Energy Efficiency Case Study – Lee McKenzie

At Mount Compass on the Fleurieu Pensinula, Lee & Jill McKenzie operates a 700-cow dairy.

While the on-farm infrastructure includes a number of irrigation system types between movable sprinklers and centre pivots, the energy efficiency audit focussed on the largest centre pivot that services a 15 hectare area.

The pumping system comprises of a Kelly and Lewis pump powered by a 45 kW motor, which moves water from a holding dam upslope to the pivot through 700m of 200mm PVC class 12 pipeline. Static head loss at the site is some 36 metres.

Audit results

In the 2014-2015 financial year, electricity costs totalled $19,913 + GST for the meter supplying the pivot, bore pump, two small pivots and a van der Bosch system. Through the audit process, it was calculated that the large pivot consumed 33,953 kWhr (based on applications rates of 6ML/Ha), resulting in the following break down of power costs:

- $7,484 + GST – Large pivot
- $11,496 + GST – Bore pump, 2 small systems and van der Bosch system
- $213 + GST – Service fees

A breakdown of cost by electricity use shows how energy is expended throughout the irrigation system and highlights how energy is lost through static and friction.

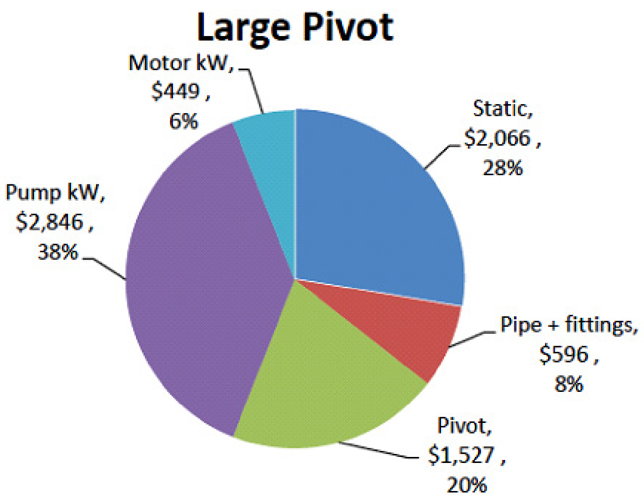

Table 1: Breakdown of irrigation costs by system component

Energy Use benchmarks

With an energy use benchmark of 374kWhr/ML, the large pivot is in the mid-range when compared to other irrigation systems. This is partly due to the relatively low pipe and fitting components, compared to some other systems.

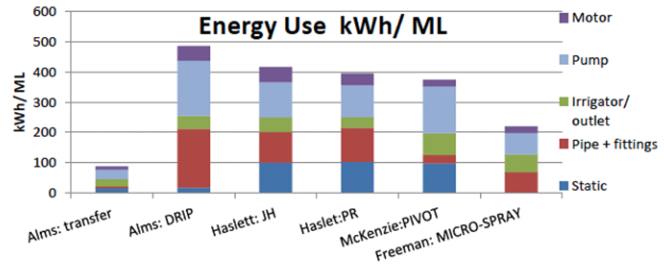

Table 2: Energy use (kWh/ML) in comparison to other audited irrigation systems

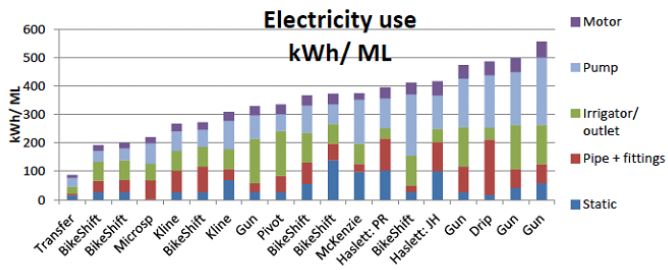

Table 3: Energy use (kWh/ML) in comparison to other South Australian irrigation systems

Energy cost benchmarks

Powering the large pivot costs the McKenzie's approximately $82.80/ML of water applied, putting the system in the mid-range when compared to other systems, and above average when considering the cost per mega litre and the length of the pipeline. This equates to approximately $1.10/ML/m of head generated.

