

# Benefits and costs of improving pumping efficiency

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## ***Pump repair or replacement can substantially improve performance, but energy savings will depend on management of the irrigation system***

**T**oday's energy costs require growers to operate their irrigation pumping plants as efficiently as possible. High efficiency means maximum pump output per dollar spent on energy.

Pumps that are initially efficient can become inefficient through pump wear, changes in groundwater conditions, and changes in the irrigation system. Periodic tests can provide information needed for decisions on pump repair or replacement.

It is well known that repairing or replacing an inefficient pump is beneficial, but little documentation exists on the benefits versus costs of improving efficiency. Growers need such information to determine the economic feasibility of any improvements. A study of the benefits and costs of increasing pump efficiency was therefore conducted in the central coastal area of California.

### Procedures

Pump tests were made by Pacific Gas and Electric Company (PG&E) personnel before and after repairs or replacement of 63 pumping plants. Measurements included pumping head, discharge pressure, pump capacity, and input horsepower. Data on the costs and types of improvements were also obtained.

A statistical evaluation was conducted to determine the effect of the improvements on

pump output and efficiency. The analysis indicated relationships between pumping plant performance before repairs and increases in performance afterwards, and made it possible to estimate expected improvements in performance as a result of the repairs and their expected costs.

### Results

**Pump performance.** New pump bowls were installed in about 75 percent of the pumping plants. Pump bowls were repaired in nearly 16 percent. Other corrective actions included rewinding motors, repairing or replacing the well, replacing column pipe, and chemical rehabilitation of the well.

Average pumping plant efficiency increased from 46 percent before repairs to 61 percent afterwards, with an average increase of about 33 percent (table 1). Average pump capacity increased 41 percent from

about 960 gallons per minute (gpm) to nearly 1360 gpm, but little change in total head occurred. The average input horsepower increased from 89 to 96.

These results show that the efficiency increase was due to increased pump capacity, since the average total head remained unchanged. The data on total head suggest that most of the irrigation systems at the time of the pump tests were surface types, commonly used after crop establishment in the central coastal area. For such systems, total head would be relatively unaffected by improved pumping plant performance.

Before the repairs, nearly 57 percent of the pumps were less than 50 percent efficient, and only 7 percent had efficiencies greater than 60 percent (fig. 1). After repair, only 17 percent of the pumps were less than 50 percent efficient, while 65 percent had efficiencies greater than 60 percent.

Before repair, 68 percent of the pump capacities were less than 1000 gpm, and 22 percent were between 1000 and 2000 gpm. After repair, 38 percent of the capacities were less than 1000 gpm, while 41 percent were between 1000 and 2000 gpm.

Although total head changed negligibly, on average, an increase greater than 50 feet occurred in about 7 percent of the pumps, and a decrease of at least 50 feet in another 7 percent. The efficiency changes for these pumps may be due partly to changes in operating conditions between tests. Pumping plants with large head increases had an average efficiency increase of about 80 percent compared with the average increase of 33 percent. This large increase may reflect not only the repair but also a change from a

**TABLE 1. Average performance of pumping plants before and after repairs or replacement**

Characteristic	Before	After	Increase
Water horsepower	44	60	36
Head (feet)	199	200	0.5
Capacity (gpm)	963	1,356	41
Input horsepower	89	96	8
Efficiency (%)	46	61	33

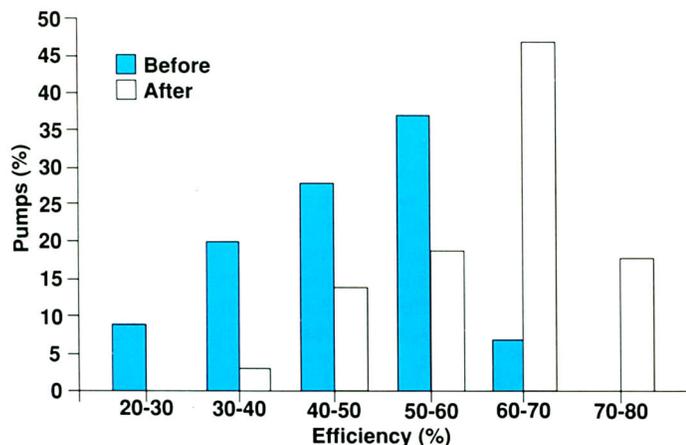


Fig. 1. Before repair or replacement, nearly 57 percent of the pumps were less than 50 percent efficient. Afterwards, 65 percent had efficiencies above 60 percent.

