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# Efficient Irrigation Pumps

Cooperative Extension South Dakota State University

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# South Dakota Cooperative Extension Energy Information

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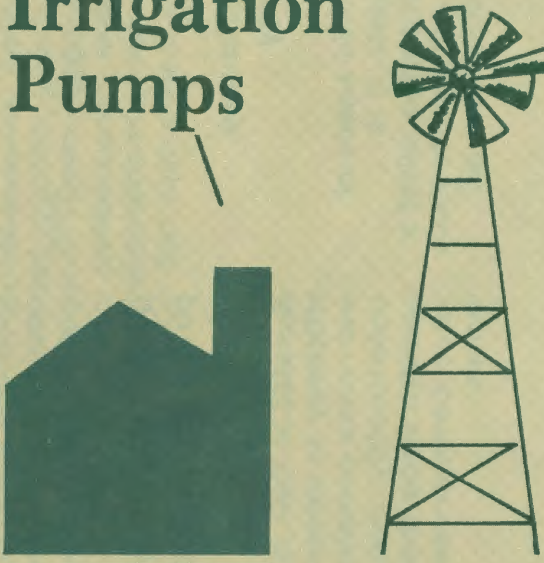

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OFFICE OF ENERGY POLICY
ENERGY INFORMATION

# Efficient Irrigation Pumps

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Want to reduce electricity or diesel fuel costs for pumping irrigation water by as much as 30 per cent?

You can, just by selecting the proper pump and then adjusting and maintaining it for maximum efficiency. Your pump is an integral part of your whole irrigation system and any inefficiency will increase energy consumption and production costs.

So choose your pump with care, not just on the basis of initial cost. Your pump must fit your situation--depth to water, lift, amount of pipeline, pressure at the field, and discharge needed. When these requirements have been determined, then shop for a pump.

The right unit for your installation is found by selecting the type first and then checking pump characteristic curves to find the one pump that gives you the discharge you desire at the correct pressure and which operates at the highest efficiency.

Even if that pump has a higher initial cost, it will be cheaper to operate and will save you money every year.

## Types of pumps

There are four basic types to choose from for irrigation. Each one has its proper application, so the one you select will depend on the actual conditions under which you will be using it. The types are propeller, centrifugal, vertical turbine, and submersible.

Centrifugal, vertical turbine, and submersible pumps all operate on the same principle of centrifugal force. The only difference is in the location and orientation of the impeller relative to the motor. Propeller pumps push water vertically with a propeller, and are ideal for high discharge, low head situations such as pumping from surface water sources or canals into a distribution ditch. Propeller pumps have little application in South Dakota.

Centrifugal pumps are much more versatile in application. They can be sized to meet a wide range of pressure-discharge relationships, but their primary application is for surface water supplies and as booster pumps to increase pressure in a pipeline. They can be placed above the water level if the suction lift is kept below limits established by the manufacturer. They must be primed (the suction line and pump chamber filled with water) before each use, so frequent interruptions are undesirable.

Propeller, vertical turbine, and submersible pumps are all submerged, so priming is not a problem. Vertical turbine and submersible turbine pumps are used in wells. The power unit for the vertical turbine is located on the ground surface; for the submersible it is close coupled to the pump. For both types bowl and impeller design determine the discharge-pressure relationship. Additional stages increase pressure but do not increase discharge. The submersible pump is not used much for irrigation because it is more expensive than the vertical turbine pump.

## Pump selection

After choosing the proper type of pump for a particular situation, a model and size must be chosen which will operate efficiently. Pump characteristic curves are used to make the selection. They are graphic relationships between pressure, discharge, and operating efficiency. Figure 1 is an example.

The required discharge and pressure must be known before starting the selection process.

## Discharge capacity

Irrigation requires large capacity pumps. Required discharge is determined from the number of acres to be irrigated, the crop to be grown, and the irrigation system to be used. For optimum crop production, the pump must be able to supply enough water to satisfy the amount needed by the crop during the peak use period (hot summer days) less the amount of effective rainfall received.

