Booklet 2: ATA info series

SOLAR ELECTRICITY

PLAN YOUR OWN SOLAR ELECTRICITY SYSTEM

- Choosing the right solar panel
- Adding batteries for energy storage
- Sizing and siting, installation and maintenance
- Rebates and feed-in tariffs

Published by the Alternative Technology Association

Make it. Store it. Manage it.
You've got the power.

The Enphase Home Energy Solution lets you generate, store, and manage your home's energy so that you can save money, become more energy independent, and help better the planet.

Enphase. The leader in solar innovation.
Find an Enphase installer enphase.com/au/installers

ENPHASE.

Solar Electricity Booklet 6th edition is published by
the Alternative Technology Association (ATA)

ISBN: 978-0-6481495-1-4

Alternative Technology Association

The Alternative Technology Association (ATA) is a not-for-profit organisation which has been promoting renewable energy, sustainable building and water conservation since 1980.

Level 1, 39 Little Collins St
Melbourne VIC 3000, Australia
Ph: (03) 9639 1500 Fax: (03) 9639 5814
Email: ata@ata.org.au
Website: www.ata.org.au

Reg No: A0017411T ABN: 57 533 056 318

Acknowledgements:

Several sections of Chapter 2 and the checklist on p. 61 are based on an article by Stephen Ingrouille, Principal of Going Solar Pty Ltd, first published in *ReNew 122*, titled 'Selecting PV panels in a buyers market'.

Top tips from a PV customer on p. 70 is based on an article by Aaron Hodgson, first published in *ReNew 14*.

Chapter 7 is based on an article by Richard Keech, first published in ReNew 120, titled 'Solar PV and the meter box equation'.

Images: Nick Stephenson p. 4, Natural Solar p. 31, p. 14 Off Grid Energy Australia, Jo Thomas p. 54

ATA PUBLICATIONS

ATA

positronic solar

Supplying quality on and off grid systems for over 25 years

Fronius

solarbatt

WINAICO
Approved Retailer

AUSTRALIAN SOLAR COUNCIL MASTER INSTALLER

ENPHASE.

Enphase Premium Installer

2/214 Leitchs Rd, Brendale Queensland Phone 07 3103 6018

www.positronicsolar.com www.facebook.com/positronicsolar

Licensed Electrical Contractor, Qld 67067 NSW 16693C CEC Accredited Designer and Installer of on and off grid systems

Contents

Introduction

When solar cells first became available in the 1960s, a cell providing one watt of power cost around $8000. At that rate, a panel with barely enough power to run a dim light globe would have cost over $300,000!

Things have changed, of course. With current prices at around $1 to $2 per watt, a typical 3kW system that can generate enough energy to offset the consumption of a whole energy-efficient house now costs around $4000 to $5000.

Although incentives such as feed-in tariffs are generally lower than they used to be, and rebates have been removed, the steadily decreasing cost of solar photovoltaic (PV) panels combined with the steadily increasing cost of mains electricity means that it still makes excellent financial sense to install a solar power system at home. A solar electricity system can completely offset your electricity use, and a larger system on an energy efficient home can possibly earn you a credit on your electricity bill.

Even better, this electricity source is clean and renewable.

Think about energy efficiency

How big a system you need and how much it costs depends on how much energy your house consumes. You can reduce the cost of the system you need and maximise its potential to be truly carbon neutral if you first undertake an energy audit and reduce your energy consumption as much as possible.

The investment of a few hundred or even a couple of thousand dollars on making your home more energy efficient will usually pay for

Energy Independence with the off-grid experts

1300 334 839

www.offgridenergy.com.au

info@offgridenergy.com.au

off-gridenergy AUSTRALIA

victron energy

BAE

BYD

selectronic

LG Chem

POWERWALL

itself in energy savings faster than the same investment in solar PV, and you could then buy a smaller, cheaper system.

A bigger system can have better returns for households, though, even those that don't use much electricity, especially when feed-in tariffs and electricity prices are high.

We look at energy auditing and system sizing in Chapter 5.

Financial and environmental benefits

With the current low cost of solar panels, grid-interactive systems now usually pay for themselves between 3 and 10 years. Over time they will repay the initial investment many times over when compared with the cost you would have incurred buying electricity from the grid.

With feed-in tariffs generally lower than the rate paid for electricity from the grid, there's better value using the solar electricity on-site to run appliances rather than exporting it to the grid. This is why some households are moving to hybrid systems with batteries, so that stored solar electricity can run appliances at any time of the day. Solar electricity exported to the grid can still offer excellent returns though, given that feed-in tariffs in some states have increased.

Many people are more focused on the environmental rather than financial benefits when choosing to install a solar system. Solar panels do not create any greenhouse gases when generating electricity, unlike fossil-fuel power plants. Numerous studies have also demonstrated that within its first two to four years of operation, a solar panel generates electricity equivalent to that used in its production, depending on the panel. Hence, a solar panel repays its embodied energy 'debt' within this time. This is significant in the context of a panel typically generating electricity for at least 25 to 30 years.

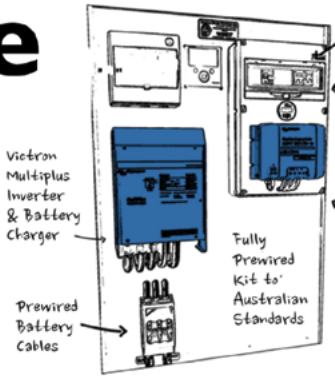
More information

How Green is my Solar, ReNew 135

What is the energy payback for PV?
http://bit.ly/1lWjuZ4

Off the Grid? No Worries

Check our website or call us for a quote.



Power your off grid house, shed, or cabin with our pre-wired solar kits.

Includes Batteries, Panels and pre-wired electronics shipped direct to you for easy installation.

rpc.com.au

02 6689 1430

RAINBOW POWER COMPANY

Even switched on households need the latest advice.

ARE YOU

- ☑ *Going solar?*
- ☑ *Adding batteries or going off-grid?*
- ☑ *Transitioning to an all-electric home?*
- ☑ *Looking for help lowering your bills?*

An ATA Energy Consult can help you

Purchase your 1-hour consult today with an ATA independent expert. Consults are conducted in-person, via phone or Skype.

www.ata.org.au/ata-energy-consult

or call 03 9639 1500

The Alternative Technology Association (ATA) is a not-for-profit organisation that provides independent advice on sustainable solutions for your home.

#1 Choosing a system

There are three main types of solar electricity system to choose from: grid-interactive, hybrid solar and stand-alone power systems. Which one is right for your household?

Households need to choose the right system for their current needs, and think about how it can be adapted to include new technologies in years to come. The most popular option has been to supplement grid power and reduce electricity bills with a grid-interactive system, however hybrid systems that include batteries to store solar electricity are gaining appeal. The price of home energy storage is expected to drop further in the next few years with technology breakthroughs and improvements to battery chemistries, meaning solar households should be 'battery-ready'.

Grid-interactive systems

Most solar customers choose a grid-interactive system, also known as a grid-connect system. Any electricity produced by the solar PV system but not needed by the house at the time it is produced is simply fed into the mains grid. The home can still, of course, draw electricity from the grid when insufficient electricity is being generated by the solar panels. Note that in some areas, the energy utility may place a limit on how much you can export, or even prevent it altogether.

Grid-interactive systems have two main components, the solar

panel array and a grid-interactive inverter, connecting into the household's switchboard and electricity meter.

Grid-interactive advantages

- Easy to operate and low-maintenance
- Most cost-effective option
- Electricity companies pay consumers for the surplus energy fed back into the grid via a feed-in tariff.

Grid-interactive drawbacks

- Grid-interactive systems will not work during a power blackout. Grid-interactive solar inverters will shut down for safety reasons if the grid fails to prevent electricity from being fed back into the grid during maintenance
- Solar feed-in tariffs can vary depending on which state you live in and which electricity supplier you use and are subject to change.

Hybrid systems

Hybrid solar is a typical grid-interactive PV system with the addition of batteries and is the most rapidly developing system that we cover in this booklet. Solar

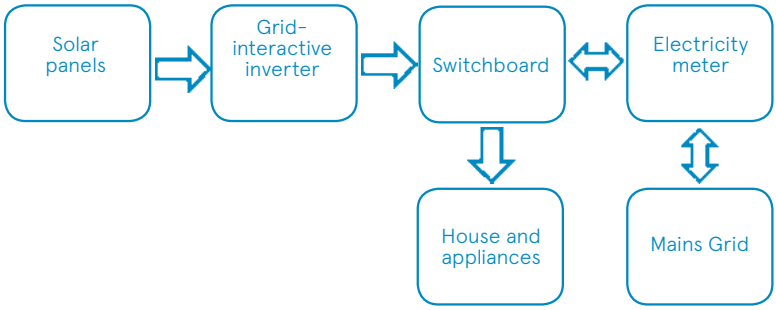


Figure 1.
Grid-interactive systems have two main components, the solar panel array and a grid-interactive inverter, connecting into the household's switchboard and electricity meter.

electricity generated during the day can be stored in the battery for later use, such as in the evening when electricity tariffs are higher. Combining a battery with a grid-interactive system provides much more autonomy from the mains grid and allows you to charge your batteries on low-cost off-peak tariffs.

There are two methods of 'coupling' generation sources to the battery bank—AC and DC coupling. Just like an inverter converts the DC electricity from solar panels into appliance-friendly AC, batteries also need an inverter to render their stored energy useable. If the batteries are DC-coupled, they can share the inverter with the solar panels, while if they are AC-coupled, they'll require a separate inverter of their own (it may be built into the battery, in which case the battery is known as an "AC battery").

An AC-coupled storage system is connected to the AC side of a solar PV system's inverter, much like any grid-connected appliance. Depending on the specifics of the system, they can store energy from solar generation as well as the grid.

