EECA BUSINESS
PUTTING ENERGY TO WORK

SMART IRRIGATION

IRRIGATION NEW ZEALAND

Irrigation Energy Efficiency Evaluation Pilot Project Summary Report

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Contents

Executive summary

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.

This project has grown the capability to be able to complete these types of evaluations. The industry now has four consultancies that are proficient in the energy efficiency analysis. It also enabled a process and scope to be refined so that consistent and meaningful results would be possible from a larger industry wide program. The project identified key points to include.

- It is important both the irrigator and the contractor have an equal understanding of expectations – transparency of the outcomes and what is being investigated and reported.
- Consistent recording, reporting and benchmark calculations are needed.
- The contracts are critical to enable collection of data and information off third parties.
- The timing and constraints of site visits and information collection need to be factored into any future program.

The level and accuracy of information collected is a major determinant of the outcome and thoroughness that the evaluation can deliver. With robust information the benchmarks calculated will enable the industry to quantify energy efficiency and improve over time.

As this project was managed and endorsed by INZ, as the respected and recognised industry body, the INZ role was crucial to get buy-in from irrigators. The success of any subsequent program will benefit from having a central, independent and respected body to manage it and disseminate the information.

From the 14 systems evaluated 12 had improvements to make. The actions identified are achievable and the payback and capital costs to make improvements are realistic.

This project confirms there is considerable scope to improve energy use efficiency of on-farm irrigation systems.

BACKGROUND INFORMATION

This pilot project is a partnership between Irrigation New Zealand (INZ), EECA, and the lines companies of Canterbury and North Otago to determine if an opportunity exists to improve the energy use efficiency of on-farm irrigation systems and their operation, and if so what is the scale.

The pilot project is the result of an EECA proposal in 2012. Initially an on-going industry wide irrigation energy evaluation was proposed. However due to a lack of evidence around the opportunity and costs it was decided to complete a pilot project to obtain more certainty of the opportunity and potential savings. The concept was to complete a number of targeted, detailed evaluations to enable an industry wide programme to be developed with confidence that it will succeed.

Using the pilot evaluation results to showcase and provide tangible examples of the benefits will give irrigators confidence to invest in capital and other improvements. The findings and learning's from this pilot project will help develop and promote a wider industry programme whilst limit the liability of it.

This report is a summary report of the 14 on-farm irrigation system energy evaluations carried out. It is produced by INZ, as project manager, to inform the project sponsors (EECA and the contributing lines companies) of the opportunities and learnings. It summarises the methodology and results.

Pilot programme

Irrigator selection

Participants were selected with no bias towards informed or leading edge farmers. To get an unbiased and representative sample lists of irrigation customers were provided by the participating lines companies and irrigators picked at random from them. They were then contacted by INZ, given a full explanation of the pilot project and then given the opportunity to participate. In nearly all instances the opportunity was taken up. The exceptions were because they were already undergoing system changes or had recently upgraded and felt that their systems were operating efficiently. There was no measurement provided to substantiate these thoughts.

The fact that the evaluation was significantly subsidised was a large incentive to participate. The cost of an evaluation for an uncertain outcome had previously been a barrier to have an irrigation system evaluation.

Irrigators with usage of 200 000 kWh per year were targeted to provide worthwhile results and a realistic system size.

Evaluations

Fourteen evaluations were carried out. The number of evaluations carried out in each region is detailed below.

Region	Lines company	
North Canterbury	Mainpower	5
Mid Canterbury	Orion	1
Central Canterbury	Electricity Ashburton	4
South Canterbury	Alpine Energy	1
North Otago	Network Waitaki	3

Irrigation is a seasonal activity. When irrigation begins and ends is entirely dependent on the climatic conditions. A typical season would extend from mid-October through to mid-April but could be shorter or longer depending on climatic conditions. This seasonal nature means that the window of opportunity to evaluate the systems on-farm is limited to when irrigation activity is happening.

The evaluations were undertaken by qualified irrigation evaluators or engineers. The evaluations and analysis undertaken were in accordance with *The New Zealand Irrigation Performance Assessment Code of Practice (INZ 2010)* and analysed against *The New Zealand Piped Irrigation Systems Design Code of Practice (INZ 2012)* and *The New Zealand Piped Irrigation Systems Design Standards (INZ 2012).*

The evaluations covered the two aspects of irrigation efficiency:

1. Motor, pump and delivery system (headworks & mainline) efficiency & performance – %
2. Seasonal irrigation scheduling/operation efficiency – %

The second aspect recognises that even if the pump and delivery system is correctly designed and installed, if the operation and management of the system is incorrect then there will be energy inefficiencies in the system.

Four contractors were used to carry out the evaluations:

- Aqualinc Research Ltd – provider of consulting services to the water sector
- Demand response – provider of energy efficiency and management services
- Hydroservices – irrigation management and water resource consultancy
- Irricon – environmental and irrigation consultancy.

The complicating factor in irrigation energy efficiency is the skill of the irrigation manager in scheduling irrigation events and matching the depth of water applied to demand. The amount of water applied and timing (turning the water on and off) can significantly affect the energy used simply by the volume pumped. The difficulty in evaluating irrigation systems is trying to measure and quantify this.

Another complication is how the irrigation system fitted into the overall farm systems. In many instances irrigation systems may not have been the most efficient available but for a number of constraints on farm, physical and/or management, they were the most suitable.

Capability

Prior to this project the capability and expertise within the industry to carry out these particular energy evaluations was limited. This type of energy evaluation was seldom done on farm and efficiency of energy use has not traditionally been a focus of irrigation service suppliers or farmers.

WATER METERING

A major reason for the lack of energy evaluations to date is the previous lack of water use data. The opportunity that the water metering legislation[1] has provided is substantial. It has now created a reliable data set to compare with electricity records and quantify energy use per unit of water pumped.

This and other benchmark information will enable the industry to quantify energy efficiency and improve over time.

CORE COMPETENCIES

Each of the consultants used have their core competencies in one or both of the two aspects of irrigation efficiency. In each case the capability, processes, tools and links within the consultancies has had to be grown to cover one or the other aspect. This has been developed as the project has gone on and has been a significant outcome from this pilot. Their understanding of how irrigation is fitted into farm systems has also grown.

The industry now has four consultancies that are proficient in the energy efficiency analysis.

Contractual arrangements

Contracts between INZ and consultant were drawn up to:

- detail the contractor's obligations and expectations
- define the term
- set fees, invoicing and payment schedules and processes
- protect the intellectual property of the project and client
- ensure appropriate liability insurance was held.

