Irrigation NZ and EECA

Irrigation Energy Efficiency Evaluation Pilot Project

Summary report

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IRRIGATION NEW ZEALAND

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

14 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	

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

Actions grouped	Number
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.

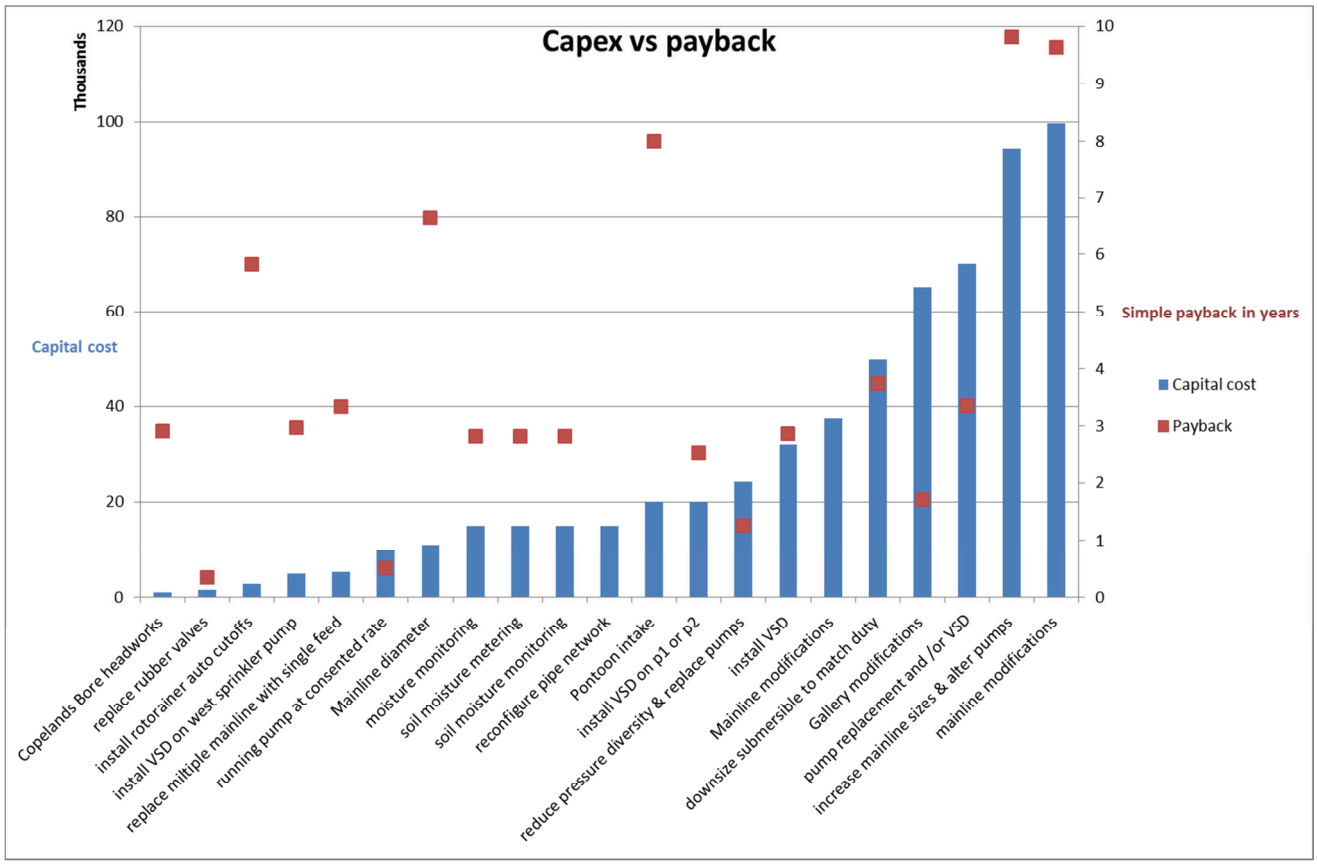
Precision irrigation does not feature highly in this project but the installation and use of this new technology can have very fast payback and large reductions in energy use simply by using less water. It precisely matches water application with soil moisture conditions at a finer resolution than the 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