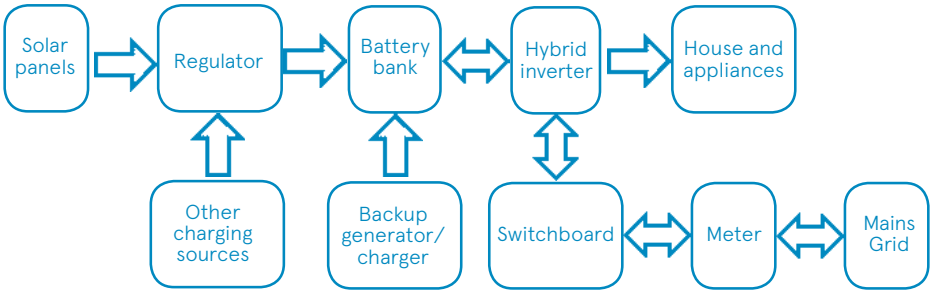


Figure 2.
A DC-coupled hybrid system might be configured as above, where the solar panels charge the battery via a charge controller, otherwise known as a regulator.

DC storage is either connected to the output of the solar PV panels (via a dedicated DC-DC converter or solar charge controller, depending on the system design) or to the DC connection on a special solar inverter called a hybrid inverter. DC-coupled storage systems may or may not be capable of storing grid power, depending on system design and configuration

Hybrid advantages

- Electricity can still be available during a power blackout if the system is set up this way. An isolation switch usually needs to be added to the system
- Significant reduction in power bills by using stored as well as direct solar electricity to run appliances
- Consumers gain further independence from the grid than with a standard grid-interactive system, but the grid is still there if needed
- Excess power can still be sold back to electricity retailers.

Hybrid drawbacks

- More expensive than standard grid-interactive systems with longer payback times. This will improve in years to come
- The batteries tend not to offer as much energy bill savings as the solar panels
- Complex, with more components that can go wrong
- Require specialist expert design and installation.

Stand-alone power systems

Solar panels can also be used in stand-alone power systems (commonly abbreviated to SAPS) to provide all of a home's power needs, without any connection to the grid. To do this, stand-alone systems include batteries to store the energy produced by the solar panels for later use, for example, on cloudy days or at night. Stand-alone systems are generally used by homes without access to a grid connection in rural or remote areas, but are sometimes used to avoid electricity supply costs even where the mains grid is available.

SAPS advantages

- May be the only option where mains electricity is not available
- Can be cheaper than connecting to the grid in more remote areas

- Negates the need to purchase electricity (and pay connection fees) from a retail supplier

- Off-grid solar systems can be designed to power single items only such as water pumps, large appliances and solar hot water systems.

SAPS drawbacks

- Higher maintenance than other systems and relatively expensive

- More electrical components, so there's more that can go wrong

- Require specialist expert design and installation

- Batteries require significant storage space such as an extra room or shed

- A significant amount of solar energy produced is lost i.e. not used, particularly during the sunnier months. This excess solar cannot be shared with other homes and businesses connected to the grid.

More information on stand-alone and hybrid systems

The design of stand-alone and hybrid systems is more complex than for grid-interactive systems. Chapter 4 looks at considerations for hybrid energy storage systems, and there are many other sources

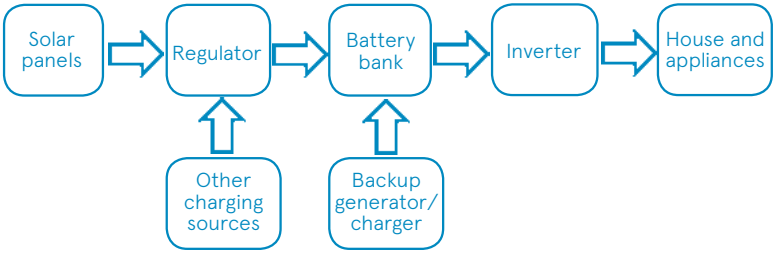


Figure 3.
A stand-alone system typically has the components above including batteries to store the energy produced by the solar panels.

A typical AC-coupled hybrid system. The battery bank is on the right, the yellow box is the inverter/charger and the red box is the grid-interactive inverter. Image: Off Grid Energy Australia.

of information, including installers who specialise in this area. The ATA can give advice by email or phone, and has produced these articles in *ReNew* magazine:

ReNew 128: Know your renewables: Off-grid basics

ReNew Inverter Buyers Guide

ReNew Regulator Buyers Guide

ReNew Battery Buyers Guide

ReNew Solar Panel Buyers Guide

ReNew Energy Storage Buyers Guide

Visit the *ReNew* Buyers Guide page (www.renew.org.au/buyers-guide) to find the issue containing the most recent buyers guide, as these are regularly updated Magazine issues can be purchased and downloaded from the ATA shop at shop.ata.org.au.

DCS OFF GRID LITHIUM STORAGE SOLUTIONS

DCS $LiFePO_4$ (LFP) lithium ion battery cell technology provides:

- **minimum 6 times the lifespan of any AGM/GEL battery**
- **less than a quarter of the weight and space**
- **and has a much wider operating temperature range.**

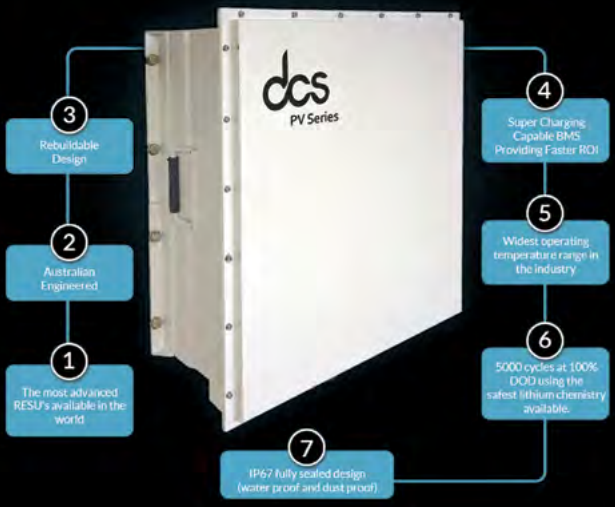
DCS off-grid systems are paired with industry leading European inverter manufacturers, such as Fronius and SMA, providing the perfect solution for dwellings and businesses with a daily power usage of between 9kWh and up to 90kWh.

At the heart of each DCS off-grid system is our 5/7kW Battery Management Unit (BMU), combining the superior reliability of our stringently tested isolated off-grid transform design, CC/CV DCS PV series battery charging profiles, auto genset input and smart relays for automated turning on of water pumps and other auxiliary items. This central unit allows for monitoring and controlling all aspects of the system, so all you need to do is make yourself a cuppa, sit back and congratulate yourself on choosing such an advanced off-grid system.

INTRODUCING

THE WORLDS MOST

ADVANCED **LITHIUM ION** ENERGY STORAGE BATTERY UNIT



dcs

DEEP CYCLE SYSTEMS

SPECIALISTS IN LITHIUM ION BATTERY STORAGE TECHNOLOGIES.

- EASILY INTEGRATED WITH EXISTING OFF GRID 48V CHARGE CONTROLLERS

46 MAIN WESTERN ROAD
NORTH TAMBORINE, QLD 4272
TEL: 1300 795 327
MOBILE: 0420 684 092
WEB: DEEPCYCLESYSTEMS.COM.AU

easy Warm®

power on your roof

Easy PV Hot Water

easywarm.com.au | easywarm.co.nz

#2 All about solar panels

Solar panels come in a large range of types, shapes and sizes to suit different applications.

Most people will be familiar with rectangular solar panels installed in an array on the roof, but you can even get solar panels to replace roof tiles, flexible panels for curved surfaces and frames to mount panels on the ground. This chapter describes how solar panels work, the types available, a range of quality considerations and how much they are likely to cost.

How solar panels work

Solar PV panels directly convert energy in the form of light from the sun into electrical energy. Between 4 and 22 per cent of the energy falling on a panel is converted to usable electrical energy. The rest is reflected or lost as heat.

The electrical energy produced is DC (direct current) and is converted to AC (alternating current) power before being fed into appliances in your home or the mains grid. This conversion is done by an inverter. Systems can either have a single inverter, separate from the panels, or a microinverter on each panel instead, effectively making them 'AC solar panels'.

A solar panel generally consists of a number of solar cells wired together to provide a specific voltage and current rating. Each cell in a solar panel produces only a small voltage when exposed to light. Typical cell output voltages are around 0.5 volts, which is why each solar panel has many cells. A common configuration is 36 cells connected in series to produce a panel with a voltage of around 17 volts at maximum output.

Types of solar panels

There are currently three main types of solar PV panels available—monocrystalline, polycrystalline and thin film (also known as amorphous).

Originally all panels were made from silicon slices cut from a single large crystal. A panel made this way is known as a monocrystalline panel. These provide the highest efficiency but are more expensive to produce than other types.

Some manufacturers use silicon which has been cast in blocks. These are called polycrystalline panels. They are cheaper to produce and thus cheaper to buy, with performance that is similar to monocrystalline panels.

Thin film panels (usually amorphous silicon, but there are also other technologies) are less efficient than crystalline panels but have less costly production methods, with silicon deposited in thin layers on a backing material or directly onto a glass plate. This process also means that the amorphous material can be applied directly to flexible substrates, so that flexible panels can be manufactured. Flexible panels using very thin monocrystalline cells do exist, such as the eArche solar panel from Energus, but they are semi-flexible units designed to bend around gentle curves only.

A relatively recent breakthrough in solar panels has involved panels made of a combination of crystalline and thin film technologies. These panels combine the best aspects of both types to produce high efficiency panels with minimal output loss as they heat up (a common issue with crystalline panels). Known as HIT (Heterojunction with Intrinsic Thin layer) panels, these can outperform many other panels, but at a premium price.

Roof-integrated solar panels are also available. These usually consist of PV panels designed to replace one or more standard roof tiles. This has the advantage in new homes of reducing the quantity of roofing materials required for the house, thus effectively lowering the cost of the system, but as with any integrated system, there are potentially higher costs if they fail.

Which type you choose will depend on your requirements, constraints and budget. For example, you may be looking for the most efficient panel to generate the greatest output from a limited roof area, in which case you'd choose crystalline panels over thin film and select the most efficient panel available through your chosen supplier.