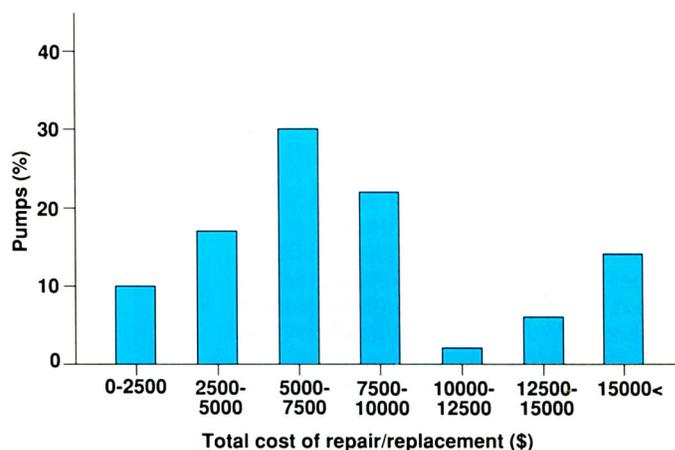


Fig. 2. Improvements cost \$5,000 to \$10,000 for 52 percent of the pumps, and less than \$5,000 for 27 percent. However, 22 percent of the repairs cost more than \$10,000.

low-pressure to a high-pressure irrigation system, which would force that pump to operate at a point of higher efficiency along the performance curve. For pumps with substantial head decreases, however, the efficiency increased an average of about 19 percent. This behavior may reflect a change from a high-pressure to a low-pressure irrigation system, which may have forced pump operation to move away from the point of maximum efficiency. Such a change is possible, since sprinkler systems are used for crop establishment and furrow irrigation is used thereafter in this area.

Input horsepower changes (change in input horsepower as a percentage of the initial horsepower) were relatively small for most of the pumps. Input horsepower increased for 59 percent of the pumps, however, as a result of the repair or replacement.

The analysis shows that 52 percent of the repair or replacement costs were between \$5,000 and \$10,000, while 27 percent were less than \$5,000 (fig. 2). However, 22 percent of the repairs cost more than \$10,000, with a maximum cost of nearly \$44,000. These high costs generally included repair or replacement of the well. The average cost was about \$9,400, although if costs greater than \$10,000 are excluded, the average would be about \$6,100. This reflects the cost of repairing or replacing the pump bowls only.

**Correlations.** Correlations between conditions before repairs and the change in pumping plant performance after repairs were investigated to help determine an expected output given a set of initial conditions. Although no strong correlations were found, the analysis did reveal some trends. Generally, as the initial capacity increased up to about 1000 gpm, the change in capacity as a result of repairs or replacement also increased. For initial capacities larger than 1000 gpm, the capacity change remained nearly constant. A trend was also seen between the initial pumping plant efficiency and the change in efficiency from the repair/replacement: generally, the smaller the initial efficiency, the larger the change. This result would be expected, since the opportunity for large changes in efficiency decreases with higher initial efficiencies. Also, the smaller the initial pump output, the smaller the initial efficiency.

Correlations between cost of repair/replacement and changes in the pump performance and between cost and initial conditions were negligible. Relating an expected cost to an expected improvement in performance thus was not possible. This suggests that the type of corrective action was independent of the initial conditions. A statistical analysis revealed that the expected cost for repaired/replaced pumps would be between \$3,100 and \$9,000 for 80 percent of the time. Unfortunately, this range is too wide for reliable estimates of expected costs.