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

Figure2

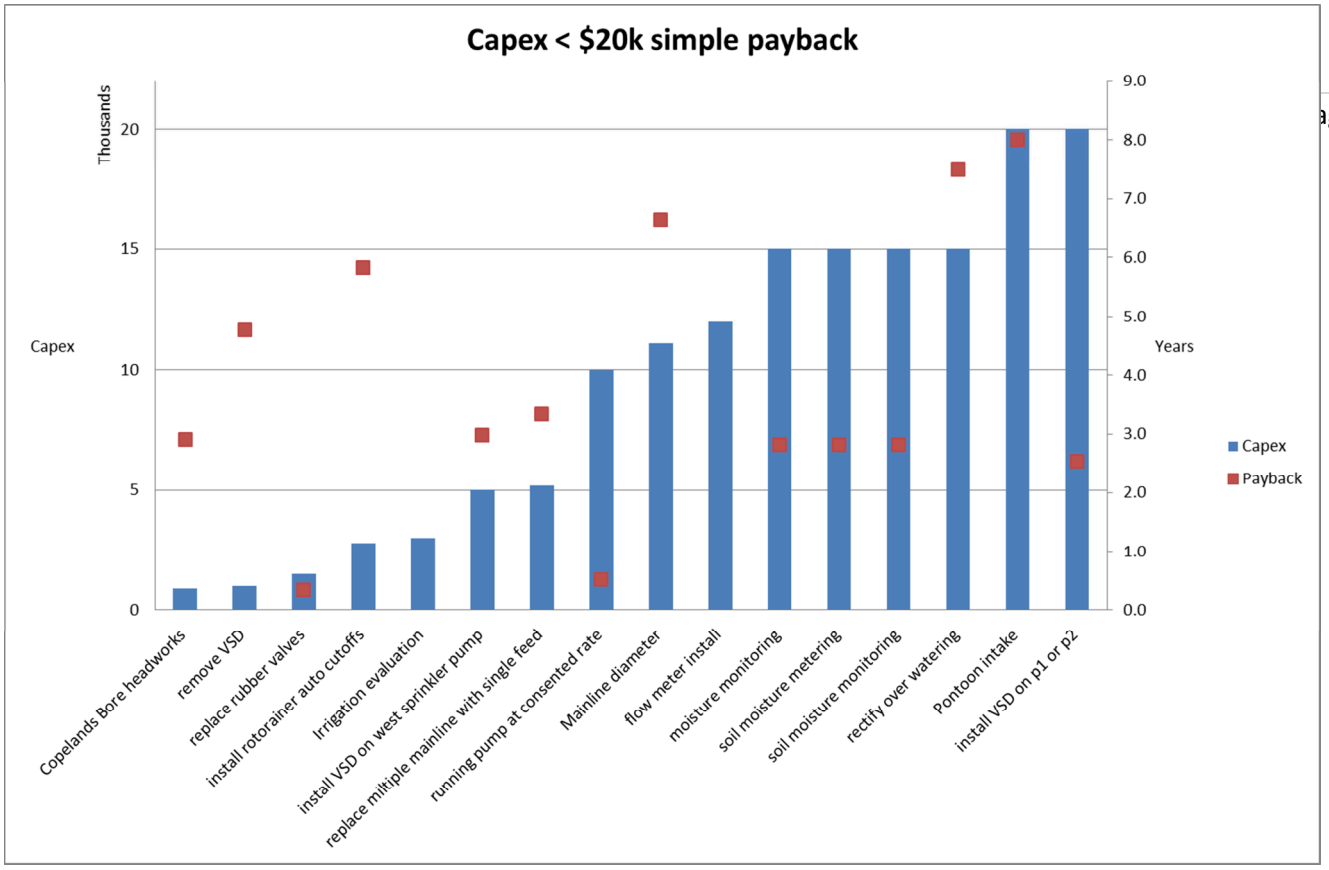
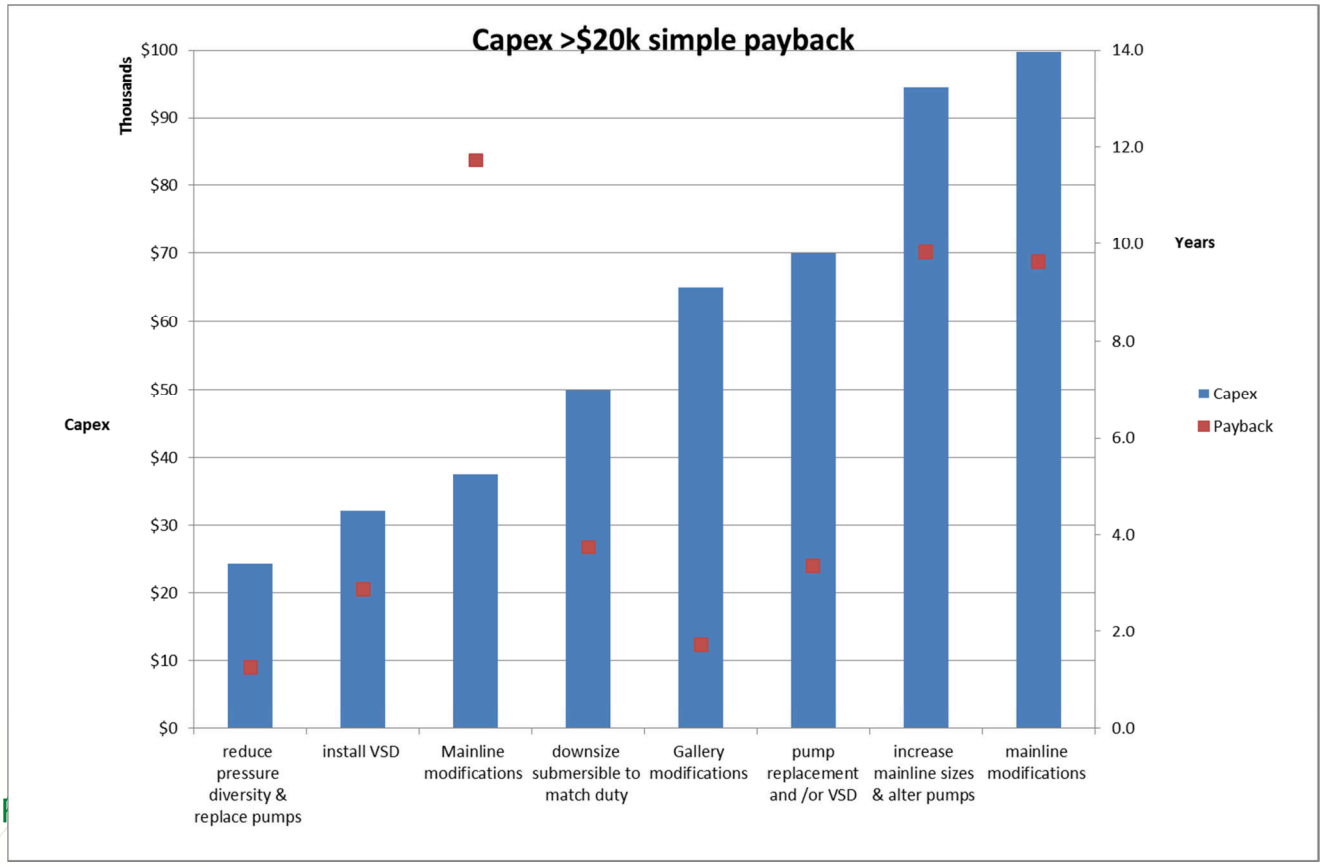
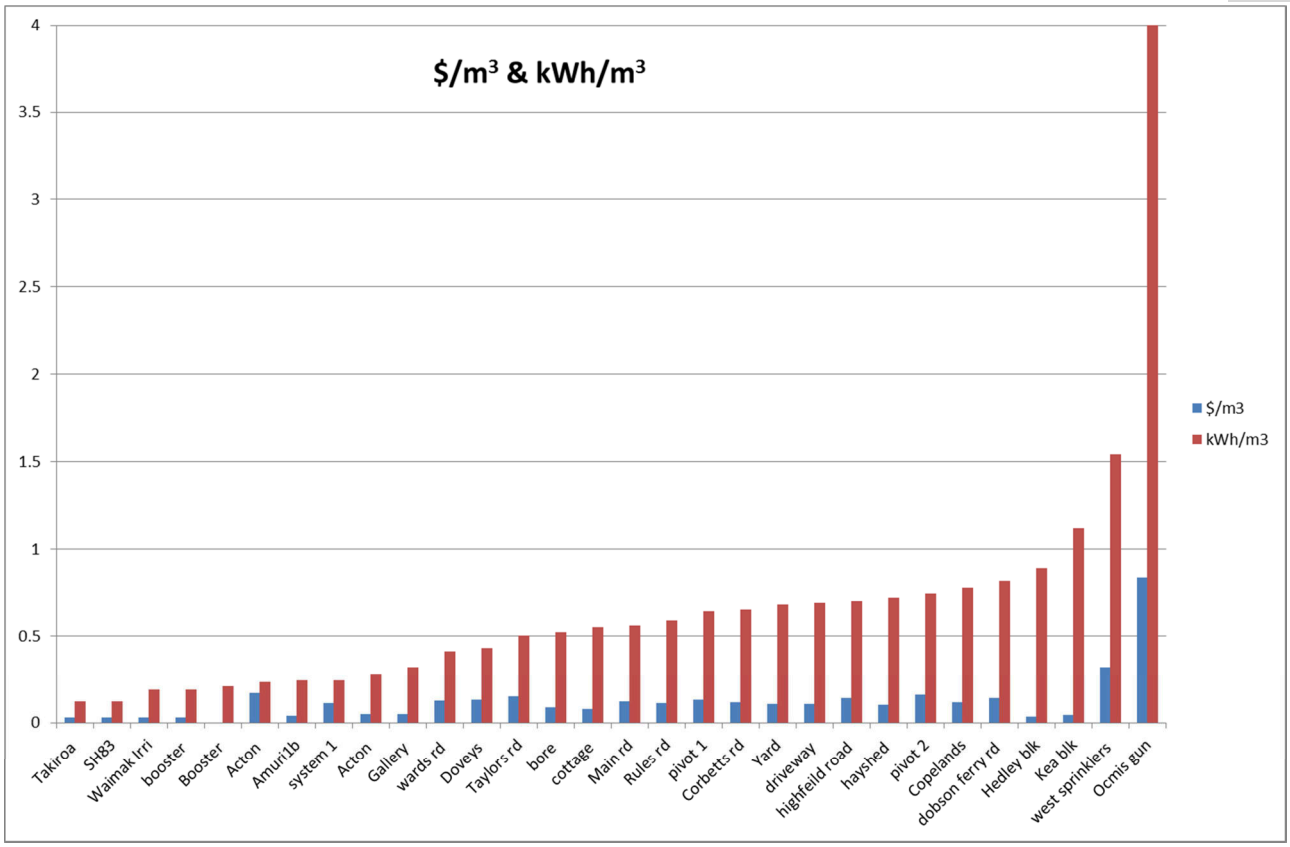


Figure 3



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



There is a wide range of kWh/m^3 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/m^3per 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.

Appendice

Appendix 1

Data and information collection

1. Consent/supply agreement information
    - Flows
    - Annual volumes
    - Any relevant conditions
2. System description incl
    - 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 incl
    - 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

3. Motor, pump and delivery system (Headworks, Mainline and irrigators) Efficiency & Performance
4. 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 indentified 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

Recomendations

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