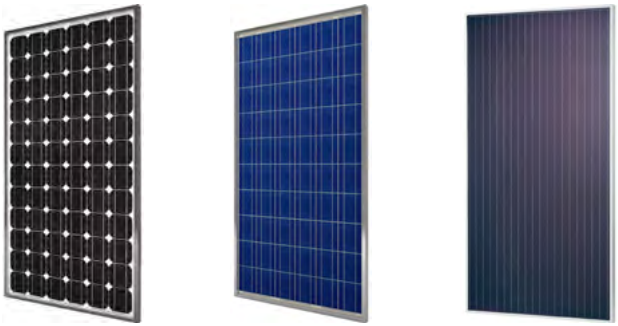
Climate may also have an effect on your decision. Some panels perform better than others when they are hot (the typical condition of a solar panel in Australia during the warmer months). HIT and thin film panels perform better in heat than other panels, but manufacturers have been improving the high temperature performance of mono and polycrystalline panels in recent years to the point where it doesn't make that much difference now.

Panel quality and selection

There are several considerations when assessing panel quality.

Firstly, to be eligible for rebates, panels sold in Australia must have Clean Energy Council approval, demonstrating that the panels have been tested and meet Australian and international standards.

One way to determine panel quality is via independent testing results from Photon



There are three main types of solar panel: monocrystalline (left), polycrystalline (centre) and thin film (right).

Laboratory and Öko-Test in Germany, although not all panels are included in these tests. Manufacturers striving for excellence in production are likely to have their products listed towards the top of the Photon Laboratory results table.

Panel efficiency is another way to compare panels. This is a measure of the output of the panel in relation to its collection area. Currently, panel efficiencies are in the range of around 4% to 22%, with most being in the 14% to 18% range. If you have limited roof space, the higher the efficiency the better, as long as the result is not a panel that's excessive in price. More efficient panels will generally cost more.

Panel efficiency is largely dependent on the technology used, though, and isn't necessarily an indicator of quality.

You can also compare the power tolerances of panels. Many panels will have a power rating of, for example, 250 watts with a power tolerance rating such as '+ or - 5%'. This means that the actual panel wattage could be 5% more or 5% less than 250 watts. Better brands of panels tend to be under-rated and so have a positive power tolerance rating, for example '+5%'.

If you have limited roof space, the higher the efficiency the better, as long as the result is not a panel that's excessive in price.

Solar panels in stand-alone or hybrid systems

The solar panels used in stand-alone or hybrid systems are, to all intents, the same as those used for grid-interactive systems.

Panels designed for battery-based systems are usually configured as suitable for 12 volt or 24 volt panels, but with the recent popularity of maximum power point tracking (MPPT) regulators (which match the solar array's voltage to the battery bank voltage at maximum

efficiency), almost any solar panel can be used with any battery voltage, provided the battery voltage is less than the solar array voltage. This allows the use of higher voltage panels in stand-alone systems, allowing for large solar arrays with low cable losses.

Panel sizes

Solar panels are available not just in a range of wattages, but also with different rated output voltages to suit particular tasks, such as for grid-interactive installations, which often use panels with a higher output voltage, or for battery-based installations. Panels designed for the higher voltages of grid-interactive systems are commonplace today.

Solar panels are also quite large compared to years gone by, with panels up to 360 watts in size now available. These are large and heavy, but they can speed up installation of a system by reducing the number of mounts, frames and electrical connections required.

How much do solar panels cost?

In general you will find that larger (higher wattage) panels provide the best value for money; that is, the greatest amount of energy for your dollar. However, the very largest panels can be very new and potentially unproven in the market and prices can vary even among panels of similar size, with 'popular' panels (those preferred by many installers) often being cheaper.

With increasing mass production of panels and technological advances, the price of panels has fallen dramatically in the last few years. Installed costs are around $1 to $1.50 per watt in all states except the Northern Territory where the average installed cost is around $2.80 per watt. Lower-priced panels are available if buying larger quantities. For top-end panels such as the aforementioned HIT units, prices can be over $2 a watt.

Some panels built for specialised applications (such as flexible panels for mounting on curved surfaces) may cost more per watt than normal panels.

Working life and warranties

The working life of a solar panel should be in excess of 25 years

and many panels come with a 25-year performance warranty. There are several warranty types to consider.

The manufacturer's product warranty typically provides ten to 12 years coverage for defects in the manufacture of a panel, although some manufacturers are now providing a manufacturer's warranty of up to 25 years. Good panels undergo a number of tests before they leave the factory, including a flash test to measure output, and electroluminescence testing to pick up faults and tiny cracks. Problems are extremely rare with quality PV panels but the warranty is important just in case.

The manufacturer's performance warranty guarantees the output over a number of years, allowing for the de-rating that gradually occurs when panels are exposed to sunlight. For example a warranty might provide for 90% output after 10 years, 85% after 20 years and 80% after 25 years. Many panels have similar performance warranties, but there are some variations.

Problems are extremely rare with quality PV panels but the warranty is important just in case.

Regardless of the warranty period, the guarantee only has value if there is someone around to honour it. The international solar industry remains very fluid, with many manufacturers going out of business in the recent past, although the market seems to have stabilised more recently. In Australia, several solar retailers have also gone into liquidation over the years, which can mean the end of any warranty coverage. It is very much a case of 'buyer beware', as even a manufacturer's past longevity is not necessarily a guarantee.

Under Australian consumer law importers are responsible for manufacturers' warranties, so it's important to know who your

importer is because sending the panels back to the country of manufacture may be impractical.

To guard against this issue some manufacturers provide prepaid insurance at no extra cost, which ensures the warranty will be honoured even if the manufacturer goes out of business. Others provide comprehensive insurance, at an extra cost, which covers just about everything from theft to failure for a period of a few years.

A warning here: remember to read the fine print on all insurance policies, including excesses. If the manufacturer pays for their product insurance annually, rather than it being prepaid in full, the insurance may lapse after the company becomes insolvent, meaning you can lose both warranty and insurance coverage.

Another important aspect of the warranties is the installation or workmanship warranty. This is the part of the warranty that is the responsibility of the system installer and covers their workmanship as opposed to the panels or inverters within the system.

It is also important to understand whether the installer or solar retailer will assist in enacting any manufacturer warranties should a fault occur with a major system component.

Find a reputable installer via the Clean Energy Council's Approved Solar Retailer Scheme. Accredited installers adhere to a code of conduct overseen by industry.

Maintenance

Solar panels require virtually no maintenance, but dust or grime on the front of the panels will substantially reduce the output so they should be cleaned periodically, depending on the level of dust buildup. In some cases rainfall is enough to keep the solar array adequately clean. Bird poop is particularly problematic and needs to be cleaned, as covering only a small part of one cell can reduce the overall array output considerably.

More information

A Solar Panel Buyers Guide, ReNew 142

Clean Energy Council's Approved Solar Retailer Scheme.
www.solaraccreditation.com.au/retailers/how-to-choose-solar

selectronic

The multi-mode inverter you need now to take you into the future

- Made in Australia
- Up to 10 year warranty
- On-grid (with included transition to off-grid)
- Off-grid
- Always have the latest features via free software updates
- Compatible with most batteries

Grid Independence | Outstanding Reliability | Ultimate Flexibility

+61 3 9727 6600 | www.selectronic.com.au | facebook.com/SelectronicAustralia

QUALITY INVERTERS/CHARGERS/BATTERIES

Ph: 03 9775 1590 www.excelsiorpower.com.au

FREE CATALOGUE AVAILABLE, CALL OR VISIT OUR WEB SITE!

INVERTERS - HUGE RANGE

NEW!! OVER 45 MODELS

SURGE WATTS	SPECIAL PRICE
1000	
4000	
6000	
8000	

12, 24 & 48 VOLT MODELS
VOLTS & WATTS DISPLAY
HIGH EFFICIENCY

FREE REMOTE CONTROL ON LARGER MODELS
SUPER PERFOMANCE & RELIABILITY!

NEW!!! INVERTER/CHARGER

4000 WATT SURGE
6000 WATT SURGE
FREE REMOTE & DISPLAY

COMPLETE OFF GRID SYSTEMS

TOTAL SYSTEM PACKAGES

SYSTEMS FROM $1399
INVERTER CABLES
SOLAR PANELS
BATTERIES, SOLAR REG
SYSTEMS ALSO MADE FOR YOUR SPECIFIC REQUIREMENTS!

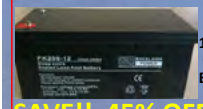
BATTERY CHARGERS

MODEL	VOLTS	AMPS
BC1210	12	10
BC2012	12	20
BC2410	24	10
BAT50/12	12	50
BAT25/24	24	25
BAT50/24	24	50
BAT100/12	12	100

FROM 3 TO 100 AMPS
FULLY AUTOMATIC MULTI STAGE
AMPS & VOLTS DISPLAY ON MOST
AVAILABLE IN 12, 24 AND 48 VOLT

LOW WHOLESALE PRICES, HIGH QUALITY, 20 YEARS EXPERIENCE. BUY DIRECT AND SAVE!

AGM DEEP CYCLE BATTERIES



DEEP CYCLE AGM
PREMIUM QUALITY
10 YEAR DESIGN LIFE
(MOST ONLY 3-5)
BEST VALUE IN AUS
DON'T MISS OUT!!

SAVE!! 45% OFF BATTERIES

VICTRON ENERGY INVERTER/CHARGERS

PURE SINE WAVE
SMART CHARGER
GENERATOR SUPPORT
12, 24 & 48 VOLT
FROM 800 TO 10,000 VA
BIG $$ DISCOUNTS!!!!!

SOLAR PANELS

HIGH EFFICIENCY
HIGH QUALITY BRANDS
12 AND 24 VOLT
FIXED MODULES
FOLDING MODULES
WITH REGULATOR ETC
MPPT REGULATORS

Phone: 03 9775 1590
Email: enquiries@inverter.com.au
Factory Address:
Fact 1, 16 Titan Drive
Carrum Downs
Vic, 3201

NEW MODELS
BEST PRICES
BEST QUALITY

EXCELSIOR POWER
www.excelsiorpower.com.au

#3 What is an inverter and why do I need one?

A solar inverter converts the DC current generated by your solar panels to the AC current needed to run your appliances. Find out which inverter suits your system.

There are three main types of inverters used in solar power systems—grid-interactive, stand-alone and hybrid inverters, which are both grid-interactive but can run as a stand-alone inverter.

A grid-interactive inverter is the most common type. It converts the DC (direct current) power generated by the solar panels into the 240 volt AC (alternating current) power needed by the mains grid and by appliances in the home. It requires the mains grid voltage to be present or it will shut down for safety. This means that if there is a mains grid failure, your solar system will shut down and will not supply energy until after the mains grid returns to normal.

