



## Centre Pivots – Capital and Operating Cost Trade-off

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### Capital versus Operating Costs for Centre Pivot Systems

Centre pivot systems are capital intensive investments. Both up-front capital investment and on-going operating costs have to be considered when taking the decision to install a centre pivot.

There is a trade-off between capital and operating cost. A slightly higher capital investment up-front can reduce operating costs over the life of the system. Cheap, under-designed systems are expensive to run!

Because of this trade-off between capital and operating costs, it is important that the investor is fully aware of all aspects of the design and operation. This will allow him/her to select a system that is designed to provide the required outputs at minimal cost, thus contributing towards profit.

This Agnote identifies the capital and operation costs of centre pivot irrigation systems and presents a case study to demonstrate the trade-off between these two cost factors.



*Figure 1: A centre pivot system in operation*

### What are capital and operating costs?

#### Capital costs

The capital costs consist of equipment purchase and installation costs. They include the costs of pipes, pumps, sprinklers, the power unit (either diesel or electric), line construction costs (for electrical installations), and their installation. Other associated costs, such as land clearing, earth movement and road construction are often included in capital investment costings. However, when discussing the issue of the capital versus operating costs, generally only the cost of the system hardware (pipes, supply lines and pump) are considered.

Capital cost is influenced by the size of the pipes in both the machine and the supply line. The larger the size of these pipes, the more the capital cost of the system.

The most commonly used span pipe diameters are 162 mm (6&5/8"), 197 mm (8") and 213 mm (8&5/8"). Many pivots have a combination of large and small diameter spans.

#### Operating costs

Operating costs include the costs incurred for energy, maintenance, repairs and labour.

Energy costs (fuel or electricity) are the major component of operating costs. They can vary significantly for a given size of pivot, depending on the span pipe and supply pipeline specifications. Foley (2006) reports that a diesel-operated machine operating at 35 m (50 psi) consumes approximately twice as much diesel as a machine operating at 17.5 m (25 psi) at the pump discharge point.



Figure 2: Water storage, filter and motor to operate a centre pivot system

### Case Study with Two Different Pivot Pressures

Discussed below are two common pivot systems – one operating with a centre pressure of 29.5 m (42 psi) and another one at 21 m (30 psi). Both are 400 m (50 ha) pivots irrigating perennial pasture applying 9 ML/ha. The pump efficiency of both systems is 75%. Electric motors were assumed to be 90% efficient, and a diesel fuel consumption of 0.3 L/kWh was assumed. Both pivots operate 7m (10psi) regulated sprinklers.

The 29.5 m (42 psi) pivot has seven 162 mm (6 & 5/8”) spans. The other pivot with 21 m (30 psi) head also has seven spans; however, it has two 213 mm (8&5/8”) and five 162 mm (6&5/8”) spans. The two large diameter spans resulted in 8.5 m (12 psi) less head loss along the pivot.

Note that there may also be excessive head loss in the supply pipelines. We are only considering the effect of the size of the pivot span pipes in these examples.

Table 1 compares the energy consumption of the 2 pivot systems. The electric system with 29.5 m head pivot needs 132 kWh for every ML of water pumped compared to 98 kWh per ML for the 21 m head system. Similarly, for the diesel operated systems, the 29.5 m head requires 36 litres per ML pumped compared to 27 litres per ML for the 21 m head system. With diesel and electricity, the energy requirement is about 25% less at the lower pressure.

Table 1: Comparison of Energy Consumption between 29.5m and 21m head centre pivots

Pressure head	Electric (kWh/ML)	Diesel (L/ML)
29.5 m (42 psi)	132	36
21.0 m (30 psi)	98	27

Using the energy consumption from Table 1, Table 2 provides the pumping costs of the two pivot systems with different centre pressures. The higher pressure system has an operating cost 1.3 times higher than the lower pressure system.

In relation to electricity consumption it has to be remembered that off-peak electricity costs almost 1/3 of the peak electricity cost. The peak electricity pumping cost is almost the same as the cost of pumping with diesel at the present rate.

The main reason for the difference in the centre pressure between the two systems is the use of different diameter pipes. For the same flow rate, smaller pipe sizes have a bigger friction loss than larger pipes. The additional pressure required for small diameter pipes causes an increase in operating costs.

