

Energy Efficiency in Dairy Sheds

A Preliminary Report

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28 November 2006

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1 INTRODUCTION

This report is part of a study by Venture Southland into the economics of dairy shed operations and how they can be improved. Venture Southland is a joint initiative of the Invercargill City Council, Southland District Council and Gore District Council and delivers Enterprise, Tourism, Promotion, Events and Community Development services to the region. In November 2003, Venture Southland completed an assessment of Southland's energy situation. One recommendation in the resulting report was for further investigations into the energy efficiency of dairy sheds.

DairyInSight and the Sustainable Farming Fund are the major funders of the project which began in September 2005. The objectives of the project are to identify potentially cost-effective measures that will improve dairy shed efficiency, try these out on a number of Southland dairy farms and provide an independent and un-biased report on the results.

The Centre for Advanced Engineering (CAE) is undertaking the research work. CAE is a not-for-profit organisation based in Christchurch and plays a strong integrating role within New Zealand's engineering and technology sectors, undertaking major projects that seek to build technological capabilities in areas of national importance.

The members of the CAE project team responsible for this report are:

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Mr Gregory has worked as a mechanical project engineer in engineering consultancies and in the cement industry and has a strong interest in energy management.

This report was written in September 2006 to record some of the observations made so far in

this project. It describes the way energy is used in the milking shed of a typical Southland dairy farm and outlines the main opportunities for reducing energy costs. It is intended as an introduction to energy use in the milking shed for general readership and not as an exhaustive technical reference.

This is a preliminary report based on limited information and analysis. More detailed reports will be prepared as the project progresses.

The information in this report is based on preliminary analysis of data collected from two Southland farms - Graejo Trust located near Thornbury and Coldstream Downs located in the Waimea Valley. Further information on these farms can be found by following the links on www.cowshed.org.nz.

The report also takes into account information provided by suppliers of equipment that can improve the energy efficiency of the dairy shed.

Dairy shed energy usage is affected by management practices and other factors and will vary from farm to farm. This report is based on Southland farms and assumes that the following management practices are typical of most farms

- cows are milked twice a day
- the milking season is 270 days long
- the milking lines are washed after each milking but hot water is used only once per day
- the milk is collected daily and the milk vat washed with hot water prior to the start of the next milking following collection
- the water heaters are re-filled with cold water immediately after use and the heating elements switched on.

When considering energy-saving options that require plant alterations or investment in new plant, ownership of equipment is an important factor. For this report, it is assumed that all the dairy shed equipment is owned by the farm owner with the exception of the milk storage vats which are owned by Fonterra.

2 THE MILKING SHED

This report focuses mainly on dairy farms of medium to large size (herds of 300 to 1000 cows). On these farms, two designs of milking shed are common – the herringbone shed and the rotary platform shed. The main difference in the operation of these two designs is the way in which the cows are moved to and away from the milking machine with the rotary design being better suited to large herds. The milking equipment used is very similar in both and the following description is applicable to both designs.

2.1 Milking

Milk is extracted from the cow's udder using pulsating cups that simulate the action of a suckling calf. At the peak of the season, a cow produces about 10 litres of milk at each milking. The milking time for each cow is about 7 to 10 minutes.

Power for the pulsation is provided by the vacuum pump which also 'sucks' the milk into a central collecting vessel known as the 'milk can'. From the can, the milk is pumped to the milk storage vat via filters and the plate cooler.

The vacuum pump is normally driven by an electric motor and is one of the most important pieces of equipment in the milking shed. Some sheds use two pumps operating in tandem.

It is normal for the vacuum pump to operate at a pressure of -45 kPa gauge i.e. a 'vacuum' of 45 kPa. An air bleed valve is commonly used

to regulate this pressure by automatically admitting extra air into the vacuum line when required.

The air pumped by the vacuum pump is discharged to the atmosphere. This exhaust air is warm and moist. Waste sealing water (from liquid ring pumps) is usually discharged to waste.

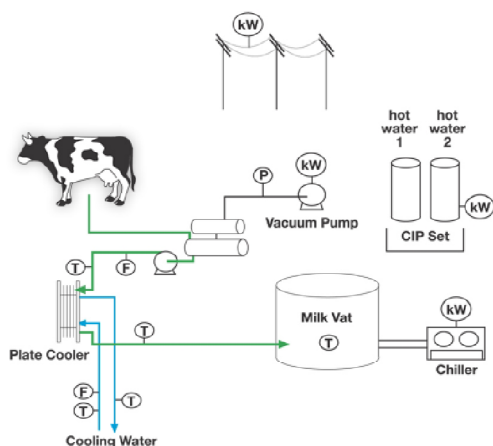
2.2 Milk cooling and storage

The plate cooler is a heat exchanger that uses water to cool the milk. The water is continuously pumped through the cooler during the milking period and discharged into a storage tank for later use. It is normal for the milk to be cooled from about 34°C to about 20°C in this way.

On the two large farms we have data for, the cooling water flow is in the range 1.3 to 3.3 litres/s. The milk flow is intermittent but when the pump is running, the flow rates are in the range 1.8 to 2.8 litres/s.

The remainder of the chilling takes place in the milk storage vat. The vat is fabricated from stainless steel and has capacity for at least one full day's milk production. The size of the vat is determined by the size of the herd but typical sizes for large farms are 15,000 to 20,000 litres. The milk is collected from the vat by a tanker truck which usually calls once a day during the main part of the season. When there is sufficient storage capacity, milk may be collected every second day. Normally, the milk vats are owned by the milk processing company.

The vat is fitted with cooling pads or coils that carry refrigerant liquid supplied by an electrically driven refrigeration unit. Electric motor



driven stirrers in the vat keep the milk at a uniform temperature as it is cooled.

The refrigeration unit (condensing unit) is usually a package comprising a hermetically sealed compressor, air cooled condenser and all ancillary equipment.

2.3 Cleaning

Following milking, the milking lines are rinsed with cold water and then cleaned by pumping a solution of hot (80 °C) water and detergent through them. A typical cleaning regime for the milking lines is shown in Table 1.

While most farms use hot water for the morning lines wash and cold in the afternoon, some wash with hot water twice a day.

Milk vats are cleaned after the milk has been picked up and before the vat is re-filled. For most farms, this is a daily process. The cleaning regime is similar to that outlined for

the morning cleaning of the milk lines. Typically, 500 litres of hot water are used each day for vat cleaning.

The water for cleaning is normally heated in an insulated, stainless steel or copper cylinder which is similar to (but larger than) a domestic water heater. A typical dairy shed has two water cylinders of 500 litres capacity and each is usually fitted with two or three 3 kW heating elements.

The used cleaning water is discharged to waste.

2.4 Effluent disposal

At the completion of milking, the shed and yards are hosed clean and the effluent from this operation is collected in a pit adjacent to the dairy shed. Normal practice is to pump this effluent to a spray irrigator positioned in a nearby field.

