MACALISTER DEMONSTRATION FARM – THE SOLAR DAIRY

Information Sheet 13
October 2018

BACKGROUND

The MDF has been looking at energy issues in-depth since 2011 as part of an evaluation of the proposed carbon emissions reduction scheme (CPRS) and an investigation of emissions reduction strategies. At the time it was decided that the technology was too expensive, the pay-back period at over fifteen years at the then feed-in tariff rate was too long and at the calculated return on investment there were better projects on the farm to fund. We recommended a wait and see.

However, while the feed-in tariff rate has dropped to 36% of what it was in 2011, the cost of technology has also fallen dramatically. The project all came together when the Board of the MDF was approached by Rocky's Electrical in mid-2017 to develop a solar project to reduce energy costs at the dairy. Combined with the fall in capital costs, commercial operations are also now able to install large systems to meet their needs and feed surplus power back into the grid. The timing was now right to re-examine the prospect of a solar driven dairy.

THE CURRENT SYSTEM

At the MDF we milk twice each day (5.30-7.30am and 3.30-5.30pm), the chiller runs for about half an hour after each milking and milk is picked up in the morning or afternoon, alternating from one year to the next. One thousand litres of hot water (90°C) is heated for the twice daily plant wash and is feed by 400 litres of preheated water (55°C) supplied daily from the refrigeration heat extraction unit. Only 250 litres of hot water (65°C) is used to clean the vat. All hot water is heated at off-peak times.

The smart meter at the MDF enabled Rocky's to download (for free) and analyse the power usage at the dairy for every fifteen minutes of every day in the last year – you won't be surprised that each day was remarkably similar except for when many cows are dried off in May - August. You can see our energy consumption patterns in the graphs (Fig 1 & 2). About 115kWh (50%) of the dairy power is used to heat hot water, the remainder is split between the two milkings.

Fig 1: Daily power consumption over a week

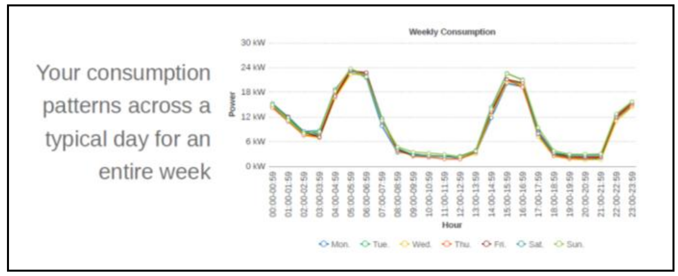
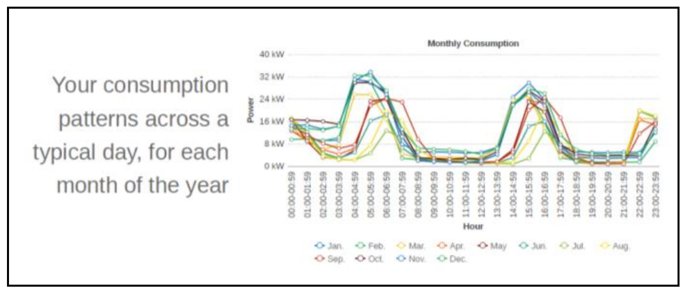


Fig 2: Daily power consumption over a year



THE BRIEF

We asked Rocky's to design a system to meet our particular needs:

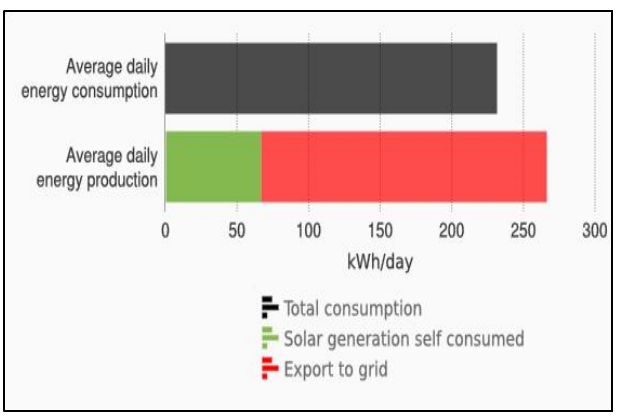
- Deliver a power bill for the dairy of $0 (or as close as possible) at the same time as reducing the carbon emissions generated by farm operations.
- Use high quality components to maximise efficiency and extend the effective life of the system to as long as possible.
- Construct the system as a ground mounted system – without a single large roof surface we didn't want panels on every roof surface facing every which way. More importantly, OH&S is paramount, so to enable safe cleaning we wanted the panels in easy reach and didn't want the added expense of guard rails on every rooftop. We were comfortable funding the extra cable costs from the old hayshed paddock as a trade off.
- Consider the installation of a battery system to maximise the use of our own power and to insure against power outages.

