Dairy farmers milk free energy

CASE STUDY

Key features

- Large scale solar water heating to reduce hot water bills
- Differing technologies to recover energy from milk vat chiller units, and
- Portable solar water heating units for share milkers

Key benefits

- Hot water bill savings of 50-76%
- Heat energy exchanged from the chiller can be used to heat water to 85°

The Energy Efficiency and Conservation Authority (EECA) has been working with dairy farmers and technical experts on four demonstration projects using a variety of solar water heating and waste heat recovery systems to reduce energy costs in the dairy shed.

Each year:

- 140,000 kWh of solar energy falls on the roof of a typical dairy shed[1]
- 24,000 kWh of heat energy is wasted to the atmosphere from a typical milk chiller[2]
- Many dairy sheds consume over 126,000 kWh[3] of electrical energy, of which up to 32% heats water and 21% cools milk
- Smart dairy farmers are cutting their electrical energy costs by milking the free energy in their dairy sheds… and it's good for the environment too!

Plenty of free energy, and plenty of ways to capture it

With all that free energy from the sun and the milk chiller, there are plenty of ways to capture and use it to the benefit of the farm bottom line, and of the country.

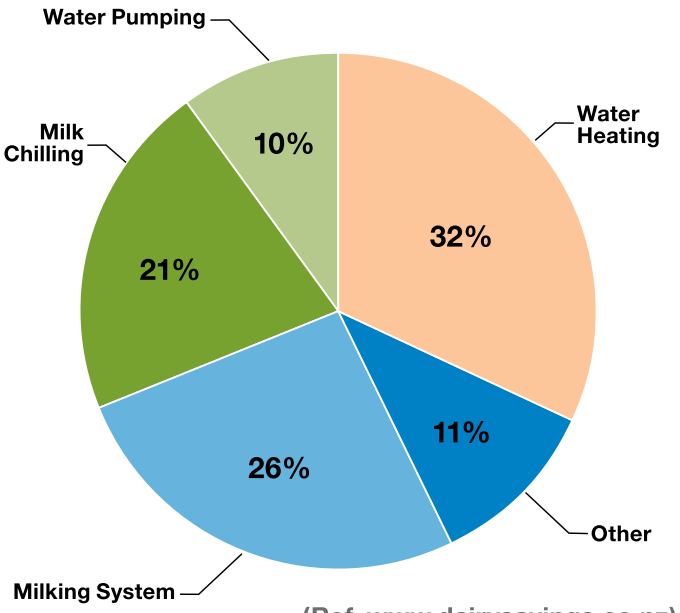
The projects are in various stages of assessment, but all are demonstrating proven or promising results.

The technical details of the individual projects are covered in the second half of this case study.

1. Assumes 100m² roof area. Utilises NIWA solar radiation data 1971-2000
2. Assumes chiller energy costs represent 21% of the annual dairy shed power bill, per Genesis Energy Dairy Savings website data
3. Based on an assumed average dairy farm annual power bill of $20,000 at $0.16 per kWh.

The projects aim to produce most of a dairy shed's hot water needs (32% of the farm power bill), by using free energy from the sun and waste heat from the chillers (21% of the farm power bill).

Energy Consumption on a Typical Dairy Farm



(Ref. www.dairysavings.co.nz)