After morning milking	After afternoon milking
hot wash with acid detergent on five days per week	cold wash with acid detergent every day
hot wash with alkali detergent followed by a cold wash with acid detergent on the other two days	

Table 1: A typical cleaning regime for the milking lines

3 ENERGY USE IN THE DAIRY SHED

The main uses for energy in the milking shed of a typical dairy farm in Southland, New Zealand are :

- pumping water, milk and effluent
- generating the vacuum needed to extract the milk
- chilling the milk
- heating water.

The usual source of energy for the dairy sheds is electricity and a typical farm uses about 100,000 kWh per year. Electricity costs vary a little depending on the purchasing arrangements but are in the range 12 c/kWh to 16 c/kWh after discounts and excluding GST. The annual cost for a typical farm is therefore about \$12,000 - \$16,000.

Most Southland farms do not pump water to irrigate their pasture land. In areas such as Canterbury where spray irrigation of dairy farm pasture is common, total electricity costs will be much greater than in Southland. The energy efficiency of spray irrigation is not included in the scope of this project.

3.1 Pumping

Pumps are used to :

- transport bore water to the storage tanks
- transfer water from the tanks to the farm houses and stock troughs
- transfer milk to the storage vat
- supply washdown hoses
- circulate cleaning water through the milking lines and storage vats
- pump away effluent.

For these there are no realistic energy options apart from electricity.

3.2 Vacuum

A typical vacuum pump is of the liquid ring type (see photo) and driven by a 10 to 15 kW motor. The pump is used during milking and the following cleaning and typically runs for

about 6 to 8 hours per day.

A vacuum pump drawing 10 kW and running for 1600 hours per year uses 16,000 kWh – about 16% of the total shed usage. At 14 c/kWh, the annual cost is \$2,200.



3.3 Water heating

Hot water is required for cleaning the milking lines and the milk storage vat(s). A typical cleaning regime uses 1000 litres of hot water each day – 500 litres to wash the milk vat and 500 litres to wash the milk lines.



Cleaning procedures can vary from farm to farm. If hot washes are used after every milking, hot water consumption will increase to 1500 litres per day.

To heat 1000 litres of water from 20°C to 85°C each day for a season of 270 days theoretically requires 20,000 kWh but heat losses from storage cylinders and pipework might increase this to 25,000 kWh – about 25% of the total annual energy usage. If all of this energy is from electricity purchased at 'anytime' rates (say 14c/kWh), water heating will cost about \$3,500 per year.

There are a number of other ways of heating water at lower cost and these will be looked at in depth as part of this project.

3.4 Milk chilling

Milk needs to be chilled to less than 7°C within three hours of the completion of milking and there are suggestions that this temperature



may be reduced to 4°C in the future to meet the requirements of major export markets.

Nearly always the first part of the chilling (from 34°C to 20°C) is carried out in a plate heat exchanger using the farm water supply. As this water has to be pumped anyway, the extra electrical energy used for this pre-cooling step is minimal.

The balance of the chilling is traditionally done

in the milk storage vat using a direct expansion refrigeration unit with air cooled condenser. A typical dairy shed uses about 20% of its electricity (20,000 kWh) to run the refrigeration unit and at 14 c/kWh this electricity costs about \$2,800 per year.

3.5 Other energy users

Other uses for electrical energy include lighting and smaller drive motors e.g. the drive motors for the rotary milking platform and the yard backing gate and maybe a small air compressor.

4 OPPORTUNITIES FOR REDUCING COSTS

In most dairy sheds, the vacuum pump, water heaters and milk chiller account for about 70% of the cost of electricity. This project is focussing on opportunities for reducing this cost by means such as:

- changing operating practices;
- improving maintenance;
- improving the efficiency of equipment operation; and
- using energy sources that are cheaper than electricity.

Based on the data collected so far from two farms (Graejo Trust and Coldstream Downs), the most promising of these opportunities have been identified and are described in the following paragraphs. More detailed investigation may show that some of these opportunities are not economically attractive at current electricity prices. Equally, some additional opportunities will be discovered as the project progresses.

4.1 Vacuum pumps

The main opportunity for reducing electricity usage is to fit the existing pump with a variable speed controller. This is an electronic device that automatically varies the speed of the drive motor to provide the optimum rate of air flow from the milk can. In the normal system, the pump is sized for maximum milk production and at all other production rates, an air bleed valve opens to admit air into the vacuum line thus preventing the vacuum pressure from becoming too great. This type of control results in unnecessary use of energy.

Variable speed drive systems for vacuum pumps are available from:

Corkill Systems Ltd (Varivac)

Waikato Milking Systems (SmartAir)

Claims of up to 80% saving in electricity are made. Suppliers also claim that this technology provides better control of vacuum pressure and that this can result in happier cows, faster milking and improved cow health (evidenced by a lower somatic cell count).

Water ring vacuum pumps are common in many dairy sheds but more efficient designs are available. Examples include the lobed (Roots) blower and the sliding vane blower. These more efficient designs can be used on their own or in combination with speed control to produce even greater efficiency.

During this project we will monitor the electricity usage for vacuum pumping in a number of dairy sheds to demonstrate the energy savings available from using speed control and high efficiency pumps. We will also monitor vacuum line pressure to see how well it is regulated and somatic cell count to see if better pressure regulation has any measurable effect.

We will also comment on the following:

- is a speed controller a good investment?
- does speed control work well with all liquid ring pumps?
- do some speed controllers work better than others?

4.2 Water heating

The cost of heating water can be reduced by:

- reducing the quantity of hot water used;
- reducing losses from hot water storage cylinders; and
- using a lower cost energy source to heat the water.

4.2.1 Reducing demand for hot water

Traditionally, dairy cows are milked twice a day and the milking equipment washed with hot water at least once a day. Management changes such as once-a-day milking and the use of detergents that are effective in cold water can significantly reduce the demand for hot water and save heating costs.

4.2.2 Reducing heat losses

Heat losses from storage cylinders can be minimised:

- improved insulation of the cylinder and piping;

- correct piping design;
- elimination of water leaks; and
- correct setting of thermostats.

Delaying the start of heating until the latest possible time ('just-in-time heating') also saves electricity but may be difficult for farmers to manage.

4.2.3 Alternative energy sources

Heating water to 85°C is a very simple process and there are many sources of energy that can be used in place of, or to supplement, mains electricity for this task. These include:

- burning of fuels such as wood, coal, oil or gas;
- heat transfer from milk;
- heat transfer from refrigeration gas;
- electricity from a wind-powered generator;
- electricity from a hydro generator; and
- solar energy.

Some notes on the feasibility and likely economics of using these alternatives are given in Section 5 of this report.

In this project, we will keep an open mind on all of these possibilities but initially propose to concentrate on the following options that seem likely to be of most interest to farmers.

