Case Study: Using a VFD Pump with a Corner Arm Centre Pivot

Key Findings

- Using a VFD (variable frequency drive) resulted in energy savings of 5 to 42% depending on field terrain and placement of the pressure sensor.
- Reduction of carbon dioxide equivalent emissions similarly varied from 1 to 12 tonnes/yr.
- The potential for energy savings is much higher if the VFD monitors the pressure at the end of the pivot, especially on rolling terrain.
- Improperly sized pumps have a large effect on the returns from installing a VFD system.

Background

A centre-pivot irrigation system consists of a number of self-propelled towers supporting a pipeline rotating around a pivot point. Water supplied at the pivot point flows radially outward for distribution by sprayers or sprinklers located along the pipeline. The water is usually delivered to the pivot point by an underground pipeline with the pump located in the corner or on the side of the field. Some centre pivot machines have a corner arm system which consists of a pipeline connected to the end and supported by a steerable tower. This extra pipeline swings outward into the corners and allows irrigation of most of the area in the corners as shown in Figure 1. Most centre pivots also have an end gun which waters past the end of the pivot or the corner arm. Corner arm centre pivot irrigation systems are commonly used in Alberta to irrigate quarter section (160 ac) and some section (640 ac) fields.

The flow of the centre pivot irrigation system increases when the corner arm swings outward into the corners. A corner arm centre pivot operates about 20% of a circle at the maximum flow rate and 80% of the circle at lower flow. A typical flow rate range for a quarter section system irrigating approximately 155 ac(63 ha) is 700 to 1200 gpm (2650 to 4540 L/m). A corner arm centre pivot pumping unit is normally run at a constant speed that delivers the maximum flow rate and pressure required. However this means for most of the circle the pump is running at a higher pressure than required.

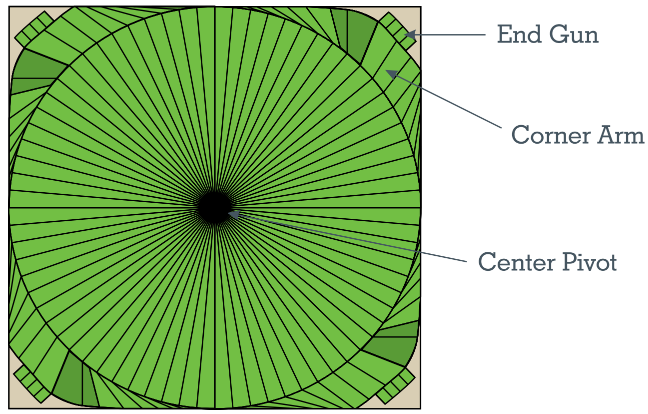

Figure 1. Schematic for path of corner arm centre pivot irrigation system.
Source: Image provided by Valley Irrigation

The VFD can be used to adjust the motor speed to allow the pump to deliver only the required flow rate at the required pressure. This reduces the energy required to operate the pumping unit. A case study was conducted to determine the energy savings when using a variable frequency drive on a pumping unit for a corner arm centre pivot irrigation system on a 155 ac (63 ha) field.

Results

VFD's on irrigation pumps normally monitor pressure and adjust speed to maintain a constant water pressure. The pressure is typically monitored close to the pump but can also be monitored at the end of the pivot using a radio signal. Both the pressure at the pump and pressure at the end of the pivot were used as variables in the case study. Other variables used in the case study were pump type and level and rolling terrain. Results of the case study are shown in Table 1. The price of electricity used to determine savings was $0.16 per kWh. Energy use data was converted to 12 in (30 cm) of water use per year.

Case Study: Using a VFD Pump with a Corner Arm Centre Pivot

Table 1. Results from case study for using a VFD on a pump providing water to a corner arm centre pivot irrigation system

Control sensor at pump discharge				
	Level terrain		Rolling terrain	
	Turbine	Centrifugal	Turbine	Centrifugal
Energy Saving (kWh/yr)	2,100	11,360	2,040	1,512
Saving ($/yr)	$336	$1,818	$326	$242
Saving (%)	5	26	5	5
Carbon equivalent (tonne/yr)	1.4	7.4	1.3	1.0
Control sensor on corner-arm				
	Level terrain		Rolling terrain	
	Turbine	Centrifugal	Turbine	Centrifugal
Energy Saving (kWh/yr)	13,660	14,720	18,072	8,980
Saving ($/yr)	$2,186	$2,355	$2,892	$1,437
Saving (%)	30	33	42	28
Carbon equivalent (tonne/yr)	8.9	9.6	11.7	5.8

Summary

Energy savings were substantially higher when the VFD monitored the pressure at the end of the pivot compared to monitoring the pressure near the pump. Monitoring the pressure at the end of the pivot allowed the VFD to provide the minimum amount of pressure for the pivot to operate properly. Energy savings averaged 33% when the VFD monitored the pressure at the end of the pivot compared to 10% when the VFD monitored the pressure near the pump. The reduction of carbon dioxide equivalent emissions averaged 9.0 tonne/yr when the VFD monitored the pressure at the end of the pivot. The highest energy savings of 42% was obtained with a turbine pump on rolling terrain showing the potential for energy savings is higher on rolling terrain if the VFD monitors the pressure at the end of the pivot. Improperly sized pumps had an effect on the performance of the VFD at the centrifugal level terrain with the sensor at the pump site and the centrifugal rolling terrain with the sensor at the end of the pivot site.

Initiated by Alberta Agriculture and Rural Development, funding for this Canada-Alberta cost-shared project was provided by Agriculture and Agri-Food Canada though the Agricultural Flexibility Fund, as part of Canada's Economic Action Plan.