Contracts were also drawn up between INZ and each of the irrigator clients to:

- set terms and conditions
- detail client obligations and expectations
- indicate cost and subsidisation extent
- set fees, invoicing and payment schedules and processes
- protect the intellectual property of the project and client
- enable access and limit liability
- enable access to clients electricity records from their electricity retailer.

The contracts are critical to enable collection of data and information off third parties.

1. Resource Management (Measurement and Reporting of Water Takes) Regulations 2010.

Methodology

COMMUNICATION
INZ initiated all of the irrigator selection and communication, and also continued to act as a conduit for reporting, ongoing discussions and information gathering. The irrigators had to feel comfortable that the consultant engaged was proficient and capable to complete the work. The INZ project manager did not attend each site visit but went on at least one of each consultant's visits (more if necessary) to ensure that there was consistency and efficiency of data and information collection.

As the project was managed and endorsed by INZ, as the respected and recognised industry body, the INZ role is crucial to get buy-in from irrigators.

SITE VISITS
In consultation with the irrigator INZ assigned one of the contractors to carry out a site visit to measure and record data and the irrigation system. The visit typically took approximately 3-4 hours on site (excluding travel time). The timing of the visits often had to fit around other farming operations and could not always be coordinated at the earliest opportunity. In the spring on both arable and dairy operations normal farm tasks took precedence. This factor further reduces the window of opportunity to complete evaluations. Most site visits for this project were conducted from January to April and had to coincide when irrigation was occurring as irrigators were reluctant to turn their system on as it was considered a waste of water and money and could impact other operations due to water logging of soils and inconvenience.

The timing and constraints of site visits need to be factored into any future program.

DATA AND INFORMATION COLLECTION
The range of data needed to be collected is substantial. To complete a thorough evaluation a wide range of data is needed. See Appendix 1.

Some systems had very good information but others accessing the information proved to be time consuming and problematic. Reasons include:

- Broken or non-existent gauges in crucial positions within the irrigation system
- Difficulty accessing or incomplete historical information particularly around what had been originally installed under the ground or subsequent improvements and alterations
- Service companies and suppliers who installed the system who no longer are in business
- Time taken to gain data from external third parties who held the information on behalf
- Non-existent, inaccurate or incomplete recording and recollection of irrigation scheduling
- Multiple pumps and/or irrigators information being collected at one point (water meter or electricity meters) with no ability other than assumptions to differentiate.

Where there was incomplete data, assumptions were made within reports to be able to make recommendations. If there was a lack of data for water use, analysis of the electricity records with equipment specifications and farmer knowledge were able to be used with a reasonable level of confidence to aid analysis.

The level and accuracy of information collected is a major determinant of the outcome and thoroughness that the report can deliver.

SCOPE

The array of possible problems causing energy inefficiencies that could be encountered within an irrigation system is varied. The solutions range from relatively inexpensive replacement of small equipment parts or maintenance, to very large projects such as mainline alterations or replacement, and major system redesign and purchase of very capital intensive irrigation infrastructure and equipment.

As this project went on it became apparent that the irrigator expectation was that if a fault was indicated that was causing inefficiency then a fully costed and engineered solution would be offered. In many cases that could involve major infrastructure upgrades or alterations which carry a high cost and need to be fully designed. This was not the intention of the project and a refined scope has been written up (see Appendix 2). This clarified what was within the scope of investigations.

It is important both the irrigator and the contractor to have an equal understanding of expectations.

REPORTING FORMAT

Without existing reporting formats to follow EECA provided some other industry examples. These were adapted to suit the project and nature of the irrigation industry and the readers of the reports. The scoping exercise also helped refine the report format. The format was provided to each of the consultants to follow for a consistent product.

Within the reports consistent key benchmarks are calculated so INZ can build up an industry wide picture of energy use and indicative values to measure performance against. There has been very little benchmarking and recording of these values from an industry perspective and on farm. Consequently there is no baseline to measure performance against and slippage of performance can go unnoticed.

Consistent reporting and benchmark calculations is needed.

Results

- 14 systems evaluated
- 12 systems with Identifiable actions to improve energy efficiency
- Many systems with multiple options and actions needed
- 20 different measures to improve energy efficiency
- Range of capital expenditure required from $900 to $99,000 (one outlier at $970,000 to build storage facility)
- Simple payback period ranges from 6 months to 12 years.

Systems evaluated

Al of the systems evaluated were pressurised piped irrigation systems with one or both of groundwater and surface water sources and multiple irrigator type.

Water source	Groundwater	Surface
Single source	4	6
Multiple source	4	1

Irrigator type	Pivot	Travelling irrigator	Guns	Moveable sprinklers	Fixed sprinklers
Number	10	7	2	6	1
11 systems had multiple irrigator types					

Identifiable actions to improve efficiency

On all but one system (13 out of 14) there was actions identified to improve energy use efficiency. The actions covered a large range and could be grouped into the following categories.

Actions grouped	Number
Alteration of headworks – these recommendations ranged from removing restrictions to resizing intake pipes and installing monitoring points.	4
Alterations to distribution network – the main recommendations are to have more direct feeds, and to resize to reduce friction loss or use higher pressure rated pipes.	5
Install Variable Speed Drive's – and in one instance investigate removing a VSD.	4
Reconfigure supply to match demand – this was on systems with multiple pumps and irrigators interconnected and required redirecting and designating supply to match demand where possible.	4
Intake improvements – these ranged from improvements to existing structures and replacement of substandard intakes	3
Soil moisture monitoring for improved scheduling and precision irrigation.	9
Make pump changes – suggestions ranged from replacement to resizing to removing.	3
Irrigator changes – a combination of small improvements to existing irrigators or changing irrigator type. This may require large infrastructure changes.	5
Irrigator evaluation – the investigations did not extend to assessing individual irrigator performance by putting buckets out under the irrigator to measure the efficiency and uniformity of them. But it was identified that doing this could show up some other possibilities or areas of inefficiency. All irrigators should have this done on a regular basis to measure performance.	6

In a lot of cases the installation of monitoring points and equipment was recommended and although this would not in itself reduce or improve energy use and efficiency it would enable better information to track system performance and by default energy use.

In some instances there is more than one option to rectify a problem and the irrigator could choose between them.

Soil moisture monitoring was the most recommended action and indicates the correct scheduling of irrigation could make a significant impact on energy use.