Grid-interactive inverters vary enormously in size, from 10 kW or larger units for big domestic and small commercial systems, down to tiny 250 watt microinverters, which are designed to be mounted on the back of a solar panel to make the panel itself a grid-interactive module. These

may be useful for those who want to start small and increase their systems over time, or for people who rent and can't install a permanent system.

Stand-alone inverters do not connect to the grid at all and are used in homes where there is no mains power or where owners choose to disconnect from the grid completely—or where some of the energy comes from a solar battery system separately from the grid. For grid interactivity as well then you would probably use a hybrid inverter.

Monitoring the inverter's output

Most grid-interactive inverters have at least a basic display, usually a small LCD to show you the common parameters such as mains voltage, power from the solar array and energy generated for the day. Many inverters have the ability to add remote displays with more information, and some even have computer connections and internet interactivity, and can upload data in real time to a web portal. If monitoring your system is a high priority then you should check out what information the inverter can display and what add-on options are available.

Quality considerations

Like most electronic devices, inverters vary in quality. Low-cost units can seem like a bargain, but if they don't last long then it's a false economy. That's not to say that there are not some good-value inverters coming out of China—there are. The problem is knowing which ones are worth buying.

Most reputable renewable energy installers will offer high quality inverters from Europe, the US or Australia. This is done to ensure few or no warranty claims, and it's a good indication that these are the inverters to use. If there are several inverters that would suit your needs, you may well be better off spending a bit more for a well-known brand, after all, higher reliability can easily offset the initial slightly higher cost.

Working life and warranties

A good quality inverter should last at least 10 years, if installed properly, and given no accidents such as direct lightning strikes. Lifespan will vary, depending on a number of factors including

ambient temperature, mains grid voltage and mains power quality. Many large electrical spikes, caused by large loads like electric motors, will eventually cause damage to even the best equipment. Other factors that can affect lifespan are dust, heat, ventilation and vermin such as ants. To guard against the cost of an early failure look for long inverter warranties. Five years is a suggested minimum, while ten years is better. A five-year warranty with the option of buying an extra five-year warranty is often available and can be good value and offer peace of mind.

Cost of an inverter

There is no such thing as a typical cost, but for a good quality grid-interactive inverter expect to pay $0.20 to $1.50 per watt, depending on brand, size and features.

Hybrid inverters, which also have the capacity to operate from batteries and often contain a high capacity battery charger, will be more expensive per watt, possibly up to $2 or more per watt. Prices will be lower when purchased as part of an overall solar-battery system.

Stand-alone and hybrid inverters

In a stand-alone or hybrid system the inverter converts the DC electricity from the battery bank into the 240 volts required by the house. This allows you to operate conventional 240 volt appliances. Hybrid inverters are designed to work with both a battery bank and as a grid-interactive inverter, allowing you the best of both worlds. These can also charge the battery bank from grid power after the mains power is restored, which is a very handy feature.

In a stand-alone system, and in some hybrid systems depending on the configuration, the inverter size depends on the appliances that you need to run. Because of the cost of buying a large inverter, using power-hungry appliances like electric frypans, air conditioners, hairdryers and fan heaters is best avoided or minimised. Paying a little more for an energy-efficient appliance could save you a lot of money on system costs.

While an inverter is found in most stand-alone systems, not all appliances need be run from it. There are several reasons why

you might want to run appliances directly from the battery bank. Some DC appliances may be more efficient than the equivalent AC versions. You might also want to eliminate the use of plugpacks and their conversion losses, after all, why convert DC from the batteries to AC and then back down to DC again for small devices like modems, phones and the like? Lastly, you might also want a degree of independence from the inverter because inverters can fail. Running your lights or more critical devices directly from the battery bank means you are not reliant on the inverter for these devices.

While devices designed to run from extra-low-voltage DC from the battery bank can provide several advantages, including a degree of redundancy from the inverter and higher efficiency, they will require the added expense of suitable wiring, so this has to be considered.

More information

Inverter Buyers Guide, ReNew 137

As easy as AC to DC: inverter basics, ReNew 129

Modern inverters have a large range of features. This unit has an input range of 80 to 1000 V, making it suitable for almost any array configuration. It has wi-fi and ethernet interfaces, a USB socket for datalogging and firmware updates, a signalling output, a built-in web server so that owners can log into it from anywhere in the world. Image: Fronius.

#4 All about energy storage

Battery technology has developed rapidly in the last few years to the point that current and prospective solar households are debating when's the right time to add battery storage to their solar electricity system.

With the steadily rising cost of grid electricity, more and more people are looking to make the best use of the solar electricity they generate to offset as much mains grid power as they can. While there are a number of ways to do this, including shifting loads to the middle of the day or diverting excess energy to heavy loads such as an electric water heater, if those options are not possible or desirable, or you have other needs, such as a degree of backup during grid failures, then an energy storage system is an option.

The batteries are charged by the solar panels, with the power for the home taken from the batteries when needed (in a stand-alone power system) or from both the grid and the batteries, depending on the battery state of charge, time of day and the system settings (in a hybrid system).

Lead-acid vs lithium

Lead-acid batteries have been used for storage in home renewable energy systems, however lithium batteries are rapidly becoming more cost-effective.

Important considerations when selecting batteries are battery type, life span and size. Lithium batteries can be more deeply discharged (i.e. more of the battery capacity can be used before recharging) with less loss

of life span, so their total cost of ownership is less than lead-acid batteries. They require advanced battery management systems (BMS) to ensure the battery voltages do not stray outside the allowable voltage ranges, as lithium batteries are more easily damaged with excessive high or low voltages. However, BMS systems are readily available and only add a small amount to the price of a lithium battery bank, and many lithium batteries come as a complete set of batteries and BMS in a box, ready to use.

All-in-one systems

While it's common for a system to be installed using individual components which are wired up on-site, complete 'systems in a box' have become more readily available.

These consist of the battery bank, inverter, solar controller and even the backup generator (if used), fitted into a single enclosure which is transported to the customer and placed in position. The system is connected to the solar array and the home's mains wiring, and the installation is then finished.

The advantage of such a system is that it can be delivered and installed in just a few hours, as most of the work of mounting and wiring the individual components is done at the factory.

The main disadvantage of such systems is that they are not as easily expanded as a system built from scratch, although some expandable systems are starting to enter the market. They tend to be fitted to enclosures with very little extra space, so if you choose to increase battery capacity in the future you may need to use a higher density battery such as a lithium-based battery or move the new larger battery into its own separate enclosure.

Can I just add batteries?

Current solar household

The majority of solar PV systems currently installed in Australia are unlikely to be 'battery-ready'—an existing solar customer cannot simply purchase a lead-acid, lithium ion, flow or sodium battery and have it retrofitted to their existing system.

The solar panels can be retained, of course, but most solar customers will need to replace

their existing grid-interactive solar inverter, add a second inverter or add a DC to DC converter to their system. Which approach is taken depends on whether the system uses AC or DC coupling and the capabilities required of the system.

Existing solar owners wanting a new DC-coupled system could replace the existing grid-interactive inverter with a hybrid inverter, to which the batteries and solar panels are connected. AC-coupled households could keep the existing grid-interactive inverter and connect the batteries to the system by a new inverter-charger or hybrid inverter.

Replacing the grid-interactive inverter can be avoided, though, through fitting a DC to DC converter between the solar array and the battery bank. This enables the battery to charge directly from the solar array. When the battery discharges the DC to DC converter steps the battery voltage back up to a nominal voltage that meets the requirements of the grid-interactive inverter. The main disadvantage of using this DC to DC converter approach is that the system cannot run without the grid, so battery backup isn't available.

Many battery products on the Australian market are now being sold with an inverter, some as part of an integrated 'all-in-one' storage unit and some with the inverter separate from the battery.

Another key component of the system is the isolation switch, which enables the system to operate during a power outage. This is incorporated into a DC-coupled system, however, this is not included in a standard AC-coupled system and will need to be added if backup power is important.

Adding batteries to a microinverter system

If your solar system has a microinverter under each panel (Enphase is the dominant microinverter supplier), your energy storage options are a bit more limited. Since there is no central inverter to which a battery can be attached, your only option is to connect a battery to your house switchboard. This means

Nick Pfitzner and family are the proud owners of the first Tesla Powerwall home in Australia. He describes their configurations and the lessons they've learnt so far in *ReNew* magazine, issue 137. Image: Natural Solar.

the battery must have its own inverter to convert its energy into standard household electricity at 240 volts AC. This option is quite easy if you use a battery with an in-built inverter, for example the Enphase AC battery.

New solar household

Installing a battery at the same time as a solar electricity system can be more practical as you can have a single hybrid inverter instead of two. You can also install a larger solar system in the knowledge that the extra energy it generates can be stored and used later.

However, if the system is installed with a view to installing a battery at a later date, then the hybrid inverter may be obsolete by that stage and unable to support

new and improved battery technologies available at the time of adding storage.

Is it for me? Making a financial decision on batteries

It's clear that as prices continue to drop, batteries have great long-term potential to transform our electricity grids. And many of us want more independence from big energy companies. But most families need to watch their budget too—would your bill savings be big enough to justify adding batteries to your solar system?

Grid-connected batteries are likely to become financially attractive to households around 2020/2021, compared to a solar-only system, based on expected battery price reductions and improvements to battery warranties. This will help to reduce the payback time on such a system, which is worked out by dividing the total cost of solar and battery system by the annual savings on power bills. The payback time should be less than the actual warranty on a system, as you can't bank on the batteries lasting longer than the warranty. At the moment the warranty on batteries is around ten years, but the payback time can be much longer.

The warranty on solar panels is around 25 years though, and payback is usually between 3 and 10 years, making the investment on a grid-interactive solar system worthwhile.

Advice for existing PV owners

Grid-connected solar PV customers considering retrofitting batteries to their system could wait for storage prices to drop and the market in Australia to consolidate around the most optimal technologies and systems.

If you do decide to retrofit a battery now, consider whether you want the retrofit battery system to provide power in a blackout. An isolation switch (costing $250 to $450 + installation) will be required along with a new hybrid inverter and communications system that can handle system operation in the event of a power outage. Not all hybrid inverters can operate in a blackout situation.