FS 670, "Irrigation Management on Corn," gives the estimated daily peak consumptive use rates for corn in South Dakota. Other full season crops have similar peak rates, but short season crops have lower rates.

System efficiencies vary greatly with management, but gravity systems generally are 50 to 60 per cent efficient while

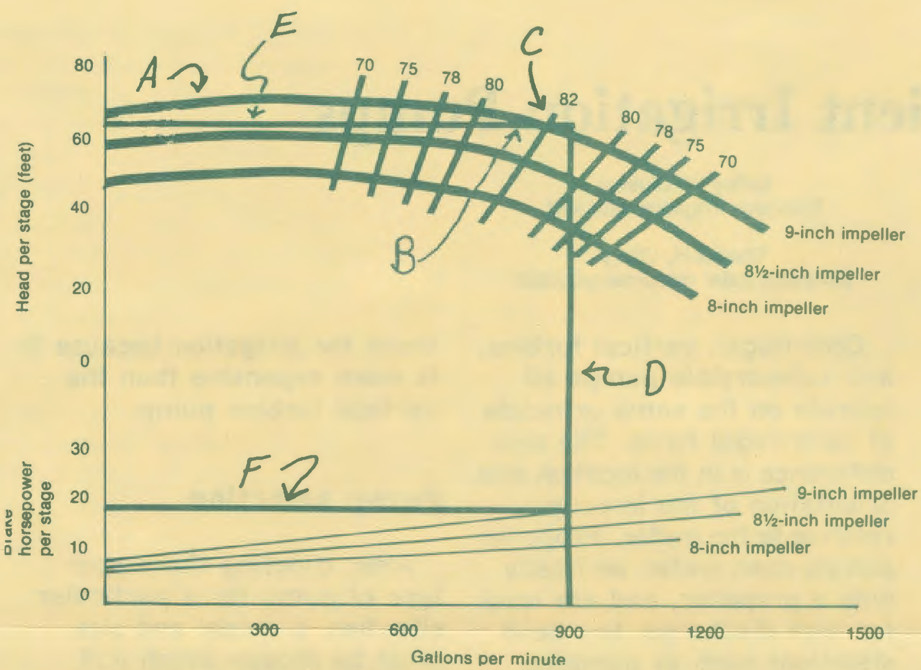


**Fig. 1. Pump curve for a hypothetical pump. The irrigator needs 910 gpm; maximum efficiency is at 850 gpm.**

sprinkler systems can be 70 to 85 per cent efficient.

Table 1 gives a procedure to calculate discharge based on irrigated acres. Maximum discharge may be limited by the irrigation permit or by the maximum output of the well. In such cases, the smaller value must be used.

## Pressure required

The pressure required from the pump is determined by three factors: the lift, delivery system friction loss, and pressure needed at the distribution system. Lift is the difference in elevation between the water surface at the source of supply, or the water level in the well during pumping, and the highest point in the pipeline (Fig 2). Delivery system friction loss and system pressure must be supplied by the manufacturer. The system must be operated near its recommended pressure for it to function properly. An example of pressure calculation is given in Table 2.

**Table 2. Calculation of necessary pressure.**

| | Example | Your farm |
|---|---|---|
| Lift (elevation) | 63 ft | ______ft |
| Friction loss 6.5 psi x 2.31 = | 15 ft | ______psi x 2.31 = ______ft |
| System pressure 70 psi x 2.31 = | 162 ft | ______psi x 2.31 = ______ft |
| Total pressure | 240 ft | ______ft |

## Reading a pump curve

Every pump has its own unique performance curve which shows how efficiently it will operate for different combinations of discharge and pressure. Under normal operating conditions, pressure will decrease as discharge increases (A in Fig 1). Superimposed on the curve are lines showing the efficiency of the pump (B). The objective of pump selection is to find a curve that will give the desired pressure and discharge at the highest efficiency.

