy costs. Usually, too little or non-uniform field slope, low flow rates, too large of set sizes and excessively long irrigation set time are all factors that contribute to lower irrigation application uniformity with furrow and flood systems.

## Irrigation Scheduling Affects Energy Costs

Decisions of when to irrigate and how much water to apply affects the total irrigation time for the season and total energy costs. Effective irrigation scheduling should protect against too frequent irrigation or applying too much water during an irrigation event, both can result in percolation losses of water below the root zone and inefficient use of energy required for pumping. A variety of climate based, soil-moisture monitoring, or plant stress monitoring techniques are available to growers to assist with irrigation scheduling decisions. Use of these different irrigation methods will be the focus of the next issue of this newsletter.

Some crops can be purposefully stressed or under-irrigated to reduce irrigation costs with minor impacts or actual benefits to the crop, while this approach does not work well with other crops. This approach to irrigation scheduling is referred to as "regulated deficit irrigation" (RDI).

***Crops Where RDI Has Been Practiced With Success:***

- **Prunes –** intensively irrigated prunes that do not undergo much stress use slightly more than 3 acre-feet of water per irrigated acre. Experiences suggest that reductions in irrigation from mid June through August improve sugar content of fruit, reduce drying requirements, and may enhance bloom in the following crop. The reduction in applied irrigation water and pumping costs may be on the order of 25 to 40 percent or from about 3.25 acre-feet water per acre in intensively irrigated prunes reduced to 2.25 acre-foot per acre. A pressure chamber, a tool, which detects crop water stress is a useful tool to carry out RDI strategies in prunes.

- ***Wine Grape -*** respond favorably to stress mainly after berry softening and result in higher sugar content and more controlled canopy growth. Experiences suggest potential to reduce applied irrigation water and pumping costs by as much as 40 percent or from about 2.25 acre-foot per acre under intensive irrigation to about 1.5 acre-foot per acre. The pressure chamber is also a useful tool in wine grape.

- ***Olives –*** grown for oil respond favorably to moderate levels of stress from June to mid August by improving the oil quality without affecting yield. Olives grown for canning are more sensitive to the stress because fruit size is important. Reducing ET for non-stressed olives by about 25 percent is suggested from June to mid August. At this point, there is very little experience with using a pressure chamber to monitor crop stress.

- ***Almonds -*** the jury is still out as to how well almonds respond to under-irrigation. There appear to be benefits related to more uniform hull split but there are concerns about declining shoot growth and longer term impacts on meat yields. Work is ongoing with the pressure bomb.

- ***Walnut -*** so far walnuts do not seem to respond well to management induced water stress. Walnut appears much more sensitive to under-irrigation than the crops listed above. Consequences of water stress are reduced shoot growth, reduction in yield, and kernel shrivel.