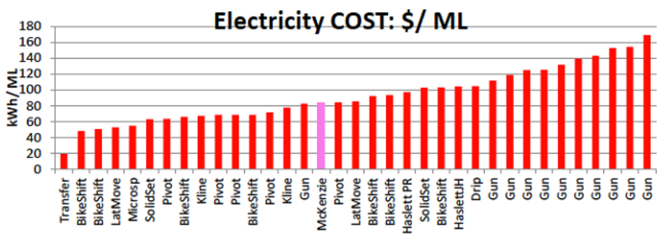

Table 4: Total electricity cost ($/ML) in comparison to other South Australian irrigation systems

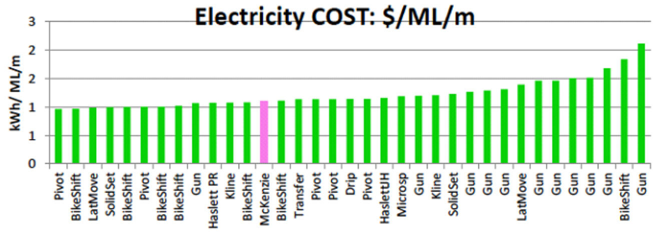

Table 5: Total electricity cost ($/ML/m) in comparison to other South Australian irrigation

Improving energy efficiency

Friction losses through the mainline and fittings currently account for $596 / year. Duplicating the mainline serving the pivot could reduce friction losses by 50%, reducing the total head, overall electricity costs (including a reduction in pump and motor kW losses). This could save $533 / year, assuming the pump remains at 59.6% efficiency.

However, the cost involved with duplicating the mainline is approximately $25,000, not including installation and fittings. While this outlay makes the investment unlikely, there may be specific fittings that would be worthwhile replacing.

Tests conducted on the pump revealed that it was operating at 59.6% efficiency, costing $2,846 per year in additional operational costs. Identifying the underlying causes of the pump's inefficiency could be useful in reversing this trend.

If the pump impeller were an obvious cause, replacing it would be worthwhile, so long as costs were less than $2,500. If no action is taken in the short term, the pump should certainly be upgraded when it reaches the end of its life, preferably with a model offering a higher energy efficiency rating.

A new motor was installed shortly before the audit was undertaken, with an assumed energy efficiency rating of 94% at a cost of $449 / year. Considering the high level of efficiency and the age of the motor, no current action was recommended.

Reducing costs in operation

Distribution Uniformity

An examination of the pivot showed distribution uniformity performed at a rate of 88% in non-windy conditions. The average application rate was 6.25mm, whilst some emitters only applied 5.5mm. Given that the pivot is used exclusively to grow shallow rooted annual pastures, short irrigation bursts are applied at either this application rate or at 50% speed (approximately 13 mm) to meet crop water demand.

Irrigation Scheduling

In systems with shallow rooted pastures, it is necessary to balance the requirements of the plants with climate and weather factors in order to sustain efficient water use. Distribution uniformity was found to be poor during windy conditions, so it is advisable to avoid irrigating during such times.

A soil moisture probe has been installed at the site, and allows decisions to be made in line with pasture requirements.

Tariffs

As the annual energy consumption is less than 100MWhr, the bills are 'normal non-contestable' based on consumption and service fees.'

In the 2014-2015 financial year, the meter operated on a Time of Use (TOU) tariff model at a charge of 32.31 cents/kWhr for power drawn during peak demand times and 17.16 cents/kWhr for power used in off-peak times. 33% of power was charged at the peak rate, with the remaining 67% charged at the lower tariff, resulting in an average tariff cost of 22.1 cents/kWhr. The annual service charge was $213.

As the majority of power is used during the off-peak period (67%), the TOU model is the most effective in this instance. However, there are several TOU tariff plans that would reduce the amount currently spent on electricity.

