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ENERGY USE AND EFFICIENCY MEASURES

# for the New Zealand Dairy Farming Industry

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**Climate Change Office**

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EECA
Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

# Contents

# List of Abbreviations

### Energy & Power

| | | |
|---|---|---|
| J | joule | basic unit of energy |
| kJ | kilojoule | 1,000 joules (E3) |
| MJ | megajoule | 1,000,000 joules (E6) |
| GJ | gigajoule | 1,000,000,000 joules (E9) |
| PJ | petajoule | 1,000,000,000,000,000 joules (E15) |
| W | watt | basic unit of power = 1 joule per second |
| kW | kilowatt | 1,000 watts |
| kWh | kilowatt-hour | 3.6 MJ |

### Others

| | | |
|---|---|---|
| ha | hectare | 10,000 square metres |
| kg | kilogram | |
| t | tonne | 1,000 kg |
| ℓ | litre | |
| $CO_2$ | carbon dioxide | |
| CCO | Climate Change Office | |
| EECA | Energy Efficiency and Conservation Authority | |
| MAF | Ministry of Agriculture and Forestry | |
| MED | Ministry of Economic Development | |

# 1.0 Introduction

AgriLINK New Zealand Ltd was contracted by the Climate Change Office (CCO) to collate and provide a stock take of the existing information on energy efficiency measures for the New Zealand Dairy Industry with a particular focus on irrigated dairying. This includes a database of information sources, costs, and suppliers of services and products.

There is good information and technologies available to a dairy farmer if they want to investigate improving their overall energy efficiency. This includes internet sites like Genesis Energy www.dairysavings.co.nz which provides case studies and an energy use calculator and EECA's www.eeca.govt.nz 'find an expert'. Handbooks are available like the one recently launched by the Ministry for the Environment, Energy Efficient Ways. Specific information on a particular technology can be gathered from companies like Danfoss which provides the successful "Varivac" variable speed drive to newly emerging initiatives like Deosan's Supernova Detergent Wash Programme that can halve the quantity of hot water required for plant cleaning.

This report brings together an extensive list of energy efficiency measures for the dairy industry and provides a foundation that can be added to in the future as well as providing comments on the actions required to improve energy efficiency.

# 2.0 Energy Use in the New Zealand Agricultural Industry

In this report all energy use has been calculated to the farm gate. Beyond the farm gate energy use varies enormously depending upon the sector and how far away the customer is. Protected cropping for example only uses a small amount of energy for grading and short-term storage; while kiwifruit uses considerably more energy due to storing a crop for up to 5 months; or the dairy sector that has a large transport component moving milk each day between the farm and factory. Section 2.5 provides an estimate of some sectors' energy uses beyond the farm gate.

By national standards agriculture is a low energy consumer. In 2002 agriculture consumed approximately 13.4 petajoules (PJ) or 2.6% of national consumption[1] (13.6 PJ in 2004).

Obtaining national energy use figures for the different sectors within the agricultural industry is very difficult. The Ministry of Economic Development aggregates the agricultural figure and uses a method of "top-down" accounting, where it sources data directly from fuel and electricity supply companies.

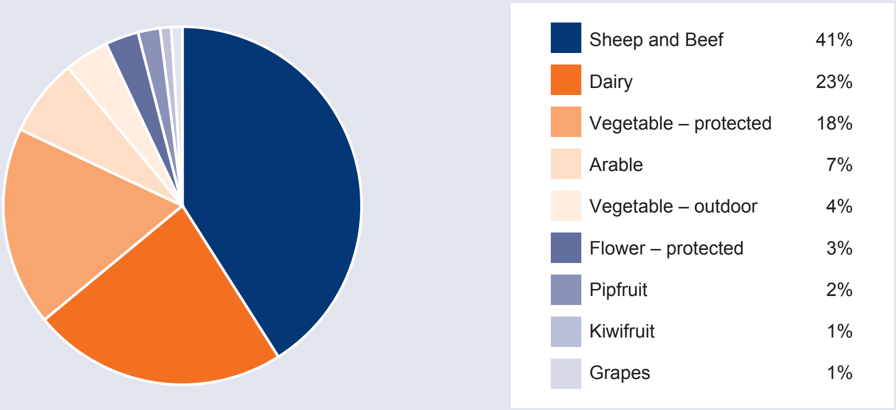
In order to construct a set of national agricultural energy use figures for each sector a method of "bottom-up" accounting was used to build a national energy use model. The results are presented in Table 1 and Figure 1. Energy use to the farm gate was calculated at 14.2 PJ. This is 0.8 PJ higher than that calculated by the Ministry of Economic Development; however their figure does not include an allowance for gas. Barber and Wharfe[2] found that gas contributed 50% of protected vegetable heating and 25% of protected flower heating, or approximately 1.4 PJ.

Sims et al.[3] in 2004 also calculated energy use for the different agricultural sectors, and while the total was similar (14 PJ) the distribution was quite different. The biggest difference was in sheep and beef, 5.9 PJ in this study versus 1.8 PJ in the Sims report. In this study the dairy sector is lower by 1.0 PJ and arable is 2.0 PJ lower. This does highlight the difficulty in bottom-up accounting where small assumption differences become significant when they are extrapolated onto a national scale.

