Dairy Australia

Solar PV ready reckoner

Solar PV is globally recognised as the cheapest way to generate electricity and is shown to reduce electricity bills and provide a reasonable return on investment.

Dairy shed solar PV

How much should I spend on solar photovoltaic (PV) installation?

Quick answer: Approximately twice your annual energy bill, but ensure you also invest in changes to move your energy consumption to the middle of the day (for example, using timers for hot water).

Long answer: look at your hot water consumption and other energy loads that can be moved to match the solar PV production and size accordingly, further guidance below. Engage with an installer that has been around for a long time.

A solar system is made up of solar panels which create the electricity in Direct Current (DC) form and an inverter which converts the DC electricity into Alternating Current (AC) and synchronises the output with the grid and for usage on-farm. A typical configuration is to have the inverter sized at 75% of the capacity of the solar panels. A "40kW system" will typically have 40kW of panels with 30kW of inverter capacity.

As of December 2022, more than 50% of dairy farms in Australia have solar PV systems with most installing a system with around 30 kilowatts (kW) of export capacity (inverter capacity) with a 3 phase connection.

Solar PV is increasingly being used for irrigation which is covered separately in **Solar irrigation**.

Numerous dairy sites have reported they are not achieving the expected return on investment for solar PV, most often due to having installed a system which is too large to utilise the electrical production on-site or due to export limitations (5kW for single phase, 30kW for 3 phase).

Morning and afternoon milking means that dairy shed energy demand does not match solar PV generation profiles. So, to use the electricity produced, thermal storage can be utilised. A dairy shed that uses 900 litres of 82°C water each day requires around 80 kilowatt-hours (kWh) of electricity when using resistance heating (or less than 30kWh when using a heat pump). A 30kW solar PV installation will produce on average 110kWh of solar electricity per day in southern Victoria (about 50% more than this summer and 50% less in winter). This is an ideal match for heating 900 litres of hot water using resistance heater which can be timed to maximise utilisation of your solar PV production. Excess electricity can be sold to the grid or stored in a battery (see **Batteries for dairy farms** for more information).

There are lots of resources on the internet for advice on solar PV installations. For the basics, we recommend watching these videos on YouTube.

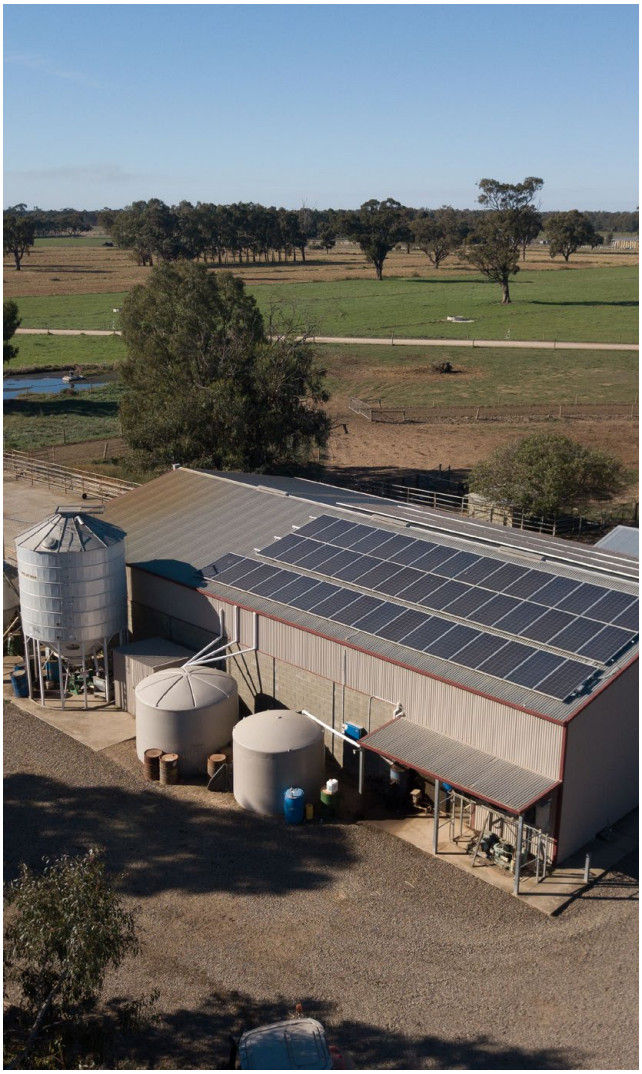
Solar Basics: Introduction from Finn, 3 minutes