The result is a 61.38 kW solar system – that's 186 Jinko 330W solar panels with two ABB 27.6KW inverters - to generate 266kWh/day against our average daily usage of 231kWh/day. But why produce so much more than we need? If nothing changes in the way we manage our milk and the times we milk the cows we need to push enough energy back into the grid to draw on later, with a little extra to cover the difference in cost between off-peak power that we buy and the feed-in power that we sell and a little more again to cover the service charges on our bill. For the MDF that's a loading to produce about 15% more energy than we actually use to cover the extra expense.

So, what if we have a power outage during the day – can we use the solar system to run the afternoon milking? Without a battery system the answer is no – the system isolates itself for safety reasons and the power generated cannot be used.

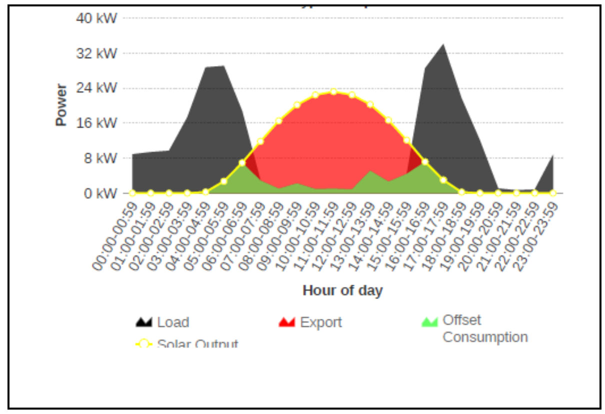
Unlike many businesses, energy consumption at the farm is at its lowest when solar energy is at its greatest. Total energy consumption is lowest in the months with the lowest solar radiation. On average across the year, 75% of the power generated by the system will be exported to the grid and only 25% of power used directly in farm operations (Fig 3). So, without a way to store energy, the grid is important in maintaining a consistent supply.

Fig 3: Solar power production to meet energy consumption



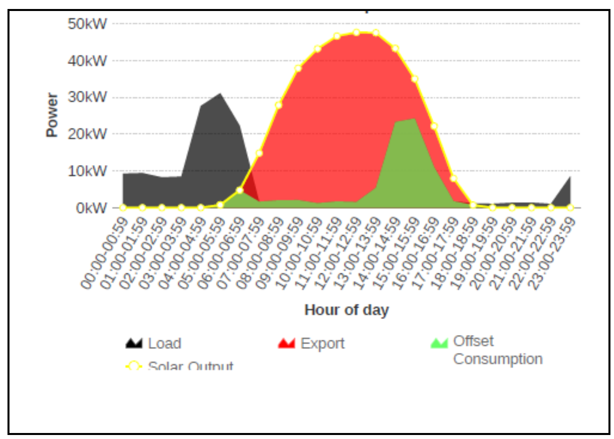
If we look at typical daily consumption averaged across the year (Fig 4) you can identify a load peak at about 11pm when the hot water system comes on and the two peaks for milking time load, a portion of which is met by the solar power system (green). Most of the power generated is sent back to the grid (red).

Fig 4: Power consumption/export of a typical day



In Fig 5 you can see that for this day in February, the peak production is higher than the typical day and most of the solar power generated is exported to the grid.

Fig 5: Power consumption/export on the best solar day

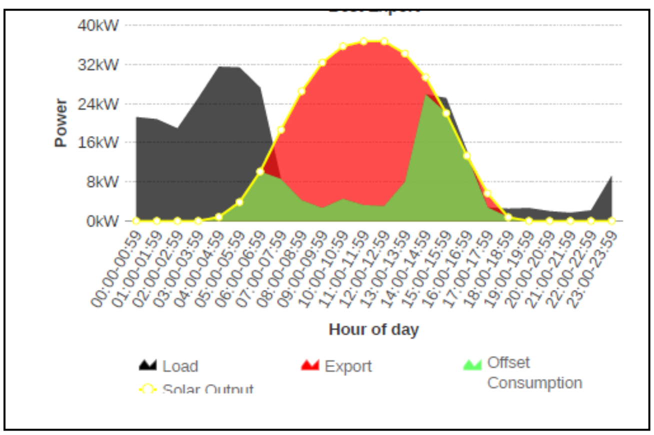


WHAT ABOUT A BATTERY SYSTEM?