**Table 1. National Agricultural Energy Use to the Farm Gate (PJ)**

| Sector | Energy use (PJ) | Sector's proportion |
|---|---|---|
| Sheep and Beef | 5.86 | 41.2% |
| Dairy | 3.30 | 23.2% |
| Vegetable – protected | 2.50 | 17.6% |
| Arable | 0.99 | 6.9% |
| Vegetable – outdoor | 0.56 | 3.9% |
| Flower – protected | 0.44 | 3.1% |
| Pipfruit | 0.24 | 1.7% |
| Kiwifruit | 0.18 | 1.2% |
| Grapes | 0.17 | 1.2% |
| **Total** | **14.23** | |

**Figure 1. National Agricultural Energy Use to the Farm Gate**



## 2.1 Sheep and Beef

The sheep and beef sector was calculated by splitting the sector into predominantly sheep farms and the more intensive beef and mixed sheep and beef farms.

In 2002 there were 3.7 million hectares of sheep farms carrying 40.2 million stock units, made up of 30.6 million sheep and 1.6 million cattle[4]. Energy use on these farms is estimated at 3.0 PJ, based on diesel use of 2 ℓ/SU and electricity at 1.3 kWh/SU[5].

In 2002 there were 2.1 million hectares of beef farms and mixed sheep and beef farms, carrying 20.7 million stock units[4]. The energy use on these more intensive operations was based on the energy intensity of nine conventional farms that contribute to the unpublished ARGOS (www.argos.org.nz) database. Total energy use was 2.8 PJ, based on 3.7 ℓ/SU and 2.0 kWh/SU.

## 2.2 Protected Crops

The protected vegetable industry covers approximately 225 ha, of which 181 ha is heated, and uses 2.5 PJ. The size of the flower industry is approximately 100 ha, 54 ha of which is heated and consumes 0.4 PJ[2].

## 2.3 Fruit

The three main fruit crops are grapes (17,300 ha), pipfruit (12,788 ha) and kiwifruit (11,964 ha). These three crops account for 72% of the area planted in fruit trees and vines[4].

Energy use in each of these sectors is described in Table 2[6].

**Table 2. Energy Use in the Fruit Sector**

| | Diesel – on orchard (ℓ/ha) | Irrigation (kWh/ha) | Area irrigated |
|---|---|---|---|
| Grapes | 365 | 1,453 | 33% |
| Pipfruit | 436 | 1,180 | 73% |
| Kiwifruit | 222 | 895 | 58% |

## 2.4 Arable and Outdoor Vegetables

The main energy uses in the arable and outdoor vegetable industry are irrigation, cultivation, transport between the paddock and a central packing shed, and grain drying. The report by Barber and Pellow[7] describes in detail the direct energy inputs into these two sectors. Table 3 shows the results in petajoules.

**Table 3. Energy Use in the Arable and Outdoor Vegetable Sector (PJ)**

| | Arable | Vegetable | Total |
|---|---|---|---|
| Irrigation | 0.393 | 0.204 | **0.597** |
| Cultivation | 0.463 | 0.288 | **0.751** |
| Transport (padd. to shed) | 0.023 | 0.066 | **0.089** |
| Grain drying | 0.108 | 0 | **0.108** |
| **Total** | **0.987** | **0.558** | **1.545** |

## 2.5 Postharvest

All the energy figures presented in this report are to the farm gate. However postharvest transport, grading and coolstorage can be significant energy users, particularly in the dairy industry. Some indicative figures are shown in Table 4.

**Table 4. Postharvest Energy Use (PJ)**

| | Transport to shed or factory | Grading and coolstorage |
|---|---|---|
| Dairy | 0.305 | a |
| Grapes | 0.006 | a |
| Pipfruit | 0.023 | a |
| Kiwifruit | 0.013 | 0.176 |
| **Total** | **0.347** | **0.176** |

"a" energy values have not been calculated in this study

All transport was based on a cartage rate of 0.069 ℓ/t-km[8]. Milk tankers travel 70 million kms per year[9] and transport 13.5 million tonnes of milk (13.9 million tonnes were produced but 0.4 million tonnes were used on farm)[10]. Based on the main season being 280 days the tankers travel 250,000 km per day to 13,500 farms or a round trip of 18 km per farm. Assuming a utilisation of 50%, fuel use is 8.6 million litres or 0.305 PJ.

The three fruit sectors were based on transporting their harvest an average of 15 km to the packhouse.

The kiwifruit grading and coolstorage, for up to 5 months, is based on 70 million trays at 0.697 kWh/tray[11]. There was insufficient information to estimate postharvest grading, manufacture, packaging and storage for the dairy, grape, and pipfruit sectors.

# 3.0 Energy Use in the New Zealand Dairy Industry

Like the other sectors described in Section 2.0, the Department of Statistics does not report national energy use specifically for the dairy sector. In order to calculate this figure a model was constructed using the "bottom-up" method and was based on MAF and Department of Statistics figures for production area, cow numbers[4], and a series of assumptions that are described below.

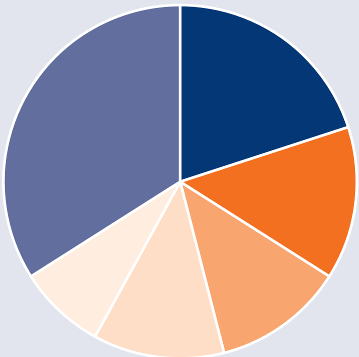
Direct energy use on a Waikato dairy farm is approximately 6.5% of cash farm expenditure, just over half of which (55%) is electricity. The MAF Policy dairy model for Waikato (2003/04) shows a 100 ha, 262 cow farm spending $7,394 and $5,932 on electricity and liquid fuels respectively. This makes energy a relatively low cost item in the overall farm budget, well behind feed, fertiliser and wages.

