Case Study: K & D Farms

ON FARM IRRIGATION ENERGY EFFICIENCY CASE STUDY
K & D Farms Ltd., Duntroon, Lower Waitaki – Kelvin and Debbie Weir.
Consulting engineers: Irricon Resource Solutions Ltd.

BACKGROUND
Irrigation is a large user of energy and the current area and expected growth of irrigation across the country is a significant component of electricity demand. Efficiency of energy use on farm has not traditionally been a focus of irrigation service suppliers or farmers. The have been very few on farm energy use efficiency investigations. This lack of data has meant there was not enough evidence, of the opportunity and costs, to give confidence to the irrigation or energy industry to carry out a proposed industry wide energy efficiency program.

During the 2013/14 irrigation season Irrigation New Zealand carried out 14 irrigation energy efficiency on farm audits across Canterbury and Otago. The audits were part of a pilot project funded by EECA[1] and the lines companies of North Otago and Canterbury. Each of the audits covered the two aspects of irrigation efficiency:

1. Motor, pump and delivery system (Headworks, Mainline and irrigators) Efficiency & Performance
2. Seasonal irrigation scheduling/operation efficiency.

This case study documents the audit results and subsequent changes carried out on the property of Kelvin and Debbie Weir in the Lower Waitaki region.

K & D Farms Ltd., Duntroon, Lower Waitaki

The initial energy efficiency irrigation evaluation was conducted on the 27th of February 2014 by Irricon Resource Solutions Limited.

The farm is a 445 hectare dairy farm and associated run-off on the south bank of the Waitaki River, at 2892 Duntroon Georgetown Road, Duntroon (Lower Waitaki).

379 hectares of the farm is irrigated. 223 ha with K-line and fixed grid[2] using groundwater and 157 ha is laser levelled border-dyke with water supplied by the Maerewhenua District Water Resources Co Limited. Each water source irrigates a distinct area of land with no overlap.

This evaluation was done on the spray irrigation systems only.

Irrigation redevelopment

1. Energy efficiency conservation authority.
2. The fixed grid system was only in the commissioning phases at the time of the assessment. It covers an area of approximately 13 hectares of steeper land that was previously irrigated using k-lines.

Design considerations

Before changes were made the spray irrigation consisted of two bores each feeding into separate sectors of the distribution system. It was developed this way as previously the farm was two separate properties.

The normal operation of both systems was either "on" or "off" with no tailoring of pumping capacity to demand. However the area being watered for each system could vary due to a combination of factors such as winter feed crops, pasture renewal and other farm activities. On the day of the audit 8 ha (fodder beet crop) was not being watered.

The system details are outlined in Table 1.

Table 1: System details

Bore	Details	BEP[3] l/s[4]	Design operating flow l/s	Flow on the day of audit l/s
Dovey Surface Pump J41/0121	Thompsons & Kelly KL 150 132kW	70	57	47.4
Taylors Road Surface Pump J40/0702	Southern Cross 125x100-315 130kW	78	60	52.3
Taylors Road[5] Submersible pump 40/0702	Tsurumi Pump KRS2-89 11kW		60	52.3

The report concluded that for both surface pumps the *'operation during the audit and also at design specifications, the pumps perform well outside the acceptable range from its BEP'*. The submersible pump was operating within the acceptable range.

To be able to effectively evaluate the headwork's efficiency the water meter data and pressure measurement on both the suction and discharge side of the pump is crucial. The pressure gauges were either broken or non-existent and there was no measuring point on the suction side of the pump. The velocities measured at the flows on the day were 2.7 and 3 m/s, these were within the acceptable range

The mainline pressure losses were high but not excessive. However the pressure at the furthest point from the pump (in excess of 300 kPa) were higher than the sprinkler design specification (294 kPa). Previously an IRRICAD[6] investigation had been done to 'assess w*hy there was obvious variation of applied irrigation between the blocks, and address the issue of mainline "blowouts"*'. It had recommended that pressure reducing valves be installed at points along the mainline. This had been done but there was still excess pressure (before the pressure regulators on the sprinklers (280 kPa)) at all points measured in the distribution system. A full irrigation performance assessment was recommended to *"... assess if, because of the topography and elevation changes, whether there are areas that are still being under watered due to low pressure and/or flow. This will also verify whether the PRV's are working as intended"*.