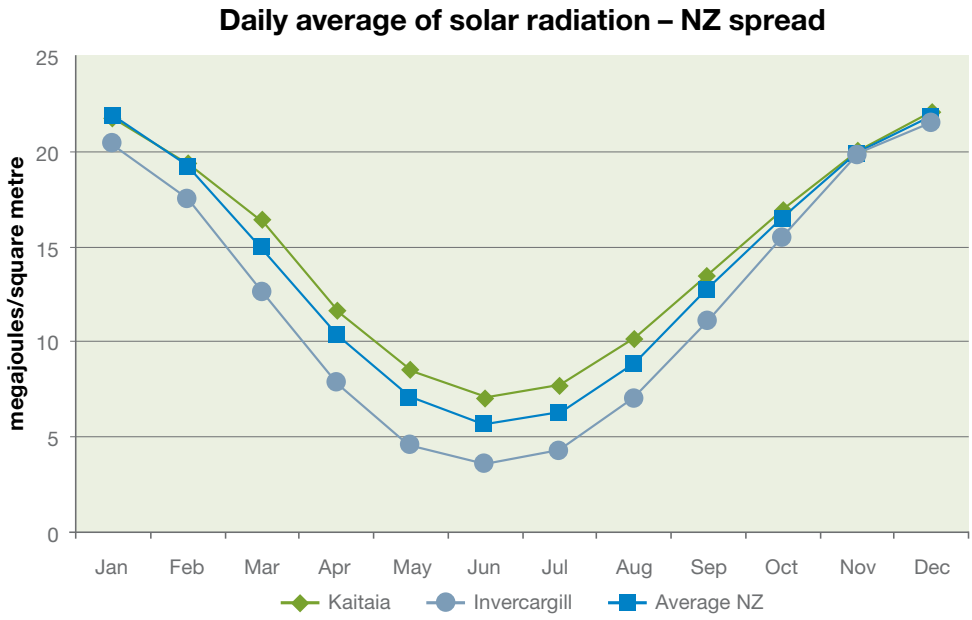
The opportunity for solar water heating in New Zealand is particularly good due to our high solar radiation levels. While there is some variation in the energy levels available between the top of the north island and the bottom of the south island, all parts of the country can use solar energy to produce hot water cost effectively.

The amount of solar energy available between summer and winter varies significantly, but the shoulder and peak radiation levels closely align with the shoulder and peak periods of seasonal milking. Over the period of a full year 140,000 kWh of solar energy falls on the roof of a typical dairy[4] shed, and a significant portion of that could be used to heat water at the times when it is needed most.

Another free energy source at the dairy shed is the heat present in the milk as it enters the vat. A vat containing 10,000 litres of 18°C, freshly extracted milk must have the chilling capacity to bring the temperature down to 7°C within three hours. If all that heat energy extracted by the chiller could be transferred 100% efficiently it could be used to heat 1250 litres of water to 85°C. However, in most dairy sheds, the chiller dissipates the heat energy to the atmosphere. An effective heat recovery system will transfer much of the milk's heat energy to stored hot water, and also improve the efficiency of the chiller unit.

The demonstration projects in this case study have applied off-the-shelf technologies in innovative ways to capture and use this free energy for heating water for the wash-down of milking equipment and vats.

4. Assumes a typical roof area of 100m^2.



Timing is everything, and storage is the solution

A key challenge encountered by each of the projects has been to design flexibility into their systems to allow for variability in milking times, tanker pick-up times, and wash-down times, to best use the free energy from the sun and chiller operation.

The solution has been to capture the free energy whenever it is available, and to store it in large capacity, highly insulated tanks until shortly before it is needed.

Some of the projects initially proposed using the existing dairy shed hot water cylinders as the primary storage location. However, those cylinders were typically being emptied and refilled twice a day giving insufficient time for full heat recovery from solar panels and, furthermore, they would lose heat overnight through poor insulation.

One of the demonstration projects was not getting the predicted level of savings following the initial installation and reported that:

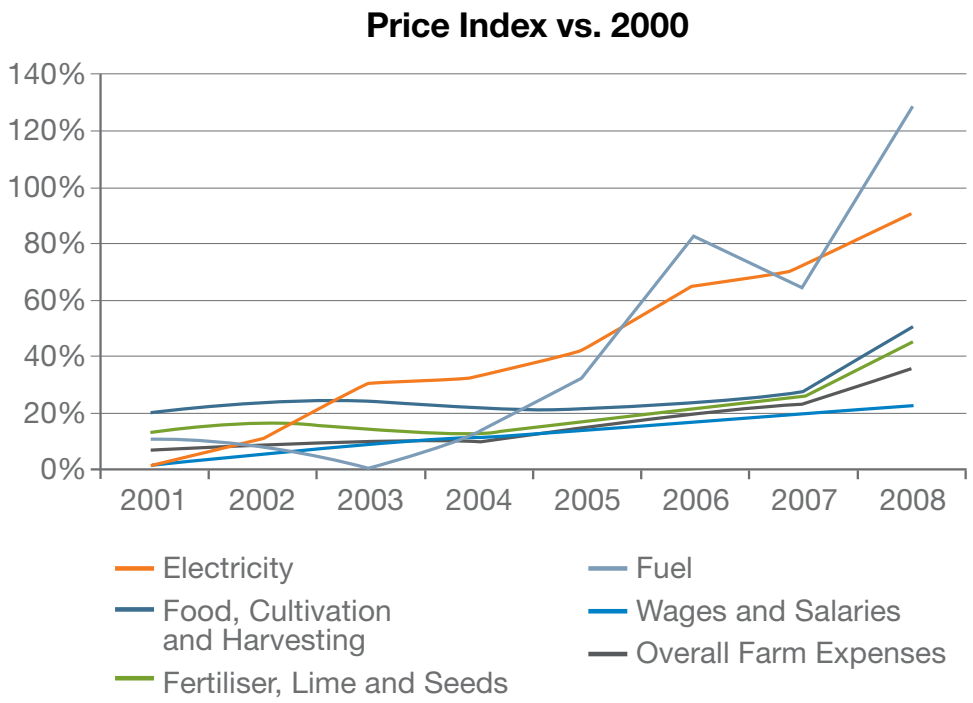
"After careful investigation we found that Fonterra had changed its method of milk pick-up and so instead of morning pick-ups we were getting afternoon pick-ups. This meant that the solar system was only getting a short period to operate (after the afternoon wash-down) before the top-up electrical system became active at night."

The solutions to these sorts of issues vary from project to project, but the common themes are:

1. Install thermal storage tanks (connected to the solar and/or waste heat recovery systems) with sufficient capacity for all of a day's wash-down requirements.
2. Use timers and/or smart controllers for electrical heating top-up control, and for releasing water from the storage tanks to the cylinders, and for topping up the storage tanks, to maximise efficiency.
3. Ensure the control settings can be adjusted to maximise efficiency around varying tanker pick-up and wash-down times.

One study has shown that existing hot water systems in dairy sheds are losing heat at 10 kWh per day. www.cowshed.org.nz

In a typical dairy shed the existing hot water cylinders are used twice a day, and have to refill and reheat between uses.



Doing what's right for the double bottom line

Electricity is one of the fastest rising costs in dairy farm operation. Dairy NZ reported in 2009, that fuel and electricity prices have increased by 130% and 90% respectively since 2000.

Upward pressure on energy costs looks likely to continue for the foreseeable future.

Fortunately, the early results from the EECA dairy shed projects are showing hot water bill savings of 50 – 76%. Returns on capital investment, based on current electricity prices, are predicted to be in the range of 3 – 7 years, depending on the size of the farm and use of hot water in the dairy shed.

As electricity prices rise, the returns on investment will be even better.

At a national level, the country's 12,000 dairy sheds have been estimated to draw 144 megawatts of power from the national grid, every daylight hour, during the milking season, just for water heating. That energy comes with considerable greenhouse gas emissions, that could be reduced by 50 – 76% if all dairy sheds took advantage of the large amounts of free energy available to them.

Demonstration projects

The four projects described in this case study have been designed so they can be replicated by dairy farmers throughout the country. However, the suitability of a given technical design or brand of equipment, and its likely performance in a given dairy shed situation, will have to be assessed by the prospective buyer. EECA's objective is to raise awareness in the dairy farming sector of the energy saving options available to it, but does not warrant or endorse any particular solution or brand described in these case studies.

Marlborough dairy farm goes solar

Project overview

The Havelock dairy farm was consuming 1200 litres of hot water a day supplied by old electric cylinders near the end of their lives. Hot water power bills were around $7,000 per year. The project was to install replacement cylinders connected to a solar array on the roof. After adding the extra storage tank to resolve problems arising from changing tanker pick-up times, and putting more controls on filling the cylinder, energy savings of 40 – 85% were being demonstrated on a daily basis depending on weather conditions.