Energy costs, particularly electricity, are of greater concern to irrigated dairy farmers. The MAF Policy budget for a 192 ha Canterbury farm with 586 cows, shows an electricity cost of $36,000 and liquid fuels of $10,900, although energy is still just 8% of total cash farm expenditure.

In a study in 2001 Wells[12] found that electricity use, excluding irrigation, averaged 160 kWh/cow. This same figure was also determined in a 2004 survey conducted by Massey University[3]. On an irrigated dairy farm Wells[12] found that long line laterals consumed on average 870 kWh/ha, big guns averaged 2,070 kWh/ha, and travelling irrigators averaged 2,600 kWh/ha.

National energy use in the dairy sector is likely to be approximately 3.4 PJ (944 GWh), ranging between 2.9–3.7 PJ. This is based on 3.9 million cows consuming 160 kWh each (2.3 PJ) plus 161,500 irrigated hectares[13] requiring an average of 2,000 kWh/ha (1.2 PJ). Figure 2 show the energy use split between the dairy shed, based on the activity proportions shown in Section 4.0, and irrigation.

**Figure 2. Proportion of Energy Use in the Dairy Sector by Activities**



| | |
| --- | --- |
| Hot water heating | 20% |
| Milk chilling | 14% |
| Milking system | 12% |
| Water pump | 12% |
| Miscellaneous | 8% |
| Irrigation | 34% |

# 4.0 Energy Saving Measures

Results from this study have been collated into several tables which broadly fit the main energy uses. Each table includes a description of the energy measure, comments including advantages and disadvantages, factors to be aware of, companies, and costs. The list of companies has been developed from personal contacts and internet searches. Inclusion in this list is not to be taken as any form of recommendation or endorsement by AgriLINK NZ of the stated skills or experience, or of any product offered by those companies or organisations. Farmers must make their own assessments of companies and organisations, products and capabilities.

The EECA website 'find an expert' also offers a comprehensive list of companies.

In the dairy shed the main energy users are[1]:

| | |
|---|---|
| Hot water heating | 31% |
| Milk chilling | 21% |
| Milking system | 18% |
| Water pump | 18% |
| Miscellaneous | 12% |

In addition to the dairy shed there is also significant energy used by irrigation systems as well as fuel use by tractors and bikes.

While cultivation is conducted by some dairy farmers, fuel use has not been investigated in this report. This will be covered in detail in a later arable and vegetable industry energy efficiency report.

The use of biogas has not been investigated in this report, but as technology develops and improves it may offer opportunities in the future to turn a waste stream into gas and electricity. The Californian Energy Commission has funded some biogas projects www.energy.ca.gov/process/agriculture/ag_pubs/CEC-500-2003-900.pdf. In New Zealand information can be found on the Bioenergy Association website www.bioenergy.org.nz

Each dairy farm is unique and each business has its own set of criteria that needs to be met. Any energy saving measures that are instigated must not compromise milk quality, nor lead to milk grades, create adverse environmental effects and to be widely adopted they must improve the farmer's profitability.

# 4.1 Energy Efficiency Barriers

As energy may only represent 6–8% of the operating budget it is often given a low priority, particularly during times when returns are good. As the industry starts to see a levelling off in returns, combined with the ever increasing cost of energy, there will be more incentive to investigate energy efficiency measures.

Compounding the problem of energy efficiency having a low priority is the situation where there is little incentive for the farm owner to invest in new technology as the energy costs are paid for by the sharemilker. In 2004, 37% of farms had a sharemilker arrangement. This leads to the situation where there is no direct dollar payback from the farm owner's investment. However some owners view the payback in terms of being able to attract better sharemilkers if they can offer a shed that has lower operating costs. Nevertheless it remains a barrier to investment.

Work conducted by the Californian Energy Commission[14] showed that the largest barrier was simply having not investigated energy efficiency improvements. The next most common barrier was that improvements were not cost effective, followed by not being able to finance improvements.

# 4.2 Irrigation

### 4.2.1 Irrigation Management

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Knowledge | Irrigation Manual<br>Essential information for anyone irrigating | | i<br>ii | $125 |
| Monitor<br>water meters | An essential component of managing an irrigation system is accurately knowing and tracking how much water has been applied. | Most meters will have an accuracy of ± 2%.<br>Meters need to be installed in a straight length of pipe, 10 times the pipe diameter before and 5 times the pipe diameter after the meter. | iii<br>iv<br>v<br>xiii | $200 to $2,500 (8") |
| Monitor<br>rain gauges | Install rain gauges under the irrigator and one outside the irrigation area to monitor irrigation and rainfall. | Ensure the rain gauges under the irrigator are representative of what is being applied.<br>The gauges should have a cone shaped lid to prevent evaporative losses. | hardware stores | $40–$200 |
| Monitor<br>soil moisture<br><br>Own equipment | Maintain soil moisture between stress point and field capacity to ensure growth is not limited. A good strategy is to maintain soil moisture half way between the stress point and field capacity. The most efficient system is to irrigate when soil is 2–3% above the stress point and stop when soil is 2–3% below field capacity. This allows maximum utilisation of rainfall. No strategy can be implemented without monitoring.<br>Measuring soil moisture provides information on when to irrigate and how much water to apply. | Continuous readings (datalogging system) give the greatest level of accuracy. This should be combined with observing the effect of various irrigation/rainfall events on plant performance.<br>Datalogger systems can be linked to telemetry or automatic control systems. | | $260–$6,000 +<br>depending on accuracy and technology used |
| Monitor<br>soil moisture<br>Weekly service | Monitoring soil moisture levels and utilising the information to schedule the irrigator can provide significant savings. | Companies providing soil moisture monitoring services. | i | $30/wk/site |
| The feel method | A simple, inexpensive method to determine when to irrigate.<br>Very unreliable. | It is subjective and should involve a number of samples in a paddock to have confidence in findings. This system requires experience to understand findings. The results give no measure of the amount of water in the soil or the volume of irrigation required. Often soil moisture in the grass root zone is not measured. | Farmer | Free |