To read a pump curve move vertically from the discharge you want (915 gpm) to curve A (line D in Fig 1), move back horizontally to read the pressure (63 ft per stage) (line E). Read the efficiency from curve B (81 per cent). Table 3 gives one example.

Examination of the pump curve (Fig 1) leads to several conclusions. First, the pump reaches its highest efficiency at 850 gpm with a pressure of 62 feet per stage (bowl and

**Table 1. Calculation of pump discharge.**

| | Example | Your farm |
|---|---|---|
| Irrigated Acres | 150 Acres | ______ Acres |
| Peak daily use rate (FS 670) | 0.26 in/day | ______in/day |
| Peak weekly use rate | 0.26 in/day x 7 = 1.82 in/wk | ____ in/day x 7 = ____ in/wk |
| Weekly rainfall | 0.25 in. (effective) | ______ in |
| Weekly water need | 1.82 - 0.25 = 1.57 in | ____ in – ____ in = ____ in |
| gpm/A | 1.57 in x 271 / Irr. system efficiency (%); (1.57 x 271) / 70 = 6.1 gpm/A | (______ x ______) / ______ = gpm / A |
| Pumped gpm | gpm/A x no. acres = 6.1 x 150 = 915 gpm | ______ x ______ = ______ gpm |
| Irrigation permit gpm | 964 gpm | ______gpm |
| Max. well discharge | 1000 gpm | ______gpm |

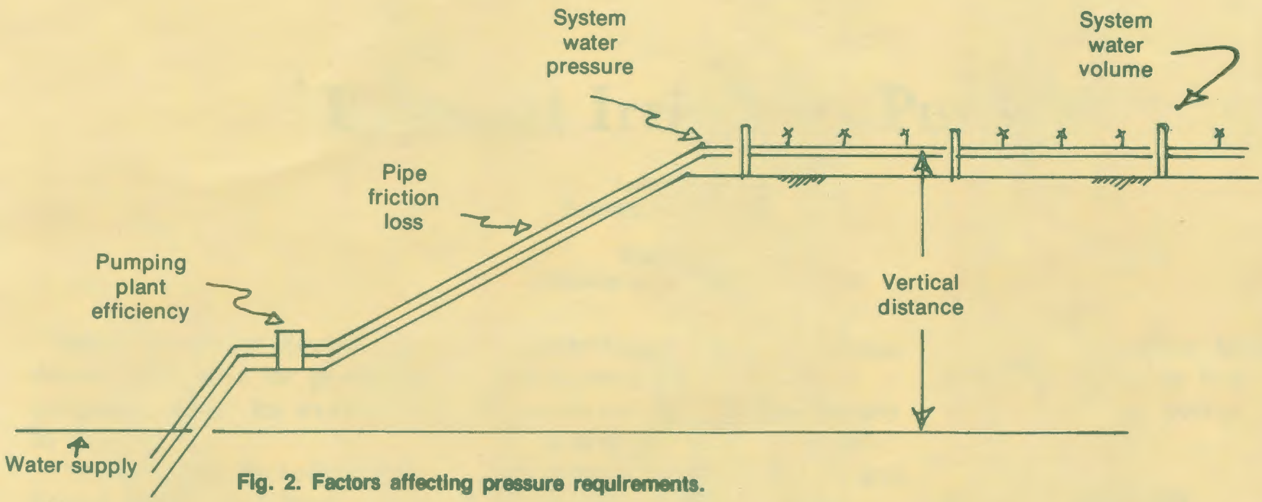


**Fig. 2. Factors affecting pressure requirements.**

impeller) developed by the 9-inch impeller. Secondly, peak efficiencies occur at lower discharges and pressures for smaller impellers.

If the pressure does not match your situation, this pump is not an alternative to consider.

A pump is selected by referring to curves for all available pumps that fit your situation and choosing the one that has the proper pressure discharge characteristics and operates at the highest efficiency. In our example, we are slightly to the right of maximum efficiency. As the system ages, pressure requirements will likely go up due to increased delivery system pressure losses or changes in the water supply; and as that happens, this pump becomes more efficient.