A DC to DC converter may be

an option if backup power isn't needed, allowing the existing grid-interactive inverter to be used. A system with a DC to DC converter will still be expensive, even for a system with a relatively small battery, and will be difficult to establish for less than $10,000 installed.

Consider whether you want the system to be able to charge from the grid. Some new inverters (for example the SolarEdge inverter) have an AC to DC charger and can facilitate battery charging from the grid. Grid charging allows the use of cheaper overnight off-peak tariffs to supplement charging from solar on low solar resource days. However, optimising this approach requires the use of weather and electricity consumption forecasting, functionalities that aren't available without additional software to control battery charging, such as the Reposit Power software which costs about $800.

Advice for homes without existing PV

Many prospective solar+battery system owners are waiting for battery prices to come down, but

Battery systems are improving all the time and legacy hybrid inverters may not provide the functionality required by the market in the future.

are keen to purchase and install a standard grid-connected solar PV system to start realising the benefits of solar.

If the solar customer later decides to add storage that requires the original grid-interactive inverter to be replaced, this replacement would probably occur part way through the usable life of the solar inverter. The lost value is offset to an extent by the initial saving from installing a standard solar inverter as compared to a hybrid inverter (a saving of around $1500).

Should the customer decide to purchase a more expensive hybrid inverter as part of their

grid-connected solar PV system now, there is a risk that this hybrid inverter may be obsolete and unable to support new and improved battery technologies available at the time of adding storage. Battery systems are improving all the time and legacy hybrid inverters may not provide the functionality required by the market in the future.

The risk of technology obsolescence is too great at present to recommend the latter option, however consumers will continue to make decisions for reasons other than economic rationality and system optimisation.

Daytime load

Another important factor in the economics of storage is the consumer's daytime load.

For consumers not on premium feed-in tariffs, solar PV without storage offers the most benefit where significant electricity consumption occurs during the daytime, during solar generation hours.

By contrast, a lower daytime and higher night-time consumption household will gain more from a solar+battery system. A consistently high daytime load leads to solar generation being used directly on-site, possibly leaving insufficient excess solar left to charge a battery for use in the evening and overnight.

More information

ATA's free Solar and Battery Advice Service includes a calculator that helps assess the economics of your proposed system.
www.ata.org.au/ata-solar-advice

ATA's free Sunulator tool gives a more indepth estimate on the economic feasibility of a solar-battery system.
www.ata.org.au/ata-research/sunulator

The NSW Home Solar Battery Guide is a comprehensive consumer guide to household solar+battery systems.
www.resourcesandenergy.nsw.gov.au/energy-consumers/sustainable-energy/nsw-home-solar-battery-guide

Energy Storage Buyers Guide, ReNew 141

Battery Buyers Guide, ReNew 131

Just add batteries: considerations for hybrid systems, ReNew 137

#5 Sizing your system

There are several things to consider when sizing a solar electricity system. The first step to a successful system is to understand how much energy you use and when you use it.

By reducing your electricity consumption as much as possible first, you will maximise the system's potential to provide 'carbon neutral' electricity for your home, and be able to store any excess electricity in a battery or feed it into the grid.

Energy efficiency

Before you buy any renewable energy system it's a good idea to do an energy audit of your home. There is no point spending large amounts of money on solar panels if a lot of the energy they generate is being wasted. Check the energy used in the home by different appliances and lighting, particularly identifying opportunities to save energy.

One of the biggest power wasters are halogen downlights. Halogens are very inefficient and convert nearly all of the energy they use into heat, not light.

As an example, if you have a 50 watt halogen light globe that is used for five hours per night, it uses 250 watt-hours of energy per night. To generate this much energy it would take, on average in Melbourne, one 80 watt or larger solar panel, worth around $100. Yet, replacing this bulb with a 10 watt LED bulb will mean that a single 20 watt solar panel would provide sufficient energy. This

LED bulbs use only 10 to 20 per cent of the electricity used by an incandescent globe. A single 10 watt LED bulb will save you at least $100 worth of electricity over its lifetime—and potentially many hundreds or even thousands of dollars if you have multiple inefficient lights to replace.

example applies to many appliances used, and spending a few hundred or even a couple of thousand dollars on more efficient appliances could save you a great deal more than this in energy costs.

Use an energy meter (such as a PowerMate Lite) to measure the electricity used by appliances. Likely problem appliances are older fridges and freezers, older washing machines, electric bar and panel heaters, older air conditioners, electric hot water systems and pool pumps, which all have more energy efficient alternatives or energy efficient versions on the market now.

As an example, you might monitor your fridge for a week using an energy meter and find that it's using 4 kilowatt-hours per day. This is a lot for a domestic fridge, so it would need to be repaired (it might just have damaged door seals or need regassing), cleaned (it might be full of dust at the back) or replaced.

For loads that you can't monitor directly with an energy meter, such as ceiling lighting and fans, basic maths will usually suffice. For example, a 50 watt light used for four hours per day will use 200 watt-hours per day or around 1.5 kWh per week.

It's important to use a good quality energy meter or your readings could be inaccurate, particularly when measuring certain types of loads such as the power supplies in modern electronics.

Tip: A good online resource to help calculate and reduce your energy use is the Australian Greenhouse Calculator: www.epa.vic.gov.au/AGC/home.html

What size solar array do I need?

The bigger is better approach

If you primarily want to help the environment and cost is of little concern, it has always made sense to install as many panels as possible, as all their generation displaces electricity from dirty, centralised power plants. Recent modelling by the ATA also shows that a larger system can have a shorter payback time, which is the number of years until bill savings recoup the installation cost.

Economies of scale in solar system pricing and feed-in tariffs increases have led to this change in payback times.

Solar system prices

Solar systems have seen significant price reductions since 2012, especially for larger solar systems. Larger systems have halved in price while the smaller ones have dropped by only a quarter. Prices vary with component quality and location, but on average a 5 kW solar system costs around $6200 in mid 2017, according to Solar Choice's residential price benchmark data.

Larger systems have always enjoyed economies of scale compared to smaller systems. While the installer is on the roof it's relatively easy for them to add more panels, and it takes the same amount of time to install a 6 kW inverter as it does a 3 kW unit, with larger inverters being cheaper per watt of capacity than smaller units.

Feed-in tariffs

In 2017 solar feed-in tariffs in Victoria and NSW roughly doubled their previous level. This change was primarily due to wholesale electricity prices in the eastern states roughly doubling to around 10 c/kWh, with other states likely to follow suit.

ATA solar sizing study

ATA studied the economics of

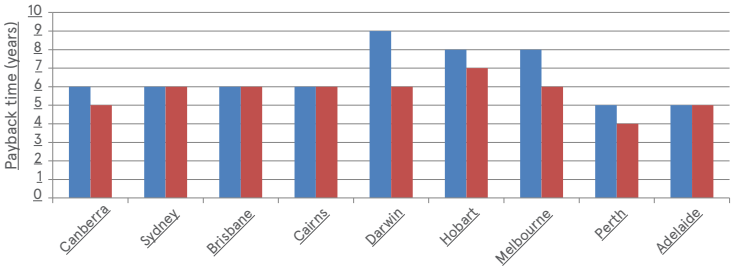


Figure 4.

Payback time by location and solar system size; it includes 2 kW (blue bars) and 5 kW (red bars). This is calculated for a stay-at-home family using 23 kWh/day on average and on a flat tariff. In no location does the 2 kW system (blue bars) have faster payback.

various system sizes by simulating a large number of scenarios in half-hour intervals for a whole year using Sunulator, ATA's free solar feasibility calculator.

ATA's primary economic measure was payback time. Payback times shorter than 10 years benefit solar customers, as the system is likely to pay for itself before any significant expenses such as replacing the inverter. The panels should last at least 20 years, so cumulative bill savings are large, especially for a larger system.

Surprisingly, the modelling found that a 5 kW system now has a shorter or equivalent payback time to the 2 kW system. In no location did a 2 kW system pay back quicker than a 5 kW one. ATA also ran scenarios for 3, 4 and 6 kW systems, and found these obeyed the same trend. See Table 4 above to compare payback times.

Payback times for a 2 kW system in the Northern Territory are longer as solar installations are particularly expensive, but this is counteracted by a relatively generous feed-in tariff, equal to the import tariff. Bigger is better there too.

For a 5 kW solar system on a flat tariff in Sydney, payback time

varied from four to eight years depending on consumption profile. Households with higher consumption achieve payback more quickly. Again, there were no cases where a 2 kW system paid back more quickly than a 5 kW system.

Low-consumption buildings

With some feed-in tariffs at higher levels, a solar system can now be economic even if it exports all its generation. For example, an export-only 5 kW system in Melbourne should generate around 7000 kWh and earn $790 per year. If the system costs $6400, on the simplest calculation it achieves payback in less than nine years. This has made low-consumption buildings such as holiday houses and storage sheds a new market for solar systems.

Constraints on big solar systems

If bigger is better, how big should you go? Roof space is an obvious factor. Most people have budget constraints and have to prioritise their spending. Don't ignore other investments that may pay off even quicker, such as insulation, gap sealing, window shading, LED lights and efficient appliances.

Electricity distributors limit the size of solar systems connected into their grid. If you've got a normal residential single-phase connection, solar systems up to 5 kW in size are usually no problem, however, going larger often requires extra paperwork and may not be allowed. The *Grid Connection* section on p. 66 discusses the process for larger systems.

One way to overcome this limitation is oversizing, e.g. connecting 6 kW of panels to a 5 kW inverter. The distributor treats this as a 5 kW system, as that's its maximum power output. Note that running an inverter at maximum for such a long period each day will almost certainly reduce its lifespan, see *The right-sized inverter* on p. 48. Another option is to install a three-phase electricity supply, which would normally support a 15 kW solar system. However, upgrading your electricity supply involves additional cost.

Smaller systems designed to match energy use

Many people might not be able

to finance a larger system. The following advice applies to systems sized to match efficient household electricity use, which will still result in bills savings and help the environment.

First decide how much energy you want the system to produce. Do you want to offset your entire electrical energy use, or just a given portion? You can determine your energy use from recent energy bills, although you should also consider whether your energy use will reduce after any energy efficiency measures.