Solar 101, A beginners guide to buying solar, 2022, 24 minutes

Simon McKay – Going solar on farm by Dairy Australia, 3 minutes

Quick tips for dairy solar installation for a typical 2 ML per year dairy

- In Victoria, a 40kW system (i.e., 30kW of inverter capacity with 40kW of panels) is often an easy choice as it avoids around $12,000 of network protection costs that are required for systems with an inverter larger than 30kW.
- The ideal configuration for a dairy shed is half the panels facing east, half facing west to increase the likelihood of producing electricity when the dairy shed is operating.
- To ensure long term, maintenance free solar production the panels should ideally be mounted at an angle of more than 110 degree angle so that a self cleaning effect during rain occurs.
- If there is any chance of shading of any panels, then it is advisable you have optimisers installed on each panel if using a string inverter or using a system with micro-inverters.



Simple steps for solar PV sizing

In general, hot water heating will be the main consumer of the solar generation and ideally the chiller operation as well if you have cold **thermal storage** (such as an ice bank or chilled glycol storage system). Care should be taken to put the right controls in place when moving hot water production from a night-time, off-peak tariff to the daytime using solar PV. Part of the solar PV load will be consumed in general shed operation (for pumps, chillers, etc.) but the hot water usage will drive most of the consumption.

Step 1 How much energy do you need for hot water?

Use Table 1 below to determine the amount of energy used.

Table 1 Annual energy consumption – kilowatt-hours (kWh) and cost ($) for water heating

Water used per day	Resistance heating		Heat recovery + resistance		Low-temperature heat pump + resistance boost		High-temperature heat pump	
Litres	kWh/year	Cost ($)	kWh/year	Cost ($)	kWh/year	Cost ($)	kWh/year	Cost ($)
300	9,800	$2,450	5,900	$1,475	4,900	$1,225	3,300	$825
600	19,600	$4,900	11,800	$2,950	9,800	$2,450	6,500	$1,625
900	29,400	$7,350	17,600	$4,400	14,700	$3,675	9,800	$2,450
1200	39,200	$9,800	23,500	$5,875	19,600	$4,900	13,100	$3,275
1500	49,000	$12,250	29,400	$7,350	24,500	$6,125	16,300	$4,075
1800	58,800	$14,700	35,300	$8,825	29,400	$7,350	19,600	$4,900
2100	68,600	$17,150	41,100	$10,275	34,300	$8,575	22,900	$5,725
2400	78,400	$19,600	47,000	$11,750	39,200	$9,800	26,100	$6,525

Assumptions: heating water from 15 °C to 82 °C and 15% heat losses per 24 hours.

Notes:

A $10,000 to $15,000 investment in heating efficiency will reduce the required size of solar PV installation by a similar amount, therefore optimising overall investment. This will also give the lowest overall electricity demand and reduce electricity costs on overcast days when the solar system is producing very little.

Step 2 Determine how much electricity is possible from a solar panel system.

You can roughly determine your system's annual generation by multiplying the installed panel capacity (in kilowatts) by 1.5 or 1.6. So, a 30kW system (22.5kW inverter and 30kW of panels) will generate 45-48 MWh/year. Note, this output varies according to location, panel orientation, ambient temperatures and amount of shading.