- use of a de-superheater in the milk chiller refrigerant circuit
- use of a heat pump (Mahana Blue) to extract heat from the milk chiller refrigerant fluid and upgrade it to produce water at 85°C.

- solar water heating panels.

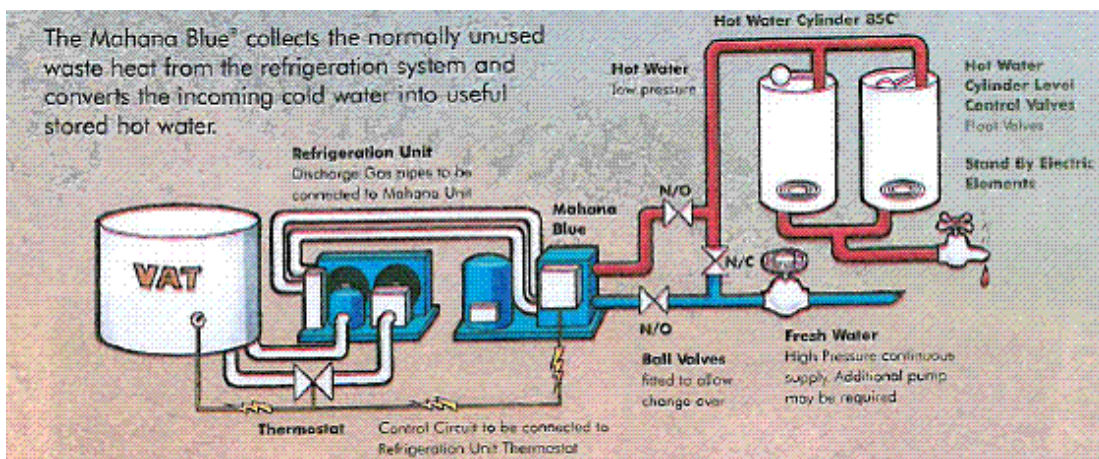
The chiller superheat is the heat contained in the refrigerant gas before it is condensed in the condenser. Dairy Technology Services (DTS) offer a brazed plate heat exchanger for heating water from refrigeration gas superheat and advise that these are now fitted as standard to all new refrigeration units. DTS claim that water heating energy savings of up to 53% are possible. In this project, we will check this claim by monitoring a de-superheater installation and measuring the quantity of cold water heated and the quantity of electricity used to heat it.

One of the difficulties of hot water heating from superheat is that only a small amount of energy is available at more than 80°C. This is where heat pumping is advantageous. The Mahana Blue system (Heatcraft Ltd), takes energy from the superheat and from the condenser and heat pumps to the hot water system via a heat exchanger (see figure below).

This system has the potential to reduce water heating energy usage by 62%

Heat pumping directly from ambient air can be considered but this has the disadvantage of only using the heat and not the cold provided by the heat pump. However mass production might give an effectively low capital cost.

Solar energy absorbers can heat water during daytime hours and a correctly designed system will displace up to 70% of the electrical energy previously used for water heating. Electric elements must still be retained for topping up the water temperature to 85°C and to make up the solar energy shortfall on cloudy days.



4.3 Milk chilling

4.3.1 Pre-cooling with water

Electricity usage by the refrigeration plant will be minimised if maximum use is made of the 'free' cooling available from the farm water supply. Factors which affect the efficiency of this pre-cooling include the temperature of the water supply and the heat transfer characteristics of the heat exchanger.

Water supply temperatures at two farms (Graejo and Coldstream) have been monitored during March and April 2006. At Graejo where the water is from a bore, the temperature has remained in the range 11°C to 13°C. At Coldstream, where the water supply is from a dam in a surface stream, the temperature fluctuates in response to the ambient air temperature. It is warmer in summer and cooler in autumn. There is also a significant temperature fluctuation between morning and afternoon. Some typical temperatures are:

	mid-March	mid-April	early May
5 am	10 °C	7 °C	8 °C
3 pm	16 °C	16 °C	11 °C

If a cooler has been correctly sized and is in good condition, it should be possible to cool the milk to within 2°C to 4°C of the water temperature. For example, at Graejo Trust farm where the water is 12°C, it should be possible to cool the milk to at least 16°C. The difference between these two temperatures (4°C) is often referred to as the *approach temperature* and is a good indicator of the effectiveness of the cooler.

Possible reasons for a cooler having an approach temperature greater than 4°C include

- insufficient surface area in the cooler
- heat transfer surfaces dirty
- milk and/or water velocities too low.

In this project we will be measuring the cooler approach temperature and the fluid flow rates to determine whether cooler performance can be improved. Possible ways to improve performance include :

- increasing the surface area of the cooler by adding more plates

- cleaning the water side of the cooler
- reducing fluctuations in the milk flow rate caused by stop/start operation of the milk pump.

Based on data collected to date, optimising the pre-cooling process is likely to reduce refrigeration costs at most farms by several hundred dollars per year. In a case where the cooler efficiency is currently very low, a saving of \$1000 per year could be possible.

On/off operation of the milk pump will reduce the effectiveness of the cooler but the extent of this effect needs to be checked. Continuous operation can be achieved using a variable speed drive (Corkill Systems Ltd, Waikato Milking Systems, DeLaval).

The current design of the plate cooler is the most simple possible with a single parallel counter-current pass of water and milk. The project will investigate the influence of the number of plates on performance. More plates will give a larger heat transfer area but will lower the internal velocities giving lower heat transfer rates. If optimisation of existing single pass coolers does not reduce the approach temperature to 4°C or less, consideration will be given to using a two pass design. This would give superior cooling without excessive pressure drop.

4.3.2 Pre-cooling with chilled water

To increase the cooling capacity of the pre-cooler, the cooling water can be chilled using a refrigeration system (e.g. DTS clip-on water chiller). This system offers no energy advantage over the conventional milk chilling system and is usually proposed as a way to increase milk cooling capacity when existing equipment is undersized.

While not reducing energy usage, it could be effective in reducing electricity costs if low cost off-peak electricity was used to run the chiller and the chilled water stored in an insulated tank until required for use. These 'cold storage' options are further discussed below.

There are other ways (besides refrigeration) of reducing the temperature of the cooling water. These include the use of an evaporative cooling tower or simply running water over a roof when temperatures are low. It is not

proposed to investigate these options.

4.3.3 Cold storage

If the milk cooling system is designed so that all of the cooling can be done with chilled water or ice slurry, it becomes possible to generate the ice or chilled water at any time of the day and store it until milking time.

While this method of chilling the milk is expected to be less energy efficient than the traditional direct expansion cooling, it allows the refrigeration load to be spread over a longer period and may permit the use of cheaper (night rate) electricity.

4.3.4 Minimising milk vat heat gains

While the chilled milk is stored in the vat, its temperature will rise as heat flows through the vat walls from the surrounding air and from solar radiation. The refrigeration plant must run periodically to deal with this temperature increase.

