ReNew
Technology for a sustainable future

Off-grid & hybrid special

Win a Daikin US7 super-efficient 7-star reverse-cycle air conditioner
*Australian and NZ residents only; details p97

just add batteries?
What solar households need to know

Plus
Latest in battery tech
Electric vehicles off-grid
Share your solar & more

Hybrid haven: best of both worlds
DIY diverter: stop water waste
Sustainable skills: renewable energy courses

Solar inverter
Buyers Guide inside

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### Off-grid and hybrid special
Solar and storage at home or in the community + more

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- Installation of solar and batteries begins in a mini-grid trial by AusNet Services in Mooroolbark. Page 34.
- All-electric retirement can look this good and be powered by solar + batteries. Page 66.
With the current buzz around energy storage, many solar households are wondering whether to add batteries to their PV system. This issue we look at the pros and cons, and just what you need to consider when adding storage. Our cover home is a grid-connected solar beauty in WA that featured recently in issue #35 of our sister magazine Sanctuary (read more at www.sanctuarymagazine.org.au). In line with the theme of this issue, the home’s architect Paul O’Reilly from Archterra Architects says that many of his clients are asking about installing batteries as well as solar (and he’s looking forward to reading this issue to help them decide on the best approach). We also look at battery technologies, battery recycling and case studies of people living with off-grid or hybrid systems. Our special starts on page 40.

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In this section we share info about products that sound interesting, sustainable and useful. Product listings are not an endorsement by ReNew or the ATA of any particular product—they are for reader information only. They are not product reviews and we have not tested the products.

01
Garden furniture from tyres

Tyres are a bit of an environmental nightmare, and even though recycling does happen, the global stockpile of old tyres continues to grow.

Rather than downcycling them by shredding them into rubber crumb, Retyred Furniture upcycles them into useful, long-lasting garden furniture, plant pots and even mirrors. No new rubber is used; their pieces are entirely made from discarded tyres.

The range includes many varieties of chairs, tables, ottomans and even garden storage trunks and baskets. You can buy a single chair or table, or a complete set.

The products are all handmade in a small village in Indonesia under fair trade principles (although not officially Fairtrade-certified), so workers get fair pay for their efforts—Retyred Furniture staff visit the factory regularly and have a family-like relationship with the workers.

RRP: Prices start from $15 for a 22cm diameter pot through to $1590 for a full dining set. Chairs start at around $140. For more information and to buy, contact Retyred Furniture, 3 Manns Rd, Mullumbimby NSW 2482, office@retyredfurniture.com.au, www.retyredfurniture.com.au

02
Use your solar power locally

We’ve seen a few power diverters (devices which divert excess solar electricity into simple loads such as water heaters, rather than exporting it to the grid) hit the market in the last few years, but the Powerdiverter is the only one we have seen rated to handle heating elements up to 4.8 kW.

Like all diverters, the Powerdiverter continuously monitors the power usage within the home and when it detects excess solar electricity exporting back to the grid, automatically sends this excess power to the heating element in your hot water system, storing the energy as hot water. This lets you use your solar-generated electricity to offset expensive mains electricity, rather than selling it back to the energy company for a few cents per kilowatt-hour.

The Powerdiverter’s power sensor comes in either wired or wireless versions to suit your particular installation requirements. No plumbing is required as the unit simply connects to the existing element in your hot water service. While it can’t operate a heat pump, if your heat pump has a separate backup element then it should be able to operate that (if the element is separately accessible, rather than controlled by the heat pump’s controller).

RRP: $995 (currently available for pre-order at $895). For more information, contact Power Diverter Pty Ltd, PO Box 6109, Silverwater NSW 1811, ph: 1300 277 426, sales@powerdiverter.com.au, www.powerdiverter.com.au

03
2017 Permaculture calendar

Now in its ninth year, the 2017 Permaculture Calendar is ethically produced on post-consumer recycled paper and printed using vegetable-based inks.

The calendar is filled with inspirational and thought-provoking images that support and reinforce the permaculture message.

Learn each of the 12 design principles over the course of a year and be reminded of suitable garden activities with daily icons and phase times according to the moon planting guide.

Includes a handy rainfall and temperature chart to keep track of the year’s events, and moon symbols for northern and southern hemispheres.

RRP: $14, discounts are available for multiple copies. For more information and to buy, contact Permaculture Principles via their website at www.permacultureprinciples.com
Sustain your skills
Courses in the renewable arena

We’ve updated our renewable energy courses guide ready for enrolment time. You’ll find the table of courses—from TAFE certificates to postgraduate degrees—on our website, and here Anna Cumming has a look at what’s new in the industry.

IN THE two years since we last published a review of the renewable energy courses available in Australia, things haven’t all been rosy for the renewable energy (RE) industry. Months of uncertainty at federal level over the national Renewable Energy Target, funding cuts to climate-related science, and the scaling back of feed-in tariffs for solar generation have all contributed to a reduction in the size of the industry.

The latest available Clean Energy Council (CEC) figures put the number of people employed in the wider RE industry at 14,020 (CEC) figures put the number of people employed in the wider industry at 14,020 (CEC) figures put the number of people employed in the wider industry at 14,020 (CEC) figures put the number of people employed in the wider industry at 14,020 from the peak of 19,120 in 2011–12. However, for the financial year 2014–15, down a big 27% from the peak of 19,120 in 2011–12. However, for the financial year 2014–15, down a big 27% from the peak of 19,120 in 2011–12. However, for the financial year 2014–15, down a big 27% from the peak of 19,120 in 2011–12.