Table 2 Solar PV output – approximately average annual output in kilowatt-hours

	Annual solar PV system generation (in kWh)			
Solar PV system size	**Southern Victoria**	**Northern Victoria**	**Greater Sydney**	**Southern Queensland**
10kW	13,400	16,800	14,200	15,300
15kW	20,100	25,100	21,400	23,000
20kW	26,900	33,500	28,500	30,700
30kW	40,300	50,300	42,700	46,000
40kW	53,700	67,000	56,900	61,300
50kW	67,200	83,800	71,200	76,700

Assumptions: Panels are north-facing, with no shading. Expect a 15% reduction if facing east and 5% reduction if facing west.

Notes: In the above table 'size' is the inverter size and assumes the inverter is 75% the capacity of the panels.

Step 3 Match your needs for hot water with the solar panel output plus some extra for other shed loads.

Using Tables 1 and 2 you can estimate how much solar production will be utilised by hot water production and size the solar PV system so that you get at least 50% direct utilisation of the production (compared to most household solar PV systems which only achieve 30% direct utilisation). Putting these two together gives the following recommendation:

Table 3 Recommended solar PV system size vs hot water used and hot water system type

	Recommended solar PV system size		
Volume of hot water used per day	**With resistance hot water**	**With heat recovery or a heat pump**	**If able to utilise cold storage**
<500 L	10–15kW	10kW	Add 10kW
500–1,000 L	20–30kW	15–20kW	Add 10kW
1,000–2,000 L	30–50kW	20–30kW	Add 15–20kW
>2,000 L	>50kW	>30kW	Add >30kW

The above sizing recommendation with 50% of panels facing east, 50% facing west is an approximate 'ready reckoner' and should help you achieve greater than 50% on-site solar utilisation on average. Each site will have its own unique circumstances which needs consideration, for examplethe amount of shading and the direction of panels.

If you intend to start using electric vehicles, then go for a larger system.

A **solar irrigation** system will be much larger and need its own assessment.

If you need better energy reliability and intend to install a battery, then a larger system will be required. Before spending $30,000 to $50,000 on a battery, it's recommended you invest $3,000 to $5,000 on an energy audit to assess the benefits of a battery and properly size the battery system. **A detailed assessment should be made if you are sizing a system to go 'off-grid'**.

General tips when buying solar PV systems

1 Due to the mismatch of solar PV production and the dairy shed electrical demand, solar PV on its own is not ideal and will yield low utilisation and ROI. However, when matched with strategies that utilise the solar PV production such as hot water storage or water pumping then it is typically a good investment.

2 Do some basic research at sites like solarquotes.com.au so you understand the terminology.

3 Get multiple quotes. Expect to pay around $1,350 per kilowatt of installed capacity after government rebates. For a 30kW system, expect to pay around $40,000 after government rebates.

4 Select an installer who is experienced with solar PV for dairy farms and willing to visit your site to make a proper installation assessment that considers aspects such as mounting options, roof structure, etc.

5 Go for a 'Tier 1' inverter (e.g., Fronius or SMA) to ensure high quality components as this is the most complex part of the system. Also, be sure to install the inverter in a protected but ventilated area away from direct sun light or rain.

6 Check the warranty coverage in the quote. You should expect 10 years for the inverter, 12 years for the solar panels and five years for the workmanship.

7 Ground-mounted systems are not compatible with cow herds given their enjoyment of scratching on the edges of the panels. If you are planning a ground-mounted system where cows will be grazing then the mounting needs to be high enough to stop cows scratching on the panels and strong enough to withstand their rubbing on the support structure.

8 If you use more than 1,500 litres of hot water per day, consider installing a heat pump or heat recovery first so that your solar is below 40kW (max 30kW inverter).

9 Ask about smart phone apps available that connect to the inverter so you can view the solar PV performance and some also allow for checking the performance of the solar system.

