

# Energy Efficiency in Dairy Sheds

*July 2007*

## About the Project

The *Energy Efficiency in Dairy Sheds* project has provided farmers with a robust and objective view on ways, with good practice, that farmers can achieve significantly improve energy efficiency and operating costs for all types of dairy sheds.

Based on real time energy monitoring and independent assessment, the project has provided a much-needed information source for farmers who have been wary of making energy management decisions based on incomplete information and claims made within sales literature.

In addition, this study has highlighted a number of critical points for the dairy sector to consider.

First, there are gains to be made from better matching dairy shed practice with available electricity tariff options – specifically the use of a night rate. However, a night rate is only a price signal that reflects a constraint on the electricity network. It should be noted at the outset that farmers who take advantage of a night rate will then have little price incentive to make real efficiencies in energy use. Savings are achieved in terms of cost, but not in energy efficiency.

Second, it is possible for existing dairy sheds to make some immediate efficiency gains in the area of water heating. As in any industrial situation, drips, leaks and uninsulated pipes can waste significant amounts of hot water. In a dairy shed this type of inefficiency can amount to several

hundred dollars per year.

Third, the study highlighted the overall importance of gaining efficiencies in water heating. It has been shown that there are many options available and the performance of these systems and devices is in most cases very close to the claims made by the manufacturers and suppliers.

Finally, the study has demonstrated that any farm seeking a best practice approach to energy efficiency will need to focus on approaches to designing the dairy shed and the specification of best-in-class equipment.

This collaborative study has identified a number of related issues which merit further investigation. There is an obvious need to work with equipment suppliers to ensure that farmers can measure their energy consumption easily and accurately. Further investigation is needed into opportunities to use improved thermostats and temperature control systems, and there is potential to develop ice slurry cooling systems which utilise night rate.

In the long term, a clear set of standards is required for the performance of dairy sheds and their design. The findings from this study suggest that without the adoption of national design standards or best practice guidelines it is unlikely that significant gains will be made in energy efficiency across the industry.



## Why this project is important

Electricity is a significant cost for the dairy sector and a major factor in rural energy demand growth. Technologies have been developed to improve energy efficiency with New Zealand dairy sheds but a lack of independent assessment and easily-accessible information has meant that many farmers have remained unaware of potential efficiencies, or have been unwilling to commit time and investment into this area.

Energy Efficiency in Dairy Sheds has identified cost-effective measures that will improve dairy shed energy efficiency based on practical trials on working dairy farms in Southland.

The project was funded by Dairy Insight and the Ministry of Agriculture and Forestry's Sustainable Farming Fund, with field work and analysis carried out by CAENZ.

The findings and results have provided the means for dairy farm owners and managers to make informed decisions relating to the selection of equipment and best practice in the dairy shed. It has also provided equipment designers and suppliers with an objective performance measure which will help to inform product development and innovation.

### How we went about it

Equipment trials were carried out on five Southland dairy farms during the 2006/07 dairy season. The trials examined the performance and effects of various pieces of equipment including a heat pump, de-superheater, solar water heater, vacuum pump variable speed drives, milk pump variable speed drive, milk vat insulating wrap and a chilled water milk cooler.

Data from monitoring systems was reported via the internet ([www.cowshed.org.nz](http://www.cowshed.org.nz)) and used by the project team to calculate energy savings and return on investment.

Cost-effectiveness was evaluated using standard economic decision making tools and most often the 'simple payback method' – how many years of savings it takes to equal the initial cost. In most cases it was assumed that a dairy farmer would be unlikely to make a change unless the payback period was five years or less.

Cost savings were based on April 2007 electricity prices, with some rounding for ease of comparison. For farms buying electricity on an 'anytime' pricing plan, the typical average price was 15 c/kWh (after deducting any discounts and before adding GST) but this includes the fixed daily charge. In valuing savings, a marginal cost of 14 c/kWh was used.