Financial analysis

As part of the reports the contractors were asked to provide some indicative costs and savings of the actions recommended in both kilowatts and dollars. From this a simple payback period was calculated. In the most part this was done although it can be difficult to quantify the savings potential from some actions such as soil moisture monitoring.

Soil moisture monitoring has been shown to typically have a payback period of approximately two years and in some instances within one year. The payback is dependent on the existing practices. This technology and expertise is becoming more affordable and accessible within the industry.

Precision irrigation does not feature highly in this project but the installation and use of this new technology can have very fast payback and large reductions in energy use simply by using less water. It precisely matches water application with soil moisture conditions at a finer resolution than the existing conventional equipment allows. This is only available for centre pivots at this point and does not suit every situation but does have large benefits to those that have installed it.

Payback

The payback periods range from six months to 12 years. There is little correlation with the cost of actions identified and the payback period as figure 1 shows.

The overall average payback is 4.4 years but the average of actions under and over $20,000 respectively is 3.8 and 5.5 years.

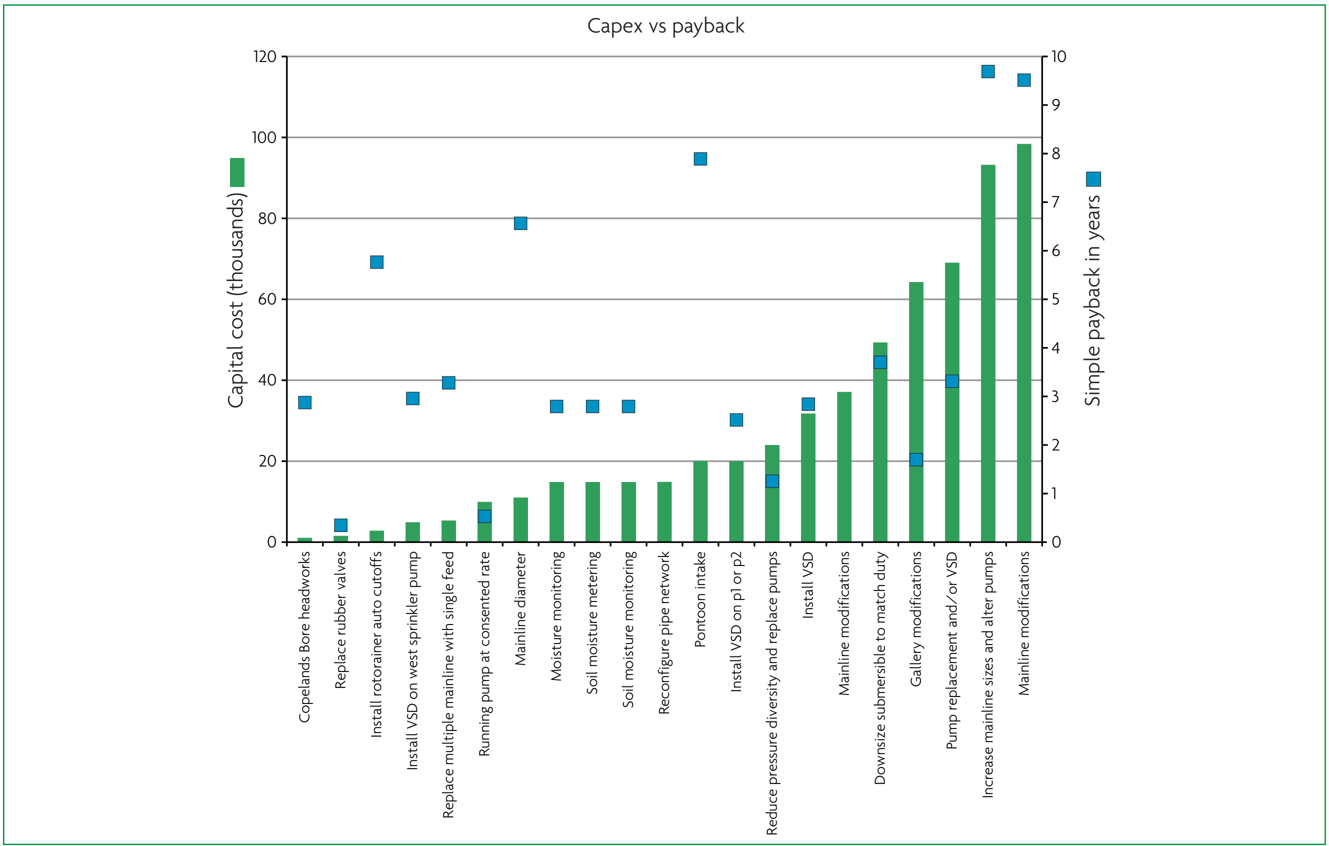

Figure 1. Capex vs payback

Figures 2 and 3 shows the payback for actions that cost less than and greater than $20,000.