Think about how much electricity you use during the day when the sun shines and the solar system will be generating. If the feed-in tariff is lower than the rate you currently pay for electricity, the solar generated electricity will be of greatest value when it is consumed on-site, as opposed to being exported into the grid.

As an example, if an electricity retailer is offering you 11 cents per kilowatt-hour, but you currently pay 30 cents per kilowatt-hour during the daytime, then you will be better off using the solar electricity to power your home or business. Think about how this daytime electricity generation can be used to run appliances, even if you're not at home. You could divert excess electricity to an efficient hot water system such as a heat pump. This process is explained in the *Efficient Hot Water* booklet available from the ATA webshop.

Don't ignore other investments that may pay off even quicker, such as insulation, gap sealing, window shading, LED lights and efficient appliances.

The right-sized inverter

You might think that if you want to install a 3 kW solar array then you would also install a 3 kW inverter. However, there are reasons to install either a larger or smaller inverter, depending on what you

value—maximum generation for the inverter size or maximum system reliability.

Installing an inverter larger than your array means that the inverter is never running at maximum load. Like all electronic devices, inverters are likely to last longer when they are stressed less, so oversizing the inverter is likely to extend its lifespan somewhat. It also means that you can expand your system by adding more solar panels in the future.

On the other hand, installing an inverter that is smaller than the array will result in the inverter reaching maximum output earlier in the day and running at full output until later in the evening. This is unofficially termed `overclocking', in reference to how computer CPUs are driven harder than they are designed for. However, overclocking ignores the fact that for much of the day some of the array capacity is simply wasted. While solar panels may be cheap, underutilising their output will extend the payback period of their embodied energy debt and reduce the lifespan of the inverter from running at maximum.

Expanding your system

What if you decide that you would like to expand your current system? The best way to do this partly depends on the current system itself. If the system was installed with an oversized inverter then you may simply be able to add more solar panels to the existing array.

However, if the existing system has no room for expansion then you can simply add a second array and inverter combination—in effect, adding a second system to your home.

Theoretically, you can add as many array/inverter sets as you wish as they all operate independently. However, the grid connection capacity will usually be a limiting factor.

Even many larger inverters are designed to work in parallel and some can connect together so that they all communicate with a single control and datalogging system.

When designing a system, you need to consider if future expansion is likely and, if so,

which method—paralleling systems or installing an inverter with expansion room—is the most suitable method for your system. Although installing a larger inverter might work out to be the cheaper option, it only does so if you actually go ahead with the expansion some time in the future, otherwise you have installed an inverter larger than needed.

Another issue to consider when expanding a system is how it will affect your current contract with your energy company. Will you lose your feed-in tariff if you expand? If so, expansion may well be financially pointless, as the income from the energy generated may in fact decrease once the system has been expanded. Talk to your energy company about this first.

Hybrid and stand-alone system sizing

Sizing a solar array for a hybrid or stand-alone power system is more complex than for a grid-interactive system. In a stand-alone power system you are aiming to have sufficient energy from the solar panels to keep the batteries suitably charged for your usage, even if there is a string of cloudy days.

Hybrid systems have the grid as a backup, so your solar array doesn't need to cover all your energy needs, but you may still aim for that. You will also need to allow for losses in charging of the batteries, inverter inefficiencies, temperature derating and battery ageing, among other factors. Work with your system installer to determine both your solar array and battery bank size. There are also resources available to help. Past issues of *ReNew* include information on solar array and battery sizing for stand-alone systems and the ATA's experts can also assist.

More information

ATA's free Solar and Battery Advice Service can help determine costs, payback times and bill savings when planning a system.
www.ata.org.au/ata-solar-advice

ATA report *Solar Sizing: Bigger is Better*
www.ata.org.au/ata-research/bigger-solar-is-better

Solar sizing latest: 'Go big' with your PV system, Sanctuary 40

#6 Siting considerations

Solar panels can tolerate a wide range of climatic conditions, including snow, frost, wind, hail and high temperatures. Find out how to position them for best performance.

The company you purchase the system from should do an on-site analysis to ensure your site is suitable for solar panels. The following advice will help you get the most out of your solar installation.

Which direction?

Ideally a solar site is a north-facing (or almost north-facing) roof or ground space that is not shaded during the day. Panels may also be mounted on other roof areas, all the way through to completely east-or west-facing; however, a loss of output will occur. For an east-or west-facing roof with a 20° pitch, average daily generation will decrease by up to 15%.

Where the array consists of panels facing in more than one direction, the array should be electrically split so that each section of the array only consists of panels all facing the same way. In these cases it is usually best to use an inverter with two independent solar array inputs so that each array section operates independently, without being affected by the other.

Minimal shading

It is important that the panels are not shaded much during the day throughout most of the year. If one panel in an array of two or more series-connected panels has a shadow across it, then some

The Christie Walk community has had to negotiate solar access rights with neighbouring developments, including going to court to prevent unreasonable overshadowing from the north. Read more in *Sanctuary 39*. Image Jo Thomas.

of the power from other panels in the array will be wasted by the shadowed panel, unless each has its own bypass diode or shading protection, such as a maximiser.

If partial array shading is unavoidable, the system installer should allow for this, either through bypass diodes on the panels or by configuring the array such that the shaded panels have the least effect on the rest of the system. This can be done using inverters with more than one independent input, as described above, or by installing AC panels, which have micro-inverters on each panel, making each panel independent.

One area to consider is the

System or load type	Tilt angle	
	Latitude < 25°	Latitude > 25°
Consistent load throughout the year	Latitude value	Latitude + 5° to Latitude + 10°
Maximum load in summer	Latitude – 10°	Latitude value to Latitude – 5°
Maximum load in winter	Latitude + 10°	Latitude + 15° to Latitude + 20°

Table 1: Optimum mounting angles for fixed panels at various latitudes. Based on information from: Introduction to Renewable Energy Technology Resource Book, Brisbane Tafe

shading caused by future developments. What happens if your neighbour adds a second storey that shades your solar array? Discussion with the neighbour can often solve the problem before building begins. If they are less flexible then talk to your local council regarding the planned extensions or building and lodge an official complaint if necessary.

If all else fails, the only solution may be to relocate some or all of your solar array.

Most states have various development controls or legal principles that regulate solar access, but the levels of protection over a landowner's right to sunlight have room for improvement. Find out more in *Right to light: solar access and the law* in *Sanctuary 39*.

Getting the pitch angle right

Panels are often set at the roof angle for aesthetic reasons and to simplify mounting. Slight variations in panel angle don't make that much difference to the annual energy production, so unless you have a radically steep or flat roof

angle, mounting panels at the roof angle is usually the best solution.

However the panel angle should be considered if you want to maximise the energy output from your system at certain times of the year, especially if you want to maximise the total annual energy output. This means producing as much electricity as possible when the sun is strongest, i.e. in summer. To do this, the angle for an array can be set to maximise summer input. This will usually be less than the latitude angle.

A steeper-than-latitude angle maximises input during winter, when the sun is at its lowest and weakest, and often this is the best approach for stand-alone systems. In the southern hemisphere, the optimal midwinter angle from the horizontal is the angle of the latitude at that location plus about 10° to 15°. It is important to have a tilt of at least 10° on the panels so that they can be washed clean by rain.

If you are able to adjust the tilt twice a year then you can improve both the midsummer and midwinter outputs by as much as 25 per cent. However, this requires the use of adjustable frames which are more expensive and probably not worth it.

See Table 1 on p.47 to calculate the best tilt angle for your array.

Panel trackers

Panel trackers can be used with ground-mounted systems. These are mechanical devices which keep the panels facing directly towards the sun over the whole day. They will increase the energy output substantially, but they will also increase the upfront cost and add extra maintenance to the system. With the low prices of solar panels it's usually cheaper to simply add more panels to a system, and eliminate any maintenance that a moving array would need.

More information

Right to light: solar access and the law, Sanctuary 39

#7 Metering & solar PV

There are several metering options when it comes to installing a grid-interactive or hybrid solar PV system, although usually only one option is available in each state.

Traditionally, your local distribution business (the electricity company that manages the poles and wires) had pre-determined a metering solution for anyone wanting to install a solar system. At the end of 2017, the responsibility for metering in all states apart from WA and the NT will transfer to energy retailers (the company that sends your energy bill).

In Victoria, all homes and many businesses already have digital meters, whilst in other states, this will now be by consumer choice.

Irrespective of whether you have a choice over the meter, it is important that you understand the type of meter and metering arrangement to be used when installing your solar system.

Meter basics

Most old accumulation (spinning disc) meters have only one measurement element, in the same way that a car has one odometer. Imagine if driving backwards caused your odometer to wind back: this is actually what happens with the old spinning disc meters where there is solar PV installed—any solar-generated electricity exported to the grid simply winds back the meter. However, the meter can't record the amount of electricity generated or sent to the grid, and

therefore no feed-in tariff credit can be awarded.

Digital meters can typically record electricity flow in two directions separately. These are generally called bi-directional or even 'smart' meters, with the 'smart' part generally referring to advanced functionality beyond remote communications.

In broad terms, there are two main types of metering arrangements, gross and import/export (or net) metering, which are explained below.

Gross metering

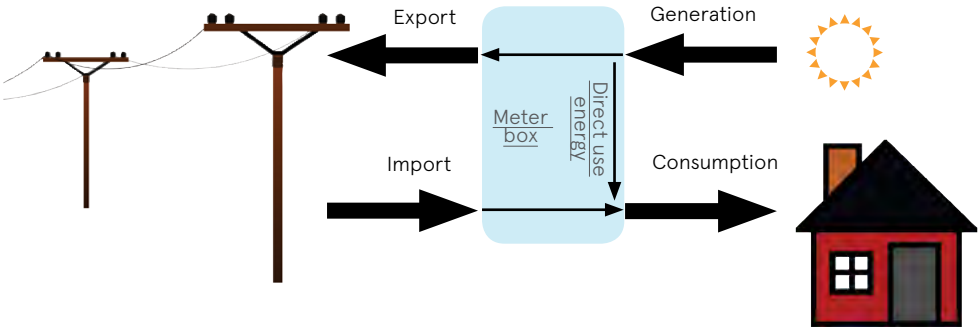
Gross metering simply means that the 'gross' amount of the solar generation (that is, all the solar generation) is measured by the meter, regardless of what portion is used on-site and what is exported to the grid.