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Tensiometers<br><br>General information | An inexpensive soil moisture monitoring system.<br>They are not affected by osmotic potential of the soil solution (i.e. salt concentration) however plant roots can be affected[15].<br>The tube requires refilling after a dry period.<br>Can take 24 hours for an irrigation to soak soil to the deep of the ceramic tip. As a general rule a 1 mm application will decrease the tensiometer reading by 1 centibar[16].<br>Avoid repeatedly standing close to the tensiometer to prevent soil compaction.<br>Measures soil water tension through vacuum pressure on the tip. As the soil around the tip dries, water moves out of the tip until the equilibrium is re-established between the tip and the soil. Thus a vacuum is created equivalent to the soil water potential. The soil water potential relates directly to the amount of energy the root uses to remove water from the soil, hence is a measure of plant stress rather than soil water content[17]. | If the tip is in an area of limited root activity or loses contact with the soil you can get unrepresentative readings of grass soil moisture status[15].<br>Can only measure soil moisture in the immediate area of the tensiometer tip.<br>Tend to be installed in permanent positions.<br>Install midway between the irrigator and the limit of its throw, avoiding wet or dry spots. A shallow and deep tensiometer should be installed. The shallow tensiometer indicates when to start irrigating and the deep when to stop to avoid deep percolation losses[18].<br>Advisable to install a number of tensiometers across the farm to account for topography, soil type and climatic differences.<br>If irrigation cycle takes more than 3 days it is recommended that there are tensiometers installed at both early and late cycle periods as application rate may need adjustment[16].<br>Mark tensiometer sites clearly so can find them. | | |
| Irrometer tensiometer | There are different tip types according to soil type.<br>Can be equipped with a pressure transducer for data logging. | Available in probe lengths of 150–1200 mm. | x<br>xi<br>xii | $260–$900 |
| Soil spec tensiometer | Tubes with a rubber cap are installed at desired monitoring sites. A portable electronic monitor is used to take tensiometer readings.<br>Convenient for properties with a large number of monitoring sites.<br>Must allow time for re-equilibration after installing needle at each site[16]. | To maintain same size air bubble for each reading usually will need to read tube and top up with water daily[16]. | xi<br>xii<br>xiii | $1,350 |

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Capacitance sensor | These sensors use electrical capacitance to measure soil moisture. Originally they were connected to a data logger for continuous monitoring but now are also available in a portable version.<br>EnviroSCAN and Diviner are two products. | It is imperative that any soil moisture monitoring equipment is placed in a representative part of the paddock and that the installation does not disturb the surrounding soil as that will change the water holding characteristics of the soil being monitored. | vi<br>xiv | $4,500 + |
| Time domain transmission | The Aquaflex product uses this principle.<br>Measures the dielectric constant of soil to find its volumetric water content. The sensors measure the signal oscillation frequency, which is related to the soil dielectric constant. The signal gives a good indication of the soil moisture status [17]. Temperature is also measured. It can be linked to a datalogger, (with or without telemetry options) or spot read using a lap or palmtop.<br>Sensors measure soil moisture over a 3 m length and cylindrical 6 litre volume of soil. As soil moisture is not uniform this method gives spatial averaging to readings increasing the accuracy. | Sensor cable can be expected to last approx 10 years.<br>Sensor tape is laid in the paddock and a long data cable connected between the tape and battery box. This allows the tape to be laid in the paddock (giving representative readings of the grass) and the battery box attached to a fence post for protection.<br>To minimise pugging damage over the top sensor it can be laid at 100 mm depth.<br>Like all monitoring systems installation is critical and soil is re-laid over cable as close to the original configuration as possible. | ix<br>x<br>xi<br>xii | $1,350 + |

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Avoid irrigating in windy conditions | This is not always possible if the system does not have extra capacity. Not irrigating in windy conditions may lead to reduced grass growth. Also windy periods can last for days.<br>Windy conditions require greater application rates. | Operating at lower pressure can increase droplet size and reduce losses, but need to monitor application rates to avoid run-off.<br>Using drop tubes on centre-pivots and travelling irrigators places the water closer to plants and reduces distortion and losses.<br>Growing shelterbelts can reduce wind influence but they must be designed to filter the wind, not block it or get turbulence and damage. Shelterbelts have to be sighted so as not to interfere with the irrigator's path of application. They can harbour insects and reduce the productive pasture area. They provide shelter and shade to cows.<br>In windy conditions lane spacing is reduced and application rates can be decreased to improve distribution. Evaporation rates will be higher. Systems discharging water close to the ground are less affected by wind, e.g. centre-pivots or booms with drop tubes, long laterals, k-lines or micro-sprinklers. | Farmer | Zero |
| Irrigation when required on a little and often basis | This may mean running the irrigator at higher speeds and two shifts per day (consideration of time component, labour availability is necessary) or running two irrigators covering half the area each, so applying half the water volume each[19], or changing nozzle sizes. | Light soil types require low application depths; some sprinkler irrigators cannot achieve this.<br>Short cycle systems need to be incorporated into the system design. | Farmer | Zero |
| Irrigating at night if possible | Advantage of reduced evaporation losses and possibly night-rate electricity tariffs. | Most systems cannot supply sufficient water to operate only at night.<br>May be possible in wet seasons and during shoulder seasons to utilise night application for maximum advantage. | Farmer | Zero |