The mood across the industry is upbeat in 2016, and it is expected that job figures will begin to grow once project development begins in earnest again under the RET in the coming years.

David Tolliday, Renewable Energy Training Coordinator at Holmesglen in Victoria, shares this feeling. “The initial RE boom [homeowners taking advantage of rebates and premium feed-in tariffs to install solar PV] has passed, and the solar install industry has settled to around 4200 accredited installers—a good sustainable number,” he says. “The big opportunities now are in bigger-scale stuff like commercial solar, and battery storage on grid-connected systems.”

So, how to get involved? For those wanting to get into the industry or upskill, there is a wide variety of training and courses to choose from, from undergraduate and postgraduate university courses in engineering or focused on broader energy strategy, to hands-on solar design and install certificates offered by TAFEs and private registered training organisations (RTOs), and even free online MOOCs (massive online open courses). See our previous RE courses guide in ReNew 129 for a comprehensive look at the types of courses available, prerequisites and typical training pathways; here, we look at what’s new since 2014.

TAFE and RTO courses
At the more hands-on end of the RE training spectrum are certificate courses in system design and install. These can cover wind and micro-hydro systems too, but are “generally more focused on solar PV due to demand,” says Michael O’Connell, instructor and course facilitator at Swinburne University.

Funding cuts to the TAFE sector in recent years have seen course offerings reduced, but it’s still possible to find grid-connect and stand-alone design and install courses in every state and territory; see the online table accompanying this article for details. In addition, the CEC maintains a list of training organisations registered with them, which includes private RTOs as well as TAFEs.

It’s important to note that you don’t need to be a qualified electrician to get this sort of training. “While our Certificate 4 in Design & Install Grid-Connect Systems is aimed at electricians, actually anybody can do the design component,” says Michael, “and our Design & Install Stand-Alone Systems certificate is available to anybody with relevant skills and experience, because it doesn’t involve working with 240V power.”

You do need to be a licensed electrician to be able to install and work on any equipment with voltages higher than 50V AC and 120V DC, though.

Russell Harris recently completed the Design Grid-Connect Solar PV Systems course with David. “I’m an engineer with 10 years experience in the solar/RE industry, so for me this was a refresher,” he says. “I run my own consulting business now, advising companies on the technical and financial merits of solar for their business. Although the Holmesglen course focuses on residential systems, it has a strong technical element to it and I found it useful for understanding the practicalities of what installers have to deal with.” He recommends students considering this kind of study look for rigour in how the course is designed and assessed, get recommendations, and of course make sure the course is accredited.

David says Russell’s experience is more and more common: “There’s starting to be more interest in commercial solar systems of 100kW and above—they are financially more viable. The training required to design and install these systems is basically the same. We are seeing self-employed people coming back for more qualifications and extending their businesses. You don’t have to be an installer either—there are jobs available working for solar companies doing system design.”

THE NEXT BIG THING
“Distributed generation and storage are changing the energy landscape permanently,” says Glen Morris, vice president of the Australian Solar Council and Energy Storage...
Electric vehicles on the move
The market in Australia and overseas

Bryce Gaton reports on the evolution of government support and global carmakers’ production plans, which together are driving uptake of electric vehicles.

THIS year has seen a plane fuelled only by the sun travel around the world, a plethora of home electric storage systems come on the market, Australian households with solar PV systems pass the 1.5 million mark and a Tesla Model S travel from Sydney to Broome. Given 2016 is just past halfway through, what else is to come? Is 2016 to become the year that the hoped-for seismic shift in sustainable transport, energy sourcing and use truly begins?

The power to change things is more in our hands than ever before and I will offer examples from around the world that hopefully we can look back on in 20 to 30 years time to say, “We really did start the sustainable transition then!”

Electric cars around the world
Right now, pure EVs with a 300+km range—the ‘Bolt’—are rolling off the Chevrolet production line to arrive in US showrooms in the last quarter of this year.

Similarly, Mercedes, Volvo, Renault, Nissan, BMW, Kia and many other Chinese makers already offer pure EVs in their lineups, and most of these have announced plans to match the 300+km range of the Bolt and Tesla Model 3. Mercedes is releasing plug-in hybrids (PHEVs) and even Jaguar is rumoured to be well down the track in developing an electric sedan and SUV to match the belatedly perceived threat to their core market from Tesla’s Models S and X.

And VW, as part of its mea culpa for the dieselgate emissions scandal, has recently announced plans to heavily move into electric vehicle design and production.