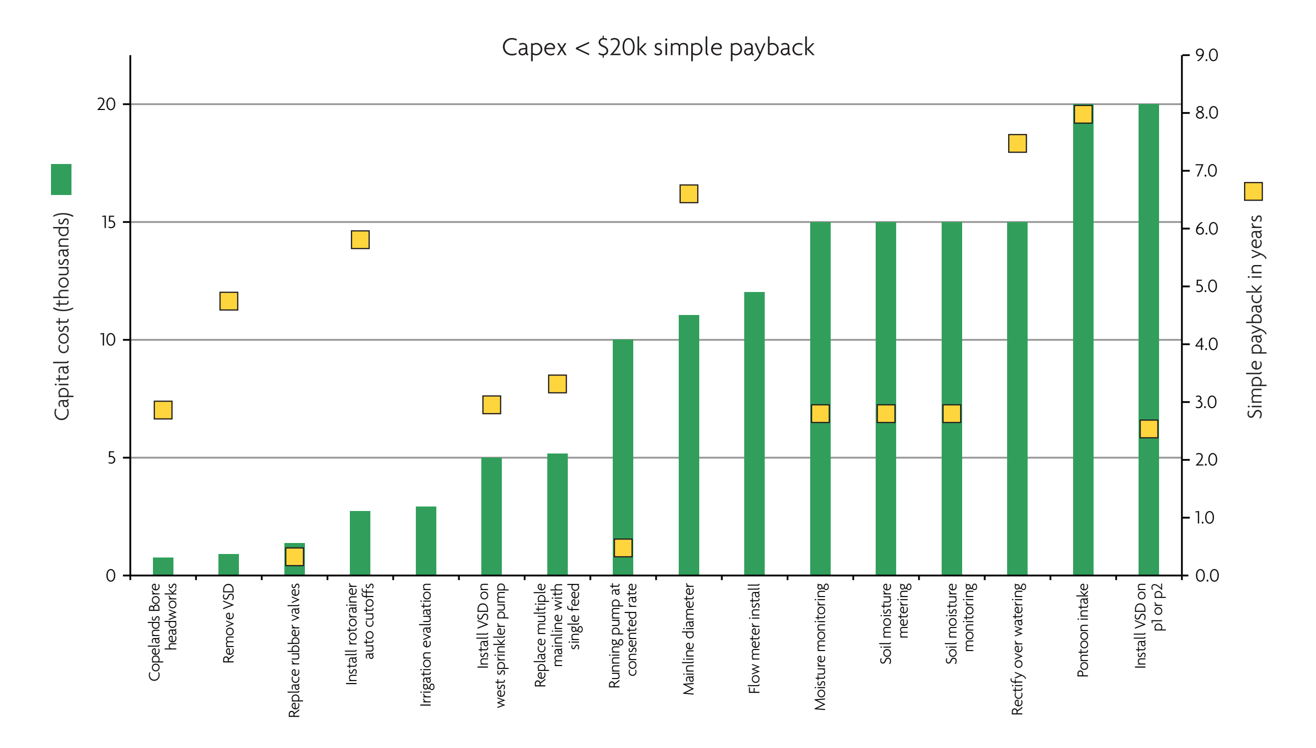

Figure 2. Capex < $20k simple payback

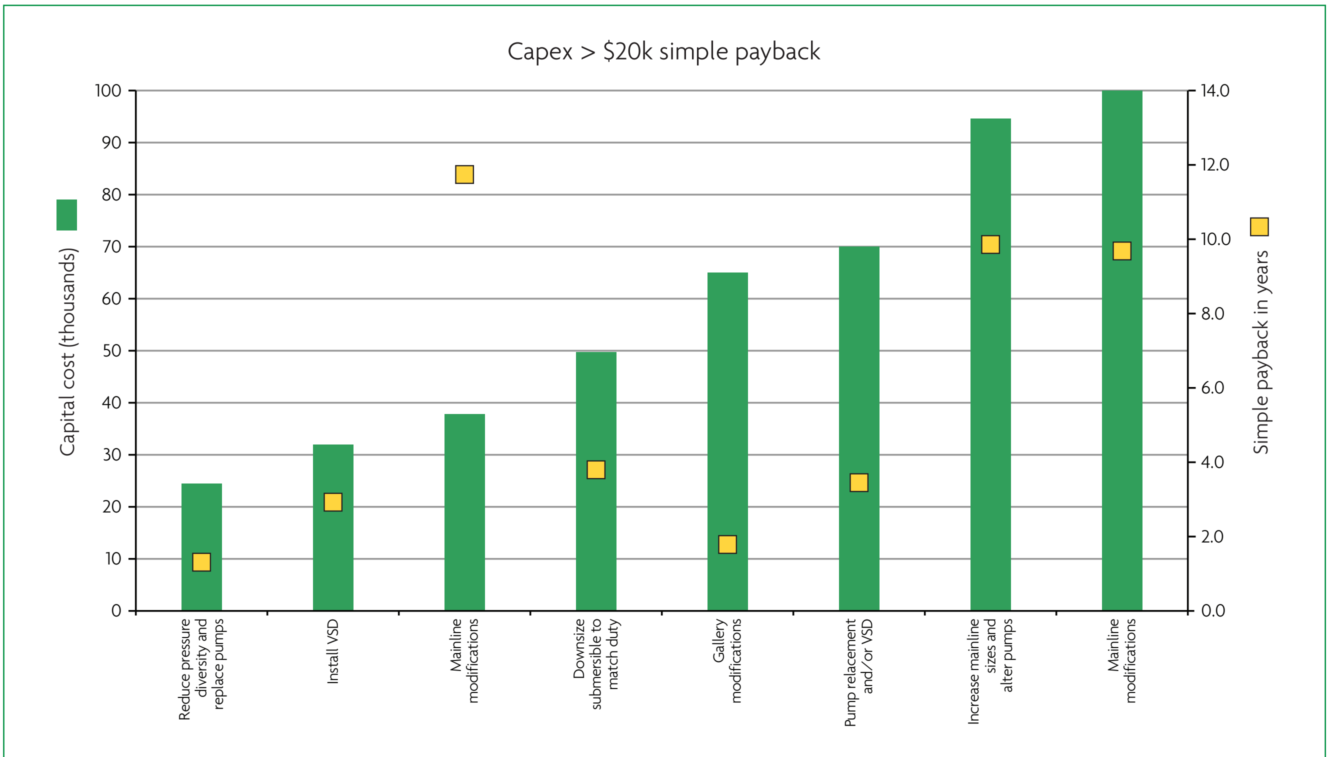

Figure 3. Capex > $20k simple payback

The reports also calculated the costs of pumping a cubic metre (m^3) of water in kilowatt hours (kWh) and dollars. Where possible this was done to the individual pump. Figure 4 graphs the results.

