

Energy efficiency of centre pivot irrigation drives

Hydraulic oil drives on certain centre pivots can consume a large portion of the total energy used in irrigation.

Making the right choice of drive systems can markedly improve the economic returns from the investment. This case study shows how the choice of drive system affects pump motor efficiency and energy consumption.

Background Information

A hydraulic-drive centre pivot with an end-gun was tested to determine the energy consumption for each megalitre (ML) of irrigation water applied to a sugarcane crop.

This centre pivot is located on a family farming operation in the Arriga district of the Tablelands region in north Queensland. A pair of pivots operate from one pump shed, along with other irrigation infrastructure on the farm.

In the pump shed is a Danfoss variable frequency drive (VFD) motor controller running a 3-phase 45 kW 2-pole WEG electric motor that is close-coupled to a Southern Cross 125×100–200 centrifugal pump with a 210 mm diameter impeller. These units supply water downhill to the 8-span hydraulic centre pivot. The VFD was reported to have an efficiency of 93% at this energy supply rate. A feedback loop to control the VFD was incorporated into this irrigation system from a pressure transducer located on the outer-most span pipe of the centre pivot with a set point of 17.6 m head (25 psi).



Figure 1 Layout of tested centre pivot on the left hand side of the irrigated fields. (Image courtesy of Google Earth Pro)



◀ **Figure 2** Pump discharge line pressure and flow rate measurement

What we did

In mid-December 2019, tests were conducted on the equipment used at the site using a calibrated transit time flowmeter (PT868 Panametrics) and a thickness gauge (Olympus 45MG) (see Figure 2). Testing was conducted when the centre pivot and end-gun were operating on the low north-west sector of the field (see Figure 1).

What we found

- The pump delivers 59 L/s at 20.8 m to the centre pivot when the end-gun is operating. This equates to 5.1 ML of water applied per day. It takes about 4.7 hours to apply 1 ML of water through the pivot.
- A positive suction head of 8.86 m (12.6 psi) is received by the pump. Measured pump total dynamic head (TDH) of 20.8 m maintains pivot end pressure at 17.6 m (25 psi). However, the pump curve shows that the actual TDH is 23.5 m at this duty point, but it is reduced further by head loss (3.5 m) occurring in the pump shed, possibly due to a blockage in the impeller.
- The system consumes 36 kWh in total energy each hour as measured in the pump shed. During this test, the energy for pumping was 55% (20 kWh) of the total energy used each hour. The remaining 45% (16 kWh) of the energy was consumed by the oil hydraulic pump that moves the centre pivot, long electrical cable losses and operation of the end-gun pump.
- Total energy required to apply 1 ML of irrigation water is about 170 kWh. At an energy cost of \$0.30/kWh, it will cost \$50.88 to apply 1 ML of irrigation water, which amounts to \$1814.40 per week for continuous operation.
- A similarly-sized electrically-driven centre pivot using standard speed electric drives would save at least 10 kWh in energy consumption for each hour of operation. The energy cost savings for this electric drive machine would be \$504.00 per week for continuous operation.

Conclusion

This irrigation pumping energy assessment on the Tablelands demonstrates the potential cost savings derived from choosing energy-efficient centre pivot drive systems.

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