G-set fixed grid irrigation (six months post development)

3. Best efficiency point – flow rate (L/s) at which the pump efficiency it at its maximum (%).
4. Litres per second.
5. In 2010 the submersible pump was added to the system to lift the water to the surface as it was considered that the Southern Cross pump was "struggling to keep up".
6. IRRICAD is an Irrigation design and analysis computer program.

Operation and scheduling considerations

The main crop under irrigation is pasture and it is watered 'on demand'. Soil moisture probes are used to determine when to irrigate. The design of the system provides for a ten day return period applying 43–48 mm of irrigation. During the peak ET periods of the season (in excess of 5mm/day) this is insufficient to 'keep up'. The lighter soils (majority of the area) have a profile available water holding capacity (PAW) of 105 mm so to maintain the soil water above stress point the trigger is when the soil water deficit is 52.5mm. The application of 43–48 mm almost matches but the observation that during the peak of the season the system falls behind suggests that the capacity of the system is *"barely adequate"* and may be limiting pasture production. An exacerbating factor is the variation of topography and elevation meaning the application is not even over the area with some areas being either under and overwatered.

The operation of the system with areas taken out for winter feed crops allows a certain amount of flexibility but the pumping system is not set up to cope with the variations in demand this creates.

Key recommendations

1. The main recommendation was to revisit the pumping configuration and to consider installing a variable speed drive (VSD) so the pumping capacity can better match the demand.
   This was to address the issue of both pumps not operating at or near their BEP meaning energy was being wasted and irrigation performance was being affected. At the time of the audit there were plans to continue putting in more fixed grid and/or centre pivots so the report suggests that it is timely for the irrigation designer not only looks at the distribution options but also the pumping and VSD options. (A full system redesign was outside the scope of the audit which only considered the possible energy savings with the existing infrastructure and distribution system).
2. Full irrigation performance assessment.
3. The installation and repair of gauges to measure and monitor pump performance and headwork's efficiency.

New pump shed

Changes made

As a result of energy audit and a desire to better utilise the available water Kelvin and Debbie have made some substantial changes to their system. The changes were carried out during the winter of 2014 ready for the start of the 2014/15 season

A summary of the changes are:

1. The majority of the k-line have now been replaced with G-set (98 ha) and a pivot covering an easier 36 ha plateau. Kelvin was already trialling the fixed grid G-Set irrigation system designed by Grafton irrigation and manufactured by RX plastics[7]. It is the intention to replace all the k-lines.
2. A new pumping station (replacing Taylor's road 130 kW) with 3 x 45 kW Southern-cross pumps, VSD and harmonic filter, new headwork's and new shed (fully insulated and air-conditioned).
3. Linking the two pump stations with telemetry so they can *'Talk'* to each other
4. Mainline changes
   a. New installation to supply the pivot.
   b. Joining the two separate systems with a manual control valve.
5. New effluent injection pump (and associated backflow prevention). This has enabled effluent to be spread through 50 ha of the G-set.
6. Booster pump for the higher G-set installations to maintain pressure. This has eliminated the need to pressurise the whole system just for the sprinklers at higher elevations.

By changing the pump station and enabling the pumps to 'talk' to each other the flexibility of the system to cope with different demands has improved immensely. Previously each system was a standalone with only two set duty points at 40 and 60 l/s flow and the generation of a set pressure which was too high. Now the combination of three smaller pumps controlled by a VSD and the two pump sheds linked allows the range of duties anywhere from 10 to 117 l/s flow. Joining the mainline allowed the flow to be directed anywhere and the system can run everything or any smaller number of G-set or pivot for either effluent spreading or irrigation. The use of the VSD means that the pump/s are always operating at or near the BEP for each pump and flow required maximising the efficiency of energy used.

