Australian Government
Department of Industry and Science

Dairy Australia
Your Levy at Work

Smarter energy use on Australian dairy farms

Feasibility of stand-alone renewable energy systems

Since 2012 almost 1,400 dairy shed energy assessments have been conducted in all dairy regions across Australia as part of the national Dairy Australia project *Smarter energy use on Australian dairy farms*, funded by the Department of Industry and Science as part of the Energy Efficiency Information Grants Program.

As part of this project, the Alternative Technology Association (ATA) was commissioned to undertake a feasibility study into stand-alone renewable energy systems for the dairy industry. This fact sheet summarises the outcomes from that study.

Can storage help the dairy industry?

With costs falling and take-up rising of solar and other renewable energy systems, businesses are increasingly interested in storing the energy they produce to maximise its benefit and reduce their bills.

Renewable energy's main challenge is that its use is restricted to when the renewable resource is available (e.g. when the sun shines or the wind blows). Storage allows more of that renewable energy to be retained so it can be used on-site at a later time – and further reduce electricity consumption from the mains power grid.

How does this work? What should a dairy business consider when thinking about installing renewable energy systems coupled with storage?

The value of storage for dairies

There are two main economic benefits of using storage in conjunction with renewable energy to reduce electricity bills.

Firstly, storage allows a business to purchase more of its electricity from the grid during cheaper off-peak times, or directly from an on-site solar PV system, and store it for later use during peak times – when the electricity tariff is higher. That means avoiding paying some or all of the higher peak charges.

Secondly, many large businesses like dairies are charged not only for the energy they consume (in kilowatt hours or kWh), but also for their 'demand' on the electricity network (in kilowatts [kW] or megawatts [MW]). The higher the power demand the business places on the network, the higher the demand charge will be. This is something that is typically charged on a monthly basis.

In this context, storage can also provide a portion of a dairy's peak demand – thereby lowering its demand from the electricity network and reducing its demand charge.

There is of course the separate environmental benefit that storage can allow more renewable energy to be utilised on-site, furthering lowering a dairy business' carbon footprint.

The key questions to ask regarding the economic benefits of energy storage are:

- Does the value of the avoided peak and demand charges outweigh the up-front and operational costs of installing storage in the first place?
- Can I get a reasonable return on investment from a storage project?

The economics of small scale storage

Storage costs are typically presented in dollars per kilowatt hour ($/kWh). Whilst somewhat useful, this metric is limited in comparing the relative costs and value to the end user of different battery chemistries. This is because different battery chemistries contain different properties with regards to 'useable' energy capacity.

In the same way that the end user is interested in the 'life-cycle' costs and value of demand-side energy technologies such as solar photovoltaic (PV), it is life-cycle costs and value that must be properly analysed when considering the utilisation of storage in either a hybrid (grid-connect) or off-grid scenario.

The relative costs and value of storage to the end user are a function of:

- capital cost
- any required maintenance costs
- the 'useable' energy capacity – largely determined by the optimal depth of discharge employed in ongoing operation
- the battery capacity at a given charge/discharge rate – known as the 'C-rate', and
- asset life (which is typically a function of the number of cycles at a given depth of discharge).

The discharge rate measures the time it takes to discharge a battery before it needs recharging. The capacity of some batteries (specifically lead acid-based technologies) is reduced if the battery is discharged over a shorter period (e.g. one hour).

The amp hour capacity is reduced as well as the amount of lifetime cycles. This is an important consideration for households or businesses who may wish to access the energy stored in a battery relatively quickly (e.g. a daytime or evening peak).

Newer lithium-based technologies do not suffer from these charge/discharge constraints in the same way – improving their effective operation.

Table 1 provides qualitative guidance as to the strengths and weaknesses of different battery chemistries in relation to the five properties listed.