Gross feed-in tariffs in NSW and ACT led to the installation of gross meters in those states. Gross metering for new PV installations is now less prevalent in Australia.

Note that gross metering doesn't allow you to realise the financial value for energy that is used on-site at the time that it is generated, whenever the feed-in tariff paid to you (for the electricity you generate) is lower than the electricity consumption tariff paid by you (for the electricity you import from the grid).

Gross metering can be done with a single meter that contains two separate elements (across which the electricity flows) or two separate meters, with one meter being dedicated to solar generation while the other meter records electricity consumed in the home or business. Where two meters are used, these can be old accumulation meters.

Gross metering is quite simple from the perspective of your energy bill. You continue to pay for all energy used in the home as though you had never installed the solar system. The amount of solar energy generated does not alter the measurement of energy used in the house or business, so what you pay for energy used will be unaffected, provided you don't



Energy flows through the meter box with net metering.

change your consumption levels or your retailer doesn't change your energy tariff.

All of the solar electricity generated attracts whatever feed-in tariff is offered by your retailer. As an example, if you generate 100 kWh and the feed-in tariff rate is 10 cents per kilowatt-hour, you should receive a $10 credit on your electricity bill.

Import/export or net metering

While import/export metering (more commonly called net metering) is technically less complex, the energy flows are more challenging to understand. With this type of metering arrangement, it is important to understand the key energy flows that occur in a household or small business that has grid-connected solar PV. In simple terms, there are four main energy flows:

- electricity Generated by the solar system, G, measured on your inverter(s)

- electricity Imported from the electricity grid, I, measured at your meter

- electricity Consumed by the household, C, which is not normally directly measured

- electricity Exported back to the grid, E, also measured at the meter.

Your electricity retailer simply sees all electricity flowing into and out of your property, but what goes on behind an import/export or net meter is a more complex story.

Electricity imported from the grid is not the same as total electricity consumed by the household, as some of the consumed electricity may be coming from the solar system (direct-use energy). Under import/export or net metering, the meter actually records electricity import or export after household consumption is taken into account.

For example, if you consume one unit of electricity in your house at the same time as your PV generates one unit of electricity, your meter will measure zero change with regard to both imported and exported energy from the grid.

If you consume two units of electricity in the house and are generating only one from your solar system, then you will import (and purchase) an additional one unit from the grid—which will be recorded by your meter.

Misunderstandings can arise from not appreciating this metering arrangement: a solar owner might say, 'My meter is showing lower generation than my inverter, so my inverter or meter must be wrong'. Instead, this person hasn't understood that solar generation and export to the grid are not the same thing under import/export or net metering.

More information

ATA's Consumer Guide to Smart Meters is available free at the ATA Webshop.
shop.ata.org.au/shop/consumer-guide-to-smart-meters

#8 Rebates & feed-in tariffs

There's a lot to learn about rebates, feed-in tariffs and the financial incentives for investing in solar.

Rebates: Small-scale Technology Certificates

Currently, the only direct federal incentive available for small-scale solar systems is delivered under the national Renewable Energy Target (RET). The RET allows for the creation of Small-scale Technology Certificates (STCs) for grid-interactive and stand-alone small-scale solar, wind and micro-hydro systems. These certificates effectively discount the upfront cost of installing these technologies. The STCs are created and traded through the renewable energy market—with the process usually being taken care of by your solar installer.

STCs are issued by the Clean Energy Regulator for the generation of renewable energy, which electricity retailers and other 'liable parties' (such as large users of electricity) are then obliged to purchase in order to fulfil their mandatory commitments under the RET legislation. The RET seeks to ensure that around 20% (33,000 GWh) of Australia's electricity generation comes from renewable sources by 2020.

As a solar consumer, you can create and trade the STCs yourself—paying full price for the solar system upfront, and then recouping the value of the STCs from the RET market at a later date. Some solar owners choose to take this approach in the

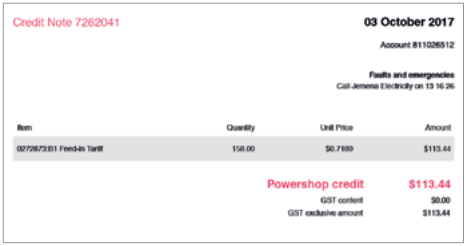
Meter Readings

Electricity

Based on the actual meter readings on 2 October 2017

Meter	Previous Reading	Current Reading	Quantity
Import Off peak period	004189.800	004324.500	93.536 kWh
Import Peak period			41.464 kWh
Solar	007609.400	007767.500	158.000 kWh

The electricity bill above shows Off peak and Peak electricity use in kWh, as well as the number of kWH fed back into the grid from solar. With solar, you are likely to get a credit (at right) for solar exports alongside your power bill.



Credit Note 7262041

03 October 2017

Account 811026512

Faults and emergencies
Call Jemena Electricity on 13 16 26

Item	Quantity	Unit Price	Amount
027267331 Feed-in Tariff	158.00	$0.7189	$113.44

Powershop credit $113.44

GST content $0.00

GST exclusive amount $113.44

hope for a better price for their certificates.

If you do wish to go through the process of creating and trading the STCs yourself, you will either need to engage with an STC agent to sell your certificates to, or create an account in the online REC Registry administered by the Clean Energy Regulator. You will also need some patience and effort to negotiate this process!

Feed-in tariffs: selling your surplus electricity

If you have a grid-interactive solar system, you will sell any excess electricity to the grid through your electricity retailer via a feed-in tariff—a fixed rate paid per kWh of electricity exported to the grid. Feed-in tariffs vary across states and territories, between retailers, and in some states, even across distribution networks.

In the majority of states, feed-in tariffs are operated on a `net' basis—with any electricity generation from your solar system first being consumed in the property and then any excess being exported to the grid. The total value of your `exports' is then deducted from your overall bill at the end of each billing period, in order to pay you the feed-in tariff value.

Ask your electricity retailer what type of feed-in tariff policy they may have, what rate you could expect to get after system installation, and critically, whether your tariff rate for your electricity consumption (or `import' from the grid) will change once you install solar. This is all important information to find out before signing up to a solar deal, so that you can choose the best deal for you.

Most states now allow you to shop around for an electricity retailer. Making a comparison of retail tariffs for electricity, for both regular consumption and for export, is important to ensure that you find the best deal available to you. The Australian Energy Regulator is the independent regulator of the National Energy Market and administers the tariff comparator website EnergyMadeEasy.

Not all states feature on this website, but most states have their own independent price comparators.

More information

The Clean Energy Regulator maintains a list of STC agents.
www.cleanenergyregulator.gov.au/RET/Scheme-participants-and-industry/Agents-and-installers/How-to-register-as-an-agent/List-of-registered-agents

The REC Registry is located online.
www.cleanenergyregulator.gov.au/OSR/REC/The-REC-Registry

Energy Made Easy website.
www.energymadeeasy.gov.au

Solar Choice has an up-to-date list of feed-in tariffs around the country.
www.solarchoice.net.au/solar-rebates/solar-feed-in-rewards

Join our COMMUNITY

BECOME AN ATA MEMBER

Inspiration, independent advice, sustainable solutions, one-on-one consultations, community events, free back issues of *Sanctuary* and *ReNew* magazines

Helping you reach your sustainability goals

www.ata.org.au

#9 Purchasing & installation

Ready to buy? Here's what to consider when signing up for solar.

As with all major purchases, you should carefully consider both price and quality when buying a system.

Always get at least three suppliers to quote for the same size system so you are able to compare prices, makes, models and warranties. When comparing prices, note that a quality system may cost more, but that this may be a cost that's worthwhile for a system with a long and useful life. Always ask for details on the type and quality of solar panels and inverter.

Websites such as Solar Quotes can make it easy to obtain multiple quotes without having to ring around.

Accreditation

Check that your solar retailer has Clean Energy Council Approved Solar Retailer Accreditation where participants adhere to an industry code of conduct. The code addresses issues of accountability and quality.

Also check that any installer you deal with has Clean Energy Council accreditation. Grid-interactive or stand-alone solar systems with 240 volt wiring have to be installed by suitably qualified and Clean Energy Council (CEC) accredited renewable energy installers. An accredited installer for a battery installation will hold either grid-connect installation accreditation with a

battery endorsement or grid-connect installation accreditation plus stand-alone installation accreditation.

Contact the CEC for a list of accredited retailers and installers in your area.

However, accreditation does not enable you to ascertain their competence or the quality of their work. You can be more confident in their ability if they provide you with a written quote and undertake a detailed generation analysis onsite, as part of a 'no-obligation' free quote. You should ask about the maintenance and operation requirements of your system, and don't be rushed into making a decision.

You could also do an internet search on a potential retailer or installer to see if there are complaints from other consumers, or ask for references.

Grid connection

Before you go ahead with installing a grid-interactive solar system, you may need to address grid-connection issues with your electricity distributor. The electricity distributor is responsible for the physical connection of your system, and house, to the electricity grid. There will be a single distributor in your location, so you cannot choose an alternative distributor. The process and technical details for grid connection will vary depending on your specific electricity distributor.

For most small systems (e.g. less than 5.0 kW), and in most locations, the process of grid connection is streamlined. Once installed, your solar installer fills out the relevant paperwork that is sent to the distributor and/or retailer, advising them that the system is ready for connection to the grid.

For larger systems (e.g. above 5 kW), you may be subject to a negotiation process with your distributor for grid connection. For these larger systems you need to speak to both your distributor

and solar installer first and find out as much information as you can with regards to likely timeframes, information requirements and costs. It is likely that you will need to engage an energy professional to assist you to negotiate the grid connection process. This may be lengthy and costly.

Below are some of the key issues to consider and discuss with your system installer and distributor.

Technical specifications

The technical and other requirements specified by distributors for grid connection vary considerably and are often in excess of Australian Standards (AS4777) and those specified by state or territory regulators. Your installer must be aware of these technical specifications for connection to your specific electricity distributor.

Connection agreement and charges

The process and guidelines for obtaining grid connection vary significantly between distributors.

You can be more confident in their ability if they undertake a detailed generation analysis onsite, as part of a 'no-obligation' free quote.