We will evaluate the heat gained by the milk by measuring the electrical power required to maintain the desired temperature. We will then evaluate the economics of adding additional thermal insulation to the vat in the form of a 'wrap' of insulating foam material. Several suppliers have advised that they can supply and fit such wraps.

5 ELECTRICITY AND ALTERNATIVE ENERGY SOURCES

5.1 Electricity

The primary source of energy in most dairy sheds is electricity supplied by a retailer (e.g. Meridian Energy or Contact Energy) via the distribution network that covers most of the country. In recent years, New Zealand has had a good supply of electricity available at a low price. The country now seems to be entering a new period of energy supply and pricing. Wholesale prices for electricity have increased significantly and seem likely to remain high because of the high international price of petroleum products coupled with the depletion of New Zealand's gas reserves.

As part of this project we will study the current cost of electricity delivered to Southland farms and also attempt to predict how this cost might change over the next few years. We will pay special attention to the way in which electricity prices vary according to time of day. Some farms currently control water heating to make use of lower cost electricity available at night. There is also potential to reduce milk chilling costs by using an ice bank that is 'charged' at night but this will only be attractive to farmers if electricity charges are significantly lower when the ice bank is being cooled.

5.2 Fossil fuels

Dairy shed energy systems are relatively small so with the exception of natural gas available to a few farms in the North Island, fossil fuels are seldom used. The possibility of wide-spread gas reticulation will not be considered.

Liquefied petroleum gas (LPG) can be used but there is little indication at present that this will offer an economic advantage over electricity. The cost of transport and retailing will continue to keep the energy cost of LPG similar to that of electricity.

The use and cost of diesel and petrol as transport fuels will not be considered.

5.3 Biogas (methane)

While cows produce significant amounts of methane in their digestive systems, direct capture of this would be problematic and will not be considered further.

The best opportunity available is to produce biogas (mainly methane and carbon dioxide) from biomass digestion. Over the last 25 years, there has been much interest in the production and use of biogas on the farm but so far, the cost and complication have been too great to make it an attractive alternative to electricity and fossil fuels.

We are aware of systems that seek to utilise cow droppings collected around the dairy shed as the energy source for a biogas producer but so far haven't been able to find a system currently in use in New Zealand. It seems likely that the cost of purchasing and operating suitable equipment makes this investment unattractive to most dairy farmers.

5.4 Energy in milk

Milk leaves the cow at about 39°C and after initial handling is about 35°C. It needs to be cooled to 7°C. Typically the amount of milk produced is about 10 times the amount of hot water required at 85°C for cleaning. By any estimate the amount of energy that needs to be removed from the milk far exceeds the amount required for hot water heating. The low temperature of the milk requires that some form of heat pump be used. Such a heat pump might be the existing refrigeration system which has superheat temperatures above 85°C.

5.5 Air

Energy in air can be used as a source for heat pumping but given that milk and water are at higher or similar temperatures (and at higher densities), air is unlikely to be the best energy source.

5.6 Water

Some farms (e.g. Coldstream Downs) have water supplied from a farm dam. The temperature of the water will be about the local average air temperature or a little higher given solar heating of the dam water. This is a potentially useful source of energy. Energy from the water could be heat pumped for hot water also giving chilled water for milk cooling. From an energy point of view however, this is similar to using milk as the heat source (see 5.4 above) and not as direct.

5.7 Solar energy

Solar energy can be used for water heating or to produce electricity using photovoltaic cells. The second option is not currently economic except for special (physically) isolated cases and generally as part of an integrated system.

Solar water heating systems are widely available for domestic and commercial use and are known to have been installed in some dairy sheds. There is no doubt that a solar-assisted water heating system will significantly reduce electricity usage. The main question that this project will address is ‘at what electricity price does solar-assisted water heating become an attractive investment?’.

5.8 Wind

Small-scale wind generation has been often mentioned as an opportunity for farmers in remote areas. A decision to generate electricity from wind is independent of dairy shed efficiency as there is no interaction with shed operations; it is simply an alternative source of electricity.

A possible exception to this would be electrical energy generated specifically for hot water heating. It is conceivable that a system dedicated to hot water heating might have a lower cost as there would be no requirement to synchronise with the mains electricity system. Factors such as the variability of the wind and the inability to store surplus energy on windy days could be significant obstacles to an economic system however.

5.9 Micro-hydro

The Energy Efficiency and Conservation Authority (EECA) estimates costs for a micro-hydro scheme with dc power to be 15 to 30 c/kWh. This is marginal compared with the current typical retail price of 14 c/kWh. Like wind power it is possible that a system dedicated to hot water heating only might be cost effective. Only a few farms will have the water flow and head required for a micro-hydro scheme.

6 DATA COLLECTION

This project includes the measurement of temperatures, water and milk flows and electrical energy usage in several Southland dairy sheds. The purpose of these measurements is two-fold

- to establish the range of temperatures, flows and energy usage found in a 'normal' Southland dairy shed before starting improvements
- to measure the changes that result from the energy efficiency measures implemented as part of this project.

6.1 Instruments

A variety of measuring instruments was installed in the Graejo and Coldstream dairy sheds in January 2006. These included :

- temperature sensors (measuring air, milk and water temperatures)
- flow meters (turbine type for water flows and magnetic type for milk flow)
- electricity meters (electrical energy use, power and power factor)
- pressure sensors (vacuum line pressure).

At each site, there is a weather station that measures air temperature and humidity, wind speed and direction, rainfall and solar radiation.

Similar instruments will be installed on other farms during winter 2006. These will be used in the 2006/07 dairy season to monitor the results of changes to equipment and processes that will be demonstrated in this project. The changes will be designed to improve energy efficiency and reduce operating costs.

6.2 Datalogging

Each of the instruments is connected to one of two dataloggers. A Campbell Scientific CR1000 for the dairy shed instruments and a CR200 for the weather station. The dataloggers have been programmed to record measurements at time intervals of 1, 5 or 30 minutes and also to process some of these readings and record the result such as maximum and minimum readings and accumulated totals.

The instrument readings and the calculated figures are stored in the memory of the datalogger until a request is received from a computer connected to the logger via the internet.

6.3 Data telemetry

At each site, the two loggers are cabled to a serial server, router and modem located in a panel in the dairy shed. The modem is connected wirelessly to the internet using the Woosh Wireless network. A remote computer connected to the internet and running Campbell LoggerNet software downloads the data at regular intervals and stores the downloaded information as a series of comma delimited text files. This computer can be located anywhere that internet access is available. In this case, it is located in Christchurch.

The data files are used in two ways:

- imported into a standard spreadsheet (Microsoft Excel) for technical analysis
- used to generate graphs and similar images which are uploaded to the project web site.

6.4 Web display

It is an important aim of this project to make as much information as possible available to any interested party. The project website <http://www.cowshed.org.nz> is the main means of doing this and so data from the farm instruments is being displayed there in 'near real time'.