### What we found

To provide an appropriate context, the study began with an assessment of how energy is used dairy shed:

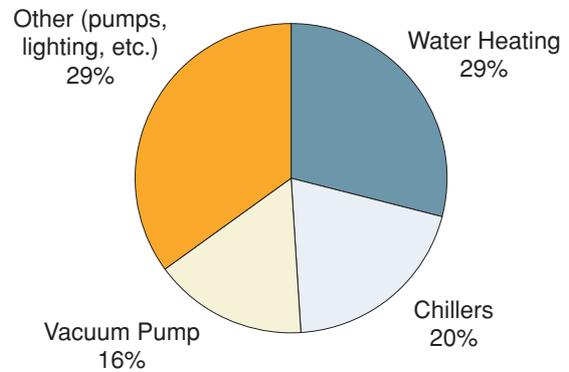


Figure 1: Typical energy use in a Southland dairy shed

Electricity is the main source of energy in the dairy shed and for a medium to large farm this costs about \$12,000 - \$16,000 a year. In most dairy sheds the vacuum pump, water heaters and milk chiller account for 60% -70% of the cost of electricity.

This project focused on opportunities for reducing this cost by:

- Changing operating practices
- Improving maintenance
- Improving the efficiency of equipment operation
- Using energy sources that are cheaper than electricity.



## Water Heating

Water is heated and stored, then used for cleaning the milking equipment and storage vats at various times through the day. An adequate supply of hot water is essential for maintaining good hygiene and high milk quality.

While there are no quick fixes to total dairy shed efficiency, this project demonstrated that some electricity savings can be made at low cost by minimizing hot water use, adding insulation, checking thermostat operation and repairing leaks. The study noted one dripping valve with a measured flow of six litres per hour, which was calculated to be costing at least \$300 per year. The study also found that the heat losses from the water heaters and pipes were significant and that reducing this loss through improved insulation can save up to \$500 per year with very little investment cost.

Hot water use can be reduced by substituting a cold wash for every second hot wash and at one detergent supplier (Deosan) advocates this method. For a typical 50 bale shed this would produce an annual saving of \$680. The study notes that while this may suit some, there are others who will prefer to maintain their existing washing practice. For these, there are other opportunities to achieve this level of saving but at the expense of some capital investment.

The study found some dairy sheds equipped for night rate heating but shed managers not well-informed about the opportunity to save cost by restricting water heating to the night hours. The study showed that switching from an 'anytime' plan to a day/night pricing plan and heating most of the water at night could reduce annual energy costs for a 50 bale shed by \$2,000.

The success of a day/night system depends on shed staff knowing how it works and why it is important to avoid using electricity during the day. If staff are skilled at following a prescribed operating regime, it is likely that significant savings can be gained. If not, it is better to achieve efficiencies through capital expenditure on a heat recovery system such as the Mahana Blue heat pump.

The trial confirmed that the Mahana Blue heat pump can significantly reduce electricity consumption for water heating. At the heat pump trial site, the saving was 56% of total water heating costs and was worth \$1,800 per year. This gave a pay-back of 5.4 years on the capital cost.

In another trial, a DTS desuperheater system saved around 26% of total electricity consumed for water heating. The study concluded that this is a cost effective measure where farms use more than 350 litres of hot water per day but where capital expenditure is constrained.

Solar water heating was investigated and found to be uneconomic at current electricity prices - the capital cost was too high in relation to the saving made. The study also concluded that solar water heating is not yet a mature technology for the dairy sector, especially in Southland.

- Reduce the quantity of hot water used
- Reduce losses from hot water storage cylinders
- Use a lower cost energy source to heat the water
- Recover waste heat.



## Vacuum Pumping

Most Southland dairy farms use either a water ring type or a lobe blower type of vacuum pump. Selection of the pump type is influenced by a number of considerations including the initial cost, noise level and maintenance costs. The study found that the accumulated effect of using a variable speed drive and an efficient pump design can have a significant impact on the amount of electricity used for vacuum pumping and recommends this for all new sheds.

Speed controllers can also be easily fitted to existing pumps, although the payback period may exceed five years. At one of the trial sites electricity use for vacuum pumping was reduced by 56% after fitting a variable speed drive to a rotary vane pump. Variable speed drives provide the additional benefit of reducing dairy shed noise

- Reduce power required for pumping by fitting a variable speed drive
- Install pumps with greater efficiency than a common water ring type.