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Reduce peak load | Turning the irrigator off during milking to reduce peak load tariff charges can reduce line charges. To do this a time of use meter is needed. | Additional labour may be required.<br>Will waste some water as the pressure in the line falls and builds up again.<br>Starting the pump and motors puts load on them even with soft starts and VSDs adding extra wear and tear.<br>The majority of irrigation systems are designed to operate for 20–22 hours per day. Stopping for milking will upset the irrigation application pattern and may reduce grass growth. | Farmer | Zero |

**Limitations to uptake, key factors that could improve energy efficiency, and areas requiring further study or development:**

1. Monitor soil moisture levels, starting irrigation early in the season, maintaining high soil moisture levels but avoiding percolation drainage and utilising rainfall where possible. Monitoring soil moisture levels is essential to provide direct quantitative information on how much water to apply and when to apply it.

**Sources of information and manufacturers:**

| Company reference | Manufacturer/ service company | Phone number | Website | Location |
|---|---|---|---|---|
| i | Hydro-Services Ltd | 03 341 0970 | hydro@caverock.net.nz | National |
| ii | Environment Canterbury | 0800 324 636 | www.ecan.govt.nz | Canterbury |
| iii | Netafim NZ (water meters) | 09 256 2551 | www.netafim.com | National |
| iv | Deeco Services Ltd | 0800 433 326 | www.deeco.co.nz | National |
| v | Prosol (water meters) | 09 414 1028 | www.prosol.co.nz | National |
| vi | AgriLINK New Zealand Ltd | 09 237 1273 | www.agrilink.co.nz | Franklin/ Auckland |
| vii | T-L Pivot and Linear NZ Ltd | 0800 8569 587 | | Canterbury |
| viii | Rainer Irrigation Ltd | 03 308 1593 | | Canterbury |
| ix | Scott Technical Instruments | 03 374 2101 | www.scottech.net | National |
| x | Water Control Solutions | 03 349 2605 | www.wcsolutions.co.nz | National |
| xi | Pyne Gould Guinness Irrigation & Pumping Ltd | 0800 TO IRRIGATE | www.pgg.co.nz | National |
| xii | Water Dynamics Ltd | 0508 477 422 | www.waterdynamics.co.nz | National |
| xiii | Fruitfed Supplies Ltd | 09 571 5913 | www.fruitfed.co.nz | National |

#### 4.2.2 Irrigation System

For optimum irrigation efficiency the system needs to be designed to match the maximum evaporative demand of the grass or crop and allow variation in the depth of water applied.

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Improve irrigation uniformity | Improving irrigation uniformity reduces the mean application depth applied to ensure an area is fully irrigated. For example improving distribution uniformity from 70% to 90% will reduce water and energy use by 30%, or alternatively allow 30% more area to be irrigated[20]. | Choose the most appropriate system at the design phase, as changing systems once installed is not usually economic.<br>Soils vary across paddocks so a compromise is usually required. It may be possible to irrigate different soil types separately but often this is impractical.<br>Auditing systems can show inefficiencies in the design and/or operation of the system. Irrigators can audit their own system or contract the services of company specialists. | i<br>ii<br>iii<br>iv | audit $1,000+ |
| System maintenance | Pre-season maintenance including replacing worn sprinklers and nozzles, and removing blockages in pipes and emitters allows system to run more efficiently during the season.<br>Check well performance by measuring static water level and specific capacity (pumping rate/drawdown) and compare the results with previous measurements such as at drilling[18].<br>During the season monitoring pumps, cleaning blocked emitters and detecting leaks improves efficiency. | Maintenance pre-season reduces risk of having non-operational periods during critical irrigation application times which could lead to low soil moisture levels and reduced grass growth. | Farmer | Low–medium |
| Variable speed drives | Reduces wear and tear on pump and motors by evening out the load.<br>Particularly useful where changes in elevation affects hydrant pressure. Avoids the need to use energy dissipating devices like pressure reducing valves. | May be able to reduce motor size and lower capital investment. | v | Medium–high<br><br>15 kW unit $8,000–$10,000<br><br>Soft start controller $2,000–$3,000 |

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Use energy efficient pumps and motors | Highest pump efficiency occurs when operating at the highest efficiency flow and selecting the pump brand and model matching irrigation requirements. | Differences in efficiencies between brands can be small. | | |
| Use appropriately sized pumps, pipes and irrigators | Match irrigator number and size to pump capacity. | May require additional labour and capital inputs to maximise system capacity if extra irrigators are required. | | |
| System design | Minimise head loss in rising columns, and mainlines by appropriate sizing.<br>Tight bends and sharp corners restrict flow resulting in higher pressure losses[21].<br>Over-sized pumps results in excessive pressure within the irrigation system pipes which can require the gate valves to be partially closed. This means high electricity usage for the volume of water pumped. | Correct pipe diameter sizing of rising column and headworks reduces friction loss and pressure loss so smaller motors can be used and less electricity.<br>Replacing rising columns will only occur if they are damaged, corroded or pressure loss is excessive – a high investment option.<br>Headwork and mainline replacement is generally uneconomic until redesigning the system. | | |
| Use efficient irrigators | Centre-pivot, linear move types and fixed-boom linear type irrigators are the most efficient, followed by rotorainers and solid set irrigators, then travelling guns, followed by side-rolls and K-lines. | | | |
| Centre-pivot | High initial cost, but short return interval (1–3 days).<br>Energy requirement can be high.<br>Uniformity of application better than most other systems.<br>Can operate at 90% efficiency if less than 500 m long[22]. | Fitting low pressure spray nozzles can save energy but may require higher application rates to be used leading to lower application efficiency and longer operating times, so may not save significant amounts of energy[18].<br>Used with accurate soil moisture measuring systems they can achieve very efficient irrigation applications. Accurate soil moisture measuring can give confidence to turn irrigators off without sacrificing grass growth rates. | i<br>ii<br>vi<br>vii<br>viii<br>ix | |