	Current efficiency rating	Inefficiency costs	Ideal efficiency rating	Potential savings
Pump	59.6%	$2,846	70%	$1,379
Motor	94%	$449	94%	$0
	Total inefficiency costs per annum	$3,295	Total potential savings per annum	$1,379

Table 6: Potential costs savings through improved energy efficiency measures

		Peak	Off-Peak	Service	Total	Saving
	kWhr / year	11,056	22,797	365 days	$33,853	
Current contract (Origin)	$/kWhr $	0.323 $3,572	0.172 $3,912	0.584 $213	$7,697	
Option 1 Origin Energy + 20% discount	$/kWhr $	0.286 $3,163	0.152 $3,456	0.704 $257	$6,876	$821
Option 2 Pacific Hydro (1 year contract)	$/kWhr $	0.304 $3,362	0.140 $3,201	0.740 $270	$6,833	$864

Table 8: Tariff comparison for large pivot consumption

		Peak	Off-Peak	Service	Total	Saving
	kWhr / year	28,035	57,804	365 days	$85,840	
Current contract (Origin)	$/kWhr $	0.323 $9,058	0.172 $9,919	0.584 $213	$19,190	
Option 1 Origin Energy + 20% discount	$/kWhr $	0.286 $8,020	0.152 $8,763	0.704 $257	$17,041	$2,150
Option 2 Pacific Hydro (1 year contract)	$/kWhr $	0.304 $8,526	0.140 $8,116	0.740 $270	$16,911	$2,279

Table 9: Tariff comparison forall consumption on meter

Alternative energy sources

Diesel

Based on the cost of diesel being between $1-00 - $1.05/L, a highly efficient diesel genset is able to produce power at a cost of around 25-26c/kWhr. At the time the audit was conducted, this did not present a cost effective alterative.

However, since the price of power in South Australia has risen recently, it now may be worthwhile investigating how feasible it may be.

Solar PV

Conventionally installed solar photovoltaic (solar PV) systems have been generally found to be not well suited for use with irrigation systems. This is due to the peak and trough demand patterns commonly used in irrigation – on both a daily and seasonal basis.

Solar power is best used as it is produced (i.e. during daylight hours) especially since no current affordable battery storage options exist. This further limits the usability in irrigation systems where scheduling is undertaken at night. Using the average pumping hours for the 2014-2015 financial year, a 50kWp solar system would have a payback period of 15 years, if the irrigation can be scheduled to work every day, except when too wet or not required. This does not take into account power losses and set up costs to connect a remote solar PV panel to the pump site. Another limitation of powering the large pivot with solar is that on average the pump only operates for 3-4 hours per day in the irrigation season. This would mean that only 35% of the solar PV power produced would be actually used.

There may be merit in producing power through a solar PV system for the bore pump in the McKenzie's system. Water is pumped from a bore to a holding dam before being transferred to the large pivot. As the water can be pumped from the bore to the holding dam in advance of irrigation shifts, it is possible that this could be powered by a solar PV system during the day. A detailed feasibility study would need to be undertaken to determine the value in running the bore pump from solar sourced power.

The pivot audited provides irrigation to 15 hectares on the McKenzie's Mount Compass farm.

Recommendations

As a result of the audit, a number of recommended actions were flagged with the irrigator:

- **Further investigations** regarding the pump impeller are required to ascertain the reasons for the inefficiencies. A new impeller may be worthwhile so long as the costs are reasonable, but the outlay of a new pump will most likely be cost prohibitive.
- **Regular monitoring of system components** should be undertaken to maintain current efficiency levels:
  - **Pump pressure gauge** – recognise normal readings and investigate significant variances
  - **Flow rate** – if the flow rate varies significantly from the norm, investigate
  - **kW drawn on meter**
- **Monitor tariff schedules** available by other electricity providers. www.energymadeeasy.com.au is a good reference point.

Catch can tests were undertaken to ascertain the distribution uniformity of the pivot.

For more information

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