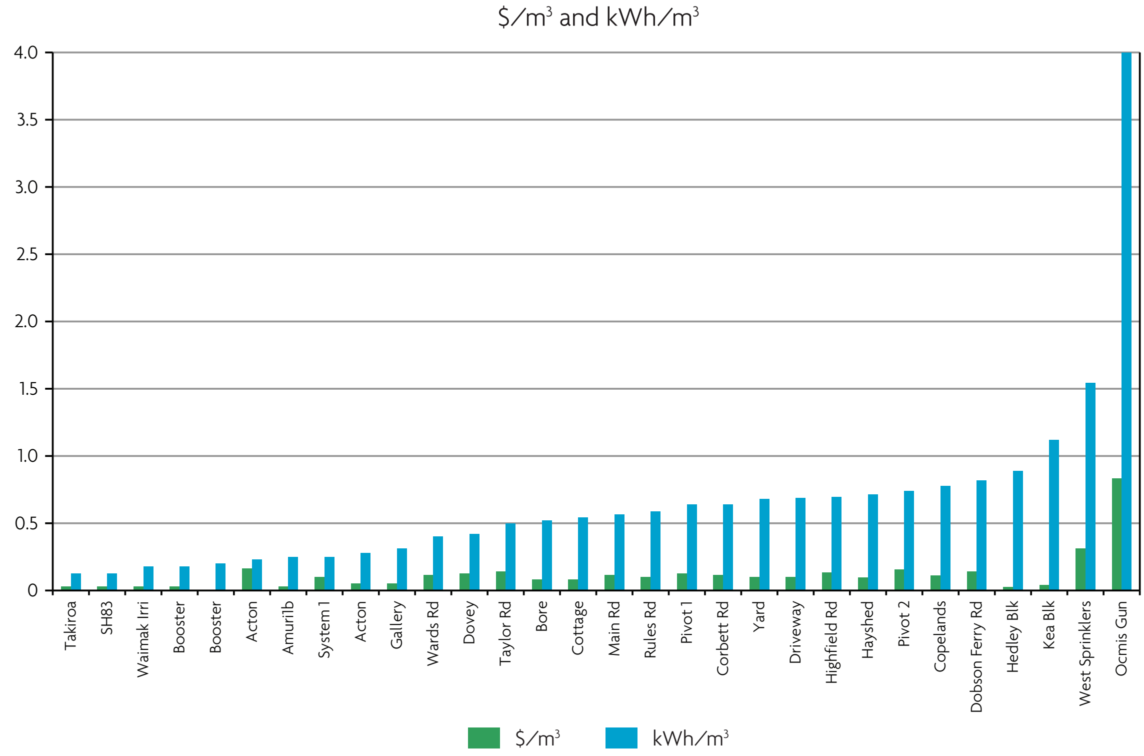

Figure 4. $/m³ and kWh/m³

There is a wide range of kWh/m³ from 0.12 to 4. There will always be a variation as water is pumped from and to, differing heights for each individual irrigation system.

To produce a benchmark across the industry other factors that need to be considered are the distance of the distribution network to supply the irrigator and the pressure requirements of the irrigator. A benchmark of kWh/m³ per unit of total head (pressure required) could be made. This analysis could not be made with the data obtained but it would be a useful benchmark to measure.

EVALUATION COST

The average cost of the 14 evaluations was $6,193. This varied from between systems depending on:

1. How much data was readily available
   This determined time taken to source the necessary data and also the level of investigation able to be carried out. More data meant investigations took longer and cost more but the end result was a more thorough and useful report and solutions.
2. The complexity of the system
   The more interconnected the system was with multiple components the more time had to be spent on the analysis.

Observations

At the beginning of the process the irrigators were asked how they thought their system was running. There was a mixed response. Very few if any could state how much their water per unit was costing in energy or dollars or if their system was running efficiently. Some recognised they had issues because irrigators were visually not operating as they thought they should. But they did not know how to go about looking into the perceived problems. Irrigators equated the system visually operating correctly with good efficient operation when in fact it could be masking the opposite with energy or water (and hence energy) being wasted because of excesses in the system.

There was a general lack of awareness of operating efficiency and the costs of running a system. The irrigators knew how much their electricity bills were for a season but had done little or no further analysis. One larger enterprise with multiple farms had done some detailed analysis and developed spreadsheets to calculate and record energy cost per installation and per unit. They however were still willing to undertake an evaluation on a property as they had recognised there were some issues but had not been able to identify the issue. Unfortunately the property was not evaluated due to the irrigation equipment being stowed for the winter months.

The most crucial factor was being able to access good data. Water meter data is crucial to provide a thorough analysis. Of the 14 systems analysed 5 did not have complete water meter data. This was due to these properties being part of a larger community scheme that measured the water use on a scheme basis and did not require the individual irrigator shareholders to meter their take. This is now changing with all of the major irrigation schemes having already decided or considering requiring individual metering.

Simple maintenance of irrigation systems, equipment and their components including monitoring equipment was varied. In some cases there was substantial improvement to be made which would in turn improve water use efficiency and energy efficiency. Often there was a culture of 'there is water coming out so it must be ok' and the preventative and ongoing maintenance was made to enable irrigation to carry rather than to maximise efficiency.

The intricacies, hydraulics and internal workings of the irrigation systems are 'not what irrigators know well'. Often irrigators are unaware of what specifications or values their systems should be operating at. The information has either never been supplied to them or it has been lost over time. Consequently they have no measure of how their systems are performing to plot against and can be unaware of issues or inefficiencies.

Turnover of farms sometimes means that system information does not get transferred to new owners or turnover of staff can contribute to the information and knowledge deficiencies.

In many cases the improvement in equipment and irrigation efficiency would result in substantial productivity gains. They may or may not necessarily result in less energy being consumed but the productivity of the energy used would be substantially improved. The productivity gains are difficult to quantify but some indication is given in the *Malbon* and *Bermar* farm reports.

Often changes to existing systems require significant investment and this large step change has been a deterrent to make substantial improvements. The recent water quality[2] setting processes have seen irrigation in the focus as it can have a significant effect if not performed correctly. The limits being proposed and the pressure being put on the irrigation industry in general will provide further impetus to make substantial change if it is warranted.

The cost of a full irrigation system evaluation is seen as a deterrent to have it undertaken, however the investigations show the paybacks can be relatively quick. In many cases the improvements would not only see an improvement in energy efficiency they would also improve water use efficiency through correct pressures and flows. This in turn improves their performance and this correlates to improved production. The quantification of this outcome is not fully captured in these reports but would be a further incentive to evaluate irrigation systems. Case studies following the changes made would be able to help quantify this.

There were only two evaluations carried out in the summer of 2013, the beginning of this pilot project. This was due to a very wet spring limiting opportunity to carry out the evaluations, and the methodology and scope of the project not being suitably refined. These two evaluations helped refine both the scope and report format. Both properties have used the recommendations and made changes to their systems in line with what was suggested. As they have now been through a full season with the changes in place a further analysis and comparison of a before and after scenario can be done.

2. National Policy Statement for Freshwater Management 2011.

Conclusions

From the limited number of systems randomly selected the evaluations show 12 out of 14 with recommendations to improve efficiency, many with a number of options. This confirms there is a large opportunity to improve energy efficiency in irrigation systems.

In the reports not every action was able to have a kWh and/or $ savings calculated.

- The 8 actions that had both calculated showed a total 243737 kWh and $7444 p.a. saved for an average capex cost of $25888 and a payback of 3.5 years.
- The 23 actions that had a $ savings calculated showed a total $184,241 p.a. saving at an average of $8010 for an average capex of $27,194 providing a payback of 3.4 years.

The savings calculated are a conservative estimate as in many instances other associated benefits would accrue. This is due to increased production because of the improved performance of irrigation equipment meaning better efficiency of water use.

