IRRIGATION SYSTEMS FOR THE FUTURE

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Irrigation has changed significantly over the last 35 years. High pressure, water driven center pivots have given way to low pressure, electrically driven pivots with much improved controls. Corner systems have increased the irrigated acres in a quarter section (160 acres). Linear or lateral move systems have been developed.

The energy crisis of the early 1970s resulted in more efficient pumping plants, and low pressure systems with spray nozzles. Power suppliers began to shift irrigated agriculture's energy use to off-peak periods with load-control programs. Irrigators reduced energy needs by lowering center pivot system operating pressure; a permanent saving of electrical energy.

Irrigation management has changed from just pumping water to a sophisticated program of irrigation scheduling. We haven't had water conservation problems, but the industry is looking at trickle and LEPA (low energy precision application) irrigation systems.

Through all the changes in equipment and management, the desired or design pumping capacity has stayed at about 1000 gallons per minute (gpm) for a 160-acre unit.

Recent Research Questions

"Can irrigation energy demand be shifted to off-peak periods with limited interference in the grower's irrigation and crop management programs?"

“What combinations, if any, of irrigation system capacity and scheduling protocol can minimize both the growers economic risk and the environmental risks associated with irrigation?"

FINDINGS

The most important needed change is to increase the capacity of the irrigation system from the current range of 5.5-7.5 gpm/acre to 9.0 gpm/acre or more. That translates to a change from 750-1000 gpm to 1200 gpm or more on a 160-acre unit. Combinations of equipment upgrades on center pivot irrigation systems and irrigation scheduling programs would allow most growers, including those growing potato, to safely participate in electrical load-shifting programs.
We found:

- The total amount of energy used during the growing season is equal for all systems. Larger capacity systems have a higher energy demand (hp or kW) but operate fewer hours than smaller systems.

- Low-pressure systems consume less energy overall than high-pressure systems.

- A 1200 gpm (or more) center pivot irrigation system, operated with a normal to slightly aggressive scheduling program, can minimize the economic risks associated with irrigating potato under the constraints imposed by a "time-of-day" energy load-control program in Wisconsin. A high capacity system, with or without load control, permits a more flexible irrigation scheduling program and provides the ability to adjust to changing seasonal and year-to-year climatic conditions.

- A 1000 gpm irrigation system can be operated under a "direct load control" program, but the grower must use a very conservative irrigation scheduling program. During extreme drought, the irrigation system will have several failures -- defined as days when the system cannot deliver sufficient water to keep the crop from suffering stress which reduces yield and quality.

- A 750-gpm system cannot irrigate potato successfully under a direct load-control program because economic losses are too large. These systems can successfully irrigate less demanding crops, such as sweet corn, snap beans, field corn and alfalfa.

RECOMMENDATIONS

For Utilities:

- Rebates on upgrades and new equipment
  - Subsidize conversions to low-pressure systems with 1200 gpm, or larger, capacities
  - Subsidize pumping plant testing and efficiency upgrades
  - Provide incentives to encourage high-capacity wells for all new installations.

- Load control programs
  - Design direct-load control programs to notify customers in advance of a control period
  - Shorten the length of the utility-defined peak period (from 12 hours to 6 or 8 hours) in DLC or TOD programs to give more customers the ability to participate in the programs
Transition period
- While new load-management programs are being developed, avoid imposing restrictions on irrigating potato
- Use TOD rates rather than DLC during transition periods

For Growers:
- Recondition or replace the high capacity well to achieve the desired 1200 gpm flow
- Replace the current pumping plant with one of higher capacity
- Increase the diameter of the pipe (lateral) on new systems to reduce pressure losses for the larger flow
- Develop or improve irrigation scheduling practices to minimize over irrigation and make best use of rainfall and off-peak irrigation

DISCUSSION:

There can be no increase in pumping capacity if the well cannot deliver the increased flow. The well construction report provides the needed information to determine if an existing well can produce the increased flow. The well drillers may have to be more aggressive in their design and construction practices with respect to the length of screen installed, slot size or opening in the screen, and size of aggregate used in the gravel pack around the screen. A natural pack can be developed which takes advantage of the much greater flow rates at the interface of the glacial outwash material and the underlying bedrock. Wells can be developed in both the glacial outwash and the sandstone bedrock to achieve the desired flow. Yield per foot of depth changes from 25-30 gpm in the outwash to 5-10 gpm in the sandstone. We don't know a lot about the depth of sandstone, so caution is advised. A test well might be appropriate. The cost of the 1200 gpm well will be higher than current ones. The investment is easily justified on the basis of reducing economic risk.

Installing a new pumping plant is done when converting to a low pressure system and increasing the flow. Costs associated with doing so would include purchase of a new pump and perhaps, a motor, removing the old pump and motor, and installing the new. Many systems have recently been converted to low pressure by reconditioning the pump and installing a smaller motor (~60 Hp). Low pressure and the increased flow (1200 gpm) will require a 75-80 Hp motor. The system should be able to operate off-peak which will please both the power supplier and the grower.

The development of LEPA (low energy precision application) center pivot or linear move systems has resulted in a need to increase the size (diameter) of the lateral. Reduced friction losses in the larger pipe at 1200 gpm can result in energy savings
equivalent to operating a 8-10 Hp motor when an 8-inch pipe replaces a 6 5/8-inch lateral. The weight of the system will increase by 4-5 tons, or 800-1,000 pounds per tower on a 10-tower system. Soil compaction or rutting problems may increase.

Obviously, the suggested changes will occur over time. Some irrigators may not implement the recommendations for several years. On some sites, the circumstances may not permit any changes.