With so much power generated and not used directly at the dairy we wondered about installing a battery system. Using the base design, Rocky's calculated how big a battery the MDF would need to store surplus power and secure the dairy against a power outage. The inclusion of a battery system – 81kWh of storage to meet total night time demand as well as to satisfy the drawing capacity of the milking plant and hot water element – jumped the price of the system by 180%, almost double, so a decision was made to proceed without the battery. This was on the basis the MDF has few unexpected interruptions to its power supply so a battery was not essential and that battery technology is still developing and we expect the price to fall within the next few years, making it a better investment. But importantly, the return on investment on a battery system is typically very low because the cost of off-peak power is not too different from the feed-in tariff, just a few cents/kWh, so there is little to be saved. Indeed, the development of microgrid trading within the power network has meant that we may be able to access a local power retailer who will take our surplus power at a premium feed-in tariff (higher than the cost of off-peak power) making it more lucrative to sell the surplus than to store it.

There are other ways to utilise the solar power than to store it in a battery. In Fig 6 you can see a large amount of power being used overnight leading up to the morning milking. What is it? It's an irrigation pump running on off-peak power - this is a hint for us to consider shifting the pump from night to day operation to maximise the use of our own power.

Fig 6: Power consumption/export on an unusual day



Any equipment that normally runs overnight (hot water and pumps) can be switched to daytime operation instead to use the surplus solar power.

Alternatively, more efficient systems can be installed to minimise power consumption. For example, modern heat pumps can be installed to run off the solar power to pre-heat water to 65°C. Heat pumps typically use about 30% of the energy of a hot water system with an element to reach the same temperature. The pre-heated water is then dumped into the high temperature hot water system to take it up to 90°C - that can happen using solar power too. But is this always the best way to go?

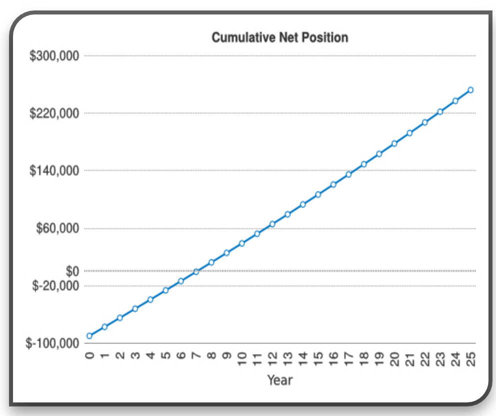
As a rule of thumb, when the feed-in tariff that the energy retailer pays to you is lower than the off-peak tariff you are charged then shift as much energy consumption to daytime as possible. On the other hand, if the feed-in tariff is higher than the off-peak tariff then sell the power to the grid and use the off-peak power to cover your needs, just as you do now. Either way, you are still producing all of the power you need to cover your own consumption and in many ways the design of this system uses the grid as its own battery.

PAYBACK AND FINANCE

As it has been designed, this investment has a payback period of around seven years. Our calculations have been made assuming a Peak Tariff at 22.1 c/kWh and Off-Peak at 11.7 c/kWh. In real terms, however, the pay-back period changes every time we have a rise in tariff and since we made these calculations power prices have risen by 4 and 2 c/kWh respectively, bringing the payback period down even further.

Using the calculated savings, you can see in Fig 7 that over the 25 years of the system lifetime the MDF will not just save on power costs but, assuming a comparable feed-in tariff remains in place, after seven years will generate an income stream. This investment generates a return on investment of nearly 14%.

Fig 7: Cumulative savings over system lifetime



The system was financed using a HP loan at a low fixed rate of interest but other, more tax-effective options and low capital options are available. Repayments were matched to the current power bill for the dairy so in terms of cashflow this investment will be cost neutral at worst. If the system outperforms the conservative predictions then we might even make some money in the short term!

LET'S GO!

Before construction started there was a pre-approval process to confirm that the local power network has the capacity to take up the power generated. This approval is given by the network operator and can take up to 60 working days (although usually 25-40 days). Some parts of the network don't have the capacity to take in large amounts of power so approval may be given for only limited feed-in, making this stage a very important part of the planning and system design.

Construction at the MDF commenced in late August 2018, with the ground-mounted panels being located behind the house in the old hayshed paddock, and the system was activated in early October.

Then came all of the safety testing and confirmation of a connection agreement with an energy retailer to confirm the purchase and rate for the feed-in power.

The functioning system is managed remotely by Rocky's, who receive alerts for faults or if the system is not working to expectation, and then they come and fix it. Meanwhile, we just plug in and enjoy the benefits of being directly connected to the sun!

The system will be monitored closely and regular reports will appear in the quarterly MDF Newsletter. As new elements are added to the system, or any changes in how we use power are made, we will report on these to you as well.