To improve uptake of irrigation energy evaluations the barriers of data availability, lack of awareness of the opportunity and cost need to be addressed.

- The water measurement and reporting regulations now mean water use data is readily available.
- This pilot project has provided the irrigation sector and INZ with some concrete information from which to make irrigators aware of the opportunities for improved energy use.
- The partnership and subsidy approach has lowered costs and thus reduced the risk from an uncertain outcome.
- Having the project centrally managed by INZ to ensure a targeted approach with consistent outcomes and processes was a major incentive for farmers to engage, giving them confidence to take up the opportunity.

Appendices

Appendix 1: Data and information collection

1. Consent/supply agreement information;
   - Flows
   - Annual volumes
   - Any relevant conditions
2. System description included;
   - Maps
   - Mainline pipe positions, sizes and type of pipe
   - Irrigator types and specifications, where they operate on the system (if applicable), (makes and models and operating specifications)
   - Heights differences over irrigated area of property
   - Typical operating configurations
3. Pump information include;
   - Positions on system and depth pumping from
   - Make models and specifications of each pump
   - Age and service history
4. Bore/water source information;
   - Depths to water and pump
   - Yields/ flows
   - Sizing and materials
   - Age
5. Electricity usage per meter information preferably for the previous two seasons;
   - ICP numbers for each of the irrigation connections
   - Line charges and time of use charges
   - Power pricing plan you are operating
6. Water use information;
   - All water meter data preferably for the previous two seasons.
7. Scheduling information;
   - Records of water application and any soil moisture monitoring information
8. Any other changes or alterations that have been made over the life of the system
9. Soils information
10. Actual performance measurements and Design performance values
11. Management systems and preferences
12. Land use information.

Appendix 2: Scope document sent to irrigators and contractors

INZ/EECA IRRIGATION ENERGY EFFICIENCY

The evaluations will be a base level assessment that covers the two aspects of irrigation efficiency

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

The key goals of this assessment are to:

1. Understand how much energy the site's pumping system is using and the approximate annual cost of operation
2. Understand what the key drivers for pumping system energy use are and how they interact
3. Identifying where kWh savings can be made to the systems and where Investment-Level studies are recommended
4. Indicatively quantify potential savings.

EVALUATION SCOPE

Extent of investigations
Investigations extent needs to identify performance and energy inefficiencies within the two aspects of irrigation efficiency. Investigations need to cover:

1. Motor, pump and delivery system
   - Pump energy efficiencies
   - Headworks efficiencies
   - Pipe network losses (pressure and flow)
   - System dynamics
   - Irrigator performance
   - Matching of electricity capacity charges.
2. Seasonal irrigation scheduling/operation efficiency
   - Use of soil moisture monitoring tools
   - Matching supply and demand
   - Forecasting and forward planning of irrigation applications
   - An assessment of the information used to schedule irrigation events and scheduling performance.

If there are no significant savings opportunities identified after the initial investigation no further investigation will be carried out.

An investment level audit and redesign of significant infrastructure upgrades is outside the scope of this report. It is an exploratory report to identify and quantify issues and give indicative costed solutions within the confines of the indicative cost. Further work may be needed to validate and test the findings before quotes for work are tendered at the irrigators cost.

Optimising energy retail pricing plans is not included in the scope of the investigations. The primary purpose is to identify where kW hours can be saved

OUTPUTS

Reporting
The reporting will be in a succinct and easy to follow format and include a status quo

- Summary explanation of the issues identified within the system that could create inefficiencies.
- Ratios of energy consumed per volume of water used
- Cost per volume unit of water per pumping installation
- Assessment of scheduling practices.

Recommendations

Recommendations will:

- Outline the potential energy savings or productivity increase opportunities
- Suggest and cost remedial actions to achieve opportunities
- Quantify the potential savings and production increases
- Outline a change management plan
- Propose ways to improve scheduling performance, collection and use of information.

COST

An indicative cost of the report is:

- $6000 for a basic irrigation system
- $8000 for a complex system.

Case Study: Ross and Sue Duncan

ON FARM IRRIGATION ENERGY EFFICIENCY CASE STUDY
Ross and Sue Duncan. Chertsey, Mid Canterbury.
Consulting engineers: Aqualinc Research Ltd., Plains Irrigation 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 Ross and Sue Duncan in the Mid Canterbury region.

Ross and Sue Duncan, Chertsey

Ross and Sue farm a 292 ha arable farm at Chertsey south of Rakaia.

The irrigation system had three pumps operating in parallel to serve a ring main network with several branching sub-mains. A single, fixed, Zimmatic centre pivot, two towable (Zimmatic & Pierce) centre pivots and a Roto-Rainer provided the method for distributing irrigation water. The ring main system was originally designed for Roto-Rainer and the distribution method has been altered with the addition of the fixed and towable centre pivots over the years.

Water is sourced from two bores and a reservoir located on site that is supplied by the Acton Irrigation Scheme taking water from the Rakaia River. The supply has also been added to over time from the original one main bore with the addition of a second bore and surface water supply. Both the addition of the pivots and the increased supply points had been done with minimal changes to the original underground pipe network other than to tee into it.

Design considerations

An IRRICAD[2] analysis was done on the design and came up with a number of issues to address. The main points were

1. Two of the three pumps consistently not operating at or near their BEP[3] due to pumps fighting against each other to push water into the main lines. The 'Acton' pump most frequently operates between 50 to 60% of the capacity flow which is approximately 30% below the BEP of 57 l/s. The 'Acton' water supply was not being utilised fully as the pump was not being allowed to pump the full amount supplied. The contract to take water meant that this water was being paid for regardless of whether it was used or not. Underutilisation was up to 25% which represented almost $10,000 of the annual charges.
2. 25 l/s overall supply deficit. To function efficiently whilst under maximum load (all four irrigators operating), the system demands 189 l/s but is only supplied with 164 l/s. This supply deficit reduces the overall system pressure affecting the overall system efficiency and the distribution uniformity of the irrigators.
3. Pressure losses in the mainline due to inadequately sized and less than optimal configuration.

1 Energy efficiency conservation authority.
2. Irrigation design software.
3. Best efficiency point.

Changes made

Once the initial investigation had been completed the information was taken to Plains Irrigation Ltd, the company used by Ross and Sue, for a second opinion and to gauge their thoughts on the proposed changes. After many follow up discussions and sharing of information a plan was finalised to upgrade the irrigation system. This involved further changes that went beyond the scope of the original investigation but which has ultimately ended with a better system.