Figure 1 The potential value of storage

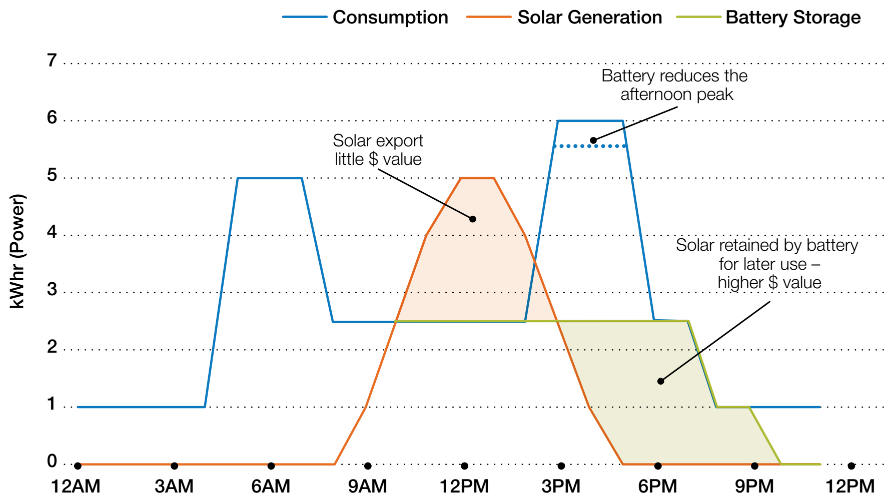

Table 1 Strengths and weaknesses of different battery chemistries

	Flooded Lead Acid	Gel	AGM	Lithium
Capital cost	Low	Medium	Medium	Medium–High
Maintenance costs	High	Low	Low	Very Low
Useable energy capacity	Low	Low–Medium	Low–Medium	High
Lifetime cycles at high DoD	Very Low	Low	Low	High
Capacity at high discharge rate	Low	Low	Low	High

Table 2 Relevant economics for comparing battery chemistries

	AGM/Gel	LiFePO4
Amp-hours	260	300
Voltage	12	3.2
kWh – 'Nameplate' capacity (per cycle)	3.12	0.96
Capital cost	$459	$540
Maintenance cost (per annum)	-	-
$/kWh – 'Nameplate' capacity	$147	$563
Cycles (10 years)	3650	3650
Recommended Depth of Discharge for 3650 Cycles (10 years)	15%	70%
kWh – 'Useable' Capacity (per Cycle)	0.468	0.67
$/kWh – 'Useable' Capacity	$981	$804
$/kWh/Cycle – 'Useable' Capacity, 10 year basis	$0.27	$0.22

A specific example of the correct economic valuation of two different battery chemistries is presented below – that of conventional lead acid (e.g. absorbed glass mat [AGM] or sealed gel) versus lithium-iron phosphate (LiFePO4).

These numbers are indicative only and it should be noted they do not take account of the additional potential charge/discharge constraint on the conventional lead-acid batteries (Table 2).

An important economic factor when thinking about storage is whether renewable energy is already installed. If it is, then this may reduce the cost of any new storage project by 10%–30%.

Electricity consumption and tariffs

In most parts of Australia, the total amount of electricity consumed by a business has a significant impact on the types of electricity tariffs the business is charged.

Medium-sized businesses that consume up to about 100 megawatt hours (MWh) of electricity per year[1] are typically charged for peak and off-peak (and sometimes 'shoulder') energy, with the bills being 'bundled' into these tariff arrangements.

The tariffs paid by medium-sized businesses resemble more closely the tariffs paid by residential customers. In addition, they are not usually charged for the peak demand (i.e. per kW or MW) they place on the electricity network.

The electricity bills of large businesses that consume hundreds or thousands of MWh per year are typically 'unbundled' – meaning they pay for each part of the electricity supply chain separately. This can include charges for peak and off-peak use, as well as network charges, retailer charges, Renewable Energy Target charges, market fees and most importantly, a separate demand charge.

Energy storage offers large businesses the potential to avoid both peak and demand charges. Larger dairies are therefore more likely to achieve a cost-effective storage project than medium dairies.

Case studies

To try and understand whether storage may be economically viable for the dairy industry in Australia, ATA analysed the electricity bills of two specific dairies in different parts of Australia and modelled the energy flows and economics of different solar-battery system sizes.

One (Dairy A) was a medium-sized electricity customer whilst the other (Dairy B) was a large customer. In carrying out the modelling, ATA used its in-house solar simulation model called the 'Sunulator' – a powerful economic analysis tool for grid-connected solar-battery systems.

Sunulator estimates solar generation at a specific location drawing on 19 years (1991–2010) of solar irradiance data from the Bureau of Meteorology. This dataset exists across five-kilometre grids for all of Australia.