## Milk Cooling

Milk cooling systems provide the least opportunity for reducing energy cost with the main area for attention being the pre-cooler. While it is well worth ensuring maximum cooler efficiency eg through regular maintenance, it is not economic to incur significant capital expenditure doing so. A milk pump speed controller is likely to improve pre-cooling performance but the economics of a retrofit are marginal.

Insulating the milk vat also saves money but again the economics are marginal for retrofitting but should be considered for new installations.

Using chilled water to cool the milk doesn't reduce energy use but does make it possible to use night rate electricity. The resulting electricity cost saving is insufficient to make this an economic investment.

- Maximise the efficiency of the pre-cooler
- Insulate the milk vat (if this can be done for less than \$1,500)



# Decision Making

Investment decisions fall into three distinct areas

1. Vacuum pump and control
2. Hot water heating and electrical tariff selection
3. Milk cooling and chilling

They are best considered in the order shown as the first decision can be made independently of subsequent decisions.

## 1 Vacuum Pump and Variable Speed Control

1.1 *Is this a new installation or does an old pump need to be replaced?*

If yes, go to 1.2

Otherwise, go to 1.3

### 1.2 New pump

Check Table 1. Based on the number of bales, find the annual saving if using a lobe blower with variable speed drive. Multiply this by 5 to get the maximum extra investment with a simple 5 years payback.

Obtain quotes for a water ring pump and a lobe blower with variable speed drive. If the difference in cost between the water ring pump and the lobe blower is less than the 5-year savings, purchase one of these, otherwise the water ring pump is appropriate.

### 1.3 Variable Speed Drive Retrofit

1.3.1 If you have a lobe blower, the electrical load is already low and there is not much saving to be obtained by adding variable speed control. The price for a variable speed controller would have to be less than \$4000 for this to be economic.

1.3.2 For a water ring pump, use the following calculations.

$$\text{Power (fixed speed)} = \text{power rating of motor(s)} \times 0.9$$

$$\text{Power (variable speed)} = \text{number of bales} \times 0.13$$

$$\text{Power reduction} = \text{Power (fixed speed)} - \text{Power (variable speed)}$$

Calculate the annual power saving;

$$\text{Annual Saving} = \text{Power Reduction} \times \text{maximum number of hours of milking per day} \times 240 \times 0.14 \text{ \$/kWh.}$$

Note: The factor of 240 is based on our findings that the annual vacuum pump running hours were about 240 times the hours on a peak day.

Multiply this by 5 to get the maximum investment with a simple 5 year payback. If the cost of a variable speed system is less than this then it is worthwhile.

## 2 Water heating

### 2.1 Quick Savings:

To save hot water energy costs due to heat loss, lag any parts of the hot water system that are warm to touch and fix any hot water leaks. This could easily save up to \$500 per year with very little investment.

### 2.2 Investment in Energy Cost Savings

Also consider doing any one, but only one, of the following. These are ranked in order of capital expenditure, not savings:

- a) Change to night time hot water heat and day/night rate
- b) Change detergent to use more cold washes
- c) Add a desuperheater to heat water from the chiller condenser
- d) Add a heat pump to heat hot water, e.g., Mahana Blue
- e) Solar hot water heating

A decision tree for achieving affordable energy cost savings in Hot Water Heating follows.

Bales	Design flow rate [L/min]	Annual saving when using lobe blower with variable speed	Additional capital expenditure justified
20	1600	\$870	\$4,300
30	2400	\$1300	\$6,500
40	3200	\$1730	\$8,600
50	4000	\$2170	\$10,800
60	4800	\$2600	\$13,000

Table 1: Annual savings using a new lobe blower with variable speed drive as compared with a water ring pump