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Rotorainer, linear and rotary booms | Lower capital cost than centre-pivot.<br>Return interval can be 7–15 days. Application rates can be low thereby avoiding ponding.<br>Can operate at 75% efficiency[22]. | Strong wind causes rotation and travel speed to slow therefore application rates increase. In calm conditions uniformity is generally good if the boom is operated at the correct pressure and correct sized nozzles are used.<br>Linear booms suit rectangular shaped paddocks. | i<br>ii<br>vi<br>vii<br>viii<br>ix | |
| Self-propelled gun sprinkler hard and soft hose | Subject to interference by wind. Operating at closer lane spacings, using low angle guns and operating at the correct gun pressure can reduce the impact of wind interference.<br>Circular application pattern.<br>Larger diameter hose, shorter hose, larger hydrants and fittings reduce pressure losses. | Irrigator may not have power to pull larger diameter hoses.<br>Changing pipe diameters is a medium to high investment. | i<br>ii<br>viii<br>ix | |
| Siderolls and hand-shift-pipes | Are moved manually down the paddock.<br>Application rates are low. Provided the same nozzles are used and they are not worn, they can achieve uniform distribution. | Low capital investment.<br>Laterals need to be shifted at the recommended spacing. | ii<br>vii<br>viii<br>ix | |
| K-line | Lowest capital investment.<br>Requires manual moving down the paddock.<br>Application rates are very low seldom leading to surface ponding. Systems are often designed to operate 24 hours a day and tend to have long rotation times.<br>Efficiency often as low as 40%[27]. | Very difficult to achieve uniform application. | ii<br>vii | |

**Sources of information and manufacturers:**

| Company reference | Manufacturer/ service company | Phone number | Website | Location |
|---|---|---|---|---|
| i | Pyne Gould Guinness Irrigation and Pumping Ltd | 0800 TO IRRIGATE | www.pgg.co.nz | National |
| ii | Water Dynamics Ltd | 021 879 957 | www.waterdynamics.co.nz | National |
| iii | AgriLINK New Zealand Ltd | 09 237 1273 | www.agrilink.co.nz | National |
| iv | Page Bloomer Associates Ltd | 021 356 801 | www.pagebloomer.co.nz | National |
| v | Danfoss – (Varivac) | 0800 326 3677 or 09 259 2519 | www.danfoss.co.nz | National |
| vi | T-L Pivot and Linear NZ Ltd | 0800 8569 587 | | Canterbury |
| vii | Rainer Irrigation Ltd | 03 308 1593 | www.briggs.co.nz | Canterbury |
| viii | Plains Irrigators Ltd | 03 307 2027 | www.plainsirrigators.co.nz | Canterbury |
| ix | Bosch Irrigation Ltd | 0800 500 424 | | Canterbury |

# 4.3 Dairy Shed

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Dairy shed energy efficiency audit | An audit investigates all energy uses in the dairy shed and provides a report detailing where the energy is being used, what savings can be made, the unit cost of these measures and the payback period. | Although it is very site dependent the cost of an audit can be significantly less than the cost of implementing a wrong decision. | i | |

### 4.3.1 Hot Water Heating

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Insulating hot water cylinders and pipes | Could save 400–1,200 kWh/year[5].<br>Savings of up to $150, and a less than 1-year payback.<br>Could save up to 50% of energy consumed by the hot water cylinder.<br>Can be retrofitted to older cylinders.<br>DTS is trialling insulating A-grade cylinders to determine if there is an economic gain in doing so. | New A-grade hot water cylinders are well insulated, but pipes can be insulated.<br>Prosol cylinder wrap is made to measure, plus they manufacture pipe insulation. | ii<br>iii<br>iv<br>v | Low–medium<br>$90–$120 |

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Location of cylinder | Sited away from prevailing winds and on sunny side of the shed. | | | |
| Using a 24-hour timer to heat water only when required<br><br>Use of night rates | Control when water is heated.<br>Could utilise night rate electricity.<br>May be better suited where there are two hot water cylinders, with only one on a timer.<br>Changing to night rates gave a 45% saving ($651)[5].<br>Installing 24-hour timer and heating from 1–8am reduced electricity cost by 42% on one farm[5]. | How will calf feeders be washed?<br>If there are grade issues (or potential grade issues) how will you have hot water for washing after night milking?<br>When and how will the vat be cleaned especially if pickup is in the afternoon?<br>Possibly more suited to once-a-day milking. | Most electricians | Low<br><br>Payback on timer < 6 months<br><br>Changing to a split tariff meter cost $85/meter |
| Correct thermostat temperature | Overheating water is wasteful.<br>A plant with 24 clusters and a 9,100 litre vat would save in a season 221 kWh per degree or $31. | Fonterra requires an 85°C hot water temperature for sanitation of the milk plant. | Farmer | Zero |
| Detect and repair leaks | Repairing dripping taps could save up to 500 kWh/year[5] ($70). | | Farmer | Low |
| Correctly sized cylinders | Over-sized cylinders result in heating water that will not be used. | Cylinder sizing changes are likely to occur only when upgraded. | | |
| Heat recovery to preheat water | Mahana Blue system can reduce hot water costs by 50–60%[23]. Can be retrofitted.<br>DTS heat recovery system can save 50% of hot water heating costs. Can be retrofitted.<br>A 10°C increase in inlet water temperature could save 2,210 kWh or $280/yr (24 cluster 9,100 litre vat). | | ii<br>vi | $1,500–$8,000 depending on complexity/size<br><br>Mahana Blue $8,000 2–3 year payback<br><br>Heat exchanger approx. $1,150 |
| Heat recovery to preheat water | Heat exchanger to raise water temperature from 11 to 40°C. Claim a 25% saving. | Shown in the innovation centre at the 2004 Fieldays. | vii | 250 litre system costs $1,200 |