Distributors are required to negotiate 'in good faith' a 'fair and reasonable' agreement and charge for connecting your system to the network. In reality the costs can vary significantly depending on your location, distributor and retailer, and there is little scope for negotiating or appealing against these charges. Check and clarify these costs, and the process, often and early.

Metering

Grid connection often requires an upgrade to your existing electricity

meter to allow recording of bi-directional electricity flow to measure energy going to and coming from the grid. The cost of this meter upgrade can be in the hundreds of dollars, and may be at the discretion of the electricity distributor. Planning and performing this upgrade is often confusing, as are the technical specifications and meter type to be installed.

See *Chapter 7, Metering & Solar PV* for more information.

Help

The National Electricity Rules regulate the behaviour of electricity distributors and, in some states, the retailers. Some state regulators also apply codes and regulations which may also apply to utilities. Should you be unable to resolve issues concerning grid connection with your distributor or retailer, or believe that their behaviour may be outside the codes or regulations, contact the energy ombudsman in your state.

More information

Read the checklists on p. 69 and 70 when you are researching your system.

The ATA can help with advice by email and phone, and offers an Energy Consult service that can help you plan a solar power system.
www.ata.org.au/what-we-do/advice-services-2/ata-energy-consult

Clean Energy Council Approved Solar Retailer list.
www.solaraccreditation.com.au/consumers/purchasing-your-solar-pv-system/finding-a-solar-retailer

Clean Energy Council Accredited Installer list.
www.solaraccreditation.com.au/consumers/find-an-installer

Solar Frequently Asked Questions
www.ata.org.au/news/solar-frequently-asked-questions

Checklists

The checklists on the following two pages will help you select a system and installer. We recommend you get at least three quotes for the same sized system to enable you to compare prices, makes, models and warranties.

13 points to consider when comparing PV panels

- Do the panels have Clean Energy Council approval?
- How do they rate on the Photon Laboratory tests and in the German Öko-Test?
- How does the PV product quality compare to the brand awareness?
- Does the supplier offer a range of PV module types?
- How does the panel efficiency compare?
- What support is offered by the manufacturers and suppliers?
- What power tolerances are offered?
- How does the manufacturer's product warranty compare?
- How does the manufacturer's performance warranty compare?
- How does the supplier's installation warranty compare?
- Is prepaid independent insurance provided?
- Are any special features included?
- Price?

Top tips from a PV customer

Based on his experiences researching and purchasing a household PV system, *ReNew* contributor Aaron Hodgson put together this list of questions that you can use when researching solar companies and installers before you take the plunge.

- What is the total purchase price for a (XX) kW system? Is there a deposit required?
- What are the additional costs on top of the system price (e.g. meter)?
- Does somebody inspect the property first to check the site is appropriate and whether extra installation costs might apply?
- What is the total waiting period from sign-up to installation?
- How many panels are required for a (XX) kW system and what size is each panel (in watts)?
- How many square metres will the panels require? What is the length/width of each panel?
- What is the brand and type of solar panels and where are they made?
- What is the average daily and yearly kWh production for this system?
- What brand is the inverter and what's its rated capacity?
- Does the inverter have a larger capacity than the panels or are they size matched?
- What does the inverter display show?
- What accessories, such as remote displays, are available for the solar system?
- What is the warranty on: panels? inverter? mounting frame? workmanship?
- What is the performance warranty?
- How long is the inverter likely to last?
- Are the solar panels and inverter made by the brand name company or are they made by a different manufacturer and relabelled? If so, who is the original manufacturer of the panels and inverter?
- Does the solar panel brand name company that honours the panels' warranty have a base in Australia that I can contact if there are any issues with the panels? Also for the company that honours the inverter warranty, if different? What are the phone numbers and addresses?
- For how long have the solar panel and inverter brand name companies been selling these products?
- If the system is significantly cheaper or more expensive than average, why?
- For insurance coverage, what is the total cost before discounts and rebates?
- What sort of after-sales service do you have for enquiries and trouble-shooting issues?
- What is your CEC accreditation number for solar installation?
- Will you organise metering and switchboard modification, including the inspection and paperwork?
- Do you organise the application for the government STC rebate?
- Is your installation work contracted out?
- For how long has your company been installing solar photovoltaic systems?
- Could you provide me with the contact details of people you have installed solar systems for who would be happy to talk to me as a referee about your work?

Solar lingo

You don't need a background in electronics to purchase a renewable energy system, but a knowledge of the basics will help avoid problems. The following technical terms are used in relation to such systems.

AC: Alternating current electricity, the type that comes from the electricity mains at 240 volts to run everyday appliances. In a renewable energy system, an inverter will be needed to convert the DC electricity from solar panels or batteries into AC to be fed into the grid or run conventional appliances.

Ampere (amp): The unit of measurement of electrical current. Symbol for current is I, the unit symbol (amps) is A.

Ampere-hour, Amp-hour (Ah): A measurement of electrical energy, consisting of the measure of current flow over time. One amp-hour is equivalent to one amp of current flowing for one hour.

Current: The 'amount' of electricity flowing in a conductor. Similar to the volume of water flowing through a pipe. Measured in amperes, or amps.

DC: Direct current electricity, the type that solar panels generate and which is used to charge batteries.

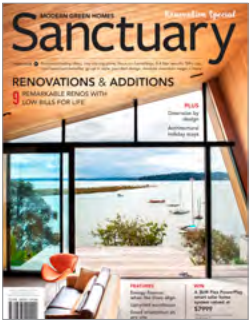
Voltage: Unit of measurement for electrical 'pressure'. Measured in volts (V).

Power: An instantaneous measurement of the energy flow in a circuit. Measured in watts (W). Wattage equals the voltage multiplied by the current flow.

Energy: A cumulative measure of energy flow or use. Measured in watt-hours (or kilowatt-hours). Equal to the flow of power measured over time. For example, a 100 watt load will use 100 watt-hours every hour, or 1000 watt-hours (1 kilowatt-hour) in 10 hours.

Low voltage: This term is commonly used incorrectly to refer to battery-level voltages. In fact, the term actually refers to DC voltages of 120 to 1500 volts and AC voltages of 50 to 1000 volts. So, 240 volt mains electricity is actually 'low voltage'. See http://en.wikipedia.org/wiki/Low_voltage for details. All low voltage work must be carried out by an appropriately qualified person such as an electrician.

Extra-low voltage: This is the correct term for the voltages typically found in battery-based renewable energy systems, such as 12, 24 or 48 volts DC.



Sanctuary is Australia's only magazine dedicated to sustainable house design. Published four times a year, every ***Sanctuary***:

- Features lavish, full-colour spreads, including floor plans and specifications, on sustainable new homes and renovations
- Profiles the work of Australia's leading environmental architects and designers
- Provides a wealth of inspiration, ideas and practical advice on how to make your home more sustainable, no matter what your budget

Subscriptions start at $40

Visit **www.sanctuarymagazine.org.au** or call **03 9639 1500** to subscribe.

ReNew: technology for a sustainable future is Australia's premier magazine on practical sustainable living.

Each quarterly issue features the latest in sustainable building practice and ways to make our homes more energy efficient, renewable energy technologies such as solar and wind, as well as the latest on electric vehicles.

Comprehensive articles, useful buyers guides and DIY stories provide practical information for you to use around your home.

Subscriptions start at $34

Visit **www.renew.org.au** or call **03 9639 1500** to subscribe.

Are you planning a home build or renovation?

Consider becoming a member of the *Alternative Technology Association* – publisher of *Renew* and *Sanctuary* magazines.

For $100 you receive invaluable information that will help you with your sustainable build or renovation including:

- Free advice service provided by ATA experts
- Subscription to both ReNew and Sanctuary magazines
- Online access to all back issues of both magazines
- Membership discounts on sustainable lifestyle products and services from select suppliers and the ATA webshop
- And you will be automatically entered in a major prize draw twice a year.

Visit **www.ata.org.au** or call **03 9639 1500** to join!

Getting help

There are many businesses that specialise in providing and installing renewable energy systems all over Australia. Each issue of *ReNew* magazine includes advertisements for businesses that specialise in renewable energy system installation.

An installer must be Clean Energy Council accredited and must be a licensed electrician. The extra money you spend on a good installer to design and install your system could be well worth it. Simple mistakes can also cost money. Before selecting an installer, ask to view photographs or references of past installations or even to look at some of the installer's work if possible. A good installer should be happy to show a customer examples of his or her work. **Note: to be eligible for government rebates your system needs to be installed by an accredited installer.**

ATA can provide free technical information over the phone or by email to its members and to the general public for a fee. For enquiries or to join ATA, go to www.ata.org.au or call ph: (03) 9639 1500.

Online resources

- Alternative Technology Association (ATA)
  www.ata.org.au
- ATA Free Solar & Battery Advice Service
  www.ata.org.au/ata-solar-advice
- ATA Energy Consultation
  www.ata.org.au/what-we-do/advice-services
- *ReNew* magazine
  www.renew.org.au
- *Sanctuary* magazine
  www.sanctuarymagazine.org.au
- *Your Home*
  www.yourhome.gov.au
- *Your Energy Savings*
  www.yourenergysavings.gov.au
- Clean Energy Council
  www.cleanenergycouncil.org.au
- Clean Energy Regulator
  www.cleanenergyregulator.gov.au

Alternative Technology Association

The Alternative Technology Association (ATA), is a not-for-profit organisation that has been promoting the use of renewable energy, water conservation and sustainable building since 1980. The ATA has thousands of members across Australia who are actively walking the talk in their own homes.

ATA also publishes two magazines *ReNew*: *technology for a sustainable future* and *Sanctuary*: *modern green homes*, available from newsstands across Australia.

Become a member of the ATA and you gain access to a large support network of knowledgeable people and receive a range of privileges to help you achieve your sustainability dreams.

Your ATA membership also provides you with a number of benefits:

- Free advice service, with answers to tricky questions provided by the ATA's experienced advisors.
- Discounts from the ATA Shop and a range of sustainable products and services.
- Invitations to local branch activities. An opportunity to network and exchange information with like-minded individuals.
- Quarterly issues of *ReNew* and/or *Sanctuary* magazines; packed with practical information on the latest and greatest in sustainable technologies.
- Updates on the ATA's local, national and international projects

ATA

For more information go to:
www.ata.org.au or call
(03) 9639 1500

ISBN 9780648149514