**Benefits.** The benefits of improved pumping plant performance depend on the management of the irrigation system. Options analyzed included (1) operating for the same number of hours, and (2) pumping the same volume of water before and after the repair/replacement. Energy savings will occur only if the improved pump performance reduces the kilowatt-hours consumed. The first option entails applying more water after repair/replacement as a result of increased capacity. The second requires a reduction in the operating time. Benefits and costs of both options were calculated using a real interest rate of 4 percent, an economic life of the pump of 10 years, and energy costs of 9 and 6 cents per kilowatt-hour.

If operating time remains the same after repair, energy savings will occur only if input horsepower is decreased. The analysis revealed, however, that 59 percent of the pumps increased their horsepower demand as a result of the improvement. For these systems, energy consumption will rise, and the primary benefit of the improved pump performance is the greater pump capacity. More water is applied and, where pressure is increased, better uniformity of the applied water is achieved. The economic benefit depends on an increase in crop yield.

Examination of the benefit/cost ratios under the first option, assuming that the benefit is annual energy savings, showed that the ratio was negative for 59 percent of the pumps (fig. 3). Energy costs for those pumps thus increased as a result of the repair/replacement. The rest showed energy savings from a decreased horsepower demand as a result of the repair or replacement, reflected in a positive benefit/cost ratio. About 23 percent had a positive ratio less than one, however, which indicates that the annual energy saving was less than the annual cost of the repair. Energy savings exceeded annual costs for only 18 percent of the pumps. Pumps with the larger ratios had decreases in horsepower demand and large operating times.

The second management option implies that, because of deteriorating pump per-

formance before repair, the operating time has been increased to maintain crop yield. The repair/replacement increases capacity, so that operating time can be reduced with little influence on yield.

The benefit/cost ratios of the second option show that the improvements saved energy for all pumping plants (fig. 3). At 9 cents per kilowatt-hour, 78 percent of the pumps had ratios greater than one (annual savings exceeded annual cost). Nearly 60 percent had ratios greater than one at 6 cents per kilowatt-hour (results not shown).

Pumping plants with benefit/cost ratios less than one had relatively low energy consumption, the result of small horsepower demand and/or operating times. In some cases, high costs and small changes in efficiency also contributed to the low ratio. These pumps had average annual energy savings of about 7800 kilowatt-hours.

Pumping systems with large benefit/cost ratios generally used relatively large amounts of energy. Even though only minor changes in efficiency occurred in some cases, energy savings were substantial. For example, pumps with ratios greater than five had annual savings of nearly 82,000 kilowatt-hours.

## Conclusions

Substantial improvements in pump performance resulted from repairing or replacing the pumping plant. In the study area, California's Central Coast, the primary improvement was increased pump capacity.

The benefit of such improvements, however, depends on management of the irrigation system. If the same operating time is continued after the repair/replacement, little or no energy savings will occur and the primary benefit will be an increase in crop yield. If, however, the same volume of water is applied before and after the repair, an energy savings might be expected.

Growers should not expect energy savings from improved pumping efficiency unless the horsepower demand is reduced or the operating time is decreased. Horsepower demand can be reduced by replacing a pump that is not operating at maximum efficiency for a given total head and capacity with a pump that is properly matched with the desired total head and capacity. The operating time can be decreased by reducing set times to prevent overirrigation, increasing the uniformity of the irrigation system, and improving irrigation scheduling.

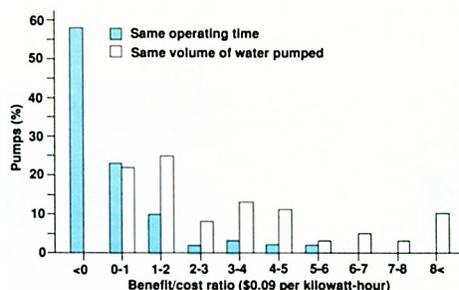


Fig. 3. Benefit/cost ratios showed higher energy costs under one management option (same operating time after repair) and savings under the other (same water volume).

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