Overall, the trend towards less polluting vehicles continues, with global uptake of EVs and PHEVs climbing at an increasing rate, growing from 45,000 EVs sold in 2011 to more than 300,000 in 2014 (see Figure 1). EVs represent more than 1% of total new car sales in the Netherlands, Norway, Sweden and the USA (closer to 20% for Norway). And in China, 2014 saw 230 million e-bikes, 83,000 electric cars and 36,500 e-buses hit the road.*

Meanwhile, policies to encourage the push away from polluting vehicles are building. Examples include:

- Paris has banned cars manufactured before 1997 from the city centre on weekdays.
- The French Government has dropped all subsidies for diesel (which it used to strongly encourage as a CO2 reduction measure) to the point that it is even talking about a scrappage scheme for diesel cars due to the issues with particulates, NOx and SOx.
- England has extended its incentive scheme (a £4500 grant) for plug-in electric vehicles to 2018.
- Germany, which has long held out against EV subsidies and incentives, is developing proposals for just such a scheme.
- Norway has recently announced a national transport plan that includes a goal for only EV and PHEV vehicles to be sold from 2025, with negotiations continuing as to the best way to implement that goal. Since Norway’s announcement in early June, both Holland and India have announced they will consider following a similar path.
Getting in front of the meter
Finding value in sharing

Can we find value for both customers and the network in sharing locally generated energy and thus accelerate a transition to 100% renewables? Bruce Thompson and Paul Murfitt discuss the potential in microgrids, virtual power plants and more.

THE transformation of the electricity network is certainly now upon us. Years of environmental advocacy, rapid technology advances and shifts in consumer demand are driving an unprecedented shakeup of our century-old supply network. With this change come opportunities (and some risks) to harness the value of renewable energy across the grid as we drive towards zero emissions.

Traditionally, Australia’s electricity networks were largely built and controlled by state governments, and operated as central power supply systems managed with two policy imperatives in mind: security of supply and cost-effectiveness. The much-heralded disruption is turning this system upside down, bringing technical and financial challenges along with opportunities.

The big shift to date has been ‘behind the meter’, where there is a clear case for householders and businesses to invest in solar PV to avoid the cost of conventional energy supply. Yet establishing value ‘in front of the meter’—sharing your locally generated energy across the grid—has so far been fraught.

With the tapering off of feed-in-tariffs, owners of solar have been frustrated they don’t receive a fair price for their homegrown generation. On the other side of the fence, network operators have been aggrieved by the need to manage the technical impacts of solar PV and wind while their business model ‘death spirals’ from lower consumption.

Beyond the angst, new models such as microgrids and virtual power plants are starting to demonstrate that sharing solar PV generation and battery storage across the grid can leverage the opportunities and help manage the risks inherent in Australia’s changing electricity sector. For customers, potential benefits include access to wholesale pricing and retail tariffs. For networks, there can be lower costs from local control and load management, particularly if the models can reduce peak demand and avoid the need for network infrastructure augmentation.

Of course, the value of sharing locally generated energy across the grid is dependent on the time of day, the time of year and the location. The key challenge for ‘in front of the meter’ solutions is not only to understand the technology, but also to apply the fundamental principles of supply and demand to determine where the greatest value can be realised.

But what is a microgrid?
Microgrids are small-scale private local electric power grids or networks with the capacity to be controlled and coordinated. As with other grids, they consist of distribution (e.g. electrical cabling), electricity generation and grid regulation. In microgrids, however, generation (e.g. solar) occurs close to consumption. This enables the sharing of energy between houses, businesses (e.g. in shopping centres) or apartments, with the potential for associated network and billing benefits.

Microgrids can operate behind a single ‘parent’ meter connection to the main grid, as often already happens in caravan parks,
Mini-grid in Mooroolbark
Neighbourly sharing

Neighbours in the Melbourne suburb of Mooroolbark are set to share their energy generation via a mini-grid in an Australian-first trial run by AusNet Services. Eva Matthews finds out what’s involved.

IN AN Australian first, network provider AusNet Services is currently rolling out a solar + storage mini-grid trial in Mooroolbark, in Melbourne’s east.

Of the 16 homes on the chosen street, 14 will each have between 3 and 4.5 kW of solar panels and a 10 kWh battery storage system installed, with a cloud-based monitoring and management platform to optimise power flows across the mini-grid and to provide demand management support to the network.

The two-year trial was announced in April and was made possible with funding from the Demand Management Innovation Allowance. Participants don’t pay for the equipment and, at the end of the trial, get to keep their panels and inverter (but the control system and battery storage go back to AusNet Services).

As at end August, all houses have solar panels, inverter and battery storage installed, enabling data gathering on energy generation and usage patterns. The control system should be in by end October, which is when testing can begin in earnest. Testing will include deciding when to charge and discharge the batteries, and at what rate, based on current and forecast customer usage and PV generation as well as the network requirements. A single objective (e.g. minimising the overall peak demand on the mini-grid) can be implemented in a number of ways, so they will be developing and testing different approaches. The stabilising device and switching equipment that enable the mini-grid to be islanded (isolated from the rest of the network) will be installed towards the end of this year.

The group of houses will operate as a mini-grid from a control and electrical point of view, but the metering and billing arrangements are unchanged. To enable financial offsetting of one participant’s generation against another’s usage would require different meters to be installed—with a parent meter for the mini-grid and sub-meters for each house—so instead they will be modelling the potential financial effects.

Two households were unable to participate in the trial; however, this will provide fortuitous real-world data for where there is less than 100% opt-in—testing how the mini-grid can serve the energy needs of these houses without having their energy contribution in the mix. AusNet Services’ Distributed Energy and Innovation Manager Justin Harding explains, “Those houses will simply appear as extra loads in the mini-grid. For example, if we are trying to reduce the net demand of the mini-grid to zero at the connection point to the main grid, all houses would need to export a small amount of energy to offset the non-participants’ load.”