Economic and energy results are based on netting off generation versus consumption data, specific to that location and user profile, for each 30 minute interval over a full year. This takes account of climate variability and gives the most accurate picture of how much solar generation will be consumed on-site (and when); versus how much will be stored and discharged from the batteries (and when); versus exported.

Based on electricity tariff information, Sunulator calculates the impact on a consumer's electricity bills (annually) and projects the savings over a 30-year time frame. Financial results include simple and discounted payback, net present value and project internal rate of return.

Dairy A – medium-sized electricity consumer

Dairy A was located in a decent part of Australia with regard to solar radiation and consumed just less than 100MWh per year. Due to its consumption, Dairy A's bill was 'bundled' – i.e. it paid one specific tariff for peak energy; and a separate (and lower) tariff for off-peak energy. Dairy A did not pay a demand (i.e. per kW) charge.

The difference between Dairy A's peak and off-peak tariff was only about 6 cents per kWh. This is not large enough to allow the upfront investment in solar and batteries to be re-couped within 20 years.

Dairy B – large electricity consumer

Dairy B was a larger energy customer – consuming almost 1,000 MWh per year and situated in a good part of Australia for solar radiation. Given its size, the business' electricity bills were 'unbundled', with the overall tariffs and charges in Table 3.

ATA modelled a solar-battery system designed to allow Dairy B to purchase and store more of its electricity at off-peak times, as well as charging the batteries directly from a solar PV system. ATA assumed that the

Table 3 Electricity tariffs, Dairy B

	$	Unit
Peak energy	0.16	$/kWh
Off-peak energy	0.04	$/kWh
Demand Charge	18.33	$/kW
Fixed (Supply) Charge	$50	per month

Table 4 Modelled inputs and outputs, Dairy B

	Size	Unit	$	Comments
Solar PV	99	kW	-	50% system East facing; 50% west – to maximise morning and late afternoon generation. North facing, 30 degree tilt. 80% panel to socket efficiency.
Lithium (LiFeP04) batteries	200	kWh	150,000	Useable energy storage. Charging efficiency 95%. Discharging efficiency 95%. Maximum state of charge 98%. Replace in 15 years. Includes Balance of System costs.
Discount rate	10	%		Potential value of capital investment to Dairy B.
Annual electricity bill			134,000	Before the solar + batteries were installed.
Annual bill saving			17,500	

1 In Victoria, this threshold is 160 MWh per annum.

solar PV system had already been installed at Dairy B. The system size, configuration and costs modelled in Table 4.

As can be seen, Dairy B needed to spend in the order of $150,000 upfront to install the batteries and related components. (This cost estimate took into account the latest price estimates announced by Tesla in May, 2015, but should be noted are not currently available in Australia).

The potential bill savings per year were just under $20,000. Discounted at 7%, this means that Dairy B would get its capital investment back in around 14 years.

The challenge with storage however is the lifetime of the batteries themselves. Most conventional battery technologies, including lithium, cannot be assumed to last much longer than 10 years. It is possible to make them last a few years longer if they are not cycled deeply during their working life.

The challenge for Dairy B (and any dairy) is therefore whether they can achieve full payback of the money invested before it becomes time to replace the batteries, inverters and related system components.

Given the current costs of energy storage, it is unlikely that many dairies across Australia would be able to achieve an attractive economic return on a renewable energy/storage project in 2015.

However just as solar technology costs fell rapidly from about 2008, storage costs are predicted to decline significantly over the coming decade – with some technology analysts forecasting that prices will fall by 50% by 2020 and 70% by 2025.

Should these cost reductions materialise, it will be worth re-visiting the value of storage for dairy and other businesses in the coming years.

Where to from here?

Unfortunately, given the complexity of renewable energy and storage technology, there is no easy or quick way to answer the question of "how much storage do I need at my site and what will it cost?"

The only way to properly answer this question, which maximises the chance of implementing a cost-effective project at any given site, is to undertake a feasibility analysis – taking into account that site's specific consumption patterns, electricity tariffs and solar resource.

Please note:
That both renewable energy and storage technologies continue to evolve – with storage prices predicted to drop dramatically in the coming decade. Make sure you consult an expert about your individual business to see whether renewables and storage is a viable option for your farm.

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