This is being done using Campbell RTDM software to generate graphical images. These images are saved in jpg format and uploaded to the web server using file transfer protocol (FTP) software operating across the internet.

At present, data for the graphs is downloaded from the dataloggers every 60 minutes. Updated images for the web pages are generated two minutes later and immediately sent to the web server via the internet. An example of these graphs can be seen by visiting www.cowshed.org.nz.

7 PROJECT PLAN

7.1 Equipment trials

In January 2006, manufacturers of dairy shed equipment were invited to submit their proposals for equipment that could be retro-fitted to existing dairy sheds to improve energy efficiency and reduce operating costs. Using information from the Graejo and Coldstream farms together with information provided by the suppliers, the project team has selected equipment and process changes that are predicted to reduce energy usage and/or energy costs in existing dairy sheds.

Equipment trials will be carried out on five Southland dairy farms over the 2006/2007 dairy season. As at the date of this report, some trials have commenced and others are still being planned.

Details of the individual trials are set out in Section 8 below.

7.2 Measuring results

Measuring instruments of the type currently installed at Graejo and Coldstream farms are being installed at each of the other farms where energy-saving strategies are being demonstrated. Data from these instruments will be transmitted over the internet and used by the project team to calculate the energy savings and return on investment associated with each strategy.

7.3 Reporting

Interim results of the demonstration projects will be reported on the cowshed.org.nz website and a final report prepared at the end of the 2006/2007 milking season. It is an aim of the project to provide farm owners and managers with simple tools to enable them to assess the cost-effectiveness of each energy-saving strategy on their own farm.

8 DETAILS ON INDIVIDUAL TRIALS

8.1 Vacuum pump efficiency

This project will compare the energy efficiency of a water ring vacuum pump and a rotary vane vacuum pump and find out how much money can be saved by selecting the most efficient pump.

8.1.1 Predicted saving

At a vacuum pressure of 50 kPa, the commonly used water ring pump (Skellerup / Flomax WR series) delivers approx 280 litres/min of air per kW of power input. This compares with approx 400 litres/min per kW for a rotary vane pump. For a given duty, it is expected that energy usage by a rotary vane pump will be 30% less than for a water ring pump.

At Graejo Trust farm, a 38 a side herringbone shed milking 700 cows, annual energy usage for the vacuum pump is expected to reduce from 17,000 kWh to 12,000 kWh. At 15 c/kWh, this represents an electricity cost saving of \$750 per year. The expected installed capital cost of the vacuum pump is \$18,000.

A positive displacement blower is expected to have an energy efficiency similar to that of the rotary vane pump.

8.1.2 Description and main aims

At the Graejo Trust farm a rotary vane pump will be installed in parallel with the existing water ring pump. The speed of the vane pump will initially be set so that the air flow rate is the same as that of the existing water ring pump. The vane pump will be set up so it can be run at fixed speed and also with variable speed control – see below.

Energy used by the vane pump itself and by the whole cowshed will be monitored and compared with the energy used when operating the existing water ring pump. Through the milking season, the shed will be operated alternately with the water ring pump, the vane pump on fixed speed and the vane pump on variable speed.

If recommended by the pump supplier, and

after an initial period of running at the current air flow rate, the air flow rate will be adjusted by changing the motor speed.

The aim of this trial is to compare the running costs of the water ring pump and the vane pump running at fixed speed. A secondary aim is to assess the other advantages and disadvantages associated with the vane pump – noise level, cost of lubricating oil, maintenance, reduction in water usage.

8.1.3 Equipment

SuperVac 7 (with RVS Model M7000 pump) from Corkill Systems Ltd. This pump has a 7.5 kW motor whereas the existing water ring pump (Alfa Laval Agri VP240) has an 11 kW motor.

8.1.4 Installation contractors

Progressive Engineering (mechanical and piping)

Munro Electrical (electrical)

8.1.5 Instrumentation

A kWh meter is already installed on the existing vacuum pump supply cable. This will be used to measure the electrical energy usage of the rotary vane pump also.

A portable sound level meter will be used to take spot readings of the sound levels associated with each type of pump. Water usage by the existing pump will be measured using a bucket and stopwatch.

8.2 Vacuum pump variable speed control – rotary vane pump

This project is an extension of the vacuum pump efficiency project described above and will demonstrate the performance of a rotary vane vacuum pump with speed control.

Predicted saving

As noted above, it is expected that a rotary vane pump running at fixed speed at Graejo Trust Farm will reduce annual energy usage for

the vacuum pump from approximately 17,000 kWh to 12,000 kWh.

The suppliers of the variable speed control equipment predict an additional saving of 35% to 45%. A 35% saving would reduce the annual energy usage from 12,000 kWh to 8,000 kWh. At 15c/kWh, this represents an electricity cost saving of \$600 per year. The capital cost of the speed controller (installed) is estimated as \$8,000.

Description and main aims

For this trial, the rotary vane pump installed at the Graejo Trust farm for the vacuum pump efficiency trial will be fitted with variable speed control.

Energy used by the pump itself and by the whole cowshed will be monitored and compared with energy usage when the pump runs at fixed speed. This trial will be run in conjunction with the vacuum pump efficiency trial. Through the milking season, the shed will be operated alternately using the water ring pump, the vane pump on fixed speed and the vane pump on variable speed.

The main aim of this trial is to compare the running costs of the vane pump running at fixed speed with those of the pump running at variable speed. Secondary aims are to

- Monitor total electricity usage to see if variable speed control of the vacuum pump reduces energy usage in other areas eg by shortening the milking time
- Monitor vacuum line pressure to see if pressure control is improved by using motor speed control.
- Monitor somatic cell count in the bulk milk to see if there are any changes associated with variable speed operation of the vacuum pump.

Equipment

7.5 kW Varivac speed controller supplied by Corkill Systems Ltd.

Installation contractor

Munro Electrical

Instrumentation

kWh metering for the vacuum pump and total

shed load will already be in place.

Somatic cell count in the bulk milk will be monitored using the data from the test carried out by Fonterra on each load of milk collected from the farm vat. It is expected that the Farm Manager will provide access to the Fonterra SCC test results.

A portable sound level meter will be used to take spot readings of the sound levels associated with the pump running at variable speed.

8.3 Vacuum pump variable speed control – water ring pump retrofit

This project will demonstrate the performance of a water ring vacuum pump with speed control.

Predicted saving

Vacuum pumps are typically sized to produce an air flow rate (measured at atmospheric pressure) of 80 to 100 litres/minute per set of milking cups. This is intended to provide ample capacity for the times of highest production and presumably includes a design margin as well. If the pump runs at fixed speed and the flow is too high (which it is most of the time), excess air is admitted into the vacuum line through the pressure regulator.

By fitting a speed controller to the pump, the pump speed can be reduced to match the actual air flow required to maintain the desired vacuum pressure. As the power required varies approximately in proportion to the speed of rotation, a 40% reduction in speed will result in a 40% reduction in energy usage.