**Table 3. Pump selection summary.**

| | Example | Your farm |
|---|---|---|
| gpm | 910 gpm | ______ gpm |
| Pressure | 240 ft. | ______ ft |
| Pump no. | SDSU Ext. | ______ |
| Impeller size | 9 in | ______ in |
| Efficiency | 81% | ______ % |
| Pressure per stage | 60 ft | ______ ft |
| Stages needed Pres./(Pres./Stage) | 240/60 = 4 stages | ____ / ____ ______ stages |

## Power required

Once the pump is selected, you can also determine the size of power unit needed from the pump curves.

Horsepower is found by moving vertically from the discharge to the horsepower curve (curve G in Fig 1) and horizontally to read the power required per stage line (line F). Total horsepower (horsepower per stage times the number of stages) is the power requirement of the pump. It is the nameplate horsepower of an electric motor or the continuous horsepower rating of the internal combustion engine needed to drive the pump. Table 4 is one example of power unit sizing.

**Table 4. Horsepower required by the pump.**

| | Example | Your farm |
|---|---|---|
| Horsepower per stage | 17 hp | ______ hp |
| Total hp | 17 hp/Stage x 4 Stages | ____ hp/Stage x ____ Stages |
| | 68 hp | ______ hp |

## An efficient pump saves energy

With a limited supply of pumps available, it is impossible to always select a pump which will operate above 80 per cent efficiency, but approximate this figure as closely as possible because operating costs are directly related to efficiency.

Figure 3 gives the seasonal increase in energy consumption and power costs for an irrigation system with various pump efficiencies. For example, the annual electrical bill would be 5c per acre-inch higher for a 70 per cent efficient pump as compared to one at 80 per cent when electricity costs 3c per kilowatt and the total pressure developed is 100 ft. A system covering 80 acres with 15 inches of water and developing 300 ft of total pressure (90 psi + 90 ft lift) would save $183 annually if the pump operates at 80 per cent rather than at 70 per cent efficiency.

In addition to the energy cost a greater expense may also be incurred if a larger pump and power unit are needed and additional standby charges are required by the electric supplier.

## Reasons for low pump efficiencies

Irrigation pumps should be operated at their highest efficiency to conserve energy and reduce pumping costs. Unfortunately, many are operated below their peak value. Common causes for this include:

**Improper pump selection.** The pump operates under pressure-discharge conditions which reduce efficiency.

**Wear.** Wear of pump components resulting from age or pumping sand and other debris will lower efficiency.

**Improper installation and maintenance.** Pumps not receiving proper maintenance will require more energy and fail prematurely.

**Inadequate knowledge of water supply.** Pump may work against head other than used for selection. Inadequate well testing or improper design of surface water supply suction lines may cause air pumping.