Tips for getting the most from your solar PV system

1 Ensure your hot water system is coming on during the day to utilise the solar generation and that you have enough hot water storage for the morning and afternoon washdowns.

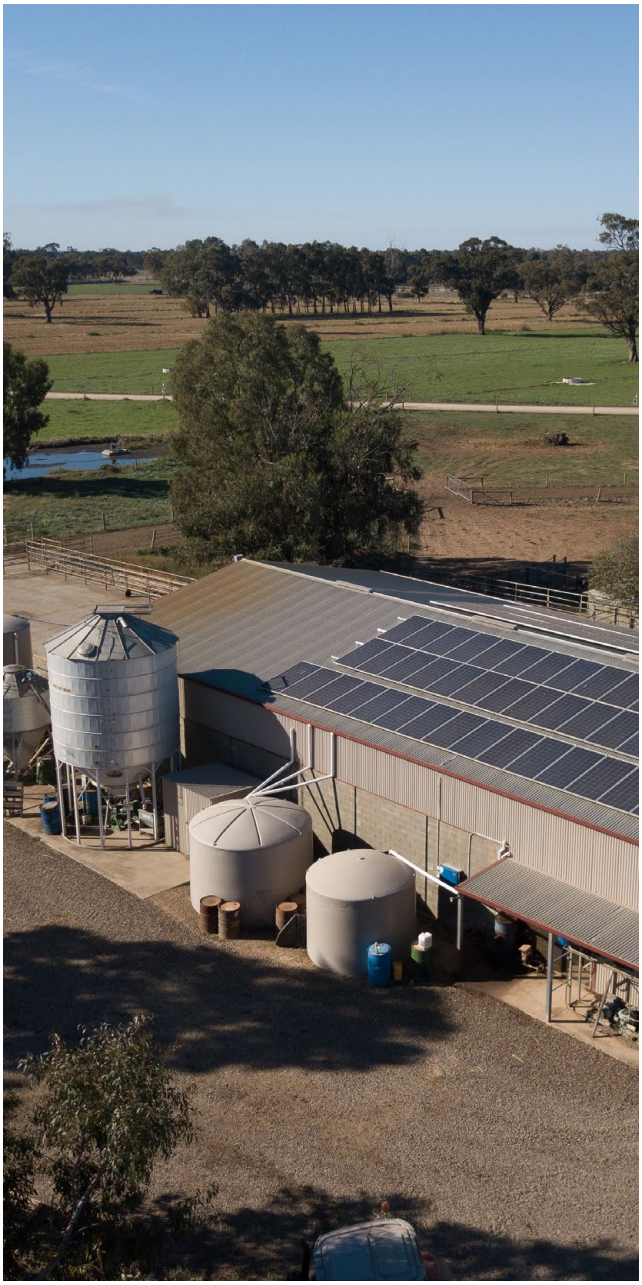
2 Systems such as Combined Energy's PV controller, Solahart's Powerstore or power diverters such as Paladin or Catch can help maximise the utilisation of solar PV production.

3 Before the installer leaves site, ensure you get the inverter app set up and working on your smart phone so you can check the solar production.

4 Check the system - installation mistakes are common but hard to find. On a clear summer day, check the inverter app to ensure you are getting the expected production. A system with a 30kW inverter and 40kW of panels should be producing 30kW of electricity in the middle of a clear sunny day.

5 Virtual power plant – if you are operating different electricity meters on the one site under a single ABN it may be possible to operate a virtual power plant to share solar PV production from one meter to another to get greatest direct utilisation of your solar generation so you can avoid importing electricity at some of the most expensive time of the day. It is expected that will become widely available from 2023.

Dairy Australia's publication '**Saving energy on dairy farms**' has further information on selecting solar suppliers and options to consider.



Sources:

For solar PV output:

sustainability.vic.gov.au/energy-efficiency-and-reducing-emissions/save-energy-in-the-home/solar-power

canstarblue.com.au/solar/solar-panel-energy-output/

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