One supplier (Waikato Milking Systems) claims that the vacuum pump energy usage will be reduced by 35% to 45% while another (Corkill Systems Ltd) claims 50% to 80% reduction. At Coldstream Downs farm (a 60 bail rotary shed milking 850 cows), the fixed speed vacuum pump uses approximately 65 kWh per day. A 40% saving would mean an annual reduction of 7,000 kWh. At 15 c/kWh, this represents an electricity cost saving of \$1,000. The estimated installed capital cost of the speed controller is \$9,000.

The actual saving achieved by fitting a variable

speed drive to an existing pump will depend on how much excess capacity the pump has. A pump that is 'undersize' to begin with will not be expected to show as great a saving as a pump that is 'oversize'. In addition, the speed of water ring pumps cannot be reduced too much or operational problems may occur (loss of the water seal).

A pump that is too small to cater for peak season flow rates may benefit from being able to operate at higher speed during periods of maximum production. This may well save energy by reducing the milking time. Equipment suppliers also claim other benefits of vacuum pump speed control

- shorter milking times because cows are less stressed and milk faster
- better control of vacuum pressure, possibly leading to lower somatic cell count.

Description and main aims

Existing water ring pumps (Skellerup / Flomax WR series) at two dairy sheds will be fitted with speed controllers. In each location, energy used by the pump itself and by the whole cowshed will be monitored and compared with energy usage when the pump runs at fixed speed. After a period of operation (4 to 6 weeks), the variable speed drive unit will be isolated and the pump run at fixed speed for a period and this pattern will be repeated throughout the season.

Vacuum line pressure will be monitored to see if pressure control is improved by vacuum pump speed control.

Somatic cell count in the bulk milk will be monitored using the data from the test carried out by Fonterra on each load of milk collected from the farm vat.

During the project we will also be alert for any negative effects on the pump itself.

Locations

Coldstream Downs farm in the Waimea Valley

Glencairn Land Company 50 bail shed at Dipton West.

Equipment

Two Varivac 15 kW variable speed drive units

supplied by Corkill Systems Ltd.

Installation contractor

Munro Electrical

Instrumentation

Suitable instrumentation (total kWh meter, vacuum pump kWh meter and vacuum line pressure transducer) already exist at Coldstream Downs. Similar electricity metering equipment will be installed at the Glencairn 50 bail shed. Vacuum line pressure at Glencairn will be monitored using the transducer installed as part of the Varivac system.

Somatic cell count in the bulk milk will be monitored using the data from the test carried out by Fonterra on each load of milk collected from the farm vat. It is expected that the Farm Managers will provide access to the Fonterra SCC test results.

8.4 Reduce hot water usage by cold washing of lines

This project will assess (by desktop study), the saving in electricity that can be made by using cold instead of hot water for more of the milk line washes.

Predicted saving

Reducing the demand for hot water will reduce energy usage and cost. Common practice in many dairy sheds is to use hot water to wash the milk lines once each day (usually after morning milking) and to use cold water for the second wash (usually after afternoon milking).

An alternative system, promoted by detergent supplier Deosan, is to halve the number of hot washes of the milk lines. This typically means that on every second day, cold water is used for both the morning and afternoon washes. A variation being promoted by DTS is to use warm (50 C) water recovered from the milk chilling plant at low cost.

Provided the milk meets the necessary quality standards, this practice is accepted as meeting food safety requirements and is acceptable to dairy processor, Fonterra.

The milk vat (or silo) must be washed after the

milk has been collected and hot water needs to be used every time. There is no opportunity to reduce energy usage by using cold water for this task.

In this project, it is not proposed to carry out a practical trial of 'skip-a-day' hot washing of milk lines. Rather, it is proposed to use calculations to estimate the likely saving in electricity usage and cost.

Based on preliminary calculations, it is estimated that for Graejo Trust farm (38 a side herringbone shed), the annual saving in electrical energy would be between 5,000 and 7,000 kWh. A large farm with an 80 bail rotary milking machine might save twice this amount - 10,000 to 14,000 kWh. The value of the electricity saved will vary depending on whether it would have been purchased at day rates, night rates or supplemented by some alternative energy source eg heat recovered from the milk vat chiller. Assuming electricity purchased at 15 c/kWh, the annual reduction in electricity cost would be in the range \$800 to \$2100. This will be offset to some extent by the higher cost of detergent suitable for cold water washing.

Description and main aims

The cost of heating water for lines washing in accordance with the Fonterra guidelines will be calculated for various sizes of milking shed. This will be compared with the calculated cost of using Deosan Supernova detergent and halving the frequency of hot washing.

8.5 Water heater heat loss reduction

This project will look at the heat loss from a 'normal' dairy hot water system and will demonstrate how this loss can be reduced using a variety of measures.

Predicted saving

The annual energy usage for water heating on a farm that uses 1000 litres of hot water each day is approximately 29,000 kWh. Typically, about 5,000 kWh of this (17%) is not used usefully but is lost to the atmosphere. One dairy shed visited as part of this project had water heater energy losses of 25 kWh/day

which translates to 6800 kWh per year.

It is expected that it will be possible to reduce this loss by a series of (mostly) minor improvements to the hot water heaters and their associated pipework. Potential savings will vary according to the size, condition and design of existing equipment but for a 'typical' medium to large shed are in the order of 3000 kWh per year. This saving is worth \$450 at an electricity price of 15 c/kWh.

A significant saving in electricity cost is also possible if a day/night electricity tariff is used and water heating is delayed until the night hours when electricity is cheaper.

Description and main aims

This trial will utilise a series of improvements to reduce the energy losses from the water heaters and piping in the milking sheds at Coldstream Downs and Tussock Creek farms. The improvements to be tried include the following :

- Management systems and/or improved automatic controls to delay the start of heating until much closer to the time that the hot water is required
- Modification of the cold water feed piping and hot water outlet piping where necessary to minimise conductive and convective heat losses.
- Insulation of the hot water piping to the maximum extent that is practicable
- Additional insulation for the water heater (cylinder wrap).
- Repair of leaking valves.

This trial will also look at the advantages and disadvantages of deferring water heating until after 11pm so that advantage can be taken of off-peak rates for electricity. Currently both farms selected for this project (Coldstream Downs and Tussock Creek Dairies) have 'anytime' metering. The farm managers will be asked to get their electricity supplier to change to a day/night tariff.

Instrumentation

The electricity consumption of each water heater will be monitored using current sensors fitted to the heating element cables.

Datalogger equipment will record the data

which will then be transmitted to a remote location (and onto the website) using a Woosh Wireless connection to the internet.

8.6 Water heating by de-superheater

Waste heat from the milk vat chiller will be used to pre-heat the cold water feed to the water heaters.

Predicted saving

On most Southland dairy farms, the energy for water heating is supplied by electricity and an annual usage of 25,000 to 30,000 kWh is typical for medium to large farms.