Simone and Joel Beatty make up one of the households participating in the trial. When they purchased their home five years ago, Simone says they noticed that a lot of the new houses being built were having solar installed, and it was something they were interested in, but hadn’t been able to afford. So when AusNet Services came knocking on their door with news of the trial, Simone says they were “definitely excited.” As well as looking forward to seeing how it all works, and the impact on their electricity bills, Simone says they have also benefitted from the information provided by AusNet Services—how they can log in to a web portal to monitor their electricity usage and ways in which they can be more energy efficient. She says they have “definitely already altered some behaviours.” And not only has there been an educational side effect of having the technology installed, it has given the neighbourhood something in common to talk about and get excited about. Simone says “everyone seems very positive about it” and adds that friends and family are jealous!

This trial follows a three-year battery storage trial by AusNet Services that tested how residential batteries can reduce customer’s maximum demand for electricity and support the network. Justin Harding says that there will likely be an “evolution of trials” into the future. This Mooroolbark trial has a strong customer learning and technical focus; the next step could be a larger project with more of a commercial focus, looking at how best to structure finances and customer agreements.
Should I quit the grid?  
If so... which grid?

If you’re thinking about quitting the grid, the ATA’s Andrew Reddaway suggests you first ask: “which grid?” You may achieve a better environmental and financial impact from quitting the gas or petrol grids, rather than the electricity grid.

WITH the current media focus on energy storage and how it could help consumers take control of their energy needs (and bills), one of the recurring questions we get asked at the ATA (ReNew’s publisher) is “should I quit the grid?”

Well, one good answer to that question might be: “which grid?”

People often focus on electricity when planning to quit the grid, but in fact there are three energy grids that most Australian households rely on in their day-to-day lives: electricity, gas (both bottled and piped) and petrol/diesel.

Everybody’s situation and motivations are different when it comes to quitting the grid, but often people are interested in saving money, becoming more self-sufficient and reducing their environmental impact. It is feasible to achieve all these things, but it’s worth taking a step back to ensure the biggest impact for the money you spend. Disconnecting your home from all three grids is possible, but it’s challenging and may require a large upfront investment. Quitting one or two grids is a lot easier and cheaper, and can provide a high degree of self-sufficiency, bill savings and a positive environmental impact.

Let’s look briefly at each of the quit options and how they interact, as quitting one grid can affect how easy it is to quit the others.

**Quitting the electricity grid**

With more than 16% of Australian homes having solar, can’t these homes simply add a battery on the garage wall and sever their electricity connection? Many recently installed solar systems are quite large, around 4 kilowatts (kW), and for many such installations, the annual solar generation exceeds the household’s annual electricity consumption. However, it’s not so simple on a day-to-day basis: the real challenge for quitting the electricity grid is getting through a cloudy week.

There will be days at a time when the sun isn’t shining and the house will need to rely largely on stored energy. This means a large battery, large solar system (to ensure the battery can be sufficiently charged) and accompanying high cost—a quick estimate is a cost of around $55,000 for a system including a 10 kW solar system and 65 kWh of lead-acid battery storage, which might suit a Sydney-based household with moderately low electricity consumption of 10 kWh per day.

On top of that, there’s the likelihood that you’ll need a petrol or diesel generator for backup on days of high consumption (e.g. when visitors come to stay) or days of really low generation (e.g. an exceptionally dark week, like the east coast flooding in June 2016, or when smoke from bushfires blocks sunlight).

It’s not impossible to go off-grid, of course, as our case studies on pages 58 and 68 show, but it requires careful design of the system to suit the household’s energy usage and location, and, over the life of the system, it won’t be cheaper than staying connected to the grid, on current prices. (However, if you’re in an area without access to the grid, it will likely be cheaper than getting the poles and wires installed to bring the grid to your door, a cost that the householder bears.)

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Electricity usage accounts for only part of household energy consumption and spend, as shown by these charts representing indicative averages for Victoria (high gas usage due to prevalence of gas heating) and Queensland. To minimise energy consumption overall and have the best environmental benefit, it’s worth considering quitting or minimising usage of the gas and petrol ‘grids’. Source: ABS and previous ATA modelling; indicative figures only due to potential inconsistencies between sources.
Just add batteries
Considerations for hybrid systems

There’s more to consider than just the brand or size when adding storage to a solar system. Damien Moyse and Nick Carrazzo highlight some of the issues to consider in a field with ever-evolving technology.

THERE are multiple ways that batteries can be added to an existing or new solar PV system. These different configurations will influence the system’s capabilities so it’s important to carefully consider the approach you take. This article covers the most common approaches currently available in Australia, but note that technology and options are developing rapidly so we will be updating this advice regularly.

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 an additional or replacement inverter and charging components will likely be needed to charge and use the batteries.

One approach (DC coupling) involves replacing the existing grid-interactive inverter with a new hybrid inverter; such inverters can both control charging of the battery and conversion of electricity from DC to the AC required for household use. As a cheaper alternative, in a fairly recent development, the replacement of the 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. Coupling refers to where within the system the batteries are connected.

DC coupling
DC coupling involves siting the battery on the DC side of (or indeed plugging it directly into) the solar inverter (see Figure 1).

The wires connecting to the battery on this side of the solar inverter carry DC electricity, so the solar-generated electricity can be used to charge the battery prior to it being converted to AC for household consumption or export to the grid.