The changes on farm were:

1. Replacing sections of the mainline that were undersized and creating excessive friction losses. Some of the original redundant mainline was dug up and reused where possible.
2. A towable pivot were replaced with a ½ circle 10 span centre pivot watering 90.8 Ha. The towable pivot spans were reused to keep the cost down.
3. Reconfiguring the supply to the irrigators by installing new and discontinuing other sections of mainline to better match the new irrigator configurations. The new ½ circle pivot supply In the reports is solely from the Acton water now fully utilising the quota and the pumps energy used. The pump is now not fighting against the other pumps and is operating as it is designed. There is provision in the new configuration to use the alternative water sources if necessary
4. The Roto-Rainer was renozzled to better match the supply and improve the distribution uniformity.
5. The other three irrigators (fixed 10 span with Z arm pivot, a Pierce 5 span towable pivot and Roto-Rainer are now all supplied from the existing two wells and pumps, one with a VSD[4]) do not operate at once, two of the three irrigators operate together. This maintains correct pressures and flows to each.

The costs to change the system can be broken into two components:

1. The alteration and upgrading of the distribution system. Approximately $90 per irrigated hectare with a lot of the work performed by the on-farm staff and utilising existing redundant mainline .
2. The new pivot at $2022 per hectare utilising the old pivot.

The results from these changes are;

- Improved energy efficiency of the Acton pump now operating at its designed duty.
- Pumps not fighting against each other to supply the mainline.
- Better utilisation of the Acton water money spent.
- Improved performance of the irrigators.
- The new ½ circle centre pivot infilled some area so a larger area is able to be irrigated.
- Less labour requirement to operate the system.

Ross and Sue are extremely pleased with how the new system is operating. They stress the key was using the information provided and taking a bigger picture look at the system as a whole to come up with the optimal solution. The energy efficiency investigations certainly kick started the whole improvement of the system and has resulted in better utilisation of both water and energy and improved productivity on the farm.

4. Variable speed drive.

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..."

Case Study: David and Clare Easton

ON FARM IRRIGATION ENERGY EFFICIENCY CASE STUDY
David and Clare Easton, Lower Waitaki.
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 David and Clare Easton in the lower Waitaki region.

David and Clare Easton, Lower Waitaki

The farm is 549 hectares in total. The irrigation system covers 232 hectares with one central surface water supply from a gallery feeding two main pumps. A third booster pump is 'in line' to raise water to 24 hectares on a terrace. The distribution system is all k-line.

The original system was designed by Kirk Irrigation in 1999. The booster pump and extra area was installed in 2001. David Easton advised that this was one of the first k-line irrigation systems to be installed in the Waitaki Valley. Much of the mainline was purchased second hand.

1 Energy efficiency conservation authority.

Design considerations

There were three main areas identified for improvement.

1. **A collapsed intake flange on one of the main pumps.**
   Because of the constriction created by the flange the pump's performance was well outside the acceptable range. The BEP[2] is 71 l/s but with the constriction the flow was 52 l/s. The pump is selected with flow in mind so while taking less the pump is still working the same but not delivering the water needed.

   This had a flow on effect of restricting the flow to the 'in line' booster pump as well limiting the supply to the k-lines on the terrace. Without a water meter on the booster pump the flow was pro-rated to calculate a flow of 9.4 l/s.

   The booster pump was designed and selected to provide 12.5 l/s which would give 4.5 mm/ha per day to the 24 hectares on the terrace. At 9.4 l/s the delivery is only 3.4 mm/ha per day. This is insufficient to satisfy the demand during the summer months. David Easton's comment that the system appears to be "falling behind" in the peak of the season backs this up. With peak ET values for the farm in excess of 5 mm/ha per day the delivery of only 3.4 mm will mean there are production losses from under watering.

   The cost to replace the flange was $1500. This has enabled the pumps to operate at its optimum getting the required amount of water. By doing this the energy savings of pumping the same amount of water but more efficiently is $4427 per year. The production increase by correct water application can also be factored in.

2. **The two main pumps shared one central intake.**
   The systems share a common intake and power supply. It is common for systems set up this way to "short change" one system, and this effects pump operation, and therefore energy use and irrigation application. Separating the systems (each pump having its own intake) has the advantage of being able to isolate the systems in the event that one pump fails, but also ensuring that each system gets its required flow. With this, each system (and pump) should have its own flow meter so the flow being supplied to each system can be benchmarked and easily checked.

3. **The extension raising water to the terrace had three smaller pipes supplying three separate k-lines.**
   The current losses from the three mainlines are 131 kPa per 100 m length of 63 mm pipe and 45kPa per 100 m of 75 mm pipe. If these three mainline pipes were replaced with one pipe and teed off at the top of the terrace, the friction losses reduce substantially. The friction losses are 26 times greater through the three pipes. This corresponds to an excess energy cost of excess energy cost for having three lines compared to one is calculated as $1560 per year. A 100 mm pipe has a friction loss of 12 m/100 m and a 125 mm diameter pipe has a friction loss of 0.2 m/100 m. Either would deliver the required volume of water and at a cost of $5200 the payback is within 4 years.

Changes made

The simple replacement of the flange has been done but being able to quantify the difference has been difficult due to only having one monitoring point on the intake. Within the system there was very limited monitoring points so that actual performance of each individual component was difficult to gauge with each connected to each other. This is a key recommendation to be able to benchmark the performance of each component and each separate system.

The overall design application is 4 mm/ha per day but this has been proved insufficient during the summer months. There is ability from a consent point of view to increase the rate of take to 130 L/s (which is exactly equal to 5mm per hectare per day over the irrigation area), however, the pumping configuration as it stands is not able to do this.

The audit has sparked the Easton's to look further at their system and they are now considering different options for distribution. Trying to get away from the constant labour component of the K-line and to improve water use efficiency and maximise their consented take they are investigating pivots on the flat and small guns on the terrace. The intake structure will be part of the bigger system change to rationalise the irrigation system on the farm.

So in the meantime the simple flange change alone is saving them over $4000 per year and the system is able to deliver more water to their pastures to maintain production and their bottom line.

