Irrigation Pumping Plant Costs

capacity of well, design and power of pumping plant must be engineered to fit water needs of crop for operating economy

V. H. Scott

George Koumbarakis, graduate student in irrigation, University of California, Davis, at the time the following study was made, assisted in the work.

Approximately half of the water used for California's irrigated agriculture comes from underground sources.

Economical development of an underground water source on the farm depends on the installation of properly designed wells and on pumping plants engineered to fit the water requirements of the irrigated crops as well as the hydrologic conditions in underground water bearing formations the well may penetrate.

The cost of pumping water may be a major item in the total cost of producing irrigated crops. Lowering water levels and changes in over-all efficiency of the pumping plant affect the pumping cost. Also, improvements in the operations of internal combustion engines and the availability—in some areas—of low cost natural gas influence the choice of the type of drive power to be used to achieve greatest economy in operation.

A study to determine what factors influence the cost of pumping was conducted in areas of Yolo, Riverside, and western Fresno counties. The cropping pattern, hours of plant operation, ground water conditions, and pumping lifts vary considerably from one area to another. The small table below gives the range of values for the depth and size of motor for the pumping plants which were selected on the basis of being typical of those plants in the area.

Types of Wells and Pumping Plants Included in Study

Location	Drive Power	Depth of Well	Size of Motor
		feet	HP
Yolo	Electric	200–600	20–50
Riverside	Electric	300–770	20–75
Fresno	Electric	1300–2250	125–300
Yolo	Diesel	400–800	40–130
Riverside	Natural Gas	180–880	40–130

Average Values of Operation Hours, Useful Life, Depreciation Rate

Pumping Plant	Av. hrs. of operation a year	Useful Life Years			Depreciation Rate Per Cent		
		Well	Motor	Pump	Well	Motor	Pump
Electric							
Yolo	1780	25	25	20	4	4	5
Riverside	3320	20	20	10	5	5	10
Fresno	5420	8	15	5	12	7	20
Natural Gas							
Riverside	4080	20	15	10	5	7	10
Diesel							
Yolo	1020	25	15	20	4	7	5

Forty-four pumping plants were selected for detailed study. Data on these were obtained from tests performed in the field and from information given by the operators, owners, and by power and gas companies. The average pumping lift for the wells included in the study in Yolo County was 72′; in Riverside County it was 220′; and in western Fresno County, 472′.

To determine the effects of variables—such as changes in pumping level, hours of operation, and others—on the cost of pumping, it was necessary to establish the total annual cost of each plant. The total cost is usually divided into fixed and operating charges.

Fixed costs include depreciation, interest, taxes, and insurance. To compute the rate of depreciation, the useful life of the pumping plant must be known or estimated. From the information given by the plant operators and from other sources, average values of the useful life have been determined and are given in the larger table above.

The difference in the values of useful life for the various groups of pumping plants is due primarily to the number of hours of operation, but other factors—such as well drilling methods, quality of the underground water, and amount of sediments in the water pumped—also influence the length of time over which the equipment must be depreciated.

Average Values of Maintenance and Attendance

Pumping Plants	Maintenance: Lubricants: Oil: Pump gal/24 hrs.	Maintenance: Lubricants: Oil: Engine gal/HP-hr.	Maintenance: Lubricants: Grease lb/yr.	Maintenance: Repairs ac. ft./ft. lift ¢	Attendance Minutes per 24 hrs.
Electric					
Yolo	0.25			0.20	10
Fresno	0.38			0.20	15
Riverside	0.30			0.20	15
Natural Gas					
Riverside	0.30	0.00067	30	0.30	20
Diesel					
Yolo	0.25	0.001	30	1.10	60

The rate of interest was computed at 6% of the average investment or 3% of the initial investment of the pumping plant over its useful life.

The criteria for establishing the assessed valuation of the pumping plants are quite different in the three counties, and in addition, tax rates are variable. The range of values for the plants in this study varied from $7 to $150.

Ordinarily, farmers do not carry insurance on their pumping plants.

Operating costs are variable charges bearing a definite relationship to the number of hours of operation, and include power, maintenance, attendance, and repairs.

The costs of power or fuel for the electric and natural gas plants were calculated from the actual power bills. Fuel

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Summary of Mean Annual Costs

	Hrs. of operation	Ac. ft. pumped	Fixed Cost: ac. ft.	Fixed Cost: ac. ft/ft. lift	Operating Costs: ac. ft.	Operating Costs: ac. ft/ft. lift	Total Cost: ac. ft.	Total Cost: ac. ft/ft. lift
			$	¢	$	¢	$	¢
Electric								
Yolo	1780	330	1.18	1.70	2.74	3.80	3.92	5.50
Riverside	3320	340	3.16	1.80	5.22	2.50	8.38	4.40
Fresno	5420	1430	4.98	1.07	7.27	1.54	12.25	2.61
Natural Gas	4080	620	2.33	1.10	2.97	1.40	5.30	2.50
Diesel	1020	350	1.95	3.40	2.78	4.80	4.73	8.20

Manure as Source of Nitrogen

studies of tilled and nontilled citrus and avocado orchards show manure to be efficient in supplying nitrogen to tilled soil

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Manure—an efficient source of phosphate and potash—is commonly used in California citrus and avocado orchards to supply organic matter to aid in maintaining soil in good tilth and to supply several fertilizer elements.