This approach means that the solar inverter will need to be a ‘hybrid’ inverter, which has a higher level of functionality than a traditional...
Finding the ideal storage
The lowdown on battery technology

Critical to any energy storage system is the battery itself. So what technologies are available and what are their pros and cons? Lance Turner takes a look inside the technologies available now and what’s in the offing.

Lead-acid
This old faithful is the mainstay of the home energy storage industry. Lead-acid batteries have been in use for over a century and are a tried and proven technology.

They consist of plates made of spongy lead (negative plate) and lead dioxide (positive plate), with sulphuric acid as the electrolyte. During discharge, both plates are converted to lead sulphate, and the discharge reaction produces water which dilutes the sulphuric acid, changing its specific gravity. This change in specific gravity is what allows you to measure a flooded-cell lead-acid battery’s true state of charge using a hydrometer.

Lead-acid batteries have several advantages:
- reasonable resistance to overcharging
- lower cost than many other technologies
- readily available
- almost 100% recyclable
- almost all inverters and charge controllers are lead-acid compatible
- widespread knowledge of the technology in the industry.

They also have disadvantages, including:
- low energy density, which means high weight per unit of storage
- can’t be regularly deep cycled without reducing lifespan
- primary reactive materials are toxic and corrosive
- can produce explosive hydrogen gas when charging
- can’t be stored partially discharged without damage—must be fully charged regularly to prevent sulphation (where permanent lead sulphate crystals form on the plates)
- Peukert effect—effective capacity reduces with increasing discharge rate.

There are several forms of lead-acid battery, so let’s look at each.

FLOODED-CELL LEAD-ACID
These consist of the battery plates suspended in liquid sulphuric acid. They are robust and generally reliable, but require the highest maintenance of all the lead-acid battery types. Their primary advantage is that they are cheaper per unit of capacity than the other forms of lead-acid batteries, although with the increase in popularity of the other forms, the difference is now minimal in many cases.

Disadvantages include:
- they must remain upright in storage and use to prevent electrolyte spillage
- electrolyte levels must be checked periodically and topped up if necessary
- they must be periodically equalise-charged to balance state of charge in each cell in the battery and to eliminate electrolyte stratification (where the electrolyte separates into layers of differing density)
- produce explosive hydrogen during normal charging cycles, so must be installed in ventilated enclosures.

SEALED LEAD-ACID
As you might expect, a sealed lead-acid battery uses the same chemistry as a flooded-cell version, but the battery is effectively sealed. The electrolyte in a sealed lead-acid battery is either contained in an absorbent fibreglass separator between each of the plates (absorbent glass mat, or AGM, batteries) or is turned into a thick gel with the addition of a silica-based gelling agent to the electrolyte (gel cell batteries, also sometimes incorrectly called silicone batteries).

Sealed lead-acid (SLA) batteries are often called by another name—VRLA (valve regulated lead-acid), as they actually have a pressure valve in each cell to allow the venting of gas for safety during an extreme
Recycling analysis
Options for lithium batteries

In a recent research study at ANU, Matthew Doolan and Anna Boyden considered the full life cycle of lithium ion batteries and their recycling options to assess environmental pluses and minuses. They present a summary here.

BATTERY use in consumer electronics is growing rapidly, with an ever-increasing range of battery-powered products, from mobile phones to laptops to power tools, and battery use in electric vehicles and home power systems adding to the equation. Many of these products now use lithium ion batteries, with such use expected to double over the next six years¹ and then continue to grow: a recent report projects a 41-fold increase in lithium ion battery waste in Australia by 2036, from 3340 tonnes in 2016 to 137,000 tonnes in 2036.²

This growing use of batteries comes at a cost to the environment, including impacts from mining of the materials used in the batteries and end-of-life disposal issues. When it comes to end-of-life, lithium ion batteries contain relatively low levels of toxic materials, compared to batteries containing lead and cadmium, and therefore in many countries, including Australia, they can be legally disposed of in landfill.

However, there are environmental and safety risks. Helen Lewis from the Australian Battery Recycling Initiative (ABRI) notes that used lithium ion batteries need to be carefully managed during transport and disposal as they can explode or catch fire if they get damaged or over-heated. There have already been some incidents in the waste industry that were attributed to lithium batteries. These risks can be managed in a properly run recycling process.

In 2012–13 in Australia it’s estimated that 98% of lithium ion batteries were sent to landfill¹, with many batteries also hoarded at home in old mobile phones. Recent initiatives have been set up to initiate collection and potential recycling or reuse via MobileMuster and ABRI, and the effectiveness of these is still to be assessed.

In addition to reducing landfill impacts, recycling of lithium ion batteries has direct environmental benefits including reducing the impacts of producing batteries from new materials—potential benefits include material recovery, less impact from mining, reduced emissions and reduced energy consumption.

Recent developments in battery technology to reduce the cost of batteries have meant a decrease in the amount of valuable material in lithium ion batteries (specifically cobalt and copper), thus reducing the financial incentive to recycle lithium ion batteries, hence regulation is needed.

Recycling techniques

It’s important to assess the most effective approach to recycling lithium ion batteries. Choosing the wrong approach could actually increase the environmental impact of dealing with the batteries at the end of their life.

There are three commercially available recycling techniques used for recycling lithium ion batteries: mechanical, pyrometallurgical and hydrometallurgical. Each process recovers different materials and amounts of energy from the battery being recycled.