Pre-heating the water using heat recovered from the milk vat refrigeration system can reduce this electrical energy usage by about 40%. For a farm such as Tussock Creek using 25,000 kWh per year for water heating, a saving of at least 10,000 kWh should be possible. At an electricity price of 15 c/kWh, this saving is worth \$1,500 per year. The capital cost of the heat recovery system is estimated to be \$3000.

Description and main aims

A small heat exchanger (supplied by Dairy Technology Services Ltd) has been installed in the refrigerant line on the milk vat chiller unit at Tussock Creek Dairies Ltd. An alternative cold feed system for the water heaters has been installed so that when the chiller unit is running, cold water trickles through the heat exchanger and enters the water heaters at a temperature of about 50 C.

The heat to raise this water from cold to 50 C is 'superheat' obtained from the refrigerant gas. In normal operation this heat is rejected to the atmosphere by the condenser coils at the chiller unit and so can be regarded as free of cost.

The main aim of this trial will be to measure the reduction in electricity used for water heating when a desuperheater is used to pre-heat the water. A secondary aim will be to consider ways in which the water heating and storage system could be re-designed to make maximum usage of the energy available from the desuperheater eg by adding an insulated storage tank.

Equipment

Brazed plate heat exchanger supplied and installed by Dairy Technology Services (DTS) and their subcontractors Southern Refrigeration and AgWeld.

Instrumentation

The electrical energy used by the water heater elements will be monitored by current sensors fitted to the element cables.

Water flow meters in the cold feed to de-superheater and in the bypass line will record the water flows.

A temperature sensor will record the temperature of the water entering the water storage cylinders.

Datalogger equipment will record the data which will then be transmitted to a remote location (and onto the website) using a Woosh Wireless connection to the internet.

8.7 Water heating by heat pump

A heat pump will be used to heat water to 85°C using heat recovered from the milk vat chiller.

Predicted saving

As noted above, water heating on a medium to large dairy farm typically requires 25,000 to 30,000 kWh per year of energy and in a conventional system, this energy is supplied by electricity.

Using the vat chiller refrigeration gas as the heat source, a Heatcraft Mahana Blue heat pump is predicted to reduce energy usage for water heating by 60%. For a medium sized farm using 25,000 kWh per year for water heating, a Mahana Blue system should reduce electricity usage by 15,000 kWh. At an electricity price of 15 c/kWh, this saving is worth \$2,200. The capital cost of the heat pump installation is estimated to be \$8,000.

Description and main aims

A Heatcraft Mahana Blue heat pump has been installed in the refrigerant line of the milk vat chiller unit at the Glencairn Land Company 50 bail shed.

As for the de-superheater project, an alternative water feed system for the water heaters has been installed so that when the vat chiller is running, cold water passes slowly through the Mahana Blue heat exchangers and enters the water heaters at a temperature of 85C.

The heat pump supplier advises that the water flow rate is about 3.5 litres per minute and so the two 500 litre water heaters fill in approximately 5 hours running of the vat chiller.

The main aim of this trial will be to measure the reduction in electricity used for water heating when a Mahana Blue heat pump is used to heat the water.

Secondary aims will be to:

- Look at ways to better match the timing of hot water production and hot water usage
- Assess the reliability and maintenance cost of the Mahana Blue unit.

Installation contractor(s)

The Mahana Blue installation (inc electrical and water piping work) has been carried out by Dairy Technology Services and their subcontractors.

Instrumentation

The electrical energy used by the Mahana Blue heat pump motor and by the water heater elements will be monitored by current sensors fitted to the cables.

Water flow meters in the cold feed to the heat pump and in the bypass line will record the water flows.

A temperature sensor will record the temperature of the water entering the water storage cylinders.

Datalogger equipment will record the data which will then be transmitted to a remote location (and onto the website) using a Woosh Wireless connection to the internet.

8.8 Solar-assisted water heating

Solar water heating panels will be used to supplement the electric heating provided by the existing storage water heaters.

Predicted saving

It is likely that a suitably sized solar energy collection system could save 50% of the energy required to heat water on a typical dairy farm. For a farm currently using 25,000 kWh of electricity each year, a saving in the order of 12,000 kWh is possible and this could be worth up to \$1,800 per year at an electricity cost of 15 c/kWh.

A system capable of collecting 12,000 kWh per year is expected to cost \$15,000 to \$20,000. Smaller systems are feasible but the electricity saving will also be reduced.

Description and main aims

The aim of this project is to demonstrate the practical use of solar water heating, to measure the saving in electrical energy usage and assess the financial benefit of the system to the farmer.

The project will be carried out at Moorabool Farm Ltd at Dipton West. Proposals have been received from SolarTech, Reid Technology and Azzuro Solar but equipment has not yet been ordered. All offers are based on installing solar collection panels on the dairy shed roof but differ in the way the solar-heated water is stored and utilised to supplement the existing water heating system.

Instrumentation

Instrumentation being installed includes :

- current sensors to measure the energy used by each water heater element
- a water flow meter in the cold feed pipeline
- sensors to measure the temperature of water at the storage cylinder inlet and outlet
- a weather station to measure solar radiation, air temperature and wind speed.

Datalogger equipment will record the data which will then be transmitted to a remote location (and onto the website) using a Woosh Wireless connection to the internet.

8.9 Optimisation of milk pre-cooler

The operation of the milk pre-cooler at Graejo

Trust farm will be investigated and changes made to maximise its cooling performance

Predicted saving

A 'typical' dairy shed might use 20,000 kWh of electrical energy each year to run the milk vat chiller. By maximising the 'free' cooling available using the farm water supply as the coolant, this electrical energy usage will be reduced. For a farm such as Graejo Trust producing 2.6 million litres of milk each year, a 1°C reduction in the temperature of the milk leaving the pre-cooler will reduce the electricity consumption of the milk vat refrigeration unit by about 1300 kWh.

In an extreme case, an 8°C reduction, (which should be possible at Graejo Trust farm), could halve the annual energy usage for cooling. Electricity cost savings of up to \$1500 per year are possible.

Description and main aims

This demonstration is aimed at showing that milk can be cooled to within 2C of the cooling water temperature if the heat exchanger is operated under optimum conditions. The project will investigate the effects that the following have on the efficiency of the pre-cooling process

- Heat exchanger surface area (number of plates)
- Heat exchanger maintenance (cleaning of milk and water passages)
- Water flow rate
- Milk flow rate.

Milk flow rate is affected by the type of milk pump used and the way in which it is controlled. Part of the project will be to install a milk pump speed controller (supplied by Corkill Systems Ltd) and evaluate the effect that this has on the efficiency of the pre-cooler.

The main aim of the project is to show that milk can be cooled to within 2C of the cooling water temperature and to demonstrate how much electrical energy can be saved by achieving this.