Farm profile

Havelock dairy farm (Marlborough)

- 600 dairy cows
- Twice a day milking
- Existing hot water cylinder (450 litre, electric)

Technology added

- Flat plate solar water heating system (27m^2) manufactured by Ecogise
- Pre-heat storage tanks (2 x 450 litre, closed loop glycol coil to solar units, electric elements for top up)
- Smart controller

Project leader

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Further information

Further information is available on the EECA Business website; www.eecabusiness.govt.nz

Eureka moment on Taranaki farm

Project overview

This project captures the heat from the vat chiller unit that would ordinarily be wasted to the atmosphere. The refrigerant lines to a standard chiller system are interrupted prior to the external condenser and re-routed through the German made Eureka Permanent Transfer System. Close to 100% of the available condenser waste heat is recovered. The Eureka design ensures hot water of 50 – 60°C is available within minutes of the chiller running. The Eureka unit has a built-in 500 litre storage cylinder which, when used with timers and controllers to fill the existing dairy shed hot water cylinder, is showing hot water electricity savings of around 76%. Expected savings from improved chiller efficiency have not yet been measured, but are expected to provide an added bonus.

Farm profile

Okato dairy farm (New Plymouth)

- 200 dairy cows
- Twice a day milking
- Existing 4 hp chiller unit on the milk vat and 400 litre electric hot water cylinder

Technology added

- Refrigerant to hot water heat recovery conversion (Eureka Permanent Transfer Heating System)
- Pre-heat storage tanks (1 x 500 litre, integrated with the system)
- Smart controller

Project leader

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Further information

Further information is available on the EECA Business website; www.eecabusiness.govt.nz

Hauraki farm puts it all together

Project overview

In this project solar panels are used in conjunction with heat recovery from the chiller to heat water for wash-down. The high efficiency panels comfortably produce the target temperature of 85°C, and use smart controllers and pumps to protect from frost and to optimise the system efficiency. The waste heat recovery from the milk chiller uses a plate heat exchanger installed at the chiller unit, and water is heated by circulation pump flowing the water from the cylinder and through the heat exchanger. Again, efficiency is optimised through smart controllers and differential temperature control.

Farm profile

Waihi dairy farm (Coramandel)

- 400 dairy cows
- Twice a day milking
- Existing 9 hp chiller unit on the milk vat and 1 x 260 litre & 1 x 500 litre electric hot water cylinders

Technology added

- Azzuro Solar Evacuated Tube Panels (16m^2)
- Pre-heat storage tanks (1 x 700 litre)
- Flat plate heat exchanger to recover heat from the chiller
- Smart controller

Project leader

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Further information

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When a share milker pays the power bill

Project overview

Many dairy farmers are share milkers; they do not own the farms nor do they own much of the plant and equipment, yet they do pay the power bill. This project involved installing a 'portable' solar solution that share milkers could take from farm to farm and reap the rewards of lower power bills. The project has two solar units, each incorporating their own 300 litre storage tank. One tank is used to fill the dairy shed hot water cylinder for the morning wash, the other tank for the afternoon wash. Early indications from this small farm project are savings to the share milker of $20 per day at the tail end of the season. Further monitoring will be done across the entirety of next season, including the period of peak solar radiation. The project leader is also exploring a leasing model whereby the share milker would have the system installed with no upfront cost.

Farm profile

Ngahinapouri dairy farm (Waikato)

- 150 dairy cows
- Twice a day milking
- Existing hot water cylinder (1 x 300 litre, electric)

Technology added

- Relocatable Vacuum Tube Solar Water Heater x 2 (each incorporating 300 litre storage tanks)
- Smart controller

Project leader

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Further information

Further information is available on the EECA Business website; www.eecabusiness.govt.nz

EECA enables organisations to increase their domestic and international competitiveness by adopting energy efficiency and renewable energy practices.

We work with businesses to identify the opportunities for energy management that are available to them and help them develop energy management action plans to make the most of these opportunities.

Good energy management has many benefits for businesses, including lower costs, increased productivity, reduced greenhouse gas emissions and a positive effect on the brand.

We have a particular interest in:

- encouraging new or under-used technology that can make processes more efficient
- projects that reduce greenhouse gas emissions, and
- developing the wood fuel industry.

For more information, contact us directly – see details below.

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JUNE 2009