Mechanical processes involve ‘liberating’ components and materials from the battery and then sorting these materials. Liberation of components and materials can be done by crushing or shredding the batteries. The materials resulting from this process can then be separated according to their physical properties such as weight (using flotation on a series of liquids) and magnetic behaviour (using strong magnets). These processes are effective at capturing most of the materials within the lithium ion battery, but cross-contamination can reduce efficiency.

Pyrometallurgical processes such as smelting, pyrolysis and refining involve the
PV and hydro powered
Tassie off-grid home

Given their distance from the nearest power pole, it made sense financially as well as philosophically for this Sydney couple to go off-grid in their new home in Tasmania. Peter Tuft describes how they went about it.

As we approached retirement my wife Robyn and I knew we did not want to spend the rest of our lives in Sydney. Sydney’s natural environment is glorious but it is also much too busy, too hot and humid in summer, and our house was too cold and hard to heat in winter. We had loved Tasmania since bushwalking there extensively in the 1970s and it has a lovely cool climate, so it was an obvious choice.

We narrowed the selection to somewhere within one hour’s drive of Hobart, then on a reconnaissance trip narrowed it further to the Channel region to the south. It has lush forests and scattered pasture with the sheltered d’Entrecasteaux Channel on one side and tall hills behind—just beautiful. And we were extraordinarily lucky to quickly find an 80 hectare lot which had all those elements plus extensive views over the Channel and Bruny Island to the Tasman Peninsula. It was a fraction of the cost of a Sydney suburban lot.

The decision to buy was in 2008 but building did not start until 2014 so we had plenty of time to think about what and how to build. We have always been interested in sustainability, and renewable energy in particular, even before they became so obviously necessary: my engineering undergraduate thesis in 1975 was on a solar heater and Robyn worked for many years on wastewater treatment and stream water quality. There was never any doubt that we would make maximum use of renewable energy and alternative waste disposal methods.

From the beginning we knew the house would be of passive solar thermal design.

The house sits high on a hill (for the views!) and faces north-east. The main living room is entirely glass-fronted, about 11 m long and up to 4 m high with wide eaves. That allows huge solar input to the floor of polished concrete. A slight downside is that there is potential for it to be too warm in summer, but we’ve managed that with shade blinds and ventilation and so far it has not been a problem. All walls, floor and roof are well insulated, even the garage door, and all windows are double-glazed. Supplementary heating is via a wood heater set in a massive stone fireplace chosen partly for thermal mass and partly because it just looks awesome. Warm air from above the wood heater convects via ducts to the bathroom immediately behind the chimney, making it very cosy indeed.

Stone and timber sourced from the site
We were fortunate to be able to use a lot of on-site materials. The external cladding, both timber and stone, was sourced from our own land. Eighteen months before building started we had some large eucalypts felled and milled into cladding boards then stacked to dry. Some very large pine trees (weeds as far as we are concerned) were processed similarly and ended up making a lovely panelled ceiling in our large living room. Our property has extensive syenite, a granite-like rock which often has beautiful large crystals of feldspar and colours varying from grey through creamy yellow to a dusky red. We spent days picking tons of loose stone from the ground surface then transporting it to a dam where we cleaned it with a pressure washer before handing over to the stonemason. The same stone was also used for the fireplace.
A story of storage
Australia’s first Powerwall home

Nick Pfitzner and family are the proud owners of the first Tesla Powerwall home in Australia. Nick Pfitzner describes their configurations and the lessons they’ve learnt so far.

OUR household had the privilege of the first Tesla Powerwall installation in Australia (maybe the world, they say). It has been a very interesting experience so far, and we’ve learnt a lot about what makes the house tick from an electricity point of view. I’ve also had the opportunity to discuss the energy generation landscape with several organisations developing similar energy storage technologies.

As a self-described Elon Musk fanboy, I became seriously interested in energy storage for our house after the Tesla Powerwall launch in 2015. I knew about other home storage systems, but mostly associated them with lead-acid systems and off-grid enthusiasts. We had previously got a quote for an off-grid AGM lead-acid system at one point, but we didn’t have the finance or space to make the BSB (big steel box) happen at that time.

However, by late last year with our finances more in order, we decided to take the plunge with the Powerwall. We chose Natural Solar as the installer. They had advertised themselves as the first certified installer of Powerwall in Australia and helped guide us through the options available.

We opted for 5kW of Phono solar panels with a SolarEdge inverter and, of course, the Powerwall, for a total cost of $15,990 installed.

Was this the most financially sound use of our money? As a simple case, we put the initial cost of installation up against our largest asset, the mortgage.

Our household electricity usage bill was just over $1900 for the previous 12 months, not including the fixed daily supply charge of about 85 cents per day (i.e. that’s just looking at usage, the part that we can change by installing solar and battery).

A reduction of around 80% in our usage charges would save us approximately $1520 over a year; more than double the value of the money in our mortgage offset, and equating to a payback of around 10 years on the investment value. However, we would no longer offset our interest payments to the tune of $750 per year, pushing the payback time well beyond the Powerwall’s warranty period. Considering we were just as likely to use the money on a family holiday as an interest offset, over the longer term, I opted to install the system and reduce my running costs today. To date, we have seen a 90% decrease in our electricity bill, year-on-year, or around $450 per quarter.

