Energy Costs

Balancing energy and water efficiency

There is no perfect irrigation system. Most systems require a trade-off between energy use efficiency and water use efficiency.

For example, changing a water transfer method from an open channel to closed pipes increases water use efficiency but also increases energy use. Similarly, a change from flood irrigation to low pressure pivot irrigation will improve water use efficiency but increase pumping costs because the water must be pressurised. However, a change from a high pressure winch to a low pressure lateral boom will result in improved water use and energy use efficiencies.

The key is to reduce or optimise the amount of water pumped around the farm as this can substantially lower energy demand and costs. Both water and energy are finite resources and have direct costs associated with them.

This means they should be considered together when making a decision about changes within an irrigation system.

Approximately 90 per cent of sugarcane growers using irrigation access the national electricity grid for their energy needs and the average volume of water applied across the irrigated area is 5.6 ML/ha (ABS 2017).

Pumping costs vary considerably depending on the way water is transferred within the system, from the source to the delivery point e.g. gravity, scheme water, deep wells and bores, and pumping into storage.

Both economic and environmental gains can be made when water is applied to meet crop requirements and is delivered to the field in an energy efficient manner. Both water and electricity are finite resources with direct costs associated with their use so making the most of the resource is important.

Energy is used to overcome the total dynamic head (TDH), which is made up of static head, friction head, pressure head and velocity head.

The number of times water is pumped to get from source to paddock and the elevation at which the water is applied are two key impacts on irrigation energy use. Sugarcane farmers in the Bundaberg, Isis and Maryborough regions report the highest static lift and stage pumping is most common in the Proserpine and Maryborough regions, followed by the Bundaberg and Mackay regions. For these reasons, per ML pumping costs are likely to be comparatively high in these regions. Applied water volume is highest in the Burdekin and this is the main driver of electricity costs in that region.

There are a range of suitable water application methods for irrigated sugarcane systems.

The field type, terrain, water quality, energy and labour availability will often dictate the application method. Each application method has associated costs and benefits in terms of water and energy use.

The main factors that contribute to energy costs are:

- **The higher the pressure required** for an irrigation system, the more energy used to pressurise it.
- **The greater the distance water needs to be moved** or 'lifted' the higher the subsequent energy requirements.

Table 1 provides an indication of energy use for the common irrigation systems and pumping scenarios found in the Australian sugarcane industry.

The lowest energy use and cost are the furrow irrigation systems, as they do not require energy to pressurise the system, while the high pressure overhead water winch is the highest energy use system.

Irrigation system	Irrigation application efficiency % (approx)	Labour requirement	Water source	Total pumping head[3] (metres)	Power required to pump 1ML[4] (kWh)	Pumping costs ($ per ML)	
						Electricity cost @ 27c/kWh5 = $/ML	**Diesel cost** @ 78.8/L6 = $/L
Furrow	70	High	River/channel	10	44	11.90	9.30
			Bore	30	132	35.71	27.90
Low pressure overhead – Lateral move[1]	80	Low (1/3 furrow)	River/channel	30	132	35.71	27.90
Low pressure overhead – Centre pivot [2]	70-80	Low (1/4 furrow)	River/channel	60	265	71.43	55.79
			Piped scheme	5	22	5.95	4.65
Drip	80-90	Medium	River/channel	50	221	59.52	46.49
			Piped scheme	10	44	11.90	9.30
High pressure overhead – Water winch	65	Medium	River/channel	70	309	83.33	65.09
			Bore	85	375	101.19	79.04
			Piped scheme	45	199	53.57	41.84

Table 1: Comparative pumping costs [1]

1. Gravity fed channel ~ 1.5 times the length of LM run
2. With pump, motor and main ~ 1.5 times CP length
3. Total pumping head = static lift + pipe / hose friction + operating pressure. Static lift (or water depth) is assumed to be 15m.
4. Assuming a pump efficiency of 70% and electric motor efficiency of 90%
5. Price calculated using 2017 tariff options for irrigators (Ergon Energy, 2017)
6. Assuming a pump efficiency of 70%, specific fuel consumption of 0.26 L/kWh, elevation 0.9, drive factor 0.95. Price calculated using the 12 month regional Queensland average, less GST and rebates (Australian Institute of Petroleum, 2017).

1 *Source: Smith (2017)*

Using the irrigation application efficiency percentage and the labour factor, it is possible to see the trade-off of water use and energy use efficiency.

Comparative cost = [Electricity pumping cost ÷ Application efficiency] x labour factor

To factor in water use efficiency, consider that for each ML required for the crop, more water must be pumped to cover the water losses through application. So, if 1 ML is required, it is necessary to pump 1.43 ML of water for a 70% irrigation application efficiency system such as flood irrigation.

To factor in labour, we can assume 1 unit of labour for the most labour intensive system and a portion of that labour for the less labour intensive systems.

The numbers in the brackets indicate the ranking of the systems according to their comparative costs. Less efficient water application systems with high labour costs and high pumping costs become far less attractive propositions (e.g. furrow irrigation from a bore) while the centre pivot using river or channel water becomes a better ranked option.