Instrumentation

Instrumentation was installed at Graejo Trust

farm in February 2006. The following instruments will be used to measure the efficiency of pre-cooler operation

- milk flow meter
- temperature sensors on the milk flow lines entering and leaving the plate cooler
- temperature sensors on the water flow lines entering and leaving the plate cooler
- kilowatthour meter on the milk vat refrigeration unit.

8.10 Milk vat insulation

An insulating wrap will be added to a milk vat to reduce the cooling load on the vat chiller.

Description and main aims

An insulating wrap supplied by Dairy Technology Services will be fitted to one of the two milk vats at the Coldstream Downs farm. The aim of the project is to measure the reduction in vat chiller electricity use that results from fitting the insulation.

The effectiveness of the insulation will be assessed by

- monitoring the rate of milk temperature rise over time when the chiller unit is off. Ambient conditions (air temperature, wind speed and solar radiation) will be available from the weather station installed nearby.
- monitoring the electrical energy usage of the vat chiller unit.

It is expected that this assessment will also be assisted by comparison with the performance of the second milk vat that will remain uninsulated.

Instrumentation

Instrumentation was installed at Coldstream Downs farm in February 2006. The following instruments will be used to assess the effectiveness of the milk vat insulation

- temperature sensors in vats 1 and 2
- kilowatthour meters on the milk vat 1 and 2 refrigeration units
- weather station instruments (ambient air temperature, wind velocity, solar radiation).

8.11 Milk cooling with chilled water

A chilled water system will be installed to provide additional cooling of the milk before it reaches the storage vat. The chilled water will be produced at night when electricity prices are lower and stored until required during milking.

Predicted saving

Using chilled water to displace some of the 'in-vat' cooling load is expected to save money (but not energy) by shifting much of the electricity usage for milk cooling into the night hours when electricity is cheapest.

This cooling system will be most cost-effective where the temperature of the farm water supply is high and milk temperature is correspondingly high when it leaves the pre-cooler.

Because there will be additional heat gains and electrical energy will also be required for the chilled water circulating pumps, it is expected that the energy usage for this system will be greater than for the conventional system that uses the farm water supply and direct expansion refrigeration in the milk vat to complete the cooling.

Assuming that electricity can be purchased at night for 7 c/kWh, a cost saving in the order of \$600 to \$800 per year is expected for a farm such as Coldstream Downs producing 2.7 million litres of milk per year and with limited ability to pre-cool this with the farm water supply. The capital cost of the necessary water chilling and storage equipment is estimated to be \$19,000.

Description and main aims

This project will be carried out at Coldstream Downs farm. At this farm, pre-cooling the milk using the farm water supply can be limited during warmer weather because of the increased water temperature and a supply of chilled water will help to ensure that the milk is adequately pre-cooled before it reaches the storage vat.

With the addition of a chilled water supply, the milk will be cooled in three stages

- in the existing plate cooler using the farm water supply as the coolant (35°C to ~20°C)

- in a second plate cooler using 6°C chilled water as the coolant (~20°C to ~9°C)
- in the storage vat using the existing direct expansion refrigeration system (~9°C to 6°C)

The water chilling unit (plate heat exchanger, water circulating pump and controls) will be connected to one of the existing milk vat refrigeration units as a so-called 'clip-on' unit. The controls will be set up to direct refrigerant flow to the milk vat as required and also to direct refrigerant flow to the water chiller when it is not needed for the milk vat.

In order to effect a saving in electricity cost, a 25,000 litre storage tank will be installed to store the chilled water and the system will be set up so that water chilling takes place only between 11pm and 7am when electricity prices are lowest.

A second plate cooler will be installed in the milk line after the existing plate cooler and chilled water will be circulated between the storage tank and this cooler during milking.

Instrumentation

The main indication of electricity usage and electricity cost savings will come from the existing kilowatt-hour meter on the milk vat refrigeration unit.

8.12 Optimisation of Electricity Purchasing

All electricity purchase options available to Southland dairy farmers will be reviewed and the systems and controls needed to minimise costs will be investigated.

Predicted saving

This project is aimed at saving electricity cost only. No predictions have been made on the extent of possible cost savings.

Description and main aims

Electricity purchasing options for all energy retailers operating in Southland will be obtained and compared. Bulk purchase arrangements through farm supply companies such as RD1 will also be included.

The project will investigate and recommend

changes to dairy shed operating procedures and to equipment controls that will reduce electricity purchase costs by making best use of available cost structures.

This will be mainly a desktop study although some of the farm managers will be encouraged to try new operating practices eg night rate heating of water at Coldstream Downs.

8.13 Energy efficient lighting

Energy inefficient light fittings in the Graejo Trust dairy shed will be replaced to demonstrate the savings achievable by using efficient lighting.

Predicted saving

Some dairy sheds are using light fittings that are inefficient in their use of electricity and electricity can be saved by replacing these with modern, energy-efficient fittings.

At Graejo Trust farm, the dairy shed uses incandescent light fittings. The milking pit has 4.4 kW of incandescent lighting and there is a further 1.5 kW in the yards. Replacement of these fittings with fluorescent and high pressure sodium fittings is expected to reduce the power requirement from 5.9 kW to 1.6 kW. Assuming the milking area lights run for 1200 hours per year and the yard lights for 1000 hours (to be confirmed), an energy saving of 5,000 kWh is possible. At an electricity cost of 15 c/kWh, this saving is worth \$700. The estimated capital cost of the new light fittings is \$3,600.

8.14 Summary of predicted savings and costs

The following table is a summary of the predicted savings and costs extracted from sections 8.1 to 8.13. All estimates of electricity cost savings are based on an assumed electricity price of 15 c/kWh.

Description of project	Farm	Estimated annual energy saving [kWh]	Estimated annual electricity cost saving [\$]	Estimated capital cost [\$]	Simple payback period [years]
Vacuum pumping					
Replacement of water ring vacuum pump by rotary vane pump	Graejo Trust	5,000	750	18,000	24.0
Speed control of rotary vane vacuum pump	Graejo Trust	4,000	600	8,000	13.3
Speed control of water ring pump	Coldstream Downs	7,000	1,000	9,000	9.0
Hot water usage and heating					
Cold water washing of milk lines (medium farm)		5,000	800	0	0.0
Cold water washing of milk lines (large farm)		10,000	1,500	0	0.0
Reduced heat loss from water heaters	Tussock Creek	3,000	450	unknown	
Heating water using a heat recovery unit (DTS de-superheater)	Tussock Creek	10,000	1,500	3,000	2.0
Heating water by heat pump (Mahana Blue)	Glencairn	15,000	2,200	8,000	3.6
Solar-assisted water heating	Moorabool	12,000	1,800	20,000	11.1
Milk cooling					
Optimisation of pre-cooling	Graejo	10,000	1,500	unknown	
Milk vat insulation	Coldstream			3,000	
Chilled water cooling	Coldstream	0	600	19,000	30.8
Other					
Energy efficient lighting	Graejo	5,000	700	3,600	5.1