And add Reposit grid credits
Natural Solar also informed us about Reposit Power, a software package designed to maximise the benefits of home storage for the consumer. In a nutshell, Reposit is a software-based controller for the entire system. It learns the household usage patterns, gathers weather forecast data and interfaces with the inverter to make decisions about import or export of energy based on two important concepts:

Tariff arbitrage. This is the practice of switching to a time-of-use grid tariff and changing the battery at times advantageous to
Hybrid haven
All-electric dreams come true

John and Elizabeth Heij have created their dream retirement home on the coast south of Adelaide: comfortable, all-electric, running almost entirely from solar + batteries, and with an EV to boot.

IT’S fair to say that 80-year-old John Heij and his wife Elizabeth are early adopters. It was 2004 when they first installed a small solar + battery system to run lights and computers in their home in the Aldinga Arts EcoVillage, on the coast south of Adelaide in South Australia. Then, in 2013, they designed and built a new house (in the same village), and as part of that, installed a larger hybrid (grid-connected) system to run their entire all-electric home and electric vehicle (EV). In addition, they’re effectively off-grid for water, with two 22.5kL in-ground rainwater storage tanks that have supplied all their water needs for the last three years.

Their power system comprises 9.6kW of Canadian Solar panels, two 5kW Kaco/Selectronic inverters, a Selectronic SP-Pro inverter-charger and 32kWh of Sonnenschein sealed lead-acid gel batteries, configured in an AC coupled system.

The size of the system means they import “less than half a kilowatt-hour per day” of electricity from the grid—a tiny proportion of the average import of 19kWh/day in their area for two-person homes (as noted on their most recent ‘bill’—or rather, credit—from AGL). Of course, their actual energy usage is higher, with most of their 7 to 18 kWh daily usage (based on June to August 2016 usage figures, higher when charging the EV) coming from the PV panels or the batteries.

The system cost between $30,000 and $35,000, but John notes that they would have done it “no matter the cost”. It’s a philosophical issue for them: “if the powers that be aren’t going to remove coal and gas, we have to do something about it ourselves,” he says.

Solar diverter
One of the interesting features of the system is the inclusion of a Sunnymate diverter (now called the SunMate) which optimally directs the solar energy. It starts by first charging the batteries, then diverts to the solar hot water system’s electric water tank element, then to the heater in the house. Elizabeth notes: “The air conditioner has to be managed manually as the Sunnymate doesn’t seem to handle motor-driven equipment. This apparently can be overcome by using relays but we haven’t gone that far yet. It handles the heater well as it is a resistive load.”

Since installing the system, they’ve never had to heat water from the grid: “even on the dullest days, it always manages to heat water.” John adds that they never get a full day of rain in their area, so there’s always some generation.

The Sunnymate can also control charging of their electric car. They only charge the car during the day and most of that charge is from solar. “We’re a bit different than some people as we’re retired and can organise our energy use for during the day,” notes John.

Driving range
Their car is a Nissan Leaf with a 25kWh battery. As “homebods”, they’ve found the car’s 145km range not a problem at all. They use it for shopping and local trips, with a recharge usually taking up to four hours at about 2.7kWh per hour; they rarely run the car.
PV-powered house and motorbike
Nick’s future is electric

With no generator and excess energy on sunny days, Nick Wardrop’s off-grid energy system has helped fuel his passion for motorbiking—literally.

IN 2003, while I was working as a design engineer for Ergon Energy’s Renewables Group, a half acre of land beside a wild river south of Cairns became available for purchase. It had a basic one-bedroom shack on it, and was beyond the power, town water, sewerage and rubbish services, but had an outside toilet and septic system, a landline and a sealed road past the door. Having been involved with renewable energy since the mid 1970s and having lived half my working life involved with remote rural PV and wind power in the Pacific region (in Kiribati, Fiji, Central Philippines and the Marshall Islands), it seemed like ‘home’! I decided to buy it and use my acquired skills.

Energy efficiency means no generator
My PV-powered system for a household of two evolved in stages. Initially, I installed a small 1kW, 24 V system which included a backup generator. I upgraded the system in 2006 to include a 48 V, 6kW inverter, 46 kWh sealed lead-acid battery, and two PV arrays of around 1.5kW (new modules, facing north) and 1kW (old modules, facing north-west). Through judicious energy efficiency measures I was able to reduce energy use, first to 3 kWh per day, and then to 2 kWh per day with the purchase of a new two-door refrigerator to replace our 15-year-old unit (which was considered 5 Star in its day and still worked okay).

This reduced energy use meant the backup generator was no longer required. However, that did necessitate some behavioural changes, such as using LPG to cook and boil the kettle in extended times of low insolation, a reduction in TV use, and even use of battery-powered radio in preference to the large stereo. When there is plenty of energy, an all-electric kitchen (microwave oven, electric kettle and toaster, breadmaker, food dryer etc) reduces LPG use. We found this a small price to pay for the added simplicity of a system without a backup generator—no refuelling, noise, moving parts or servicing, to name a few advantages.

With this system in place, we found other methods to reduce energy use during infrequent extended overcast conditions. These include postponing washing (if clothes are particularly dirty, we hand rinse and then dry and store them until there is sufficient energy to wash them). Although we don’t have a large wardrobe, we have enough clothing to cover a few weeks! Large rainwater storage tanks mean we can pump water to a larger header tank in times of high insolation, which then provides gravity feed of water to the house independent of electric power (giving about two weeks of water storage). Food drying, baking etc are also planned around periods of high insolation.