To determine the efficiency of manure as a source of nitrogen—in tilled and nontilled soils—four orchards were selected for study. A description of the experimental orchards appears in the large table on the next page.

Navels

A summary of the yield and nitrogen content of the leaves for Orchard *No. 1*—tilled navel oranges in Riverside County—is given in the table in the first column on page 15.

The trees that were never fertilized were practically nonproductive, and the nitrogen in the leaves was markedly lower than in the leaves of the trees fertilized with nitrogen. In this cultivated orchard there were no differences in yields between the trees receiving three pounds of nitrogen annually from calcium nitrate, and those receiving three pounds of nitrogen annually from manure. The amount of nitrogen in the leaves was practically the same for both sources of nitrogen. Thus, in this cultivated orchard, at the three-pound rate the results from manure paralleled those with calcium nitrate.

Valencias

In Orchard *No. 2*—nontilled Valencia oranges in San Diego County—withholding nitrogen since 1950 did not result in a significant reduction in yield, although a trend developed. In this nontilled orchard the trend was for the trees that received two pounds of nitrogen annually from manure to produce less fruit than the trees that received two pounds of nitrogen annually from ammonium nitrate.

The amount of nitrogen in the leaves of trees that received manure was definitely lower than in the leaves of trees that received ammonium nitrate.

When the spring flush of growth had fully expanded in 1954 and 1955, the leaves on the trees that did not receive nitrogen and on the trees that received manure were definitely more yellow than the leaves on trees that received ammonium nitrate.

In this nontilled orchard, manure did not supply nitrogen to the trees as efficiently as did ammonium nitrate. It is noteworthy that a large concentration of roots developed in the surface soil right

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costs for the diesel plants were calculated on the basis of results obtained from measurements of the amount of fuel consumed during a field test and the total hours of operation.

Maintenance and attendance costs were based on the information supplied by the operators and are tabulated in the third column on page 3.

A summary of the mean, annual, fixed operating and total costs for each type of drive power in the three areas is given in the table in columns 1 and 2 on page 3. The variations in total cost for each type and group of pumping plants are the results of several important factors—total lift, hours of operation, total water pumped, and over-all efficiency of the plant.

The influence of the pumping lift on the total cost is indicated by a comparison of costs for the electric plants operating in the three areas of different water level conditions. The least cost, when compared on an acre-foot basis, is $3.92 for the Yolo electric plants which have an average pumping lift of 72′. The highest cost is for the Fresno plants—$12.25 per acre-foot based on an average pumping lift of 472′. However, if the comparison is made on a cost per acre-foot of per foot-of-lift basis, the order is reversed and the Fresno plants are the least expensive units and the Yolo plants the most costly.

Similar analysis can be applied to the relationship between the pumping lift and the total cost for each of the areas. For example, a change in pumping lift from 100′ to 200′ for the Riverside electric plants results in an increase in total cost per acre-foot from $5.80 to $8.28, or an increase of approximately 47%.

The more hours a pumping plant operates the less will be the annual total cost per acre-foot. This reflects a lower rate of depreciation, and in the case of an electrically driven plant, a lower energy charge as the hours of operation increase.

The over-all efficiency of the pumping plant has an important influence on the amount of fuel or power consumed. For example, a decrease in over-all efficiency of an electric plant from 70% to 50%—based on the data from the Yolo electric plants—while operating under the same conditions, increases the power cost 51%. A decrease in over-all efficiency from 15% to 12% for the natural gas plants increases the fuel cost 39% and 23% for diesel plants.

Maintaining the efficiency of a pumping plant at a high level may effect savings in power costs alone which will more than offset the annual depreciation charge for a new pump of higher efficiency or the maintenance of an older pump in good repair.

A comparison of the annual costs of diesel and electric plants in Yolo County showed that the operation of diesel plants is approximately 21% higher than the electric plants.

A similar comparison between the electric and natural gas plants of Riverside County shows that the pumping cost—per acre-foot—of electric plants is substantially higher than that of the natural gas. However, the lift, total hours of operation, and water discharge of the wells included are different in each group. However, an analysis—based on identical operating conditions with present-day electricity and natural gas schedules—gives the advantage in fixed and operating costs to the natural gas-powered pumping plants.

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N. L. McFarlane and Robert F. Kasmire, Farm Advisors, Riverside County, University of California, co-operated in the above-reported studies.

The above progress report is based on Research Project No. 779.