## Hot Water Decision Tree

	Question	Yes	No	Comment	10 year net value*
1	Have you insulated exposed pipework and fixed leaks?	Goto 2	Do this first	This is a relative cheap and easy gain.	
2	Can staff be relied on to follow heating restrictions?	Goto 3	Goto 5	Capital expenditure will be required if not.	
3	Is the full hot water cylinders sufficient to meet your hot water needs in a normal day?	Goto 4	Goto 5		
4	Change to night rate			No more cost effective measures available after this choice.	\$20,000
5	Are you capital constrained?	Goto 9	Goto 6		
6	Is your hot water usage greater than 600 litres/day	Goto 7	Goto 8		
7	Install a Mahana Blue		Goto 10	No more cost effect measures.	\$15,800
8	Is your hot water usage greater than 350 litres/day	Goto 9	Goto 10		
9	Install a desuperheater system		Goto 10	No more cost effect measures.	\$10,000
10	Investigate reduced frequency hot washing?		Goto 11	There are a range of factors to consider, including hygiene.	\$5,500
11	No hardware solution is cost effective			Look at improving your staff reliability to enable stage 4	

\* Because these options require different amounts of capital they are compared by calculating the value over 10 years of installing one. The calculation of net value takes into account energy savings, interest payments, depreciation and tax, and is made for a farm producing a peak of 15000 litres of milk per day and using 1200 litres of hot water.

### 3 Milk Chilling

If a chiller system is running efficiently the cost of running the system is not easily reduced.

#### 3.1 Pre-cooler

Each two degrees reduction of milk temperature out of the pre-cooler reduces chilling costs by \$240 per year on a farm producing 15000 l/day and justifies about \$1400 of investment.

Note that an efficiently operating pre-cooler should reduce milk temperature to within 3 degrees of the water temperature.

Greater investment is only justified if a shorter cooling time is required.

#### 3.2 Variable speed milk pump

The installation of a variable speed drive system on the milk pump can reduce the milk temperature from the pre-cooler by smoothing the milk flow. Use the calculation above to estimate investment limits.

#### 3.3 Heat Gain and Milk Vat Insulation

Milk vat insulation reduced heat gains (as opposed to energy usage) by milk vats by upto 80%. The annual saving is about \$300 which justifies an investment of about \$1500.

If milk chilling is satisfactory on calm, cloudy days but not on warm, sunny, windy days then heat gain into the vat is the likely problem. Vat insulation is probably the most cost effective solution.

## About the Project Partners

### Venture Southland

Venture Southland is a joint committee of the Invercargill City, Southland District and Gore District Councils with responsible for the regional tourism and economic development. In 2003 Venture Southland commissioned the Southland Regional Energy Assessment, which included a number of observations relating to the growth of energy demand from the dairy sector. With the rate of dairy farm conversions running ahead of forecasts, Energy Efficiency in Dairy Sheds was initiated as an immediate follow-up project. Funding was sought from several agencies, with \$270,000 provided by Dairy Insight and the Sustainable Farming Fund.

### Sustainable Farming Fund

The purpose of the Sustainable Farming Fund is to support projects that will contribute to improving the financial and environmental performance of the land-based productive sectors. It aims to help the land based sectors solve problems and take up opportunities to overcome barriers to economic, social and environmental viability.

SFF funding for Energy Efficiency in Dairy Sheds recognised the need to examine the drivers of milk quality and production costs at the point where they converge. It aimed to deliver a robust

examination of technologies with reference to both the operational cost of energy and its contribution to quality and productivity.

### Dairy Insight

Dairy InSight is the independent farmer-owned organisation responsible for making investments into dairy industry research, development, extension and education projects and activities. It funds and co-ordinates these industry-good activities to improve dairy farmer profitability and ensure the long-term success of the dairy industry.

### CAENZ

CAENZ is an independent think-tank and research facilitator with links to the University of Canterbury, Auckland University, and the engineering profession.

Established in 1987, CAENZ plays a strong integrating role within New Zealand's engineering and technology sectors, by building collaborative frameworks, advancing solutions and progressing knowledge. A key focus is the development of technology platforms for critical infrastructure and the built environment.

CAENZ is funded by grants and sponsorship, with additional revenue from educational activities, including conferences, symposia and international events.

## The Trial Farms

Farm	Cowshed	Cowshed Size	Herd Size (Cows)	Total Ha	Effective Ha
Coldstream	rotary	60 bale	800	349	323
Glencairn	rotary	50 bale	1380*	710	703
Graejo	herringbone	38 a side	720	225	225
Moorabool	herringbone	40 a side	600	216	208
Tussock Creek	rotary	50 bale	760	265	250

\* The Glencairn herd is milked in two sheds

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