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Solar energy | Long-term payback.<br>Most likely to require additional heating source to ensure hot water meets Fonterra criteria for washing (85°C).<br>Heating costs are approximately 7–9 c/kWh. | Hot water generally required after morning milking – solar heating occurs during the day so can lose heat overnight requiring booster electrical heating.<br>Affected by cloud cover. | viii<br>ix<br>x<br>xi | New 600 litre cylinder $9,100<br>Retrofit $5,900<br>Payback 3–7 years |
| Use less hot water | Hot water wash once a day.<br>Twice-a-day milking may be able to remove a hot water wash in the afternoon provided that milk quality is not compromised. Refer to detergent and milking machine manufacturer's recommendations. | Hot water not only required for vat and plant washing, but also washing calf feeders and hand washing. | Farmer | Zero |
| Use less hot water | Deosan Supernova detergent enables less hot water to be used as part of the plant wash programme. Trials show a 25% reduction in hot water is possible[24]. A 24 cluster plant could save $320/yr. As part of the Deosan AgriQuality approval, clients are required to take part in a Quality Management System specifically designed to ensure milk quality is maintained at a high level. | Milk quality must not be compromised when reducing hot water washes. Special care is needed if there are cows on antibiotics (milked after the main herd). In this situation a normal hot wash programme is advisable to ensure there is no contamination of collected milk.<br>Sufficient hot water is required to sanitise the plant and vats. Compromises are not acceptable as milk is a food item. To reduce hot water use, an increase in one of the four washing components is required otherwise sanitation is likely to be compromised resulting in grades. The four components of washing are concentration of detergent, temperature of fluid, turbulence of fluid through the system and length of washing time. | xii | None–Low<br>200 litres $995 |

**Sources of information and manufacturers:**

| Company reference | Manufacturer/ service company | Phone number | Website | Location |
|---|---|---|---|---|
| i | Rural Energy | 04 472 1944 | www.ruralenergy.co.nz | |
| ii | Dairy Technology Services (DTS) | 0800 500 387 | www.dts.co.nz | National |
| iii | Prosol | 09 414 1028 | www.prosol.co.nz | National |
| iv | The Warehouse (EcoWrap), most hardware stores, Placemakers, Mitre 10, etc | | www.thewarehouse.co.nz www.placemakers.co.nz | National |
| v | Julian's Electrical and Energy Conservation Ltd | 0800 10 24 64 | www.julians.co.nz | National |
| vi | Danfoss – (Mahana Blue ) | 0800 326 3677 or 09 259 2510 | www.danfoss.co.nz | National |
| vii | Dairy Innovations Ltd (Charlie Morrison) | 07 853 2872 | brucmak@ihug.co.nz | |
| viii | Solar Industries Association | 04 385 3359 | www.solarindustries.org.nz | National |
| ix | Solar Energy Solutions | 0800 300 321 | www.sureflow.co.nz | National |
| x | Sunz Solar Energy Specialists | 0800 4 Solar | www.sunz.co.nz | National |
| xi | Sola 60 NZ Ltd | 0800 100 849 | www.sola60.com | National |
| xii | Deosan | 0800 22 55 33 | www.deosan.co.nz | National |

### 4.3.2 Refrigeration

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Maintenance and detect leaks | Clean and repair fins for efficient operation. Dirty ventilation fans and air ducts can increase running costs by up to 60%[25]. | | Farmer | Low |
| Insulating vat and pipes | Could save 300–700 kWh/year[5]. Energy savings are likely to be greater for vats standing outside than those inside. Energy saving in three case studies for insulating vats was 20–30%[5]. | DTS's Thermo Wrap is glued and strapped on so can't be re-used. DTS's Polar Wrap is strapped on so can be re-used and also has a PVC cover so will last longer. | i ii iii | Polar Wrap $2,017 (7,800 litre vat) Thermo Wrap $569 for the kit or $1,044 fitted |
| Spherical milk vats | Improved cooling due to insulation and vat design. | Some trials have shown that these vats are very efficient at cooling milk down from 18°C to 10°C but they are less efficient than the normal NDA vat at lower temperatures. | iv | |

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Ice banks | Off-peak electricity can be used to cool the water or create ice for chilling. | While the technology has been around for a long time, it has been uneconomic. Different techniques are being trialled.<br>Water quality is important. | v | High<br>$15,000–$17,000<br>(currently not commercialised) |
| Plate coolers to pre-cool milk before entering vat | Commonly used system.<br>2.5:1 ratio should cool milk to within 2°C of water source temperature[5]. | Design of water/milk flow ratio critical for efficient usage.<br>Coolers must be kept clean to prevent milk contamination and to provide efficient cooling. | vi<br>vii | |
| Ventilation of system | Refrigeration costs can be lowered if system is well ventilated.<br>Locating refrigeration unit on the south side and in a shady location reduces cooling costs. | Warm milk rooms should be well ventilated to minimise warming of milk in the vat. | Farmer | Low |