Irrigation system	**Irrigation application efficiency** % (approx)	**Labour requirement factor**	**Water source**	**Total pumping head** [3] (metres)	**Power required to pump 1ML** [4] (kWh)	**Electricity pumping cost** @ 27c/kWh5 = $/ML (ranking)	**Comparative cost** $/ML **pumped per labour unit** (ranking)
Furrow	70	High (1)	River/channel	10	44	11.90 (2)	17.00 (4)
			Bore	30	132	35.71 (4)	51.01 (8)
Low pressure overhead – Lateral move[1]	80	Low (0.3)	River/channel	30	132	35.71 (4)	13.39 (3)
Low pressure overhead – Centre pivot [2]	70-80	Low (0.25)	River/channel	60	265	71.43 (8)	23.81 (5)
			Piped scheme	5	22	5.95 (1)	1.98 (1)
Drip	80-90	Medium (0.5)	River/channel	50	221	59.52 (7)	35.01 (6)
			Piped scheme	10	44	11.90 (2)	7.00 (2)
High pressure overhead – Water winch	65	Medium (0.5)	River/channel	70	309	83.33 (9)	64.10 (9)
			Bore	85	375	101.19 (10)	77.83 (10)
			Piped scheme	45	199	53.57 (6)	41.21 (7)

Table 2 Comparative pumping costs [2]

1. Gravity fed channel ~ 1.5 times the length of LM run
2. With pump, motor and main ~ 1.5 times CP length
3. Total pumping head = static lift + pipe / hose friction + operating pressure
   Static lift (or water depth) is assumed to be 15m
4. Assuming a pump efficiency of 70% and electric motor efficiency of 90%
5. Price calculated using 2017 tariff options for irrigators (Ergon Energy, 2017)

Table 3 provides an example gross margin analysis of a few irrigation system configurations. This demonstrates that energy intensive irrigation scenarios account for a higher proportion of variable costs and result in reduced crop gross margins. Energy intensive systems are also most vulnerable to fluctuations in energy pricing.

2 Source: SMITH, P. 2017. Comparative irrigation costs,. In: CONSULTING, S. I. (ed.). Adapted from Welsh J.M. and Powell J.W. (2017). "Opportunities for energy innovation in Australian irrigated sugarcane." Sugar Research Australia report. Ag Econ, Burren Junction, NSW, Australia

Irrigation System	Furrow	Furrow	Centre Pivot	High Pressure overhead	High Pressure overhead
Water source	River	Bore	River	River	Bore
Pumping costs ($/ML)[1]	$11.90	$35.71	$71.43	$83.33	$101.19
Water application efficiency (approx.) %	0.7	0.7	0.75	0.65	0.65
INCOME ($/ha) 122 t @ $41.95/t [2]	5118	5118	5118	5118	5118
VARIABLE COSTS					
Applied irrigation (5.6 ML)					
Amount pumped (ML)	8.0	8.0	7.5	8.6	8.6
Water access charge (@$12.10/ML)	97	97	90	104	104
Pumping energy costs	$95.20	$285.68	$533.34	$717.92	$871.79
Total irrigation cost	192	382	624	822	976
Other variable costs (nutrition, planting, crop protection & harvest)	2266	2266	2266	2266	2266
Total variable costs	2458	2648	2890	3088	3242
Gross margin ($/ha)	2660	2470	2228	2030	1876
Irrigation cost (% of variable costs)	8%	14%	22%	27%	30%
Scenarios with the electricity price increased by 15%					
Gross margin ($/ha)	2594	2320	1910	1773	1567
Irrigation cost (% of variable costs)	10%	19%	29%	32%	36%
Reduction in gross margin (% change)	2%	5%	7%	5%	6%

Table 3: Gross margin analysis by irrigation system[3]

1. Using $/ML costs from Table 1
2. Typically, t/ha increases when irrigation efficiency improves

Next Steps

Decisions related to irrigation infrastructure, energy source and water management should not be made in isolation. Many irrigation systems are carefully designed, while others may have evolved incrementally and without thorough engineering analysis.

For already-installed systems, start with thorough pump and energy assessments.

Before investing in new components, calculate the true costs and benefits of the alternative system, including capital and labour costs. That is, make sure the change will pay.

With your productivity services officer and irrigation specialist, analyse possible changes to field design, seasonal crop requirements, application system, water transfer management, pumping systems and energy sources (including future pricing outlook).

Resources

Opportunities for energy innovation in Australian irrigated sugarcane https://sugarresearch.com.au/sugar_files//2018/01/Energy-in-irrigated-cane_2017x.pdf

Fact Sheet - Paying upfront or in the future

Fact Sheet – Pipes and pumps set

3 Adapted from: Welsh J.M. and Powell J.W. (2017). "Opportunities for energy innovation in Australian irrigated sugarcane." Sugar Research Australia report. Ag Econ, Burren Junction, NSW, Australia