Table 2: Pumping costs for different pivot operating pressures

Total Head (m) (pivot only)	Electricity *		Diesel **		
	Off-peak (\$/ML)	Peak (\$/ML)	\$ 1.20 per Litre	\$1.50 per Litre	\$2.00 per Litre
29.5 m (42 psi)	9.40	26.10	25.20	35.30	51.85
21.0 m(30 psi)	7.00	19.43	19.15	26.45	38.90

It needs to be noted that these costs are indicative for the pivot only, based on assumptions given below. The actual costs incurred will depend upon the actual head including supply and suction pipelines, pump set efficiency and energy cost.

**Assumptions:**

For **electricity**: \*

- Peak usage cost 19.745 c/kWh (7am to 11pm week days)
- Off-peak usage cost 7.117 c/kWh (11pm to 7am weekdays, and Saturday and Sunday).
- A Victorian Government rebate of 0.6 and 0.2 c/kWh respectively may be given.
- There is also a Supply Charge of \$17.37 per month.

The above is a standard tariff offered by a major energy company in the Shepparton Irrigation Region in Victoria. Alternative tariffs may be negotiated with the energy company, or other retailers.

For **diesel** operation: \*\*

- Cost is \$1.20 /L supplied (May 2005).
- Farmers are normally able to reclaim \$0.11/L GST (10%), and receive a \$0.38/L rebate through the energy grants credits scheme from the Australian Taxation Office, resulting in a net cost to the farmer of \$0.71/L. The costs calculated in Table 2 above are net of GST and the rebate.

Diesel prices have risen significantly over recent years. The future of the energy grants credit scheme is unclear. Diesel engines also have a significant maintenance requirement, which is not costed here.

Tables 1 and 2 above indicate that there is a substantial gain to be made by designing the system to operate with lower pressure. However, the big question is – “**can the saving from the operating cost justify higher capital cost for the low pressure system?**” To answer this, a *present value analysis* of the long-term pumping energy cost of these 2 systems – one with the centre pressure of 29.5 m and another with 21 m - was conducted. Present value analysis converts all the future benefits or costs to a present value. In our case study, the capital cost of centre pivot is incurred at the start of the year, which is now; so it is already a present value. However, the operating costs are incurred throughout the life of the project and should be converted to present values. Calculations were based on the assumptions that:

- Life of the machine is 15 years;
- Discount rate used is 6%;
- We are irrigating 50 ha of land, applying 9 ML/ha.

Over its lifespan, the electric system using peak rate will have a present value operating cost equivalent of \$120,915 when operating with a 29.5 m head compared to \$90,019 for a 21 m head system. Similarly, for the diesel operated system, the present value of operating costs will be \$116,745 for the 29.5 m head machine, compared to \$88,722 for the 21m head systems (Table 3).

Table 3 shows that for the electrical system using peak electricity, you can invest up to \$30,000 more in capital cost and still be better off in terms of total costs. For diesel powered systems the difference is slightly lower at about \$28,000. Even for off-peak electricity operated systems, the difference in present value between the low and higher pressure machines is more than \$11,000. This clearly shows that an initial high up-front capital investment can result in substantial savings in operating cost.

**Table 3: Present value of pumping energy cost over the life of pivot systems**

Operating head	Using peak electricity (\$)	Using off-peak electricity (\$)	Using diesel @ \$1.20/L (\$)
29.5 m (42 psi )	120,915	43,548	116,745
21 m(30 psi)	90,019	32,429	88,722
Difference	30,896	11,119	28,023

The additional capital cost associated with the use of two 213 mm and five 162 mm diameter pipe spans, rather than seven 162 mm spans, is about \$4,000. In our case study, looking at the figures above, it is reasonable to invest an additional \$4,000 for the larger pipe size to reduce the operating costs over the life of the system.

As the cost of energy rises in the future, savings of energy in terms of operating cost will become more and more attractive. It might be wise to design the system to operate under lower pressure with larger diameter pipes to minimise operating costs, rather than trying to save up-front \$\$\$ at the start.

**Points to Remember**

1. Over a machine’s life, the total operating costs are substantial.
2. Operating costs are directly related to the size of the pipes used in the system. Small diameter pipes cause higher friction losses and increase operating pressures and hence costs.
3. Reduction in total friction load, and thus reducing operating pressure, can be best achieved by increasing the pipe size of the inner spans of the machine and / or the supply pipeline. This might slightly increase your initial capital cost but will save money in the long term.
4. It is important to consider the operating costs when negotiating the purchase of a system, not just the purchase cost.

**Reference**

Foley, 2006, Centre pivot and lateral move machines, in: <http://www.cotton.pi.csiro.au/Publicat/water/WATERpak.htm>.

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