**Excessive suction lift.**

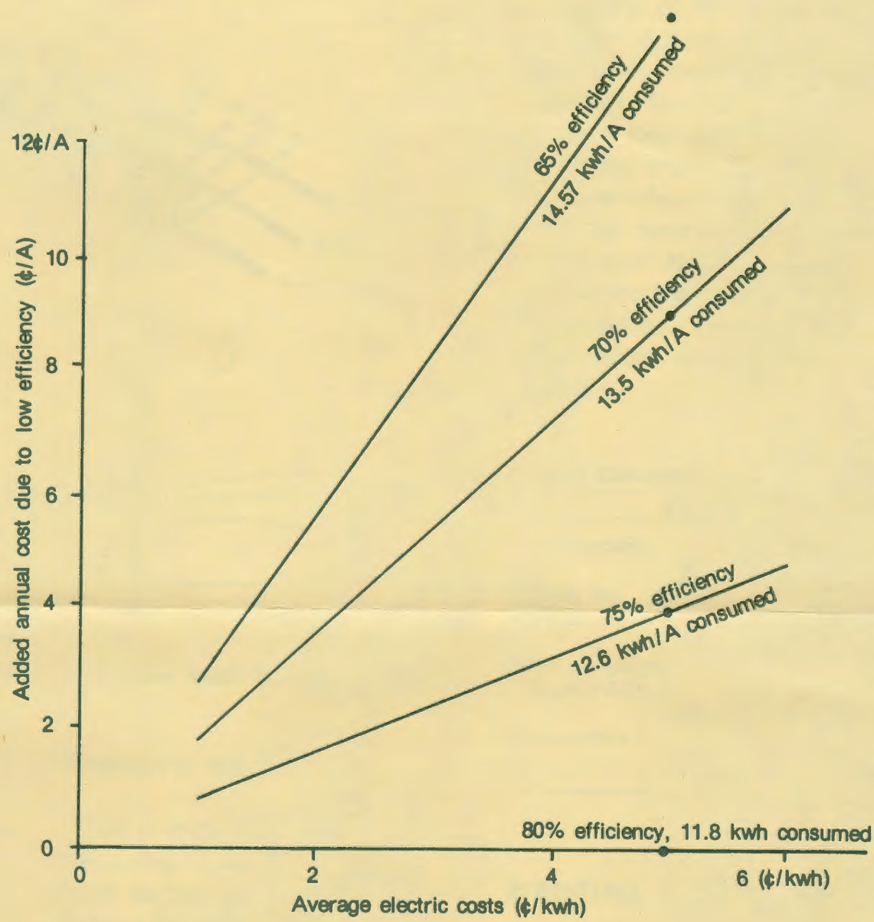


**Fig. 3. Seasonal costs for a pump operating at less than 80% efficiency [motor is 90% efficient] per 100 ft. of lift or pressure.**

## Conclusion

Efficient pump selection means lower pumping costs for irrigators. For proper pump selection, follow this checklist:

1. Select proper type of pump.
2. Determine pressure required by summation of:
   a. Elevation differences between water and field
   b. Friction loss in delivery system
   c. Pressure needed at irrigation unit.
3. Determine discharge required (the smaller of (a), (b) or (c) ).
   a. How much will water supply produce?
   b. How much will field need?
   c. How much does irrigation permit allow?
4. Find the pumps that will match required discharge and pressure by checking pump characteristic curves.
5. Pick most efficient pump.
6. Determine power required.
7. Pick power unit to match pump.
8. Properly install and maintain pump and power unit.

Pumping irrigation water consumes energy, and energy costs are a big component of irrigation expenses. A pump is selected to match a particular irrigation system. A change in plans for the system or one of its components may very well mean that your present pump or the one you have selected will be inefficient and should be exchanged for one that will operate more efficiently.

You probably will have to pay very little or nothing extra to get an efficient pump, so buy one that will save you money every year.

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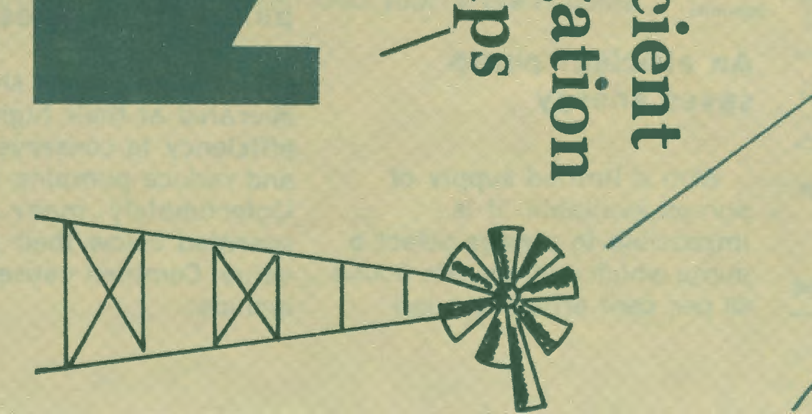

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