We also use the seven-day weather forecast to change our behaviour, so that if a number of days of inclement weather are approaching, we are conservative with energy use. Conversely, if good weather is on the way, we may use energy more profligately!

30% energy capture advantage
One of the important design decisions for the PV system, apart from large storage capacity, was to incorporate highly efficient maximum power point tracking (MPPT) charge...
System specs
- 3kW of PV split into 2 arrays (9 x Sharp 175W in 3 strings, 6 x Trina 250Wp in 2 strings)
- 2 x AERL MPPTs (1500 BMV), one for each array
- 46 kWh of Sonnenschein A600S VRLA (gel) batteries (48V, 960 Ah)
- 6kW Selectronic PSI 6/48 inverter (the 3rd Selectronic inverter I own, all still working!)

Electric appliances
- 500L lower freezer Electrolux fridge
- Sharp convection/microwave oven
- breadmaker, electric kettle and toaster, food dryer, whisks, sandwich maker
- Breville espresso machine
- fans x 5, two Haiku ultra high efficiency
- lights (30), all except five of which are high efficacy LED
- Grundfos 1.5kW deep bore pump (240V)
- Samsung 106cm LCD TV and DVD player
- Yamaha surround sound stereo
- Samsung laptop computer with Brother colour laser printer
- satellite receiver, router and 8TB server
- workshop equipment including welder, drills, saws, jackhammers
- battery chargers (many and varied), cordless phone, bedside radio
- electrical engineering and solar test equipment (calibrated)
- transfer pump (on 24V PV subsystem).

Remaining fossil fuels
- Pajero diesel (now 26 years old, bought new, around 380,000 km, fuel efficiency 10L/100 km, use has halved since purchase of Zero motorcycle)
- mower (22” cut, self propelled, Honda 4-stroke powered)
- chainsaw (2-stroke, very occasional use, mainly after cyclones)
- fire pump (used occasionally for pumping from river)
- two-burner LPG stove
- Weber LPG barbeque

Heating/cooling/hot water
- Edwards solar hot water, stainless steel 300L tank, 4m² of collectors, no booster
- cooling via natural ventilation and fans at present, or jump in the river! Small 7 Star Daikin reverse-cycle air conditioner planned (or I may win it by renewing my ATA membership!) Living less than 7 degrees from the equator for 17 years has raised my tolerance for heat and humidity

Biomass-powered sports equipment
- hiking shoes and backpacks
- swimming togs, fins and goggles
- kayaks x 2
- bicycles x 3 (road and two mountain bikes).
Mains power anywhere
An inverter buyers guide

Whether you live off-grid or have a grid-connected generation system, the right inverter can make all the difference. We check out what’s available, where to get them and which one is right for you.

CHOOSING an inverter may not be the first thing that comes to mind when you’re thinking about installing a solar or solar + battery system. But every one of the 1.5 million solar systems already installed in Australia includes an inverter and, in fact, it can be thought of as the ‘heart’ of the system— if it’s not working, your solar generation is wasted or, if you’re off-grid, you’ll be without power (or at least without mains-equivalent 240 volt power*).

But what is an inverter and why is it so important? In a nutshell, an inverter takes electricity from a power source that produces DC electricity, such as solar panels or a battery bank, and converts it into mains-equivalent power (240 volt AC), ready to be used in your house.

It is important to have a good inverter. In off-grid systems, if your home relies solely on 240 volt power from a stand-alone inverter and the inverter fails, you will have no power, even though it is still being generated and stored. In grid-connected systems, an inverter failure means your solar panels are doing nothing until the inverter is repaired or replaced.

Which inverter for your needs?
The majority of currently installed grid-connected solar systems will be using a grid-interactive inverter. A grid-interactive inverter converts the energy from solar panels into mains power and feeds it into the house’s electrical wiring—no storage is involved. As indicated by the name grid-interactive, these inverters can export energy into the grid, and require a grid connection (or an equivalent 240 volt AC supply) to operate; they can’t operate in a stand-alone capacity.

When you bring energy storage into the equation it gets a little more complex, as the inverter needs to deal with both a generation source (like solar panels) and batteries; and possibly also the grid.

In off-grid systems, a stand-alone inverter can be used to convert the DC electricity from the battery bank into mains-equivalent power to run standard appliances. An inverter-charger is like a stand-alone inverter except that it has a mains voltage level input, which can be used to charge the batteries from the mains or a generator—it is not, however, grid-interactive, so can’t export energy to the grid.

The most complex inverter type is the hybrid inverter, which can feed energy into the grid from either the solar array or the battery bank. Many hybrid inverters can also power the house from the batteries during a power failure, in effect becoming a large UPS (uninterruptible power supply). They can also charge the batteries from the grid.

This makes many hybrid inverters true bi-directional devices, and many, if not most, can handle all of the energy flows in a home energy system. Some can even divert the excess solar energy to a particular load, such as a water heater, replacing the need for a separate device, known as a solar diverter (the SunMate is one example), for this purpose.

Let’s now look at the features of each type of inverter in a bit more detail.

* Modern inverters, such as this grid-interactive unit from Fronius, 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 data logging and firmware updates, a signalling output, a built-in webserver so that owners can log into it from anywhere in the world and, being transformerless, it weighs only around 21kg.

* In fact, it will usually be 230 volt power as Australia has officially used 230 volts for some time, but most people still refer to mains power as 240 volts, so we will use the more common term in this guide.