**Sources of information and manufacturers:**

| Company reference | Manufacturer/ service company | Phone number | Website | Location |
|---|---|---|---|---|
| i | Dairy Technology Services (Polar and Thermo Wrap) | 0800 500 387 | www.dts.co.nz | National |
| ii | Julian’s Electrical and Energy Conservation Ltd | 0800 10 24 64 | www.julians.co.nz | National |
| iii | Prosol | 09 414 1028 | www.prosol.co.nz | National |
| iv | Robert Stone Stainless Ltd | 06 278 0016 | | National |
| v | Thermocell | 03 982 5000 | www.thermocell.co.nz | National |
| vi | Alfa Laval Ltd | 07 849 6025 | www.alfalaval.com | National |
| vii | Waikato Milking Systems | 0508 645 5464 | www.waikatomilking.co.nz | National |

### 4.3.3 Pumps – Includes Vacuum, Milk, and Water Pumps

| Measures for energy savings | Comments, advantages and disadvantages | Factors to be aware of | Companies | Investment |
|---|---|---|---|---|
| Regularly maintain pumps<br>Correct drive belt tension | Loose belts can reduce efficiency by 20%[5].<br>Vacuum system should be tuned twice a season. | | Farmer and most electricians | Low |
| Variable Speed Drives (VSD) | Allows vacuum pump to be matched to actual airflow requirements. Most of the time the pump will run at reduced speeds, speeding up when cups fall off a cow and can be run at high speed during washing.<br>System must allow for adjustment of vacuum during the season and during milking, e.g. higher for herd testing, lower for heifers in spring, higher for washing.<br>Soft start reduces pump wear and reduces shock loading on start up.<br>VARIVAC claims to hold a more stable vacuum than air regulators. This significantly reduces vacuum overshoot and has no air regulator to clean.<br>Savings of 40–80% of electricity consumed by vacuum pumps[25, 26].<br>Improved milk cooling efficiency, reduces milk frothing. | May be able to reduce motor size and lower capital investment.<br>Less noise and vibration results in happier cows, less cup kicking, faster milking, less effluent to remove (reduced pumping and water usage) and reduced somatic cell counts (therefore reduced penicillin usage).<br>C.S.L. VARIVAC can be retrofitted. Some types not so suitable for retrofitting. | i<br>ii<br>iii | Medium–High<br>15 kW unit $8,000–$10,000<br>Soft start controller $2,000–$3,000 |
| Gravity feed and water ram pump | | Generally more suited to sheep and beef farms due to terrain and lower flow requirements. | iv | $900–$1,750 |

**Sources of information and manufacturers:**

| Company reference | Manufacturer/ service company | Phone number | Website | Location |
|---|---|---|---|---|
| i | Corkill Systems Ltd – (Varivac) | 0800 10 7006 | www.corkillsystems.co.nz | National |
| ii | Danfoss – (Varivac) | 0800 326 3677 or 09 259 2519 | www.danfoss.co.nz | National |
| iii | Waikato Milking Systems – (Smart Air VSD) | 0508 645 5464 | www.waikatomilking.co.nz | National |
| iv | Tom Harrison & Sons Ltd (water ram pump) | 09 407 9915 | harrisons@actrix.co.nz | National |

Maintaining the water system and fixing leaks will save energy. Flow meters can be fitted into individual branch waterlines and fixed to fence posts to track water use and indicate leaks.

Improve the power factor. This can reduce costs, improve electricity capacity by decreasing current flow and reduce voltage drops. Excessive voltage drops cause overheating and premature failure of motors and inductive equipment. Minimise motor idling and lightly loaded motors, avoid operating motors above rated voltage, use energy efficient motors and operate at near rated capacity to realise benefits of a high power factor design. Install capacitors in AC circuit to decrease magnitude of reactive power[27].

Minimise phase unbalance in three phase systems – phase balance should be within 1% to avoid derating the motor. Voltage balance can be affected by single-phase loads on any one phase, different cable sizing, faulty circuits which lead to distribution system losses and reduce motor efficiency.

Use efficient power transformers of the correct size.

Check regularly for bad connections, poor grounding, shorts to the ground – sources of energy loss, hazardous, reduce system reliability. Keep motors cool and adequately vented. Regularly maintain motors.

Match motor to operating speed requirements. Increasing operating speed by 2% can increase power required by 8%[28].

## 4.4 Other Measures

1. Turning off machines when not in use.
2. Computer screen savers still draw power, turn off if not in use.
3. Turning off lights, radios etc when not in use.
4. Using energy efficient light bulbs, fluorescent instead of incandescent lights, a typical payback is 4 months. Good quality compact fluorescent lamps have similar brightness and colour rendition to standard incandescent bulbs.
5. Using natural light where possible (clear Perspex corrugated sheets).
6. Utilising gravity wherever possible rather than installing pumps.
7. Building yards on a slope so backing gates move by gravity rather than by electric motor drive.
8. Reducing cow discomfort in/around milking shed to reduce effluent discharge in milking shed and consequential removal cost – including reducing stray voltage, calm cows.
9. Burying coldwater pipes from pump to refrigeration unit keeps water cooler especially in summer.
10. Location of hot water cylinder and vat.
11. Installing small hydro schemes on streams – requires sufficient fall in the stream and reasonably close to power use item. Can be cost effective where mains electricity is not available or access costs are high – e.g. remote parts of farm[29].
12. Reducing milking time would decrease energy consumption, such as improving cow flow onto the milking platform and removing any factors discouraging cows entering stalls.

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