Tables 2 and 3 demonstrate the improvements made on a kwh/m^3 basis between 2013/14 and 2014/15[8] irrigation seasons. It shows the energy used to pump a cubic metre of water has reduced by 15 and 16% respectively for the Dovey and Taylor's road pump stations.

Table 2: Dovey pump station

Season	Total kwh	m^3 used	kwh/m^3
2013/14	111420	155485	0.72
2014/15	425520	698048	0.61

Table 3: Taylor's road pump shed

Season	Total kwh	m^3 used	kwh/m^3
2013/14	186840	327750	0.57
2014/15	385440	801952	0.48

Using the 2014/15 m^3 pumped and assuming an electricity charge of $0.17 per kW hour the reduction of energy usage for this season is a saving of $25,247.

The G-set pods are installed in clusters and configured and programmed to land management units matching soils, contours, aspect and position so that the right amount of water is applied to each area. The ability to turn sprinklers on and off via either computer control or manual switches on selected pods (for instance in gullies or wet spots) means that the runoff issue that was previously a problem under K-line has stopped. Kelvin has "no doubt about that whatsoever". The next step that Kelvin is working on is to fine tune the scheduling to take into account north/south aspect, shoulder season demand and night and day timing of irrigating.

7. This system is a permanent setup of sprinklers set at 35- 40 metre spacing's across the area being watered. Designed for steeper, rolling and broken terrain where pivot or other means of irrigation is not practical they are larger throw sprinklers set in ground encased in a protective pod. Each sprinkler has a solenoid switch controlled via a wireless or radio signal that is in turn controlled by a computer program. This is able to vary the timing and sequence of sprinklers on at any one time to vary the depth applied according to conditions and position of sprinkler.
8. The 2014/15 season was a significantly drier year than 2013/14.

The cost of all the changes has been substantial. The changes to the pumps has cost approximately $160,000, to redevelop the G-set area has cost $10–11,000/ha and the pivot area approximately $6000/ha. The redevelopment costs is more than just the physical irrigation hardware it includes fencing, tracking, stock water supply changes and other associated changes. The tangible payback has been:

- Reduced energy cost per unit of water pumped. Also during the shoulder seasons the system can be programmed to only water at night or when the electricity price is lower further reducing the energy bill.
- Able to reduce a staff member, a saving of approximately $65,000 per year
- The savings of not using a motorbike for 150–200 hrs per season
- Improved effluent management with automation and a larger area to spread reducing the need for storage and easier for staff to manage not having to shift the effluent spreader.
- Improved pasture production. With the extra grass growth from better irrigation methods it is likely stock numbers will increase. Kelvin is seeing this happen already.

The less tangible, but no less important benefits, are:

- considerably less runoff and smaller environmental footprint
- the health and safety factor of not having staff shifting K-lines on challenging and dangerous terrain
- ability to attract and retain the right staff –Kelvin has just recently employed new sharemilkers and it became quite obvious through the interview process that K-lines are seen as a negative to operating farms, being dangerous to shift in some places and time consuming as the main concerns
- Less time consumed with shifting and maintaining the K-lines. More time can be spent on maintaining stock productivity, fences and other infrastructure
- peace of mind to be able to turn off whatever portions of the irrigation system without 'blowing mainlines'
- Ability to manage the irrigation around other farm tasks rather than managing tasks around the irrigation. The return time has gone from an unsatisfactory 10–12 days to 48 hours allowing flexibility of the management of the irrigation and the farm
- More efficient use of water which with upcoming regional plan changes potentially meaning tighter access criteria Kelvin is in a good position to be less affected.

With only one season with the new system and ongoing redevelopment of the k-line area the benefits and payback are still being realised. Kelvin suggests the benefits are very hard to quantify but the ease of management, lower workload and the ability of the farms staff to concentrate on maximising productivity and maintaining the rest of the farm infrastructure in top shape is a significant benefit. There are the direct savings of energy, staff and motorbike costs which are conservatively $80–90,000 p.a. and then there are the improved staff and farm productivity to add to that.

Kelvin sums up the improvements, "It's more than just energy, it's everything – OSH, staff, labour, time, grass growth..."