2. Best efficiency point.

Project follow up

SUMMARY OF FINDINGS

- All the evaluations undertaken were perceived as beneficial, they frequently helped quantify and confirm suspicions that an irrigation system had performance issues.
- Monitoring and measuring water and energy use is a crucial first step in the change process for improving performance.
- The quantification of the consequences of poor performance, either as dollars or lost production, was a catalyst for changes that were made.
- Engaging the 'agents for change' post the evaluation (an irrigator's chosen irrigation service company, consultant and/or financial institution) is crucial. The evaluation provides 'information' and 'awareness' to the irrigator, however the 'application' component of the uptake equation also has to be addressed for change to occur. Third parties that are part of the irrigator's decision making process need to be made aware of the issues so they can champion change over the long-term.
- There is an irrigation design capability and capacity issue within the irrigation service industry. There is an urgent need to attract new talent and upskill existing personnel.
- Optimal water and energy use frequently requires 'whole system' change, this involves substantial investment and is complex in nature. Success should therefore be measured over a minimum of a 10 year time frame.
- Changes that were small in nature or relatively easy to do, from an irrigator or irrigation service company perspective, were generally carried out.
- Any future irrigation evaluation programme, whether for energy or other efficiency reasons, needs to connect with the regulator to help overcome consenting issues (both real and perceived).
- There is a need to build irrigator capability. Improving irrigation scheduling decision making is a priority.

Background

During the 2013/14 irrigation season, 14 irrigation energy efficiency evaluations were carried out to identify opportunities for improvements in energy use. These involved a detailed investigation of the two aspects of irrigation energy efficiency:

1. Motor, pump and delivery system (headworks & mainline) efficiency & performance
2. Seasonal irrigation scheduling/operation efficiency.

With limited irrigator uptake of the evaluation recommendations (approximately 40% – two farmers have made substantial changes beyond the scope of the initial investigation and four smaller changes in line with report recommendations), INZ carried out a telephone survey to determine the main barriers to change. This report provides an overview of these, alongside some solutions to them.

The telephone survey asked:

1. Did the findings and recommendations in the report make sense?
2. Were any of the recommended changes made?
3. If changes were made, what were they?
4. If no changes, why not?
5. What would help you to make the changes?

Barriers to change and solutions

MONITORING AND MEASURING

1. ***The evaluations were perceived as beneficial, they helped quantify and confirm suspicions that an irrigation system had issues and opportunities to improve energy efficiency.*** Prior to the evaluation irrigators could not quantify or pinpoint areas of energy waste as they had no benchmarks to compare against. Therefore due to a lack of information nothing was done, there was no reference point to measure improvements. Often this resulted in the assumption that any changes would be expensive and therefore not cost effective.

   This highlights the importance of monitoring and measuring as the first step in the change process.

ISSUE QUANTIFICATION AND PAYBACK

2. ***The quantification of the implications of improving efficiency either as dollars or lost production, was a catalyst for changes that were made.*** For example, an intake screen that was continually blocking and had to be periodically cleaned, was a known issue but the farmer did not know the scale or nature of the impact on energy use, irrigator efficiency and hence production.

   This highlights the importance of the cost-benefit / payback analyses provided.

ENGAGEMENT OF A CHANGE AGENT

3. In two cases the report findings were presented to the irrigator's respective irrigation service companies. The findings were used as a basis for further investigations that ultimately led to system changes and improvements in both energy and irrigation efficiency. In both cases the changes went beyond the scope of the initial report. This next step of taking the report findings to a service company was cited in three respondent's replies as why changes had not been made. It was on their 'to do' list but had to compete with other farming operational matters.

   This highlights the importance of engaging an 'agent for change' (the irrigation service company) as part of the evaluation process. The evaluation provides 'information' and 'awareness' to the irrigator, however the 'application' part of the uptake equation also has to be addressed for change.

INDUSTRY CAPABILITY AND CAPACITY ISSUES

4. Lack of follow up or difficulty finding an irrigation service company that could provide detailed design and subsequently carry out the changes was given as a reason why changes had not been or were slow to be implemented. It was commented on that capability and capacity within the service industry and their focus being on new irrigation as a priority over retrofitting and upgrades was a barrier.

   This highlights the need to grow capability and capacity within the service industry and justifies INZ's focus on developing career pathways, training and professional development programmes to attract new talent into the irrigation service industry.

COMPLEXITY AND COST

5. ***The evaluations often identified issues that were part of a 'whole system' change, that require substantial investment and are complex in nature.*** Despite the financial benefits of change being demonstrated, difficulty in prioritising and justifying significant system changes is a barrier because of the combination of financing, timing and industry capability issues.
6. For larger changes financial reasons were identified as a key barrier, mainly due to the financing requirements. The recent downward trend in the dairy payout was cited as a factor in deferring any substantial changes. However, many said that they now had the required information for change and would likely take action when things improved.

   This again highlights the importance of the 'change agent'. The irrigator's financial institution of choice needs to be engaged to provide information around financing options, alternatively information on the range of environmental financing initiatives now available could be provided.
7. The timing of change was cited as a reason why some recommendations had not been implemented. The potential irrigation downtime and ability to schedule them in outside of the irrigation season and within other farm operations was a constraint.

   Again this highlights the importance of the 'change agent'. The irrigator's farm consultant needs to be made aware of the issues and help the irrigator make the necessary farm system changes and/or schedule the upgrade.
8. ***Changes that were small in nature or relatively easy to do from both a farmer and service company perspective were generally carried out.***

REGULATORY CONSTRAINTS

9. In two instances the changes identified required a change in consenting conditions. One farmer is in the process of changing the consent to be able to make the changes. The other farmer was happy to 'live with' some inefficiencies and less than optimal irrigation for their property. They could not see the value of changes as they were very wary of the consenting issue. The uncertainty and combination of having to go through the consent process to make infrastructure changes meant that nothing was done.

   This highlights the need to better connect any future irrigation evaluation programme, whether for energy or other efficiency reasons, to the regulator.

LINKING ISSUES TO OTHER DRIVERS FOR CHANGE (WATER AND NUTRIENT USE EFFICIENCY)

10. *The requirement to minimise nutrient discharges on-farm and meet irrigation efficiency targets, given the close relationship that irrigation water use efficiency has with energy use, was cited as a reason that would drive change in the longer term. This was considered to be an equal or greater catalyst for change than the financial drivers.*

IRRIGATOR CAPABILITY ISSUES

11. To improve water use efficiency soil moisture metering was seen as beneficial in a number of the investigations, however a common reason why irrigators had not installed monitoring equipment was uncertainty as to which monitoring systems were best suited to their properties and how they then adopted this technology to help them schedule.

    This highlights the importance of building irrigator capability. Improving scheduling decision making is a priority and justifies INZ's focus on training and information provision for irrigators.

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